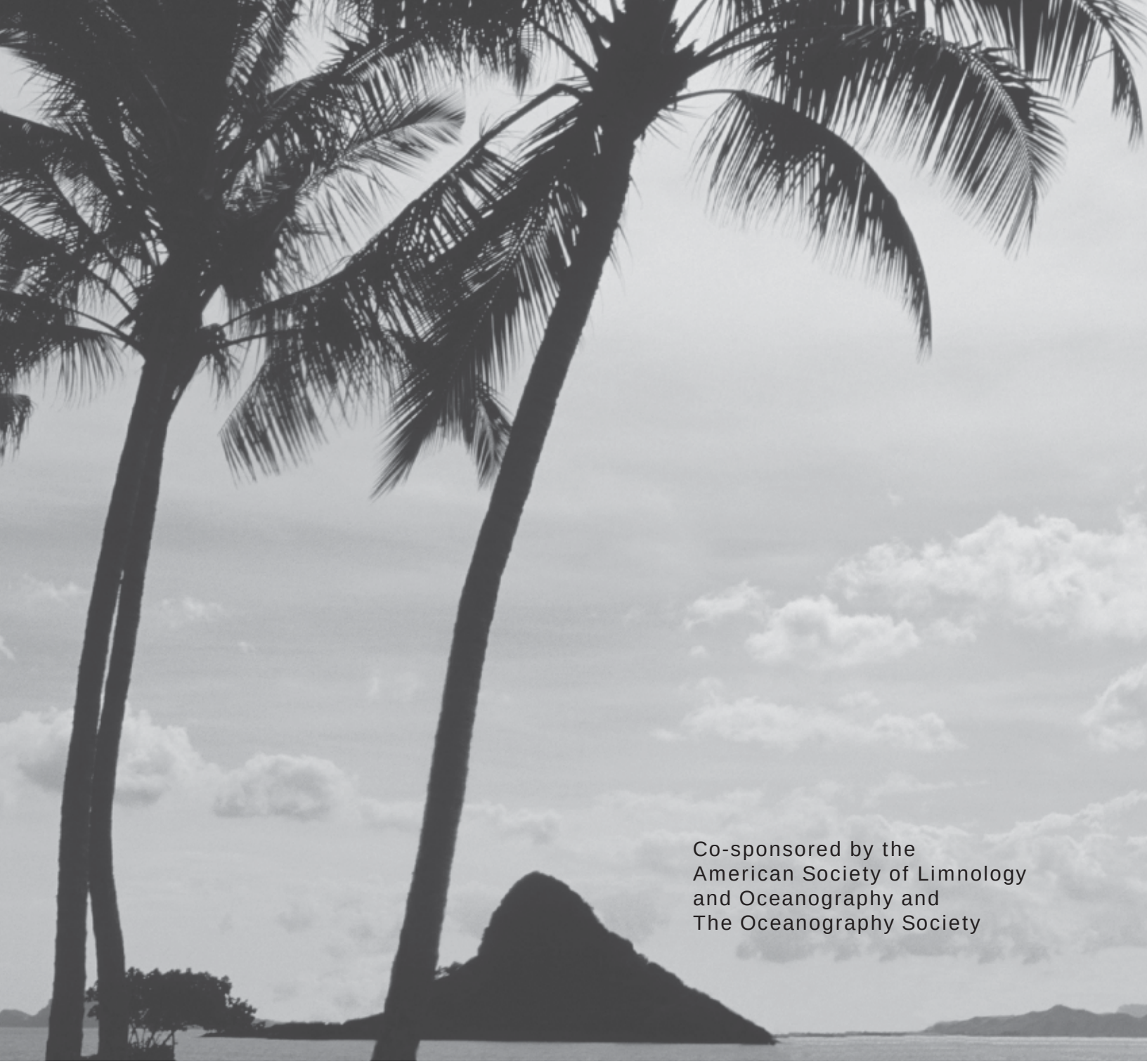

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THE PACIFIC INFLOW THROUGH BERING STRAIT: 1990-2002

Nearly continuous measurements of the northward flow of Pacific waters through Bering Strait from 1990 onward provide a remarkable record of the variable upstream forcing of the western arctic shelves and of the Arctic Ocean halocline. Extreme warmth in the mid-1990s, accompanied by major changes in the shelf ecosystem; large and complex salinity variations that within a few months will be transmitted into the Arctic Ocean halocline; and a pronounced annual cycle in the northward flow are all hallmarks of the record from Bering Strait. These and additional measurements in the Chukchi Sea suggest that the regional salinity distribution and circulation in the Bering Sea are determining factors in the variability of the northern shelf and of the injection of Pacific water into the Arctic Ocean.

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BIOAVAILABILITY OF IRON FOR CYANOBACTERIA CULTURES

The chemical form of chelated Fe appears to play an important role in regulating the bioavailability of Fe to Trichodesmium colonies in the north Atlantic Ocean. Determining the bioavailability of Fe from model ligands to Trichodesmium cultures in the lab is also important, as cultures lack the bacterial diversity associated with colonies in nature. This allows for the comparison of the effects of ligand structure on Fe acquisition between lab cultures and Trichodesmium colonies in the field, and thus differentiates between Fe uptake capabilities of the cyanobacterium in isolation, and uptake mediated or modified by associated bacteria within the colony. Therefore, uptake experiments using 55Fe chelated to a variety of model ligands were conducted on Trichodesmium cultures. These results will be compared not only to the field experiments conducted on Trichodesmium colonies, but also to other cultures of ecologically significant cyanobacteria such as Synechococcus.

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OCEANOGRAPHIC APPLICATIONS OF IRIDIUM COMMUNICATIONS: CURRENT PROBLEMS & FUTURE SOLUTIONS

Autonomous, in situ ocean observations are rapidly becoming more numerous and sophisticated as platforms and sensors become more diverse, compact, economical, and robust. While observation technologies have developed at a rapid pace, the ability to transmit the resulting data from remote ocean areas back to the land-based investigator has not. Satellite communications have existed for several decades, but application to autonomous systems has lagged due to inadequate band width and/or component power and size restrictions within the observation system. With the establishment of the Iridium constellation of communication satellites in the last decade and buoyed by reports of successful Iridium-based communications during the recent war in <?xml:namespace prefix = st1 ns = “urn:schemas-microsoft-com:office:smarttags” />Iraq, it is time for the oceanographic community to reassess the feasibility and role of satellite-based communications in existing and planned ocean observation systems. Iridium-based data transfer rates are on the order of 200 bytes/s, allowing the transfer of a 100 kb data set from a mid-ocean sensor to a land-based laboratory in just over 8 minutes. Recent examples of data transfer costs through commercial service providers are on the order of $0.15/kb. While this cost might appear reasonable for small data sets, the cost can easily become prohibitively large when applied to projects requiring many sensors involved in long-term monitoring. Recent changes in the cost structure of Iridium services to U.S. Government research agencies (e.g., DOD, NSF, NASA, NOAA), when combined with emerging Iridium-specific technologies, have the potential to reduce the unit cost of data transfer several orders of magnitude, making autonomous observations and monitoring in remote regions of the ocean both feasible and cost effective.

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THE EFFECT OF TURBULENCE ON THE ECOPHYSIOLOGY OF BENTHIC ORGANISMS

Fluid dynamic forces influence the functioning of aquatic ecosystems. This is best known in pelagic environments, where experimental and modelling efforts indicate that low levels of turbulence promote encounter rates between predators and prey, but higher levels of turbulence interfere with prey capture. Similar domed-shaped responses to turbulence have been identified in benthic macrophytes and suspension-feeding organisms. The promotion of the biological processes is related to the replenishment of locally-depleted resources, while the inhibition is likely related to both physical and behavioural responses. In the case of macrophytes, it has been suggested that turbulence, specifically shear stress, interferes with enzyme regulation related to photosynthesis. In bivalves, the inhibition of feeding may be related to pressure effects, behaviour reactions to lift, drag, and shear stress, and physiological regulation. The regulation in “polyp feeders” may be related to behavioural responses. Regardless the optimal rates, which occur between Reynolds numbers of 100 and 10000, vary with the type of benthic organism. The scaling relationship of these responses will be discussed, as an understanding the relationship between turbulence and benthic productivity speaks to fundamental processes that occur in coastal environments.

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THE EFFECT OF TURBULENCE ON THE FEEDING RATE OF A PELAGIC PREDATOR: THE PLANKTONIC HYDROID CLYTIA GRACILIS

Relatively little is known about the role of turbulence in a predator - prey system in which the predator is a passive pelagic forager. Such a predator is represented by the unusual Campanulariid hydroid Clytia gracilis (Cnidaria, Hydrozoa), which occurs as planktonic colonies on Georges Bank, Massachusetts, USA. In this study we investigated the role of various turbulence conditions on the feeding rate of C. gracilis colonies in laboratory experiments. We found a positive relationship between turbulence velocities and feeding rates whereby feeding rates tended to increase up to the turbulent energy dissipation rates of ca 1 cm2s-3. Beyond this threshold the feeding rates dropped slightly, indicating a dome-shaped relationship. Additionally, a negative relationship was found between feeding efficiency and hydroid colony size under lower flow velocities, but this trend was not significant under higher turbulence regimes.

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IRON LIMITATION OF HETEROTROPHIC BACTERIA IN THE SUBARCTIC PACIFIC OCEAN

We monitored the response of heterotrophic bacteria to a mesoscale iron enrichment experiment in the subarctic Pacific, a high-nutrient, low-chlorophyll (HNLC) region. One day after iron addition, bacterial abundance increased 1.6-fold. Within 2 days, 3-H-leucine incorporation rates and growth rates increased approximately 2-fold, siderophore receptors were downregulated, and iron uptake rates dropped by 90% compared to initial conditions. Such rapid physiological changes indicate that the bacteria were iron-limited. Twelve days after the initial fertilization (5 days after re-infusion of iron), leucine uptake and growth rates were 3- and 5-fold higher than controls. The additional stimulation coincided with an increase in chlorophyll and primary production, suggesting that bacteria were responding to increased DOC. At this time, siderophore receptors were expressed at pre-enrichment levels, and iron uptake rates increased, indicating that cells were re-entering a physiological state of iron-stress. Our data support the hypothesis that bacteria can be iron-limited or iron and DOC co-limited in HNLC regions. Sampling of the microbial community during perturbation experiments should occur on the order of hours rather than days so their response is not overlooked.

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PHYTOPLANKTON FLORAL COMPOSITION AND PRIMARY PRODUCTION IN CHESAPEAKE BAY, USA

We examined relationships between phytoplankton floral composition and primary production (PP) in Chesapeake Bay. Floral composition was reconstructed using CHEMTAX analysis of photopigments and primary production was measured by 14-C uptake. On a bay-wide annual basis, diatoms, cryptophytes, dinoflagellates, and cyanobacteria accounted for 93% of chl-a biomass. Diatoms represented the greatest proportion of chl-a biomass (0.52) with peaks in spring (0.70) and fall (0.53) compared to summer (0.28). Inter-annual variability in proportional diatom abundance was positively correlated with Susquehanna River flow. Other taxa tended to dominate under low flow conditions and showed strong seasonal and regional distribution patterns. Diatom-associated increases in chl-a biomass drove elevated rates of PP, particularly during summer and fall. During spring, diatoms were also associated with low rates of chl-a-specific productivity (PBopt and PBmax), particularly under conditions of high residual nitrate concentrations and relatively high water temperatures. Non-diatom spring bloom assemblages did not show these relationships. Our study suggests that environmental forcing simultaneously affects phytoplankton floral composition and PP. This relationship is important for understanding phytoplankton dynamics in Chesapeake Bay.

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THEORETICAL ANALYSIS OF COMPETITION FOR LIGHT AND NITROGEN BETWEEN N2-FIXING AND NON-N2 -FIXING PHYTOPLANKTON

Biogeochemical studies have increasingly focused attention on the potentially significant role of N2 fixation in the N dynamics of the oceans. It is extensively debated to what extent the competitive success of N2-fixers depends on low nitrate availability, and to what extent this competitive success also varies with the availability of other nutrients like iron and phosphorus. However, interactions with light limitation remain to be analyzed. Recent studies show that N2-fixation by marine cyanobacteria is highly light dependent, as N2 fixers require energy to break the N2 triple bond. Here, we investigate a competition model to analyze competition for nitrate and light between N2-fixing cyanobacteria and non-N2 -fixing phytoplankton. Our model predicts stable coexistence of N2-fixing cyanobacteria and non-N2 -fixing phytoplankton, where the N2-fixing cyanobacteria are limited by light energy and the non-N2 -fixing phytoplankton are limited by nitrate availability. The model also shows that the relative abundances of these two groups will vary with major environmental variables like mixing depth, incident light intensity, and background turbidity.

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TRANSPLANTATION AND ISOTOPIC EVIDENCE OF THE RELATIVE EFFECTS OF AMBIENT AND INTERNAL NUTRIENT SUPPLY ON THE GROWTH OF ULVA LACTUCA.

We investigated net growth response of the macroalga Ulva lactuca in estuaries of Waquoit Bay, Massachusetts, to internal and external nitrogen supply using a field transplantation experiment and isotopic measurements. Net growth depended on the internal nitrogen pool, obtained from the origin estuary, and the nitrogen supply provided by the estuary the fronds were transplanted to. Fronds from all three original estuaries experienced higher growth rates when incubated in Childs River than when in Sage Lot Pond. Growth rates of Ulva collected from Sage Lot Pond were lower than those of fronds collected from Childs and Quashnet rivers when transplanted into Childs River, suggesting fronds grown in a nutrient-poor estuary grew slowly when transplanted in a nutrient-rich estuary. In addition, the initial nitrogen content of fronds from Childs River was 3-fold higher than that of fronds from Sage Lot Pond. The isotopic evidence showed that transplanted fronds showed less influence from their origin estuaries. Although the initial percent nitrogen may have affected growth at first, the nitrogen pools of the fronds were soon replaced by the uptake of ambient nitrogen.

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YELLOWSTONE LAKE GEOTHERMAL ECOSYSTEM: MICROBIOGEOCHEMICAL FEATURES OF IN VENT WATER AND SOLID PHASE SAMPLES.

One third of Yellowstone Lake, WY is directly influenced by hydrothermal activity (hot water vents and fumaroles). Geothermally heated water percolating through the chamber is highly enriched in carbonate, silicate, chloride, and methane, with some locations additionally rich in iron and sulfide. The bacteria inhabiting vent systems in Yellowstone Lake have access to reduced minerals and oxidizing agents necessary to support chemolithoautotrophic life. Using a ROV, vent and bottom water was collected for analyses of water chemistry and microbial populations, from nearly 100 underwater hot vents (with high temperature (143C) and mineral (pH to 4.5, H2S to 1mM, elevated trace metals). Chemosynthetic fixation of carbon dioxide ranged from <0.012 to >100ugC/L/hr in hydrothermal waters. Canyons about 50m deep have been consistently studied in Mary Bay and West Thumb, revealing that the chemistry of the basins is different. Hydrogen sulfide and other reduced compounds present persistently in Mary Bay are usually absent in West Thumb, whereas high chloride and silicate concentrations have been observed. Evidence of bacterial deposits in several areas have been observed with scanning electron microscopy in solid samples.

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MN AS A TRACER IN THE BERING SEA

The distribution of dissolved manganese is of interest for its possible use as a tracer of the sources of the micronutrient iron. Dissolved manganese was measured on several surface transects in the southeastern Bering Sea during Aug/Sept., 2003 using a clean shipboard pumping system and a flow-through system with catalytic, spectrophotometric detection. The measured Mn exhibits a strong east to west gradient and reflects the hydrographic and nutrient regimes of the Bering Sea. An island enrichment effect was observed in samples taken near the Pribilof Islands, but not observed in samples taken off the Aleutians. Near the Pribilofs the surface mixed layer deepened to 65m and entrained near bottom shelf waters with elevated [Mn], while off the Aleutians it appeared that high nutrient, low manganese subsurface waters were freshly upwelled leading to surface waters highly enriched in nutrients, but relatively low in [Mn]. Manganese, in combination with temperature, salinity, and nutrients, can be used as a hydrographic tracer, as well as a tracer for the origin of surface waters, and can provide insight into the sources of dissolved Fe.

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A NOVEL CLADE OF MARINE SYNECHOCOCCUS DEFICIENT IN NITRATE UTILIZATION

The picocyanobacteria Synechococcus are found throughout the world's oligotrophic and coastal waters. Although most strains of Synechococcus in culture were originally isolated using nitrate, a few strains which cannot grow on nitrate as a sole nitrogen source have been described recently. To further explore nitrogen utilization in Synechococcus, we isolated cyanobacteria from a well-mixed water column from the Sargasso Sea in March 2002 using either ammonium, nitrite, or nitrate as the sole nitrogen source. Partial sequencing of the 16S-23S rDNA internal transcribed spacer from 106 clonal isolates revealed at least 3 new phylogenetic clades of Synechococcus, including one which contains only strains isolated on ammonium. Growth experiments reveal that all strains tested from this group can grow on ammonium and nitrite but not nitrate. Guided by the genome of Synechococcus strain WH8102, we are exploring the genetic mechanisms behind this deficiency. These strains suggest that the inability to utilize nitrate may be more widespread among field populations of marine Synechococcus than previously thought, and this may have implications for our understanding of nitrogen cycling in oligotrophic systems.

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OCCURRENCE PATTERNS OF SEABIRDS IN THE CALIFORNIA CURRENT: MODELING PHYSICAL AND BIOLOGICAL HABITAT FEATURES

As a part of the GLOBEC-Northeast Pacific project, we investigated variation in the abundance of marine birds in the context of biological and physical habitat factors in the northern portion of the California Current System during cruises in June and August 2000. Continuous surveys of seabirds were conducted simultaneously with the measurement of ocean properties using a towed, undulating vehicle and a multi-frequency bioacoustic instrument (38-420 kHz). At a scale of 2-4 km, physical and biological oceanographic variables explained 12.8 to 62.5% of density variation depending on species. The most important explanatory variables (among 19 initially included in each multiple regression model) were: distance to the along-shore upwelling front, sea-surface salinity, acoustic backscatter representing various sizes of prey (smaller seabird species were associated with smaller prey and the reverse for larger seabird species), and chlorophyll concentration. The importance of the latter adds support to the hypothesis that seabirds are attracted to productive areas by odors (especially from dimethyl sulfide); once in those areas they then search directly for actual prey schools.

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SOURCES OF STRUCTURE IN THE PELAGIC ZONE

When G. Evelyn Hutchinson first presented the "Paradox of the Plankton" in 1961 and puzzled over how so many species could coexist in a seemingly homogenous environment, little was known about the nature of the pelagic zone or of the physical, chemical, and biological mechanisms that might generate heterogeneity and habitat partitioning. We now know that the water column is highly structured on many scales and the ecological and biogeochemical implications of this structure are under fervent investigation by many researchers. Sources of structure include particle surfaces and microhabitats such as marine snow and fecal pellets, marine gel matrices, vertical discontinuities in temperature, salinity and density, horizontally distributed "thin-layers" enriched in organisms, particles and dissolved molecules, chemical trails generated by organisms and sinking particles, surface films, and intrusions. An overview of structure in the water column will be presented and its potential significance in ocean ecology discussed.

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DISCARDED APPENDICULARIAN HOUSES CONTRIBUTE SIGNIFICANTLY TO PARTICULATE CARBON FLUX

Discarded appendicularian houses are potentially a major source of sinking carbon in the ocean because of their large size, high abundances, rapid production rates, and ubiquitous distribution, but their contribution to carbon flux is poorly known. Using empirical data on appendicularian abundances, population size frequency distributions, the size-specific carbon content of discarded houses, and house sinking rates, the potential flux of particulate carbon in discarded houses of Oikopleura dioica and Oikopleura longicauda, two very abundant and widely distributed species, was estimated to range from < 1 to over 1200 mg C m-2 d-1 in several oceanic and coastal regions. The maximum contribution of discarded houses of these two species alone to total POC flux in both eutrophic coastal and oligotrophic oceanic regions ranged from 12 to 83%, with most values falling around 28-39%. Clearly appendicularians have the potential to greatly impact the quantity of carbon sequestered in the deep ocean.

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THE UTILITY OF A CONTINUOUS RADON MONITOR FOR TRACING WATER MASSES AND SUBMARINE GROUNDWATER DISCHARGE IN THE COASTAL OCEAN

Previous oceanographic studies utilizing the radon emanation technique for the measurement of Rn-222 were often tedious and as a result yielded poor spatial and temporal resolution. In particular, this method required large volumes of water (~20 L) and a complicated extraction system involving liquid nitrogen. With the advent of a portable solid state radon monitor (Durridge Company, Duxbury MA), an almost unlimited number of samples can be analyzed with around the clock sampling, yielding either time series data at a single location or on line analysis from a ship's intake system in transit. During the spring and summer of 2003, we employed the continuous radon monitor in two separate field applications to measure in situ Rn-222 in coastal water masses. In the first application, we utilized the system during a cruise in the Gulf of Maine to trace coastal water mass transport rate and direction. A series of shore perpendicular transects revealed high Rn-222 activities in nearshore river plumes and provided insight into the direction and rate of plume movement offshore. For the second application, we used the instrument to monitor submarine groundwater discharge (SGD) near the seepage face in Waquoit Bay, MA, a shallow enclosed estuary on Cape Cod. The resulting time series revealed a correlation between Rn-222 and salinity and that SGD was modulated by tidal stage.

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THE RESPONSE OF JUVNENILE CORALS TO MICROENVIRONMENTAL CONDITIONS CREATED BY MACROALGAE

Caribbean reefs are undergoing a phase shift from coral to macroalgal domination, which limits coral survival. This study was designed to assess conditions juvenile corals experience beneath macroalgal canopies. A combination of laboratory and field experiments were designed to explore the biological significance of juvenile coral-macroalgal interactions and test responses of juvenile corals to short-term fluctuations in irradiance created by thallus orientation. On shallow reefs of St. John and Jamaica, approximately 20% of juvenile corals (i.e., colonies less than 4 cm diameter) are shaded by macroalgae, which cover 30-90% of the substratum, respectively. Shaded corals are exposed to light regimes differing from unshaded reef communities in quantity and short-term fluctuations scaling from seconds to minutes. To investigate how these differences affect coral photophysiology, dark-adapted quantum yield was quantified using PAM Flourometery. Of three corals investigated, only shaded Siderastrea siderea showed increased yield. The response of these corals suggests the detrimental effects of macroalgae on adult corals may not extend to juveniles, and furthermore, by positively affecting S. siderea, the most commonly shaded coral, macroalgae may influence species composition on reefs.

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A MICRO-SCALE GEOMICROBIOLOGICAL MODEL OF ANAEROBIC METHANE OXIDATION BY ARCHAEA/SULFATE-REDUCING BACTERIA AGGREGATES

The mechanism responsible for anaerobic methane oxidation (AMO) remains poorly understood, despite abundant evidence that the process occurs. Incubation and inhibition experiments using pure cultures and natural sediments, in concert with studies employing rRNA probes, secondary ion mass spectrometry, and carbon isotopic analysis of biomarkers, point to a microbial aggregate composed of methanogenic archaea and sulfate-reducing bacteria (SRB). According to this mechanism, archaea oxidize methane and release an intermediate compound (e.g., hydrogen, formate, and/or acetate) that SRB consume to maintain favorable energetics. We present a radial diffusion model to investigate the physical and thermodynamic constraints on AMO. Novel aspects of the high-resolution (0.1 nm) model include: implicit coupling between reaction transport physics and thermodynamic energy yield; realistic geometry of microbial aggregates; and differential kinetics and metabolic functions for microbial cell components such as lipid membrane, cell wall, and cytosol. The model indicates that AMO via a consortium involving archaea and SRB is possible with hydrogen, formate, or acetate as intermediate transfer agent. However, organisms must function at cellular energy yields that are below the maintenance energy reported for chemoautotrophic growth.

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SPECTRAL SIGNATURES OF PHYTOPLANCTON ASSEMBLAGES IN CASE I WATERS FROM SATELLITE AND IN-SITU DATA

Distinguishing phytoplankton species from space is a major challenge for ocean color in case I waters. The well-know variability of normalized water-leaving radiances (nLw) for a given chlorophyll a concentration partly comes from the variability of optical properties of phytoplankton cells. Up to now, lack of worldwide in-situ measurements of phytoplankton assemblages prevented to develop empirical relationships. Here we used a set of photosynthetic pigments collected in the framework of the French GeP&CO program to relate changes in SeaWiFS nLw to phytoplankton species. Twenty photosynthetic pigments were systematically measured during twelve cruises (Oct. 1999 – July 2002) from Le Havre (France) to Nouméa (New Caledonia) onboard a merchant ship. We extracted all coincident SeaWiFS nLws between 412 and 555 nm and we normalized them to get a set of nLw spectra that do not depend on the chorophyll concentration. We show that SeaWiFS measurements in case I waters significantly vary with in-situ pigment composition and that at least four major phytoplankton assemblages can be successfully detected. The first global results of this classification for year 2001 will be presented.

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ARE HARMFUL ALGAL BLOOMS RESPONSIBLE FOR THE VARIABILITY IN PHYTOPLANKTON SPECIES COMPOSITION DURING SPRING BLOOMS IN THE SANTA BARBARA CHANNEL?

Statistical analyses of surface HPLC pigment concentrations collected over six years from the Santa Barbara Channel yields a prominent diatom-dominated EOF mode that correlates positively with biogenic silica and negatively with SST. This is consistent with the mode being upwelling-associated, although the mode amplitudes are highest only during some episodes of spring upwelling. As part of the Santa Barbara Coastal-LTER program, seasonal surveys of channel-wide water chemistry, physical properties, and phytoplankton community structure and a taxonomic investigation of spring bloom phytoplankton are used to explain the discrepancy in interannual diatom-mode strength. For two consecutive years, these blooms have been dominated by the toxic diatom group, Pseudo-nitzschia spp. However, the spatial distribution of this diatom is not as closely correlated with physical and chemical variables as one would expect. In 2002, high cell densities appeared in response to localized alongshore upwelling, while in 2003, high densities (>106 cells l-1) were widespread despite the presence of an enclosed eddy in the western channel. Interannual variations in basin-wide HAB intensity may drive the variability in spring diatom population dynamics.

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CONSTRUCTION OF A NITROGEN BUDGET FOR A TEMPERATE COASTAL LAGOON

Hog Island Bay, a coastal lagoon on the Virginia Delmarva Peninsula receives nitrogen (N) from a variety of allochthonous and autochthonous sources. The primary allochthonous sources from the small watershed are base flow with high concentrations of N derived from agricultural sources and direct atmospheric deposition. We hypothesized that allochthonous N inputs support ephemeral blooms of opportunistic macroalgae as well as high productivity of benthic microalgae. A nitrogen budget was developed in an attempt to distinguish the relative importance of allochthonous vs. autochthonous sources in satisfying the N demand of the primary producers within the system. Data inputs to the budget included direct atmospheric deposition, monthly base flow, seasonal sediment gross N remineralization, gross primary production by benthic micro- and macroalgae and phytoplankton, sediment water - nitrogen fluxes in both subtidal and intertidal habitats, and sediment N cycling rates including nitrification, denitrification, and N fixation. Allochthonous sources (113,000 kg N/yr) were insufficient to support observed and estimated N sinks (2,043,000 kg N/yr) in the coastal lagoon. Autochthonous sources (1,912,000 kg N/yr) were the dominant source of N supporting primary production.

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NUTRIENT REGULATION OF BACTERIAL GROWTH IN CONTRASTING BIOGEOCHEMICAL PROVINCES OF THE WESTERN ATLANTIC AND THE SUB ARCTIC PACIFIC

Bacterial distribution and dynamics in the upper ocean differ greatly over a variety of temporal and spatial scales. In many regions, organic, or inorganic nutrients, or both have been found to limit bacterial growth. As part of a larger study of microbial dynamics, we examined bacterial response to organic (glucose, glutamic acid) and inorganic (N, P, Fe) enrichment in different biogeochemical provinces in the Western North Atlantic during different seasons and in the Eastern Subarctic Pacific. Bacterial growth was enhanced by organic nutrients in the Subarctic Pacific, inside a mesoscale Fe-enrichment experiment and a nearby unenriched reference site, and in temperate and Subarctic waters of the Western North Atlantic. In contrast bacteria in the Sargasso Sea responded only to inorganic (N and P) nutrients. These difference have important implications for the cycling and remineralization of biogenic carbon in the contemporary and future ocean.

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NEAR SHORE WIND STRESS CURL OVER MONTEREY BAY FROM A HIGH-RESOLUTION MODEL AND REPEATED AIRCRAFT SURVEYS WITHIN THE AUTONOMOUS OCEAN SAMPLING NETWORK (AOSN)

The role of wind stress curl in coastal circulation is the source of much speculation. Previous observations have shown that significant wind variations exist near coastal promontories. Analysis of 18 months of output from the Navy's non-hydrostatic atmospheric model (COAMPS) run at 9 km resolution has shown that strong positive curl exists up and down the California coast and that upwelling driven by wind stress curl matches or exceeds that driven by coastal divergence. Beginning in August 2003, a major field campaign, the Autonomous Ocean Sampling Network (AOSN) was initiated. In support of that campaign, the Naval Research Laboratory began running a quadruple-nest version of COAMPS, which yields a model resolution of 3 km in the area of central California. At the same time, aircraft surveys over Monterey Bay were initiated to map SST, ocean color, and low level (30 m) winds. Twelve surveys were conducted in August 2003. The wind stress curl, particularly during upwelling-favorable conditions, is well simulated in scale and amplitude by the 3 km simulations. At 9 km, the simulations have qualitative agreement with reduced magnitudes.

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SHALLOW-WATER OCEAN: A SINK OR SOURCE OF ATMOSPHERIC CO2?

Future decreases in biogenic calcification owing to decreasing carbonate saturation state could cause a subsequent decrease in CO2 flux to the atmosphere. However, increasing deposition of organic matter within the coastal zone will cause this system to become increasingly net heterotrophic, a source of CO2 to the atmosphere. Because of a continuous and rapid increase in atmospheric CO2 as well as a decrease in biogenic calcification, the paradigm that the coastal ocean serves as a net source of CO2 is likely to change during the 21st century. Numerical simulations based on the physical-biogeochemical box model SOCM show that the coastal ocean may remain a net source of CO2 to the atmosphere throughout the 21st century. The magnitude of this net flux will gradually decrease. The net flux of CO2 is strongly dependent on the initial estimates of biogenic calcium carbonate production and net trophic status. Any changes in CO2 owing to calcification will be compensated by a simultaneous decrease in the surface water buffer capacity owing to increased invasion of atmospheric CO2.

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SOME PECULIARITIES OF CASE 1 WATERS OPTICAL PROPERTIES IN THE NORTHWESTERN MEDITERRANEAN SEA

Optical properties of ocean Case 1 waters are usually indexed with respect to only one of the optically significant components of these waters, namely the phytoplankton chlorophyll concentration (Chl). Such an indexing is the basis of the so-called bio-optical models, and it is necessarily accompanied by a natural noise, which randomly spreads around the "average" laws, and which is due to the natural variability of the inherent optical properties (IOP) and of their relationships to the apparent optical properties (AOP). Specific biases may as well exist locally, for instance in the Mediterranean sea, for situations ranging from oligotrophic to mesotrophic ones. In order to gain some insight into these local deviations, IOPs and AOPs have been monitored on a monthly basis at a fixed station in the northwestern Mediterranean sea (Ligurian sea). This time series is used to describe and to quantify the seasonal behavior of the relationships between Chl and the AOPs, as compared to what is predicted by "average" bio-optical models of Case 1 waters optical properties.

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TEMPORAL DYNAMICS OF NUTRIENTS AND PHYTOPLANKTON BIOMASS IN CENTRAL CALIFORNIA AS THEY RELATE TO THE PRESENCE OF ALEXANDRIUM CATENELLA, A HAB SPECIES

Saxitoxin, a phycotoxin responsible for the affliction Paralytic Shellfish Poisoning (PSP), occurs along the western coast of North America, yet in California the ecological fate of the toxin is virtually unknown. In the present study we aim to understand the dynamics of cell abundance in the harmful algal bloom species, Alexandrium catenella, and factors that likely influence toxin accumulation in higher trophic levels. One year of data (2003) will be presented on nutrient concentrations, temperature, salinity, phytoplankton biomass (Chlorophyll a), community species composition, and A. catenella abundance. A second objective is to identify to what degree, if at all, saxitoxins contaminate commercial fisheries in central California. Preliminary information on fish toxicity will be presented as available. Water and fish samples collected along the central California coast will be analyzed for the factors listed above, as well as PSP toxins. Examining the role of A. catenella in this highly productive region will contribute to our understanding of harmful algal bloom ecology and determine if there is need for a PSP monitoring program in California commercial fisheries.

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THE CANARY ISLANDS AREA OF FILAMENT-EDDY EXCHANGES (AFEX)

The Canary Current (CC), as distinct from other Eastern Boundary Currents, is characterized by the strong disruption of its flow by the presence of the Canaries Archipelago. Downstream of the islands a region of high mesoscale activity connects the eutrophic waters of the NW Africa coastal upwelling system with the oligotrophic waters of the eastern subtropical North Atlantic. Wind shearing at the flanks of the islands produces convergent and divergent fronts affecting the distribution and productivity of planktonic organisms. Cyclonic and anticyclonic eddies, generated year-round are spun off following the path of the CC. Cyclonic eddies help increase the organic matter content of the region by uplifting nutrient rich waters in their cores, so increasing primary productivity. Anticyclonic eddies may entrain water of high organic matter content, which originates in upwelling filaments or cyclonic eddies, and which is eventually transported to the open ocean by successive exchanges through the eddy-filament field. Overall, the AFEX region behaves both as a carbon source and pump, accelerating the blending of organic carbon-rich upwelling waters with the open ocean.

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DIATOM GENOME PROJECT: NEW INSIGHTS INTO DIATOM PHYSIOLOGY AND ECOLOGY

The whole genome sequence of the centric diatom Thalassiosira pseudonana has recently been completed and annotated as part of a large collaborative effort between researchers from the U.S., Europe, Canada, and Australia. A combination of sequence data, physical mapping, and bioinformatics analyses indicates that the nuclear genome is about 33 megabases and consists of at least 11,000 genes distributed between 23 chromosomes. Diatoms are derived from a secondary endosymbiotic event in which a eukaryotic heterotroph engulfed a eukaryotic autotroph. Perhaps not surprisingly, we have found that in addition to its autotrophic capabilities, the diatom has incorporated metabolic pathways and regulatory systems that are more commonly associated with heterotrophic eukaryotes such as yeast and animals to create a fascinating chimera of attributes. I will provide examples from our latest analyses of nutrient and light utilization by diatoms with a focus on their biogeochemical roles. I will also discuss in a broader sense how genomic identification of the metabolic potentials of organisms can provide important new insights into organism/environment interactions.

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INTRAGUILD PREDATION AND CANNIBALISM IN A SIZE-STRUCTURED COMMUNITY OF SUBTIDAL AMPHIPODS.

Ontogenetic shifts in diet are a common cause of intraguild predation (IGP), particularly for species with indeterminate growth. The role of IGP in regulating coexistence was investigated in benthic amphipods in a shallow subtidal community in the Gulf of Maine. Two abundant species, Jassa marmorata and Apocorophium acutum co-occur; both build tubes for shelter on algae and hard substrata, and juveniles primarily filter feed. However, J.marmorata grows to a larger size, is more abundant than A.acutum, and increases its relative abundance during spring and summer. This study examines the importance of size-structured IGP, cannibalism, and competition in regulating populations of these two species. Measurements of tube-building rates (an indirect measurement of competition) showed that A.acutum built at the same rate as small and medium J.marmorata, but faster than large J.marmorata. IGP was asymmetric; in laboratory trials, J.marmorata preyed heavily upon A.acutum when there was a size advantage, but the reverse did not occur. Additionally, cannibalism was low in both species. Varying degrees of competition and IGP across size classes may explain the low abundance of A.acutum relative to J.marmorata.

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IMAGING DEEP CORAL REEFS USING THE SEABED AUV

Initial characterizations of coral reef habitat along the shelf-edge and upper insular slope of Puerto Rico and the U.S. Virgin Islands were conducted with the SeaBED autonomous underwater vehicle (AUV) during March 2002 and June 2003. In southwestern Puerto Rico, a transect from 20 to 100 m depth provided unprecedented high resolution digital imagery that was used to derive species composition, abundance, and zonation patterns of benthic organisms. At the Hind Bank Marine Conservation District (MCD), four transects were conducted at depths ranging from 32 to 90 m. The MCD is a no take marine reserve that was established in the US Virgin Islands in 1999 to protect coral and fish spawning aggregations. At 40 m depth in the MCD, we found well-developed coral reefs with up to 80% living coral cover. Additional transects were obtained south of St. John, USVI at depths ranging from 27 to 53 meters. The SeaBED provided new information on a little known coral reef habitat that is common along the upper insular slopes of many Caribbean Islands.

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AN OPTIMALITY-BASED MODEL OF IRON:NITROGEN:LIGHT LIMITATION OF PHYTOPLANKTON GROWTH AND CHLORPHYLL:CARBON RATIO

Iron is not a major structural element for phytoplankton. Instead, it affects phytoplankton growth rate largely through specific effects on photosynthesis, electron transfer, and nitrate and nitrite reduction. Iron also can be stored in great excess of immediate needs. For these reasons, iron limitation should not be modeled using Monod/Liebig kinetics, as are carbon, nitrogen, phosphorus, or silicon. Furthermore, the interaction of iron with carbon and nitrate acquisition must be represented explicitly. In response to these challenges, I have adapted the nitrate:energy model of Geider et al. (1998) to reflect the peculiarities of iron limitation, and have calibrated the resulting model using the data of Sunda and Huntsman (1997). The model so derived gives an excellent fit to these data. Here I briefly describe the workings of the new model. I also illustrate the importance of modeling iron limitation in this physiologically reasonable manner, by applying the model to data from IronEx II, and comparing it to results based on Monod/Liebig kinetics.

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ON THE FATE OF ICE FAUNA IN THE FRAM STRAIT - SVALBARD AREA

Densities of sympagic (ice associated) amphipods and thus biomass values were remarkably reduced during sampling in September/October 2002 in the Fram Strait - Svalbard area compared to previous years. Using simulated trajectories and air temperature data we followed the investigated ice patches back on their way through the central Arctic and relate their recent and long-term history to our findings. Ice conditions and water properties at the sampling sites indicated intense melting. By means of both, under-ice sampling and trawling along the marginal ice edge we followed the ice amphipods on their entrainment into the water column. It is assumed that ice organisms that loose contact to their decaying platform, are lost to the ice ecosystem and rapidly sink down to the seafloor. It is furthermore believed that these animals represent a food source to the pelagic and benthic realm. Sinking velocities range between 2 and 4 cm s-1 for dying ice amphipods. Based on our present understanding on circulation and ice drift patterns, the timing of melting and its effect on the ice ecosystem we have localized the areas of vertical flux of ice-derived organisms and estimated the amount of rained out material.

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THE FUNCTIONAL EQUIVALENCY OF HALODULE WRIGHTII, SYRINGODIUM FILIFORME, THALASSIA TESTUDINUM SEAGRASS PATCHES IN CHARLOTTE HARBOR, FLORIDA.

Understanding the functional equivalency (value) of seagrass is important in guiding management techniques and understanding the effects of anthropogenic activities on habitats. Past studies have indicated that seagrass with differing characteristics may house diverse fauna in varying degrees of abundance. A study was conducted in Charlotte Harbor to determine whether seagrass characteristics (species, bed size, shoot density, canopy height) could be used as predictors of faunal diversity and abundance. Nine seagrass sites were characterized according to percent cover, bed size, shoot density, and canopy height using 1m2 quadrats and 15.25cm diameter cores. Fauna within each site was sampled using three 1m2 haphazardly placed throw traps. Preliminary analysis of the data suggests that seagrass beds of Syringodium filiforme may house a significantly more diverse species assemblage with a higher number of organisms than Thalassia testidinum or Halodule wrightii.

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THE CHALLENGE OF OBSERVING CORAL REEFS: REPORT FROM THE CORAL SUB-THEME TO THE INTEGRATED GLOBAL OBSERVING STRATEGY (IGOS) PARTNERS

Coral reefs appear to be one of the first major marine ecosystems to show rapid degradation at a global scale. Coral reefs are critically important because they contain the world's largest reservoir of marine biodiversity; they provide food security, cultural support and physical protection from storms for approximately 500 million people; they are declining rapidly from a range of human pressures; and there are already distinct signs of damage resulting from global climate change. In response to this crisis, the Integrated Global Observing Strategy (IGOS) partnership developed a report designed to integrate satellite and in situ resources to better serve the needs of coral reef researchers, marine parks, sanctuaries and protected area managers and stakeholders across the globe. Some of the goals of this report include: improve coordination and information between remote sensing, in situ and modeling groups, ensure adequate and sustainable funding for existing monitoring mechanisms; develop the capacity of remote sensing and in situ monitoring to rapidly respond to coral bleaching events and develop capacity to map and monitor coral reefs remotely at scales matching in situ monitoring.

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TRANSPORT OF PLANKTON AND PARTICLES BETWEEN THE CHUKCHI AND BEAUFORT SEAS

Transport of biogenic material from Arctic shelves to the deep Arctic basin may impact significantly the biogeochemistry and ecosystem structure and function of both basin and shelf ecosystems. Plankton and particle abundance, vertical distribution, and association with hydrography and circulation were described using a self-contained Video Plankton Recorder on two cruises (spring and summer, 2002) to the Chuckchi and Beaufort Seas as part of the Shelf-Basin Interactions program. The VPR was deployed to as deep as 350 m along four transects across the shelf-basin interface. Nine categories of plankton or particles were identified, with marine snow, copepods, diatoms, and radiolarians being the most common. Concentrations of marine snow on the Chukchi Shelf appeared to be very high, as high as observed in temperate regions, with much lower concentrations over the basin. Distinct vertical patterns associated with hydrographic structure also were observed. Particle and plankton concentrations were merged with ADCP velocity records to obtain estimates of instantaneous flux (magnitude and direction). Barrow Canyon in particular is a site of high particle concentration and high flux of material between shelf and basin.

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PHYTOPLANKTON ASSEMBLAGES ACROSS THE BROAD AREA OF HYPOXIA ON THE LOUISIANA SHELF IN MID-SUMMER (1999-2003)

The Louisiana continental shelf is the site of the largest area of bottom-water hypoxia in the western Atlantic Ocean, and results from the discharge of freshwater and nutrients from the Mississippi River system. We examined the phytoplankton pigment composition and estimated phytoplankton groups as shown by HPLC pigments (1999-2003) from the Mississippi River to the upper Texas coast. The river flow was exceptionally low in 2000 due to drought. In high flow years, the water column was stratified, except for 2003 when tropical storms caused mixing. Phytoplankton pigment composition graded from eastern through western regions of the hypoxic area. Peridinin (=dinoflagellates) and fucoxanthin (=diatoms) concentrations were the highest in 1999 in the western hypoxic area. In 2000, a low flow year, overall pigment concentrations did not differ significantly form 1999 and 2001. Zeaxanthin (=cyanobacteria) concentration was exceptionally high in 2002 in the eastern hypoxic region while peridinin and fucoxanthin concentrations were lower than the previous years but evenly distributed through the hypoxic area. Highest zeaxanthin concentrations were observed in the central part of the hypoxic region in 2000 and 2002

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A SURFACE CURRENT INITIATIVE FOR THE IOOS

Surface currents are identified as one of the most needed products from the Integrated Ocean Observing System (IOOS). To address this need an implementation plan is being created. This initiative will first focus on HF radar technology that can produce detailed maps of surface currents from the coast to nearly 200 kilometers offshore. The technology can also provide ship tracking and wave information. Many systems are already deployed in US coastal waters by a variety of academic institutions. There are several competing radar technologies, each with relative strengths and weaknesses. A steering committee has been formed by Ocean.US to develop the implementation plan. The process will involve both the operators of these systems and the users. Many challenges must be faced including frequency allocation, site acquisition, data requirements, data assimilation, required research, and governance.

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REAL-TIME SURFACE CURRENT ANALYSES IN MONTEREY BAY FROM HF RADAR DURING THE AUTONOMOUS OCEAN SAMPLING NETWORK (AOSN) EXPERIMENT

Increasing numbers of HF radars now map synoptic coastal surface currents hourly with spatial resolution of a few kilometers. As these radars become part of a global ocean observing system, real-time analysis and distribution of surface current products presents a significant challenge. Moreover, many potential users of real-time currents actually require descriptions of near surface transport (studies of evolving algal blooms or pollution spills, for example) which are most naturally described by particle studies. Beginning with the August 2003 AOSN experiment, we have been displaying (on the web) hourly surface current products from Monterey Bay in near real-time. These products are delayed by one to two measurement cycles (one to two hours) to allow for data collection from remote radar sites, processing and objective mapping of the radar measurements, and computation of derived statistical and simulated drifter products. Typically, all data products, including particle simulations, are available on the web within 45 minutes of the completion of a radar averaging interval. A description of the analysis scheme, examples of data products, and lessons learned will be presented.

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NOAA'S COASTAL OCEAN PROGRAM: CORAL REEF ECOSYSTEM RESEARCH

NOAA's Coastal Ocean Program (COP) is an internationally recognized federal-academic partnership, which conducts competitive, peer-reviewed scientific research programs. Our research assists coastal managers though providing relevant and timely scientific information. The goal of COP's Coral Reef Ecosystem Research is to understand the extent of and the reasons for the decline of the Nation's coral reef ecosystems. In 2003, COP is striving to meet our goal through five projects: the Hawaii's Coral Reef Initiative Research Program; the Coral Reef Ecosystem Integrity and Restoration Options with Watershed-based activities and Marine Protected Areas (MPA's) in the Tropical Pacific Islands Study; the Integrating Science and Management in the Caribbean Study; the Puerto Rico Coral Reef Monitoring Program; and the National Coral Reef Institute.

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COMPARISON OF SHALLOW WATER NUTRIENT DYNAMICS ACROSS BARROW CANYON IN THE WESTERN ARTIC OCEAN: COMPARISON BETWEEN SBI CRUISES

One of the major goals of the Shelf-Basin Interactions (SBI) initiative is to examine the effect of global climate change on processes that regulate exchange of carbon and materials between arctic shelves and basins. Starting in spring 2002, a variety of physical, biological, and geochemical measurements have been collected during several SBI cruises. In summer 2003, aboard the R/V Nathaniel B. Palmer, we measured NH4+, NO2-, NO3-, and PO4- levels across Barrow Canyon and the Chuckchi and Beaufort slopes and compared our data to measurements collected on four previous SBI cruises. Data from all cruises revealed consistently high peaks of NH4+ (≥2.0 M) in the upper 100 m along Barrow Canyon and suggest regular freshwater influence over this section of the continental shelf. Nitrite and nitrate (NO2- & NO3-) maximums were around 0.2 M and 15.0 M during all summer cruises with slightly increased levels during the May 2002 cruise. Nitrite peaks occurred between 100-120 m, and concentrations were non-detectable beneath 200 m. Nitrate peaks occurred deeper (≈150 m) and remained above 12 M throughout the water column. Distinct nutrient layers indicate regular uptake and remineralization of reduced nitrogen (NH4+ and NO2-) in the upper 150 m of Barrow Canyon. Our analysis indicates that with the exception of some seasonal variations, there was little interannual change in the nutrient concentrations in the Barrow Canyon between summers 2002 and 2003.

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THE IMPACT OF HURRICANES ON THE FLUX OF RAINWATER AND CAPE FEAR RIVER WATER DISSOLVED ORGANIC CARBON TO LONG BAY, SOUTHEASTERN UNITED STATES

Hurricane flux of rain and river water dissolved organic carbon (DOC) to Long Bay on the southeastern coast of the United States was determined for four hurricanes that made landfall in the Cape Fear region of North Carolina. Riverine flux of DOC following hurricanes Fran (Sept. 1996) and Floyd (Sept 1999) represented 1/3 and ½ of the annual river flux of DOC to Long Bay respectively. The majority of this DOC was not biologically available. High riverine DOC fluxes were not observed following hurricanes Bertha (1996) and Bonnie (1998) due to minimal effects these hurricanes had on river flow. The rainwater flux of total DOC to Long Bay from the four hurricanes was not as dramatic as that observed for riverine fluxes. However, unlike riverwater DOC that is refractory, rainwater DOC is highly labile. Rainwater from the four hurricanes in this study deposited between 3 and 9% of the annual flux of bioavailable DOC to Long Bay over a 1 or 2 day period likely spurring short term secondary productivity.

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MICROBIAL CONTROL OF OCEANIC CARBON CYCLE AND IMPLICATIONS FOR ECOSYSTEM STRUCTURE AND MARINE CONSERVATION

Our understanding of marine ecosystems is still largely descriptive and with little power to predict ecosystem response to future stresses. Past anthropogenic stresses, e.g. over-fishing and pollution, have had devastating effects, and future stresses (e.g. global warming, emerging pathogens, ocean fertilization and coastal eutrophication) may even more profoundly impact marine ecosystems. Do we have the necessary depth of understanding of marine ecosystems to formulate effective conservation policy? The discoveries of major roles of highly diverse microbes in the ocean, which I will recount to set the stage, have further compounded the challenge. How should we integrate microbial processes into functional and ecosystem models for marine conservation? The current emphasis on large-space-scale description and exploration needs to be enriched with mechanistic and functional studies of interactions at the biochemical and molecular level. While recognizing that microbes structure the marine ecosystem at the microscale, the new challenge is to discover a way to integrate microbial influences across spatial scales, from micrometer to the ocean-basin scale. Toward this goal, I will discuss the ecosystem roles of heterotrophic bacteria to illustrate the utility of conceptualizing marine ecosystems as biochemical networks. This integrative approach may serve as a basis for predicting how marine ecosystem may respond to future stresses.

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ROLE OF BACTERIAL CELL SURFACE ENZYMES IN MODIFYING THE BIOGEOCHEMICAL BEHAVIOR OF ORGANIC MATTER IN THE OCEAN

It is now well established that heterotrophic bacteria are responsible for the remineralization of a substantial fraction of organic matter produced in the ocean. However, it now seems that, in addition to their quantitatively significant role in carbon assimilation and respiration, bacterial interactions with particle surfaces influence the biogeochemical behavior of some organic as well as inorganic phases. They modify the behavior of not only the non-living particles but also the living organisms. Many such interactions may entail only minor carbon fluxes into bacteria but with major biogeochemical consequences. I will discuss specific examples of bacterial control of coupled carbon and silicon cycle, particle aggregation-disaggregation and phytoplankton productivity. Bacterial hydrolytic enzymes are key variables, but the (micro) environmental expression of their activities are dependent on bacterial species interacting with specific particle phases and the regulation of enzyme expression by environmental factors. I will show why it is necessary to incorporate these apparently pervasive "modification interactions" into oceanic biogeochemical models and how we might conceptualize them in an ecosystem context.

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EFFECT OF NONLINEAR MIXING ON THERMOHALINE CIRCULATION

Nonlinear mixing across a density interface resulting in transport of heat and salt is investigated with a 2-box thermohaline circulation model, Stommel (1961). The model was constructed to simulate the thermohaline behavior of a warm, saline and shallow equatorial box, which is hydraulically connected to a cooler, less saline and deeper polar box. Mixed thermohaline boundary conditions were imposed on the surface of the two boxes and diffusive transport of heat and salt were considered across the interface between the boxes. The equations governing the temporal and steady-state behavior of the system were expressed in non-dimensional form using six time-scale parameters. These parameters characterize the mechanisms responsible for the transport of heat and salt through the system. Results obtained by implementing a nonlinear thermohaline buoyancy for seawater were generally found to produce more unstable circulation patterns than those obtained by implementing a linear buoyancy approximation. The strength of thermohaline circulation was also found to be sensitive to diffusive transports of heat and salt across the interface.

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PHYSICAL-BIOLOGICAL INTERACTIONS CONTROLLING MEIOFAUNA STANDING STOCKS IN THE NORTHERN GULF OF MEXICO DEEP SEA

With exception of vents and seeps, the deep-sea environment is food-limited and reliant upon carbon produced in the overlying water column. Physical features enhancing water column production drive changes in benthic community structure and function. The northern Gulf of Mexico has one of the more physically and geologically complex continental slopes with numerous basins, knolls, and canyons. The anticyclonic loop current is a permanent feature in the Gulf of Mexico, and interacts with Mississippi River inflow to create areas of enhanced production. The loop current also produces anticyclonic/cyclonic gyre pairs which can be both short and long-lived meso-scale features. Not surprisingly, the interaction between geologic depressions and areas of increased productivity supports the highest densities of meiofauna, and explains the variance from a general relationship of decreasing meiofaunal density with increasing depth.

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DEVELOPING ECOLOGICAL FORECASTS FROM TIME-SERIES DATA

Long time series of physical and biological properties of the ocean are a valuable resource for developing models to support ecological forecasting. However, both the physics of the oceans and the organisms living in it can exhibit dynamics that can be strongly nonlinear. Conventional time-series methods assume linear relationships and thus, can overlook or inaccurately describe nonlinear relationships. We describe the development of a model that forecasts the abundance of Calanus finmarchicus from hydrographic data. This model was developed using non-linear time series techniques, and these techniques provide a more robust method for analyzing oceanographic time series.

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DYNAMIC STOICHIOMETRIES IN NANOPLANKTON DURING THE SOUTHERN OCEAN IRON EXPERIMENT (SOFEX)

Because Fe plays a central role in cellular function, its availability may influence the cellular content and, consequently, the biogeochemistry of other elements. The elemental stoichiometries of individual diatoms, autotrophic flagellates, and heterotrophic flagellates collected during the recent Southern Ocean Iron Experiment (SOFeX) were measured with a synchrotron x-ray fluorescence microprobe. Cellular Fe quotas (relative to C) of all cells more than doubled following two Fe additions. These changes were matched by increased

concentrations of other bioactive elements as well. Cellular P and S both rose 23-56% following the first addition to the low-Si 'North Patch' and following the second addition to the high-Si 'South Patch'; these changes coincided with changes in the chlorophyll concentration of the two patches. Cellular Mn, Ni, and Zn quotas in both patches increased 25-65%, but like Fe, these increases were generally observed only after the second fertilization. The Si content of diatoms in the high-silicate 'South Patch' waters decreased by 24-29% relative to cellular C, P, and S following the addition of Fe. These stoichiometric changes indicate biochemical changes in the resident plankton that suggest possible differences in the biogeochemistry of Fe-replete and Fe-deplete regions of the ocean.

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THE EFFECTS OF SMALL-SCALE TURBULENCE IN A PELAGIC ECOSYETEM MODEL WITH BIO-MECHANICAL DESCRIPTIONS OF GRAZING.

A 2D coupled physical-biological model of the coastal ocean is developed. Coupling occurs due to the advection and diffusion of biological tracers, and in the dependence of grazing rates on small scale turbulence. Model simulations are run for a stable mixed layer and a wind-driven coastal upwelling scenarios. The impacts of the coupling of grazing rates and small-scale turbulence are investigated with regard to the development of a deep chlorophyll maximum and phytoplankton bloom dynamics.

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CASE I/CASE II AMBIGUITIES IN ALGAL BLOOMS - THE CASE FOR MINERALS AND VIRUSES

Optical properties of Case I waters are, by definition, dominated by water, living algae, and their associated particulate/dissolved debris; Case II waters have optical properties dominated by terrestrially-derived, colored, dissolved organic matter (cDOM), or inorganic particles. Situations exist in algal blooms when ambiguities clearly develop between Case I and II situations. For example, viruses can rapidly transform algal blooms from simple Case I systems to a mixture of nonliving particulate detritus and cDOM that is strongly Case II in character. We will show examples from lab and mesocosm viral infection experiments supporting these quick optical transitions, as well as the sorts of optical variability that one might attribute to viral infections. Blooms of coccolithophores (technically Case I) can appear to be Case II, since they resemble resuspended carbonate sediment. We will show examples from several temperate coccolithophore blooms as well as experimental chalk patches that illustrate the Case I/II ambiguities. Using satellite ocean color data, we will comment on regions of the globe where such ambiguities might be likely.

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EFFECTS OF PROLONGED SOLAR EXPOSURE ON BACTERIAL RESPONSE TO UVR ALONG A LATITUDINAL GRADIENT

Bacterioplankton are affected by solar UVR (290-400 nm) both physiologically and structurally. However the effect of prolonged exposure to UVR has not been previously examined. Experiments were conducted at 66 N, 39 N and 02 N, approximately 165 W in the Pacific Ocean during August and September of 2003. Surface water was collected before sunrise and incubated for 48-hours in flowing seawater deck incubators under four irradiance treatments: UVB+UVA+PAR, UVA+PAR, PAR and dark. At 52-hours, the relative inhibition by sunlight of bacterial production (3H-thymidine and 3H-leucine incorporation) was determined in 4 hr incubations centered around solar noon. At all three locations and for all four treatments inhibition of bacterial production increased (when compared to initial incubations) after prolonged exposure to sunlight. Samples incubated in the dark were inhibited to approximately the same degree as those incubated in full sunlight. In general these results indicate that rather than increasing adaptation to solar irradiance, prolonged exposure resulted in microbial communities more sensitive to irradiance. The role of community structure in facilitating these responses is being examined.

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QUALITATIVE MODELING OF NATURAL AND ANTHROPOGENIC STRESSORS ON NEKTON IN LOUISIANA COASTAL SYSTEMS

Qualitative models of the effects of multiple stressors on coastal nekton populations are useful management tools. Natural and anthropogenic stressors include freshwater diversions with nutrients and sediments, fisheries, pollution, habitat degradation and sea-level rise. Qualitative modeling has four advantages: 1) a good naturalist can construct meaningful models without quantitative data, 2) feedback loops (i.e., interactions among elements) are major parts of models, 3) both direct (species to species) and indirect effects (transmitted through feedback loops) are included, and 4) 'press' experiments suggest where quantitative data are needed to test hypotheses, examine unexpected consequences, or construct quantitative models. The current 26-variable model potentially has 650 direct interactions, but only 59 negative and 76 positive direct pair-wise linkages were identified. Limited direct linkages are overwhelmed by 10 million indirect feedback loops of varying lengths. Negative feedback, at lower levels and overall, leads to system stability. Examination of reduced models indicates that indirect effects can be responsible for unexpected consequences (e.g., bycatch in trawl fisheries may reduce natural predation on shrimp populations and compensate somewhat for increases in fishing mortality).

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FERRISIDEROPHORE UTILIZATION BY TRICHODESMIUM AND OTHER MARINE MICROOORGANISMS

Iron is thought to be a limiting factor for growth of the ecologically significant nitrogen-fixing cyanobacterium Trichodesmium in some areas of the world's oceans. Little is known, however, about what forms of iron are bioavailable to Trichodemium, or how iron availability is influenced by the growth of Trichodesmium in colonies which contain and sustain a diverse consortium of organisms, including heterotrophic bacteria. We postulate that microbial production of strong iron(III)-binding ligands (siderophores) for purposes of iron acquisition is likely to influence the speciation and bioavailability of iron within the microenvironment of the Trichodesmium colony, and may serve as the basis for a mutualistic relationship between Trichodesmium and its associated microbes. We have used radiotracer uptake experiments to demonstrate that iron bound by exogenous siderophores can be utilized by Trichodesmium populations, both in the field and in laboratory culture. This presentation will also describe the first applications in a seawater environment of a molecular tool to study mechanisms of iron acquisition from iron(III)-siderophore complexes by microorganisms: kinetically inert radiolabelled chromium(III)-siderophore complexes.

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RESPONSE OF OCEAN ECOSYSTEMS TO CLIMATE WARMING

The response of oceanic ecosystems to climate warming was investigated with six coupled climate model simulations. Using vertical velocity, maximum mixed layer depth, and seasonal sea ice cover, we defined six major oceanic ecosystems. Modeled conditions in 2050 were compared with "control conditions" at the beginning of the industrial revolution (1850). As expected, high latitude regimes decreased in area and subtropical regimes increased. Vertical stratification increased, with an increase in growing season length at high latitudes and an inferred decrease in nutrient supply at all latitudes. Satellite ocean color was used to develop an empirical model to predict chlorophyll from physical conditions prevailing in the 2050 simulations. In response to simulated global warming, chlorophyll increased in the subpolar North Atlantic and the Southern Ocean but decreased in the marginal sea ice regimes in both hemispheres. Using three primary production (PP) algorithms, we estimated the PP response to climate warming based on estimated chlorophyll concentrations. The three algorithms give a global increase in PP of 0.7% at the low end to 8.1% at the high end, with large regional differences.

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THE USE OF MULTI-PARAMETER BIO-OPTICAL INSTRUMENT SYSTEMS FOR LONG-TERM OBSERVATIONS OF ECOSYSTEM COMMUNITY STRUCTURE

Technological advances in oceanographic optical instrumentation are providing the opportunity to observe the dynamics of coastal ecosystems on unprecented temporal and spatial scales. Concurrent development of bio-optical models relating the inherent optical properties to key biogeochemical parameters are providing a means to assess ecosystem community structure in terms of the relative contribution of phytoplankton, the composition (inorganic versus organic particles) and size distribution of the particulate assemblage. The application of these instruments and models for use on long-term observatories depends on the ability to maintain instrument stability, including environmental response characterization, calibration, and prevention of biofouling. In this work we demonstrate the use of a multi-parameter bio-optical observing system to provide detailed information on the particle structure of coastal ecosystems in the Gulf of Maine. We show that the combined use of integrated models, redundant proxy estimators and multi-parameter systems allows for independent verification/validation of the measured optical signals and provides a method to track both instrument response and biofouling. Such approaches are necessary to ensure that bio-optical instrumentation suites are reliable tools for long-term coastal ocean observatories.

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A TIME SERIES OF WATER QUALITY FOR THE COASTAL US FROM AVHRR AND SEAWIFS

The AVHRR (Advanced Very High Resolution Radiometer) can be used to quantify turbidity and find algal blooms in turbid coastal waters. AVHRR sensor, a five-channel instrument (two visible and three thermal infrared), has been carried on board NOAA Polar Orbiter Satellite series since 1982, with a comprehensive archive since 1985. The SeaWiFS (Sea-viewing Wide Field-of-view Sensor) ocean color sensor (eight channels) has allowed estimation of turbidity and chlorophyll concentration starting in 1997. By comparing data sets from the two sensors, relationships can be established for assessing turbidity and algal blooms in the AVHRR data, permitting the AVHRR data to act as a surrogate for SeaWiFS prior to 1997. This project will re-analyze Local Area Coverage (LAC 1.1 km) AVHRR and coincident passes of SeaWiFS for the coastal US, extending the time series of turbidity and algal blooms back to the mid-1980's. Results for the Mid-Atlantic region, including the Chesapeake and Delaware Bays, will be presented.

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OPERATIONAL GLOBAL OCEAN ASSIMILATION AND MODELING WITH THE NAVY COASTAL OCEAN MODEL

A global implementation of the Navy Coastal Ocean Model (NCOM) has been transitioned to the Naval Oceanographic Office (NAVO). Global NCOM provides ocean nowcasts and forecasts for U.S. Navy applications including boundary conditions for higher resolution regional or relocatable models. Assimilation of global ocean observations available on short operational time scales is implemented through relatively simple, low-cost techniques. Satellite altimetry and satellite sea surface temperature (SST) provide the primary sources of ocean observations for global NCOM. The sea surface height (SSH) data is assimilated by the operational Navy Layered Ocean Model (NLOM). Global NLOM has twice the horizontal resolution of global NCOM, giving it improved skill in dynamically interpolating SSH measurements along altimeter tracks. The Modular Ocean Data Assimilation System (MODAS) combines the steric SSH anomalies from NLOM with fully global SST fields interpolated from satellite and in-situ observations to produce 3-D temperature and salinity fields for assimilation into global NCOM.
Validations of global NCOM using unassimilated observations and climatologies were performed. Results selected from evaluations performed during the model development and operational test phases will be discussed. These results are used to assess present operational capabilities and indicate directions for future research and development.

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CLIMATOLOGICAL CONTEXT FOR LARGE SCALE CORAL BLEACHING OBSERVED SINCE 1979

Coral bleaching is a pan-tropical phenomenon with serious ecological and economical impacts that has become increasingly frequent since 1979. Despite the extensive scientific research and increased public awareness of coral bleaching, it is not known if large-scale coral bleaching occurred prior to the recent observational record. This study uses three 132-year historical SST data sets, ERSST, HadISST1, and GISST 2.3b to identify persistent warm periods during the past 132 years. The results of this study show that while coral bleaching and anomalously warm SSTs have occurred over much of the world in recent decades, conditions favorable for thermally induced coral bleaching may have existed in the Caribbean and Northwest Hawaiian Islands prior to 1979.

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TOWARDS SATELLITE BASED LOCATING OF COPEPODS

Information on distribution of copepods is traditionally gathered by extensive surveys collecting net samples at many stations. Lately, development of the Optical Plankton Counter (OPC) made covering of larger areas possible. This approach remains however costly and time-consuming. Recent research indicates cannibalism of female Calanus finmarchicus on their offspring before the onset of the phytoplankton bloom. Nauplia development would then first occur after females switched to phytoplankton diet, during late pre-bloom or early spring bloom. Based on this we hypothesize "there is a spatial and temporal overlap between surface culmination of spring bloom and high surface abundance of CI-CIII copepodites". Methods to locate copepodites by satellite via chlorophyll distribution in the Norwegian Sea are evaluated. For various years chlorophyll distribution is acquired from satellites (SeaWiFS, Modis) and compared with copepodite distribution (from net hauls and OPC). Given our hypothesis proves true we had a time-saving and cost-efficient way for remote locating of young copepodites. Furthermore, after modeling the transport of these copepodites, information about future locations of older copepodites can be obtained. Possibilities and restrictions of this method are discussed.

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SUB-MESOSCALE EDDIES ALONG THE NORTHERN SANTA BARBARA CHANNEL: A POSSIBLE MECHANISM FOR PARTICLE TRANSPORT ACROSS THE INNER SHELF

Sub-mesoscale anticyclonic eddies are described which occur along the northern coast of the Santa Barbara Channel (SBC). They have been identified using a network of high frequency (HF) radars and moorings in the region. These 5-15km diameter eddies are sufficiently strong to reverse the normally poleward (westward) flow over the inner shelf. They occur throughout the year lasting less than 10 days with an average life span of 2 days. The channel-wide circulation patterns of the SBC may affect the production of these vortices as they seem to be absent when flow in the basin is strongly cyclonic. Similar eddies have been observed in at least two other locations along the SBC coastline, suggesting that they are a more general phenomenon. It may also indicate that the eddies propagate along the coast. Their occurrence generally coincides with a decrease in water temperature over the inner shelf. Occasional deployments of a moored nitrate sensor indicate higher nutrient levels when the eddies are present. These eddies may be an important new particle transport mechanism to inner shelf ecosystems.

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SEASONAL AND SPATIAL DISTRIBUTION OF PARTICULATE ORGANIC MATTER (POM) AND NEW PRODUCTION IN THE CHUKCHI SEA

As part of the Western Arctic Shelf-Basin Interactions (SBI) project, the production and fate of organic carbon and nitrogen from the Chukchi Sea shelf was investigated during a spring (May) and summer (July) cruise in 2002. Seasonal observations of suspended particulate organic carbon (POC) and nitrogen (PON) and, large particle (>53 µm) size class, indicate that there was a large accumulation of carbon and nitrogen between spring and summer in the surface mixed layer due to phytoplankton productivity (estimated from dissolved inorganic carbon). Considerable organic matter appeared to be transported from the shelf into the Arctic basin in an elevated POC and PON layer at the top of the upper halocline. Seasonal changes in the molar C:N of the POM pool reflect a significant change in the quality of material being produced and presumably exported to the sediment and from the Chukchi Sea shelf. In spring, low particulate C:N ratios (<6; i.e., N rich) were observed in nitrate-replete surface waters. By the summer, localized high particulate C:N ratios (>9; i.e., N-poor) were observed in nitrate-depleted surface waters.

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TEMPORAL VARIABILITY OF EXCESS NITRATE IN THE SUBTROPICAL MODE WATER OF THE NORTH ATLANTIC OCEAN

A dichotomy exists between rates of nitrogen fixation directly measured by biological techniques, and rates inferred from the geochemical distributions of excess nitrate (DINxs) within the thermocline of the North Atlantic Ocean. Here, temporal variability of excess nitrate in the subtropical mode water (STMW) of the North Atlantic Ocean is evaluated for the 1988-2001 period. For example, DINxs values (~1.5-2.8 µmoles kg-1) and excess nitrate production rates (~3.7 Tg N yr-1) were generally high during positive phases of the NAO (e.g., 1989-1994; 1997-2000) and coincident with periods of higher atmospheric mineral dust input to the ocean. When the NAO was in its negative phase and dust inputs lower (e.g., 1995-1996; 2001), DINxs values (~0-1.0 µmoles kg-1) and excess nitrate production rates were generally low (up to ~0.5 Tg N yr-1). DINxs variability and excess nitrate production rates in the STMW layer were well correlated with the North Atlantic Oscillation (NAO). The NAO potentially influences DINxs variability by modulating the extent and magnitude of STMW formation, thereby changing the fate of accumulated DINxs during circulation of STMW in the subtropical gyre.

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USING PUBLIC-DOMAIN MODELS TO ESTIMATE BEACH BACTERIA CONCENTRATIONS

Stretches of beach along popular Huntington Beach, California are occassionally closed to swimming due to high levels of bacteria. One hypothesized source is the treated wastewater plume from the Orange County Sanitation District's (OCSD) ocean outfall. While three independent science review panels found no strong or consistent links between the ocean discharge four miles offshore and bacteria concentrations in the surf zone, the empirical data provided only intermittent evidence of the offshore plume, making it impossible to disprove the hypothesis. Computer models could have filled the data gaps with simulated concentrations, using monitoring data to verify the models. A public-domain model to address the problem is under development. Called Visual Beach, in concept it is patterned after the USEPA Visual Plumes program, using its initial dilution models to estimate plume rise and dilution and its built-in bacteria decay models to estimate concentrations. However, it is being modified to use the Environmental Fluid Dynamics Code (EFDC) to estimate long-term waste-field movement. Using time-series records of effluent flow and characteristics, ocean currents, and density stratification, continuous estimates of waste-field location are achieved.

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ON THE ROLE OF OCEANIC ROSSBY WAVE CONTRIBUTIONS TO HEAT STRESS EVENTS IN CORAL REEF ECOSYSTEMS

Rossby waves resulting from weather and climate variability can increase the frequency and magnitude of coral reef accumulated heat stress events that can lead to coral bleaching (the expulsion of pigmented endosymbionts) and, potentially, coral mortality. This work establishes a link between baroclinic Rossby waves and significant coral reef heat stress resulting from upper-ocean thermal variability. The evolution of baroclinic Rossby wave signatures in satellite sea-surface temperature (SST) and sea-surface height (SSH) data enables the monitoring of transient adjustments of the oceans to large-scale thermal anomalies. Consequently, tracking Rossby wave features in satellite data can contribute to understanding and, potentially, predicting coral bleaching events by exposing the role of Rossby wave dynamics in thermally preconditioning a reef's environment. Satellite-derived products have demonstrated successful monitoring of coral heat stress conditions, including documented bleaching. Examples are two NOAA Coral Reef Watch (CRW) operational products, sea-surface temperature (SST) HotSpot anomalies and the companion Degree Heating Week (DHW) accumulated heat stresses. This study builds on NOAA CRW's monitoring of coral heat stress by tracing heat anomalies, propagating consistent with baroclinic Rossby wave dynamics in SSH and SST satellite-derived anomaly fields, and relating their presence to high heat stress events on coral reefs.

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ROLE OF CORAL-ZOOXANTHELLAE SYMBIOSES IN THE SEASONAL UREA CYCLE ON BERMUDA PLATFORM

Repeated measurements of urea concentration on the Bermuda platform display clear seasonal periodicity, with concentrations increasing seven-fold (0.1 to 0.7uM N) from spring through late summer.
In aquarium experiments, using Diploria strigosa, we have observed daily accumulations of 40uM DOC and 15uM DON. The low (3:1) C:N ratio of the DOM produced suggests a composition rich in nitrogen, with likely components including urea and amino acids. Extrapolating our rates of DOM production for Diploria strigosa over the entire Bermuda reef platform, we demonstrate that coral-zooxanthellae symbioses could potentially be a dominant part of the seasonal urea cycle. Additional supporting evidence shows the seasonal peak in urea concentration coincides with peaks in ecosystem organic matter production (coral dominated) and annual temperature. Urea is a very labile source of nitrogen and could therefore be rapidly consumed by reef inhabitants. In addition to its trophic utility, it appears that urea may be a non-trivial fraction of the bulk DON within the reef platform. Our estimates show that urea may account for as much as 15% of the total DON pool in some areas.

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EFFECT OF TURBULENCE AND TROPHIC CONDITIONS ON THE DYNAMICS OF TRANSPARENT EXOPOLYMERIC PARTICLES (TEP): A MESOCOSM EXPERIMENT

The dynamic of transparent exopolymeric particles (TEP) as a function of the environmental patterns was investigated in 3 controlled mesocosms experiments. The effect of 4 increasing levels of turbulence and of nutrient concentration was examined in the formation and production of TEP. This study was performed in the framework of the European project NTAP (Nutrient dynamics mediated through Turbulence And Plankton interactions). Results showed that TEP were more abundant in the mesocosms with the highest turbulence intensity. The contribution of larger TEP also increased in higher levels of turbulence. It suggests that turbulence could promote TEP aggregation as well as the ultimate fate of this pool of matter, that is either accumulation at the surface and/or sedimentation. Turbulence also favors bacterial colonization of TEP. An increase in TEP concentration was observed in all mesocosms after the phytoplankton bloom and the nitrate depletion leading to a decoupling of particulate organic carbon and nitrogen. The kinetics of TEP formation seems more rapid in mesocosms with high concentration of nutrients; however higher concentrations of nutrients do not promote alone higher TEP production.

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CULTIVATION OF SULFUR OXIDIZING BACTERIA FROM HYDROTHERMALLY ACTIVE YELLOWSTONE LAKE, WY: MICROSCOPY AND MULTIPLE ENRICHMENT TECHNIQUES

Sulfur oxidizing bacteria in the hydrothermally influenced waters of Yellowstone Lake, WY influence both the chemical and biological composition of the lake. I qualitatively determined the relative success of multiple enrichment techniques and used the enrichment results along with microscope observations and direct cell counts to obtain information specific to each area of the lake. Mary Bay and Stevenson Island contained the largest number of bacteria (cells/mL) and Mary Bay vent water samples constituted the largest percentage (51.7%) of all positive enrichments. All three of the samples able to undergo repeated enrichments at 60oC were from Mary Bay. Sequential enrichments at all temperatures studied proved to be the most effective enrichment technique with 33 successful enrichments at room temperature, 11 successful 50oC enrichments, and 3 successful 60oC enrichments. The success of the sequential enrichments suggests that the sulfur oxidizing bacteria of Yellowstone Lake prefer to be cultivated in environments similar to their natural environment and favor persistent low-level nutrient additions over an extended period of time, allowing the bacteria to slowly acclimate to the conditions of the enrichment.

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AOSN IN MONTEREY BAY: OBSERVATION AND ADAPTIVE SAMPLING WITH MULTIPLE PLATFORMS

The Autonomous Ocean Sampling Network (AOSN) project brings together new robotic vehicles with advanced ocean models to improve our ability to observe and predict the ocean. This project demonstrates technology and methods for a sustainable, relocatable IOOS. An AOSN field program was run in Monterey Bay from mid July to early September 2003. The operational system includes data collection by smart and adaptive platforms that relay information to a shore where it is assimilated into numerical models, which predicted future conditions. Over 21 different autonomous robotic systems, three ships, an aircraft, HF radar, drifters, floats, and numerous fixed (moored) observation assets were used to observe upwelling processes in the vicinity of Monterey Bay. Data was communicated to shore and placed in a central repository where modeling groups and other collaborators could access it via the Internet. Key to our effort is the development of adaptive sampling control strategies to command our mobile vehicles to places where their data will be most useful. Meetings of the Real-Time Operational Committee provided a forum for reviewing progress against objectives, observational results, model output, and planning subsequent observations. Graphical observation data products and modeling results were placed on open project web sites in real-time. The success of the AOSN program depends on the collaboration of a network of institutions spread across the United States.

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SEASONAL EFFECTS ON THE METABOLISM OF COPEPODS, EUPHAUSIDS AND THYSONESSIDS OFF THE WESTERN ANTARCTIC PENINSULA: RESULTS FROM ASSAYS AND RESPIRATION STUDIES

We compared four metabolic indicators of nutritional state: citrate synthase activity (CS), malate dehydrogenase activity (MDH), lactate dehydrogenase activity (LDH) and percent body protein to each other and to respiration measurements. These comparisons were made for three species of copepods (Calanoides acutus, Metridia gerlachei, Paraeuchaeta antarctica), three species of Euphausids (Euphausia crystallorophias, Euphausia triacantha, Euphausia superba adults and Euphausia superba F6 furcilia) and Thysonessa macrura which were collected off the Western Antarctic Peninsula during the austral Spring/Summer and Fall/Winter. Most species showed significant changes in one or more of the enzyme activities. In general, species that engage diapause during the Winter months showed a decrease in CS whereas those that actively feed throughout the year showed no significant changes. Most species showed a significant correlation between fluctuations in MDH and LDH, regardless of season. There was also evidence of correlations between CS activity and respiration as well as between MDH activity and respiration, however, CS by far appears to be the best proxy for respiration. The observed patterns are consistent with existing models of survival strategy for these Antarctic species.

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INFLUENCE OF TERRESTRIAL AGRICULTURAL ACTIVITIES ON MARINE ECOSYSTEM PROCESSES IN THE GULF OF CALIFORNIA: EVIDENCE FROM REMOTE SENSING

The Gulf of California (GOC) is a biologically productive and diverse marine region, and the focus of conservation efforts. During winter, upwelling of nutrients in the eastern GOC supports large phytoplankton populations; located adjacent to this region is the Yaqui Valley, an intensive agricultural area critical to the Mexican economy. Irrigation and high levels of nitrogen (N) fertilizer use in the Valley result in large N losses to the atmosphere, groundwater, and surface waters. Because hydrologic flows through the Valley are derived almost entirely from four yearly irrigation events, and travel through a five-canal drainage system directly into estuaries of the GOC, N inputs from the Valley to the GOC are highly localized in space and time. Using remotely sensed data from AVHRR, SeaWiFS and MODIS, and a variety of statistical analyses, we show that N inputs from terrestrial agricultural activities in the Yaqui Valley may influence—or interact with—marine ecosystem processes in the Gulf of California. We additionally demonstrate that these interactions may have important implications at the regional scale.

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VIRIOPLANKTON OF THE CHESAPEAKE BAY: EXPLORING COMMUNITY DIVERSITY THROUGH METAGENOME ANALYSIS.

Despite growing acceptance of the importance of viruses and viral infection within marine microbial communties, little is known about virioplankton genetic diversity. This is due in large part to the lack of unambiguous and widely distributed viral gene markers and the difficulty of cultivating a diverse range of bacterial and microalgal hosts. A metagenomic approach was utilized for relatively unbiased assessment of Chesapeake Bay viral diversity. 3072 clones of a metagenome library were sequenced bidirectionally, resulting in over 6,000 high quality sequences. Contig spectra analysis was used to approximate total virioplankton diversity. BLAST comparison to GenBank and two other viral databases (California coastal seawater and Delaware soil) showed the vast majority of high quality matches were to known viral or bacterial sequences, supporting the common proposition that most marine viruses are bacteriophage. Interestingly, several significant hits between the Chesapeake and California libraries showed no significant homologues in GenBank. Over 70% of the sequences had no high quality match (i.e., E<0.001) to a GenBank entry, implying that virioplankton represent perhaps the largest reservoir of unknown sequence in the biosphere.

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IN SITU ESTIMATES OF EUPHAUSIID DENSITIES AND NEAREST-NEIGHBOR DISTANCES NEAR A FJORD SILL COLLECTED WITH ZOOVIS

The fine-scale structure of dense aggregations of zooplankton commonly associated with steep bathymetric features are difficult to quantify using conventional nets. Imaging optics guided by down-looking acoustic data provide a means of estimating the distribution, abundance and orientations of zooplankton on horizontal of scales of meters. Knight Inlet is a coastal fjord where intense acoustical scattering develops on the upcurrent side of the sill during daytime tidal flow. Euphausiids appear to be responsible for the acoustic scattering. This study used the ZOOVIS digital camera to quantify the densities of euphausiids within the scattering layer. In addition to estimating euphausiid densities, the presence of multiple animals within individual images allowed us to measure nearest-neighbor distances and horizontal orientation. Peak euphausiid densities exceeded 2 individuals/L. Mean nearest neighbor distances were 14 cm, however animals ranged from less than 1 cm to 32 cm apart. The results are discussed in the context of measured acoustical scattering, euphausiid patch structure and behavioral and acoustic scattering models.

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PHOSPHORUS SPECIATION UNDER ANOXIC CONDITIONS: INSIGHTS FROM THE CARIACO BASIN

Phosphorus (P) is an essential nutrient that limits biological production in freshwater and oceanic regimes. In the open ocean, dissolved P concentrations are so low that remineralization from sinking particles is an important mechanism regulating P availability in the dissolved phase. However, little is known regarding the composition and bioavailability of particulate P. Under anoxic conditions, positive feedbacks exist between enhanced regeneration of particulate P and increased production via upwelling of P-rich waters. In this study, we analyzed a series of sediment trap samples for P composition that were collected across the oxic/anoxic boundary in Cariaco Basin. Inorganic P concentrations ranged from 10 to > 90% of the Total P. Ratios of C:organic P and N:organic P remained relatively constant. While depth profiles suggested non-selective remineralization of organic P relative to organic C in sinking particulate matter, there appears to be selective remineralization within the sinking particulate organic P pool. Solid state 31P NMR reveals that phosphonates, chemically and thermally inert compounds, are preferentially removed relative to more bioavailable P esters in anoxic environments.

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EXPORT OF YOUNG TERRIGENOUS DOM FROM RIVERS TO THE ARCTIC OCEAN

Rivers discharge large quantities (250 Tg C/yr) of terrigenous dissolved organic matter (DOM) to the oceans. About 10% of this terrigenous DOM is discharged to the Arctic Ocean, a small basin accounting for ~1% of the global ocean volume. Soils in the drainage basins of Arctic rivers are a major global C reservoir, and the fate of this C is of growing concern as the effects of climate change become more evident in the Arctic. Herein we report natural 14C data indicating that DOM from several Eurasian and North American rivers is predominantly young and largely derived from recently-fixed C in plant litter and upper soil horizons. Concentrations of dissolved lignin phenols, unique organic tracers of terrestrial plant material, and 14C content in DOM were strongly correlated throughout the Arctic Ocean, indicating terrigenous DOM is mostly young and widely distributed in polar surface waters. It appears the old C stored in terrestrial soils and peats is not currently being mobilized as DOM in riverine discharge.

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OBSERVING THE DIEL MIGRATION DYNAMICS OF AN ISLAND-ASSOCIATED SOUND-SCATTERING LAYER

The Hawaiian mesopelagic boundary community, comprised of island-associated, midwater sound-scattering layers, undergoes diel migrations with both vertical and horizontal components. To understand the dynamics of the community's migration at fine temporal scales, we utilized a bottom-mounted, 200-kHz active-acoustic mooring that transmitted ten signals every 15 minutes, from dusk until dawn for 5 days. Five moorings were deployed 1.0 to 3.0 km from the leeward coast of Oahu in 0.5 km intervals. Two layers within the boundary community were observed to undergo simultaneous vertical and horizontal migrations. The shallow layer came within 10 m of the surface and 1 km of the shoreline. The deeper layer remained 90 m from the surface and 2.5 km of the shoreline. Vertical migration rates were measured at 0-1.7 m/min while the horizontal rate averaged 1.7 km/hr. We observed high levels of biomass moving rapidly, over a great distance, into shallow waters very close to shore providing insight into the significant link the mesopelagic boundary community provides between nearshore and oceanic systems.

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ENHANCED REMINERALIZATION OF ORGANIC CARBON DURING ANAEROBIC METHANE OXIDATION: THE HOT-SPOT DIAGENTIC ZONE

Marine sediments accumulating on continental margins are globally important because they provide high-resolution paleo-records, sequester carbon as buried organic matter, and are sites of methane hydrate formation. We describe a 'hot-spot' zone of localized sulfate reduction and organic carbon remineralization, 1-2 m below the sediment-water interface, in deposits from 4 sites along the SW North American margin. Fluxes estimated using pore-water profiles of sulfate, TCO2 and methane identify this zone where 12-25% of the total organic carbon remineralization occurs. This hot-spot zone (<40 cm thick) represents a peak in carbon oxidation not predicted with multi-G diagenetic models. This zone does not represent an episode of high carbon deposition nor is it a non-steady-state feature driven by sediment mass movement. We suggest that the presence of methane at this horizon is responsible for stimulating organic carbon remineralization by sulfate reducing bacteria and that anaerobic methane oxidation alone cannot support the flux of sulfate consumed. The presence of this zone implies a negative feedback mechanism whereby methane oxidation stimulates the oxidation of organic carbon.

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EDDY CORRELATION ? A NEW TECHNIQUE FOR MEASURING AREAL AVERAGE OXYGEN UPTAKE BY AQUATIC SEDIMENTS

Oxygen uptake by sediments can be determined from simultaneous measurements in the water column of the fluctuating vertical velocity (measured with an acoustic Doppler velocimeter) and the fluctuating oxygen concentration (measured with a oxygen microelectrode). Typically, the two variables are measured 10-50 cm above the sediment surface, for a period of 10-20 min, and at a frequency of 10-25 Hz. The technique is superior to conventional methods as measurements are done under true in situ conditions, i.e., without any disturbance of the sediment and under the natural hydrodynamic conditions. Furthermore, this technique can be used for bio-irrigated or highly permeable sediments, such as sands, where traditional methods often fail. The first part of this presentation describes the theory and principle behind the new technique and gives a few examples of field applications. The second part focuses on predictions of the area on the sediment surface that contributes to the measured oxygen uptake. The latter results are obtained through numerical-mathematical modeling of the three-dimensional turbulent transport of oxygen in the bottom water over the sediment surface.

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ENUMERATION OF HYDROTHERMAL VENT MICROORGANISMS BY FLOW CYTOMETRY

Particle rich environments are problematic for automated enumeration of microorganisms. Deep-sea particle enriched hydrothermal plumes have high mineral concentrations (e.g., iron oxyhydroxides) which may be responsible for non-specific binding of nucleic acid stains. Differentiation of particles and microorganisms is possible in direct microscope counts; semi-automated counts using flow cytometry are complicated due to the fluorescent signal from mineral precipitates overlapping that of stained microorganisms. Thus, a successful protocol using flow cytometry must define the signature of these abiotic particles, in order to distinguish them from microorganisms, and optimize dye and flow cytometer detector configurations to minimize this overlap. Several different nucleic acid binding stains have been tested, including DAPI, Hoechst, SYTO-13, SYTO-BC, and SYTO stains with red fluorescence. Experiments have been conducted to chemically eliminate non-specific binding of stains to mineral surfaces. Detector configuration and laser wattage of the instrument have been optimized for distinguishing microbial populations from background noise. Estimates of the abundance of hydrothermal plume microorganisms as measured by flow cytometry and epifluorescence microscopy will be compared and the results presented.

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NARRAGANSETT BAY WINDOW, A PROTOTYPE OCEAN OBSERVING SYSTEM

A coordinated system of ecological monitoring projects instituted in Narragansett Bay, Rhode Island can be scaled up to assess the status of large marine ecosystems. Major components of the Bay Window, include fish trawl surveys, continuous observations from fixed site buoys, and monthly transects measuring ecological parameters throughout Narragansett Bay using the NuShuttle sampling platform. The NuShuttle is towed at 8 knots and undulates from the surface to near bottom. The resulting vertical profiles provide a detailed measure of lateral and vertical gradients along the main axes of the Bay. The properties measured by the NuShuttle include temperature, salinity, dissolved oxygen concentration, depth, chlorophyll fluorescence, PAR, photosynthetic rates, fine scale plankton distribution (from an OPC) and plankton taxonomy (from a Hardy Continuous Plankton Recorder). Data from the various components of the Bay Window suggest that the Narragansett Bay ecosystem has undergone large changes in the last few decades. Major fish and shellfish stocks are greatly reduced, the annual productivity pattern is no longer dominated by a winter/spring plankton bloom, and summer hypoxia has become more frequent and wide spread.

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N2 FIXATION AND N REGENERATION IN TRICHODESMIUM IMS101 GROWN IN CHEMOSTATS AT VARIOUS GROWTH RATES.

Trichodesmium has been found to be a significant N2 fixer in oligotrophic waters in both tropical and subtropical regions. Recent research using batch cultures of Trichodesmium have found that they not only fix N2 but also take up other nitrogenous compounds to satisfy their N demand. In addition, rates of N2 fixation, N uptake and N regeneration varied with growth state. In this study, we used continuous culture systems to maintain Trichodesmium IMS101 at constant growth rates and physiological states to determine how growth rate affects rates of N2 fixation, N uptake and N regeneration. We grew Trichodesmium at growth rates of 0.1, 0.2 and 0.33 d-1 (doubling times of 10 days, 5 days and 3 days). All cultures were maintained at a steady biomass for at least 3 generations before experiments were conducted. N2 fixation rates were examined using both the C2H2 reduction technique and 15N2 uptake with the former providing an estimate of gross N2 fixation while the later measured net N2 fixation. We also measured rates of 15NH4+ and DO15N release from 15N2 uptake in the cultures and NH4+ uptake. The highest N2 fixation rates were measured in cultures growing at 0.2 d-1.

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EXPLORATORY ANALYSIS OF FOOD WEB STRUCTURE AND DYNAMICS IN ARCTIC POLYNYAS

Polynyas are areas of open water in ice-covered seas, characterized by high biological productivity. The NEW (Northeast Water) and NOW (North Water) polynyas, located off the east and west coasts of Greenland respectively, were sampled extensively during multi-years campaigns for both physical and biological variables. The observations gathered in these polynyas comprehensively cover the seasonal evolution of food web structure and dynamics in these areas. The data suggest that these polynyas have contrasting physical and biological characteristics. The NOW polynya appears to be more biologically productive than the NEW polynya whereas the nutrient concentrations are more similar. Hence, different food web structures between these two polynyas can be hypothesized. Here we present a first comparative analysis of the complete planktonic food web of both the NEW and NOW polynyas. We use multivariate analyses to explore linkages among physical, chemical and biological variables, elucidate seasonal changes in these linkages, and identify differences between the two polynyas. These analyses form the basis for a full synthesis of how organic carbon is processed within these unique ecosystems.

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MONITORING OF ROCKY-BOTTOM MACROBENTHIC COMMUNITIES USING DIGITAL IMAGE ANALYSIS: TEMPORAL AND SPATIAL CHANGES

Temporal and spatial variations of epibenthic rocky-bottom communities in subarctic shelf areas were investigated using digital image analyses. Underwater photographs were taken using a metal frame (50 x 50 cm) and a Hasselblad SWC in an underwater housing. Image analysis was carried out using Adobe Photoshopâ with the plug-in Fovea Proâ. Using the RGB- model of Photoshop, an efficient and non-destructive method was developed to retrieve community data of solitary and colonial organisms. A long-term study with pictures taken annually over the past 20 years at Kongsfjord/ Svalbard showed a correlation between increased abundances of brown-algae and the sea urchin Strongylocentrotus sp. and the decline of the actinia Urticina sp. Spatial variations of benthic communities on the subarctic island Jan Mayen were studied after an volcano eruption in 1970, where new marine lava grounds emerged. Examination of pictures taken in 1994 showed that differences between communities on new and old grounds were still pronounced on depths below 15 m, were the species composition is most biological controlled. The bivalve Hiatella arctica was the dominating species on new lava grounds.

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MORTALITY OF THE COPEPOD CLAUSOCALANUS FURCATUS IN THE NORTHERN GULF OF MEXICO

Mortality rates are key parameters required to understand copepod population dynamics. A time series of zooplankton samples was collected at 12h intervals between March 18-April 6 and May 15-June 9, 2003 from a petroleum platform in the northern Gulf of Mexico. The calanoid copepod Clausocalanus furcatus was a common species during sampling. This species was abundant when oceanic water predominated at the study site and decreased when riverine water reduced surface salinity. Stage development time was estimated by incubating copepods of known stages. A stage-structured life table was then constructed to estimate stage specific mortality rates. Data were first corrected for differences in stage development time and then normalized by total abundance. Cohorts were identified and tracked during periods when oceanic water mater masses were present. Nauplii experienced higher mortality rates than copepodites. Mortality rates were higher in early naupliar stages than later stages. Early copepodite stages also had higher mortality than later stages. The abundance of nauplii displayed a negative exponential relationship with potential predators (carnivorous copepods and chaetognatha), thus high mortality rates in nauplii may have been due to predation.

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LOW-LIGHT-ADAPTED PROCHLOROCOCCUS SPECIES POSSESS SPECIFIC ANTENNA FOR EACH PHOTOSYSTEM

Prochlorococcus, the most abundant unicellular photosynthetic organism in the oceans, owes its remarkably large depth distribution to the occurrence of distinct genotypes adapted to either low or high light niches. Adaptation to such light niches have been accompanied by a rapid evolution of pcb genes encoding the major light-harvesting antenna proteins in this genus. Here we show, using molecular and structural techniques, that the primitive low light-adapted strain Prochlorococcus sp. MIT9313 has one iron-stress-induced pcb gene encoding an antenna protein serving photosystem I (PSI) - i.e. comparable to isiA genes from cyanobacteria - and a constitutively expressed pcb gene encoding a photosystem II (PSII) antenna protein. By comparison, the more evolved, very low light strain SS120 has constitutive PSI and PSII antennae and the high light strain MED4 has only a constitutive PSII antenna. This shows that evolution of pcb genes in the Prochlorococcus genus has been driven directly by environmental constraints leading to the regulation of specific antenna for PSI and PSII.

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TEMPORAL VARIATIONS IN PHYTOPLANKTON COMMUNITY STRUCTURE AND PHYSICAL FORCING AT STATION ALOHA (22.75N, 158W)

Potential biological responses to basin-scale climate forcing in the Pacific are assessed based on temporal variations in phytoplankton community structure observed at Station ALOHA (1989-2002) and the output of a Regional Ocean Modeling System (ROMS) model. Phytoplankton populations were monitored monthly during this period using taxon-specific pigment analyses. These analyses revealed distinct temporal patterns, with highest pelagophyte abundance during the periods 1990-1993 and 1996-2002. For other key groups, such as the haptophytes and cyanobacteria, there appears to be a recent post-1996 enhancement in their biomass relative to the previous 7-year period of observation. An Ocean General Circulation Model, based on the terrain-following vertical coordinate primitive equation ROMS model, was used to simulate hydrographic dynamics at Station ALOHA. Preliminary analysis comparing the model simulation with TAO observations has shown that the model can realistically reproduce the low-frequency (seasonal-to-interannual) variability. The ROMS simulation during 1989-2002 will be first compared against the HOT physical measurements and then used to help interpret the observed changes in phytoplankton community structure at Station ALOHA.

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"NEREIDS", DISTRIBUTION OF NEAR-REAL-TIME SATELLITE OCEANOGRAPHY PRODUCTS FOR EDUCATION AND RESEARCH.

The Physical Oceanography Distribution Active Archive Center (PO.DAAC) has developed a reliable ingest and distribution data system, which is utilized by several satellite mission ground systems for distributing mission-critical data streams. This capability has recently been extended to capture near-real-time, ocean-related products (with a latency of less that three hours) from multiple science processing centers. The products are subsequently used by PO.DAAC's automated, near-real-time processing system (NEREIDS) to create maps and image overlays that are used to illustrate the current state of the oceans, as well as, localized events, such as hurricanes and tropical storms. Maps of sea surface temperature (from AVHRR and GOES), ocean topography (from Topex/Poseidon and Jason-1), and ocean wind and sea ice (from QuikScat) are currently distributed via a web site (http://nereids.jpl.nasa.gov) and FTP server. The maps and overlays provide a valuable source of information that can be utilized for education, outreach and applications, alike. Feedback from educators has highlighted that NEREIDS provides a useful tool for incorporating real scientific data into classroom exercises; and is particularly appropriate for middle to college levels. In this paper, we outline the current and future capabilities of NEREIDS, and discuss its potential for education and outreach.

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PHOSPHORUS UPTAKE KINETICS OF DIFFERENT NATURAL POPULATIONS OF BACTERIOPLANKTON AND EUKAROYTIC PHYTOPLANKTON IN THE NORTH PACIFIC SUBTROPICAL GYRE

Phosphorus (P) uptake kinetic experiments were conducted on natural microbial populations in the oligotrophic North Pacific Subtropical Gyre (NPSG) at Station ALOHA (22.75N, 158W) and near the Hawaiian Islands in the summers of 2002 and 2003. To assess the maximum P consumption rate (Vmax) and half saturation constant (Km), time course incubations at several P concentrations were performed. Trichodesmium colonies, and mixed assemblages of diatoms and cyanobacteria (Rhizosolenia sp and Katagnymene sp) were also tested. The Km and Vmax for the Prochlorococcus-dominated community was 10-20 nM P and 4-6 nM P d-1 respectively, similar to the mixed layer mean uptake rate at Station ALOHA (3.5 nM P d-1, s.e. 0.2 , n=54). Km values for Trichodesmium and diatom/cyanobacterial communities were 5-10 fold higher. Summertime P concentrations in the mixed layer at ALOHA are typically 25-50 nM, conditions where Prochlorococcus is close to or at Vmax, but the larger phytoplankton will be performing at less than half their maximum uptake rate. This prevailing low nutrient regime allows the slow growing Prochloroccus community to remain dominant in the NPSG.

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SIMULTANEOUS ASSESSMENT OF RELATIVE AUTOTROPHY AND HETEROTROPHY IN COASTAL REGIMES

Ecosystem function will in large part be determined by the functional groups present in the biological community. The simplest distinction with respect to functional groups of an ecosystem is differentiation between primary and secondary producers. A challenge thus far has been to examine these groups simultaneously with sufficient temporal and spatial resolution for observations to be relevant to scales of change in coastal waters. To achieve this resolution, an autonomous underwater vehicle equipped with an ADCP, fluorometer, and bioluminescence bathyphotometer was used in Monterey Bay during the summers of 2002 and 2003, surveying >500km. This study takes advantage of differences in the

bioluminescence kinetics of autotrophs and heterotrophs to measure relative abundances of the two groups within the same time space volume. This is a novel approach for distinguishing these general classifications using a single sensor and provides basic quantities for use in ecosystem models. Furthermore, it provides an efficient method for high-resolution coverage over large spatial extents. This approach is validated using fluorescence data, acoustic backscattering information and is compared to output from an ecosystem module of the Regional Ocean Model (ROMS).

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BIODIVERSITY IN THE HADAL ZONE: IMPLICATIONS FROM AN AMPHIPOD DIET ANALYSIS

Deep-sea biologists are continually challenged with sampling the ocean's deepest habitats. Deep-sea trenches comprise the ultraabyss or hadal zone, a unique environment that represents the extreme of high-pressure habitats and is characterized by a specialized fauna distinct from shallower abyssal fauna. Little is known about hadal zone species relative to other deep-sea environments, an unfortunate consequence of sampling limitations and expense. We present a novel molecular approach to further assess biodiversity in the hadal zone. Scavenging amphipods are readily captured from most deep-sea trenches and dominate our current knowledge of trench fauna. These animals "sample" their environment through foraging and carry DNA remnants of ingested items in their guts. Therefore, a molecular diet analysis of these more accessible amphipods may provide information about surrounding fauna. Here, we show that DNA signatures recovered from the guts of trench-inhabiting amphipods suggest that biodiversity in hadal zones may be much higher than traditional sampling implies. This finding is significant and indicates that biological exploration in the deepest of the deep-sea has really just begun.

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A NEW PHOTOSYNTHETIC GREEN SULFUR BACTERIUM ISOLATED FROM DEEP-SEA HYDROTHERMAL VENTS

Photosynthetic organisms are usually restricted to the surface of the land and the photic zone of aquatic systems. A possible exception to this rule is in the vicinity of deep-sea hydrothermal vents. Vents are sufficiently hot that they produce a weak light emission that has found to be of sufficient intensity such that photosynthesis in this environment could be possible. In December 2001, samples were collected at hydrothermal vents off the coast of Puntarenas, Costa Rica at the 9 N dive site along the East Pacific Rise. An isolate was cultured from these samples that shows characteristics of a photosynthetic green sulfur bacterium. Absorption and fluorescence spectra are characteristic of green sulfur bacteria that contain bacteriochlorophyll c. Pigment extraction and HPLC analysis confirm the presence of BChl c and carotenoids typical of green sulfur bacteria. Phylogenetic analysis of both 16S rRNA and the FMO antenna complex confirms that this isolate is grouped with other marine species within the phylum of green sulfur bacteria. Further characterization of this isolate is underway.

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MACROBENTHIC COMMUNITIES IN THE HIGH ARCTIC CANADA BASIN: ABUNDANCE, BIOMASS AND TROPHIC STRUCTURE

Macro-infauna was sampled by collecting box cores at 6 stations in the Canada Basin at 640-3250m in Aug/Sept2002. Total abundances ranged from 100-7650 individuals/m2 with the highest concentrations in Amundsen Gulf and the lowest in the deep Canada Basin. Biomass ranged from 2-6514mg wet weight/m2 with the same geographical trend. Polychaetes and crustaceans were most abundant while polychaetes and mollusks dominated the biomass. Visual survey of macro-epifauna revealed that abundance of attachment substrata was the major factor determining community composition. Otoliths of Boreogadus saida and Arctogadus glacialis were abundant at Northwind Ridge and three 14C-dated specimens yielded calendar ages of 5605, 9120, and 13165yBP, respectively. 15N/14N isotopic signatures of benthic organisms ranged from 10-18‰ with most taxa in the 2nd and 3rd trophic level with respect to POM values (average 5‰). Distinctive herbivores and 1st order predators inhabited sea ice and upper water column (15N/14N: 5-12‰ and 6-16‰, respectively). The findings suggest that ice, pelagic and benthic systems are linked through sinking grazers and their products rather than through direct input of algal material to the benthos.

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CO-VARIATION OF COASTAL WATER TEMPERATURE AND MICROBIAL POLLUTION AT INTERANNUAL TO TIDAL PERIODS

Water temperature and fecal indicator bacteria levels co-vary along the shoreline of Huntington and Newport Beach, California at interannual to tidal periods. During summer, cooler than average waters caused by interannual variability in sea surface temperature (SST), synoptic upwelling, and tidal-period cooling are coincident with elevated levels of microbial pollution in the surf zone. These pollution events can be attributed to the effects of weakening in stratification on the fate of a waste water plume and the prolonged persistence of fecal indicator bacteria in colder waters. During winter, warmer than average water caused by basin scale oscillations and atmospheric and oceanographic processes that contribute to the Multivariate El Nino Southern Oscillation Index are indicative of elevated total coliform levels in the surf zone. In this case, the elevated coliform levels can be ascribed to increased rainfall, and the resultant storm water inflow to the surf zone. The probabilistic relationships between temperature and microbial pollution presented here can serve as a means for predicting public health risk at beaches. Results also underscore the importance of environmental forcing on pollutant levels in the surf zone.

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FLUORESCENCE VARIATIONS OF MARINE AND TERRESTRIAL COLLOIDS: EXAMINING SIZE FRACTIONS OF CHORMOPHORIC DISSOLVED ORGANIC MATTER IN THE DAMARISCOTTA RIVER ESTUARY

Marine chromophoric dissolved organic matter (CDOM) imparts highly variable optical signatures in surface waters over short spatial and temporal scales for reasons that are not well understood. The colloidal fraction of organic material in the marine environment cycles quite rapidly, potentially contributing to CDOM variability. Separating the organic matter dissolved phase into colloidal and soluble fractions using flow field-flow fractionation (4F) allows the colloidal organic matter contribution to optical variability in bulk CDOM to be investigated. By coupling 4F with excitation emission matrix spectroscopy (EEMS), the compositional variability within different colloidal molecular weight fractions was examined via changes in three-dimensional fluorescence signatures. Surface waters from the Damariscotta River estuary displayed protein-like and humic fluorescence from separate colloidal size fractions. Colloidal fluorescence endmembers for terrestrial and marine CDOM from the coastal Maine region were compared using principal component analysis (PCA), providing fundamental information on the distributions and forms of CDOM in the upper waters of nearshore environments and the potential effect of these substances on the optical characteristics of seawater.

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INDUCIBLE NITRIC OXIDE SYNTHASE (INOS) ACTIVITY IN ZOOXANTHELLAE IS ASSOCIATED WITH CORAL BLEACHING

Coral bleaching, (loss of photosynthetic algal symbionts) is a phenomenon that is recognized as one of fundamental ecological importance. However, mechanisms by which bleaching occurs are not at all well understood. Zooxanthellae living in symbiotic association with cnidarians have been shown to possess nitric oxide synthase (NOS) activity, the enzyme that generates the multifunctional and membrane-permeable signal molecule nitric oxide (NO). In previous in vitro work, we demonstrated that in specimens of Madracis mirabilis subjected to temperature shock, algal NOS activity was dramatically elevated prior to the 'emigration' of algae from the host. We have now extended this study to zooxanthellae isolated from corals collected from the field during February (when water temperature was as low as 16 C) and August (when water temperature was as high as 28 C). Our results indicate that stressed corals (many of which were visibly in the process of bleaching), contain zooxanthellae with elevated levels of NOS activity, relative to corals that are not showing signs of stress-initiated algal loss. Algal NO production may thus provide zooxanthellae with a mechanism of vacating a stressed symbiotic relationship.

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REVERSING EUTROPHICATION IN CHESAPEAKE BAY: WHAT NEXT?

Twenty years ago regional states and the federal government agreed to restore the Chesapeake Bay ecosystem. Four years later this effort was focused on reversing eutrophication by reducing controllable N and P inputs by 40% by 2000. Although progress was made, the goal was not met and the lack of significant improvements apparent in the ecosystem has generated frustration and pessimism. A new more ambitious goal has been set for 2010 based on models of desired and achievable ecological outcomes. This presentation provides an overview of scientific and institutional successes and failures and a challenge for the science needed to achieve restoration goals. In particular, improved understanding is needed of: the effectiveness of diffuse source abatement strategies; the functioning of nutrient sinks; trophic responses; feedbacks between ecosystem structure and function; and the long-term consequences of climate variability and change. The effective functional integration of management models, observational systems, and strategic research is also a critical requirement. The Chesapeake is a prominent prototype for regional-scale, ecosystem-based management called for by the ocean commissions; therefore the outcome is of global significance.

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NORTHERN SHRIMP: FISHERY-MANAGEMENT NEEDS MOTIVATING GOMOOS & NOAA TO COMBINE EFFORTS TO MONITOR AND PREDICT COASTAL OCEAN CLIMATE

The North Atlantic Oscillation drives bottom-temperature fluctuations in the western Gulf of Maine that may be predictable up to a year in advance. Drinkwater et al. (2002) found evidence for this compelling hypothesis from NOAA fishery surveys. The temperature fluctuations affect habitat of the Northern Shrimp – an important local fishery – but the information has yet to be used in adaptive fisheries management. Management needs prompted Maine's Department of Marine Resources (a GoMOOS member) to work with GoMOOS and NOAA to develop a Web-based Geographic Information System (GIS) that merges data from all three partners. Dynamic connections using OPeNDAP and MapServer have enabled dynamic, merged data products. Now that the institutional and technical impediments to interoperability have been overcome, the region's managers, and the industry members whose livelihoods are managed, have a useful information product. Success with the shrimp project prompted NOAA to sponsor a new climate-sentinel buoy for the GoMOOS array that offers new opportunities for management and serves critical research needs. This partnership between GoMOOS and government agencies has strengthened the Regional Association in the Gulf of Maine.

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CHESAPEAKE BAY OBSERVING SYSTEM: LESSONS AND PROSPECTS

The Chesapeake Bay Observing System (CBOS) was initiated by the academic community for scientific purposes, chief among which was to obtain long-term measures of circulation processes. Early in its 13 years of operation, recognition of the effort and costs associated with long-term operation led to expanding this vision, broadening both purpose and participation. This expansion has involved an attempt to serve both extremes of the operational-research spectrum and to move beyond the single focus on physical oceanography. Unfortunate compromises and delays on all fronts during these early years have led to questions as to the ability of such systems to achieve this ambitious, multipurpose vision and to be both operational and sustainable. However, recent successes in producing operational forecasts, in realizing long-term records of estuarine processes, and in covering extreme events provide substantial encouragement. More importantly, increasing recognition of the advantages of a broader coalition in facing these challenges has brought formerly reluctant partners to the table.

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GENE EXPRESSION PROFILING IN THE TOXIC MARINE DIATOM PSEUDO-NITZSCHIA MULTISERIES USING MICROARRAY TECHNOLOGY

The pennate diatom, Pseudo-nitzschia multiseries, is the source of the neurotoxin domoic acid which causes Amnesic Shellfish Poisoning. While a considerable amount of research has been completed to investigate the biology of P. multiseries, the molecular characterization of this organism has been limited. Further knowledge of the biochemical pathways that control the physiology of P. multiseries would be hampered without an investigation into the genes that govern the regulation of these pathways. To this end, we constructed a complementary DNA library and screened our library for genes that are up- or down- regulated during toxin production, using microarrays. Expression analysis of 5376 cDNAs revealed several genes that are of particular interest to our understanding of growth and toxin production in P. multiseries.

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ZOOPLANKTON DYNAMICS IN THE LOWER SAN FRANCISCO ESTUARY: ROLE OF MESO- AND MACROZOOPLANKTON

Many components of the San Francisco Estuary (SFE) ecosystem are highly disturbed and impacted, including the plankton. For instance several non-indigenous copepod species have become established in the SFE and now dominate the zooplankton assemblage of the lower estuary (Bollens et al., 2002, Hydrobiologia, 480: 87-110). However, much less is known about trophic interactions within the planktonic food web. Here we report on the combined results of several multi-year field and experimental studies to address three heretofore understudied aspects of the dynamics of meso- and macrozooplankton in South SFE: 1) the role of mesozooplankton as grazers on phytoplankton, including seasonal and spatial variability thereof; 2) predation mortality on mesozooplankton, especially by the carnivorous, invasive copepod Tortanus dextrilobatus; and 3) the role of gelatinous zooplankton, including larvaceans, medusae and ctenophores.

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ENVIRONMENTAL INFORMATICS OF THE COASTAL MARGIN COMBINING RESEARCH WITH CURRICULUM DEVELOPMENT

The Texas A&M University System including Texas A&M University, the regional campuses in Corpus Christi and Kingsville, and the Texas Engineering Experiment Station have been recently awarded a National Science Foundation Combined Research-Curriculum Development (CRCD) project to develop four new and/or significantly-modified courses. Courses are based on the research involving large, real-time, environmental data sets used to construct realistic physical and ecological models that improve understanding of the causal relationships between environmental stressors and biological effects. A comprehensive research plan integrating different types of data from geographically-dispersed sensors into complex models improves the ability to understand, predict, assess, manage, and communicate human and natural stress impacts on coastal ocean ecosystems, including climate change, pollution, land and resource use, invasive species, and extreme natural events. A paradigm for studying stochastically-pulsed ecosystems provides natural, social, and economic bases for integrated coastal and ocean management. The curriculum development team draws from nearby campuses and both regional and national industry and includes experts in assessing the pedagogical value of the curriculum and developing suitable metrics to evaluate the learning experiences of the students.

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THE EFFECT OF NUTRIENTS AND IRON ADDITIONS ON THE PHYTOPLANKTON DYNAMIC IN THE NORTHWESTERN MEDITERRANEAN SEA

The impact of atmospheric inputs on phytoplankton dynamic was investigated in the Northwestern Mediterranean Sea. Using microcosms incubation experiments performed with surface seawater collected in August 2003 during the period characterized by a stratified water column and a low primary productivity, we studied the impact of macronutrients (nitrate, phosphate and silicic acid), iron and aerosols (Saharan and anthropogenic) on the primary production and composition of the phytoplankton community. By using taxonomic pigments as size class markers of phototroph groups we show that different degree of limitation control pico-, nano- and microphytoplankton growth. Considering the whole community, the primary prodution was maximum both when adding macronutrients and simultaneously macronutrients and iron suggesting that iron was not a limiting factor. Indeed, the concentration of dissolved iron before additions was surprisingly high (1nM) as only a very small Saharan event have been recorded since the beginnign of the stratified period. We suspect a "fertilization" of the water column by the smokes originating from the huge biomass burnings that occurred int eh South of France at this time.

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OBTAINING CURRENT MEASUREMENTS ON US COAST GUARD NAVIGATION BUOYS AS AN ENHANCEMENT TO PORTS®

The Physical Oceanographic Real Time System (PORTS®) is a program of NOAA's Ocean Service Center for Operational Oceanographic Products and Services (CO-OPS). PORTS® provides real-time information to support safe and efficient maritime commerce and informed coastal resource management. In response to user requests for water current information near navigation channels, CO-OPS has entered into a partnership with the US Coast Guard to place current measurement systems on existing navigation buoys. Five buoys in the Chesapeake Bay are being instrumented as part of an enhancement to the Chesapeake Bay PORTS®. This effort is funded by the Maryland Port Administration. A "clamparatus" to secure a Nortek Aquadopp profiler and electronics box to the navigation buoy was fabricated by OceanSciences. The package weighs 142 pounds and has negligible effect when deployed on a 12,000+ lbs. 8' x 26' navigation buoy. The biggest hurdle so far is correcting for the magnetic effect of the steel buoy on the sensor's compass. Initial Nortek compass calibration efforts have removed much of the deviation and alternative calibration procedures are planned.

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THE PHYTOPLANKTON CHLOROPHYLL TO CARBON RATIO AND PROSPECTS OF ITS RETRIEVAL FROM IN-SITU OPTICAL MEASUREMENTS AND REMOTE SENSING.

Phytoplankton have been observed to change their intercellular chlorophyll to carbon ratio (Chl/C) in response to changes in light and/or nutrients. In the case of nutrient limitation, Chl/C is coupled with the growth rate.
Measurements of oceanic phytoplankton carbon are difficult due to the presence of other organism and detritus. Methods that fractionate small particles (e.g. flow-cytometry) suggest that a bulk of particulate organic carbon (POC) near the ocean's surface is associated with phytoplankton and that the fraction of POC due to phytoplankton does not vary a lot. Variability in POC is correlated with changes in beam attenuation in both coastal and open ocean regions. Bulk chlorophyll can be obtained in-situ from either absorption or fluorescence. It follows that Chl/C can be approximated from in-situ measurements.
POC has also been found to correlate with the backscattering coefficient. Backscattering and chlorophyll are standard retrievable products of SeaWiFS, and algorithms are being developed to obtain the beam attenuation and POC from space. This opens the prospect of obtaining Chl/C from space.
In this presentation we will show evidence that optically-derived Chl/C obtained in-situ and from remote sensing data, exhibit features consistent with phytoplankton dynamics and physiology, in both the spatial and temporal domains.

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EFFECTS OF NATURAL SOLAR ULTRAVIOLET RADIATION ON THE DEVELOPMENT OF JUVENILE COHO SALMON: IMPLICATIONS FOR OCEAN SURVIVAL

Juvenile coho salmon were raised for a full year in outdoor tanks under differing spectral regimes that included the presence and absence of solar near-ultraviolet (UVA; 320-400nm) and mid-ultraviolet (UVB; 280-320nm) radiation. We documented developmental responses that could impact ocean survival of smolts. Exposure to UVR had both potentially positive and negative impacts. UVR promoted normal fin development. Shielding from all UVR resulted in significant erosion of both dorsal and caudal fins with UVA playing a prominent role. Body morphology was also affected by UVR. Shielding from all UVR retarded normal smoltification trajectory with UVA being more effective than UVB.

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MODELLING TRANSIENT MANGANESE DIAGENESIS: A SIMPLE PREDICTION AND CONFIRMATION

Diagenetic models are rarely used in a predictive role; commonly they are employed to fit and explain data. However, true predictions are possible, as in the case of a time series of porewater and sediment Mn measurements made in Saguenay Fjord (Quebec, Canada) sediments after a 1996 flood event. The data show that authigenic Mn oxi-hydroxides present at the original sediment interface and in the flood material were progressively reduced, and much of the Mn(II) diffused to the new interface, where it was oxidized and precipitated. Data from 1996 and 2000 were employed to obtain the first-order rate constants for the reduction and precipitation of Mn oxi-hydroxides, as well as the initial amounts of reactive solid Mn in the pre- and post-flood sediments. A model was employed (in 2000) to predict the porewater Mn profile to be expected in 2001. When the 2001 data was obtained, the model prediction was found to be in good agreement, particularly with respect to the substantial drop that occurred in the dissolved Mn.

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PHOTOCHEMISTRY OF DMS IN AN IN SITU IRON-INDUCED NORTHEAST PACIFIC OCEAN BLOOM

Photochemical reactions in the ocean could significantly impact the biogeochemical cycling of dimethylsulfide (DMS), an atmospheric gas with potentially great importance in climate regulation. The wavelength dependence of the apparent quantum yield for DMS photo-degradation was investigated in an iron-induced bloom in the Northeastern Pacific Ocean. In July 2002, a 64 square kilometer patch of ocean was iron-fertilized near Ocean Station Papa (50 N 144 W). Only small changes in apparent quantum yield values were observed over a period of 2 weeks outside the iron-patch. However, inside the patch, apparent quantum yields decreased by 2.5 fold 2 weeks after the initial iron injection. A positive strong correlation was found between apparent quantum yield values and nitrate concentrations. Consequently, we propose a significant role for nitrate-photolysis in DMS photo-degradation. This finding is important since factors controlling DMS photo-degradation rates will indirectly affect DMS flux to the atmosphere. Turnover rate constants calculated for DMS photochemical loss ranged from 0.06 to 0.18 1/d; values in the same range as those published previously.

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EFFECT OF MINERAL DUST DEPOSITION ON IRON(II) DISTRIBUTION IN THE SARGASSO SEA

The project Iron Atmospheric Input to the Sargasso Sea (FeATMISS) aims to quantify the effects of seasonal dust deposition on the distribution of iron in ocean surface waters. During the FeATMISS-1 cruise in July-August 2003, we followed a cyclonic eddy southwest of Bermuda over 14-days, collecting seawater column samples (including surface water using a dinghy) every 2 days, as well as aerosol and rain samples, for iron analysis. Our cruise coincided with calm weather, a large Saharan dust event and occasional rain (Cumulus) squalls, providing an ideal opportunity to assess the impact of dust deposition on iron distributions in the surface ocean. Here we report on Fe(II) concentrations determined immediately at sea by flow-injection chemiluminescence. Dissolved Fe(II) concentrations reached ca. 2-5 nM in fresh aerosol leaches and rain samples, much lower than previously reported values. These atmospheric inputs did not significantly affect the concentration of dissolved Fe(II) in surface seawater, which remained at baseline levels (10-50 pM). Our results suggest that both wet and dry deposition of mineral dust may have little direct effect on the concentration of Fe(II) in open-ocean surface waters.

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EVOLUTION, DECLINE AND FATE OF A SUBARCTIC MESOSCALE IRON-INDUCED PHYTOPLANKTON BLOOM

Iron supply plays a key role in stimulating phytoplankton blooms in High Nitrate Low Chlorophyll oceanic waters. Mesoscale in situ iron-enrichments have been a key tool in elucidating the influence of iron supply on primary and export production in tropical, subpolar and temperate HNLC waters. Although these experiments have provided comprehensive time-series of the evolution of iron-mediated blooms, they have not done so for the subsequent decline and resulting fate of these blooms. SERIES took place in July 2002, near the site of Ocean Station Papa, and involved the participation of Canadian, Japanese and international scientists during a three vessel mesoscale iron-enrichment of subarctic HNLC waters. SERIES resulted in a massive pennate diatom bloom that was observed for 25 days. We shall present a comprehensive suite of time-series measurements, from the onset of an iron-induced bloom to its decline. Furthermore, we will outline the mechanistic links between the evolution, decline and fate of this bloom.

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FECYCLE – A SULFUR HEXAFLUORIDE LABELLED MESOSCALE STUDY OF IRON BIOGEOCHEMISTRY IN UNPERTURBED HNLC WATERS

Tracer-labeled mesoscale iron-enrichments have been used to elucidate iron-mediated changes in both phytoplankton and related biogeochemical processes. However, such iron-enrichments represent large perturbations of High Nitrate Low Chlorophyll waters. HNLC waters comprise a quarter of the World Ocean, and there is a pressing need to better understand the biogeochemical cycling of iron under ambient HNLC conditions. In February 2002, we labeled a mesoscale patch of HNLC Subantarctic waters with sulfur hexafluoride, but added no iron. During the twelve day FeCycle we performed measurements on four biogeochemical components: physics and iron supply, iron chemistry and photochemistry, phytoplankton iron acquisition, and foodweb dynamics, iron recycling and export. We constructed five daily pelagic iron budgets, including vertical diffusive iron supply, viral iron recycling and downward particulate iron export. Here we present a summary of the biogeochemical budgets, and report on the impact of day-to-day variations in external forcing in driving the biogeochemical iron cycle in the upper ocean.

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CHANGES IN CDOM OPTICAL PROPERTIES DURING SIMULATED ESTUARINE SALINITY GRADIENTS

To investigate specific changes in optical properties during estuarine mixing, a series of transects through San Francisco Bay, Chesapeake Bay and Delaware Bay (USA) were undertaken to collect large water samples (> 60 L) which were concentrated by tangential flow ultrafiltration (TFF) from the marine (>33 PSU), midestuarine (~16 PSU) and freshwater (<1 PSU) member waters. TFF permeates (< 1 kDa) from the three members were used to create an artificial salinity transect. CDOM concentrates from each of the three original members was added in equal amounts to each salinity-mix. The optical behavior (absorbance and 3D fluorescence) of each end member CDOM was investigated in this full estuarine mixing transect. Treatments were performed with mixing alone, photobleaching and bacterial degradation (using bacteria collected during the original sampling event). A number of fluorescence indices were used to investigate changes in CDOM optical properties. Components of CDOM fluorescence such as protein and humic peaks were found to be altered by salinity, photobleaching and biological degradation. Specifics will be presented.

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THE NORTH SEA: A "CONTINENTAL SHELF PUMP" FOR THE ABSORPTION OF ATMOSPHERIC CO2

In order to test the hypothesis of a "continental shelf pump" of CO2 in the North Sea, dissolved inorganic Carbon (DIC), partial pressure of CO2 (pCO2) and related parameters, were measured every season during four consecutive cruises in 2001 and 2002.
The high temporal and spatial resolution of the data allowed us to determine the major factors influencing the seasonal variation of the carbon system. These are, firstly the bottom topography, then the primary production and respiration, and finally the riverine inputs. The CO2 fluxes across the air-sea interface showed high seasonal and spatial variability. For example, in spring, due to the strong biological activity, the whole North Sea acts as a strong sink for atmospheric CO2. In contrast, during summer, the southern part of the North Sea releases CO2 to the atmosphere due to strong respiration of organic carbon in the mixed shallow waters. For the whole year, the North Sea acts as a sink for atmospheric CO2. The major part of this CO2 is exported to the Atlantic Ocean, constituting the continental shelf pump.

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ENVIRONMENTAL RESERVIORS OF EXOTOXIN GENES RESPONSIBLE FOR HUMAN DISEASE

Many human diseases (e.g., cholera, diphtheria, etc.) are caused by pathogens that produce exotoxins. The genes that encode these exotoxins are frequently encoded on mobile DNA elements such as plasmids or phage. Mobile elements can move exotoxin genes amongst microbial hosts, converting avirulent bacteria into pathogens. The vast pool of free phage and bacteria in environmental samples (water, soil, sediment) represents a potential reservoir of phage- and plasmid-encoded exotoxins, respectively. Determining where exotoxin genes originate, and the conditions under which they infect bacterial hosts responsible for human disease is crucial in our understanding of the epidemiology of these infectious diseases. We have examined the distribution of phage-encoded exotoxin genes in the environment. The exotoxin genes for cholera, diphtheria, shigellosis, and staph food poisioning were detected in a wide range of pristine and impacted environments, indicating that non-human reservoirs of these exotoxins exist. Both the cholera and shiga exotoxin genes were also found in the free phage pool, indicating that they are mobile in the environment. These findings have important implications for understanding linkages between aquatic ecosystems and human health.

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MARINE VIRAL GENOMICS

Viruses are ubiquitous components of the marine environment, frequently reaching concentrations of ten-million viruses per ml of surface seawater. Very little was known about marine viruses until genomic sequences started to appear in the year 2000. This field is now rapidly moving forward, with a dozen genomes completed and scores in progress. The completed genomes show extensive evolutionary ties between marine viruses and those in other environments. Marine viral genomes also encode a number of genes involved in adaptation to the ocean, including phoH (phosphate metabolism) and psbA (photosynthesis). In addition to individual viral genomes, sequencing of uncultured viral communities has started. These metagenomic analyses show that most of marine viral sequences are novel (i.e., not significantly similar to anything in GenBank). Comparisons between uncultured sediment and seawater viral communities show that certain phage phylogenetic groups are abundant in all marine viral communities. Additionally, based on the number of overlapping fragments (i.e., contigs) from the uncultured viral shotgun libraries, the population structure of marine viral communities have been estimated to contain at least 10^3 viral genotypes in 100 liters of seawater and ~10^4 viral genotypes per kg of marine sediment. Overall, marine viral genomes are novel, diverse, and represent one of the largest unexplored regions of sequence space on the planet.

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NATURAL VARIABILITY OF PHYTOPLANKTONIC ABSORPTION IN CASE 1 WATERS: DEVIATIONS FROM AVERAGE VALUES, AS RELATED TO THE SIZE STRUCTURE OF ALGAL POPULATIONS

The spectral absorption coefficients of phytoplankton in oceanic waters have been previously shown to vary with the chlorophyll a concentration according to simple relationships. Some deviations from this "average" behavior, however, have been detected on data from recent cruises, in waters of the Atlantic ocean and Mediterranean Sea. Using detailed HPLC measurements, the influences of pigment composition and package effect can be explicitely separated for each sample. It is shown that for the considered data, the deviations observed at 440 nm do not result from variations in the pigment composition (although this composition varies significantly for a given chlorophyll a content, the contributions of the various accessory pigments to absorption tend to compensate one another). Instead, these deviations result from a higher / lower packaging effect compared to other populations with similar chlorophyll a contents. This is fully confirmed by an independent approach, which consists of estimating a "size index" from the relative concentrations of taxonomic pigments. The deviations are observed not only from one zone to the other, but also seasonally within the same zone.

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SHAPE AND VARIABILITY OF THE SPECTRAL BACKSCATTER SPECTRUM IN THE MID-ATLANTIC BIGHT

Studies have found that the measured absorption properties of phytoplankton are not responsible for the tremendous variability that we see in ocean color measurements of algal blooms. Rather, the changes in spectral reflectance are primarily due to the unique backscatter spectrum of the dominant bloom species. Consequently, in situ spectral backscatter measurements improve our understanding of how particles influence bulk optical properties, and are essential for validating and improving existing ocean color models. We present results from measurements taken in the Mid-Atlantic Bight in 2001. A high resolution profiling system with a suite of optical instrumentation was used to measure total and dissolved spectral absorption and attenuation, total fluorescence, and spectral backscatter at 140 degrees. We characterize the shape of the backscatter spectrum from Hydroscat-6 data, and its variability is assessed with respect to co-varying inherent optical properties. The resulting backscatter spectrum, and its variability, provides insight into what controls ocean color variability in Case 2 waters.

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USING SMALL CHANGES IN PH TO ASSESS THE NET AUTOTROPHIC / HETEROTROPHIC STATE OF PLANKTON ASSEMBLAGES IN SUBSURFACE LAYERS

We use high-resolution measurements of pH as a tool to investigate the net trophic status of subsurface planktonic assemblages. The basis for using pH as a probe of net autotrophy/ heterotrophy is CO2 redox biochemistry: during photosynthesis CO2 is consumed (i.e, carbon is reduced); as a consequence of CO2 removal and a concomitant increase in alkalinity, solution pH increases. Conversely, during respiration organic carbon is oxidized, CO2 is evolved and both alkalinity and pH decrease. Using a sensitive spectrophotometric dye method, we are able to resolve very small changes in pH (+/- 0.0004). If the carbon cycle in a phytoplankton layer that is isolated from the surface is in a state of net autotrophic accumulation, pH will increase over 24 hours. Conversely, if heterotrophy in that layer exceeds autotrophy, the pH will decrease and the phytoplankton biomass would be transformed into other types of particles (e.g., flocs or detritus). Growth and respiration experiments conducted with phytoplankton cultures; seawater samples from the Damariscotta River Estuary comprising phytoplankton, bacteria and protozoa; and individual crustacean zooplankton are consistent with these interpretations.

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ORGANIC AND INORGANIC NITROGEN AND CARBON UPTAKE KINETICS IN FIELD AND CULTURE POPULATIONS OF KARENIA BREVIS

The dinoflagellate, Karenia brevis, is responsible for widespread persistent blooms on the Florida Shelf. The blooms often occur in relatively oligotrophic waters raising the question of what nitrogen forms fuel these large biomass accumulations? To quantify the ability of K. brevis to utilize a suite of nitrogen substrates, we performed several sets of kinetic experiments using K. brevis cultures as well as field populations, collected under bloom and non-bloom conditions on the Florida Shelf in Fall 2001 and 2002. Short-term (0.5-1 hr) incubations were performed with labeled (N15) substrates (ammonium and nitrate) and duel-labeled (N15 and C13) organic substrates (urea, glutamate, alanine, and a dipeptide). Substrates were added at concentrations ranging from 0.06 to 400 umol N/L. Preliminary results indicate that 1) K. brevis has a high, low, and intermediate affinity for ammonium, nitrate, and organic substrates respectively; 2) K. brevis incorporates both the nitrogen and carbon fractions of the organic substrates offered, and 3) when utilizing organic compounds, K. brevis exhibits unique bimodal kinetics with enhanced uptake at both the very lowest and highest concentrations tested.

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LOBSTERS AND THE MAINE COASTAL CURRENT: CONNECTING SOURCE AND SINK

The annual catch of American lobsters (Homarus americanus) in Maine has approximately doubled over the last decade, raising concerns about sustainable fishing levels. Best management strategies require understanding of the processes that link larval sources with catch regions. For example, the Maine Coastal Current (MCC) may convey lobster larvae from hatching regions near the mouth of the Bay of Fundy to nearshore regions along the central and southern Maine coast. A deflection of the MCC and its subsequent partial reformation provide a shoreward surface convergence southwest of Penobscot Bay. Estimates of lateral mixing in the shoreward edge of the MCC suggest that about 30-45 days are required for nearshore concentration levels of neutral surface particles to reach 50% of that found in the MCC axis offshore. About 20-30 days are required to advect neutral surface particles in the axis of the MCC to the central Maine coast. The combination may provide a propitious pathway for planktonic lobster larvae hatched upstream to arrive at suitable bottom substrate. Survey data show higher lobster population densities west and south of Penobscot Bay, with a distinct "hot spot" on the west side of the Bay (Steneck and Wilson, 2001). The decadal-scale variability in lobster landings may also reflect climatic influences on the MCC as well as fishing pressure, predation or disease cycles.

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SHORELINE MODIFICATION AND HABITAT STRUCTURE AS A FACILITATOR FOR ESTABLISHMENT OF INVASIVE SPECIES

Non-indigenous species have become a growing concern throughout the world's oceans and coastal systems. On the Delaware coast, the presence of shoreline development and armoring in the form of riprap may have facilitated the invasion of non-indigenous species. We examined the benthic community structure of four adjacent shorelines containing natural marsh habitat and "modified" rock habitat in summer 2003. Community species composition was analyzed using non-metric multi-dimensional scaling to determine similarity between sites. We observed that the overall intertidal community structure differed between the marsh and rock sites with a high similarity between the marsh sites. We also examined the adjacent subtidal benthos at the marsh and rock sites and observed no difference in the infaunal assemblages in as little as 1.5m distance from the low water mark. Hemigrapsus sanguineus was the only non-indigenous species present within our transects and was found exclusively in modified habitats, indicating a preference for rocky areas. Shoreline development and armoring may be playing the role as a facilitator for invasion by non-indigenous species by increasing the available habitat.

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TRACKING TEMPORAL PATTERNS OF MOLECULAR BIODIVERSITY, MICRODIVERSITY AND COMMUNITY STRUCTURE AT VARIOUS DEPTHS IN THE SAN PEDRO CHANNEL, CALIFORNIA.

The fingerprinting tool ARISA (Automated rDNA Intergenic Spacer Analysis) works by amplifying across the bacterial 16S-23S rDNA intergenic spacer (ITS) region. The length of this region is very variable amongst bacteria, therefore fragment lengths are characteristic of the taxa present. We have sequenced over 500 clones encompassing full length 16s rDNA and the associated ITS region, allowing us to link phylogenetic associations to known fragment lengths and thus track the presence and abundance of putative phylotypes in ARISA fingerprints. Furthermore, this data allows for examination of microdiversity through ITS sequence comparisons within closely related lineages. Over three years of monthly samples from multiple depths at a single station in the San Pedro Channel have been analyzed, showing significant temporal shifts in free living bacterial communities at discrete depths and a clear stratification of community with depth. Most interestingly there appears to be a reconstitution of very similar communities at equivalent times across yearly time scales. Our clone libraries also continue to identify novel phylogenetic lineages at the 16S rDNA level.

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CONCENTRATION, PRODUCTION, AND TURNOVER OF VIRUSES AND DISSOLVED DNA AT STATION ALOHA

A newly developed centrifugal ultrafiltration method for quantification of dissolved DNA (D-DNA) was used to study the composition and production of the D-DNA pool, including viruses, in a depth profile at Station ALOHA in the subtropical North Pacific Gyre. D-DNA within viruses comprised 49-63% of the D-DNA pool and the remaining D-DNA was hydrolyzable by deoxyribonuclease (termed ehD-DNA). The turnover time of ehD-DNA in the upper water column ranged from 0.97 to 6.2 h, 3 to 10 times faster than the turnover of DNA within viruses. Based on virus production rates, viruses were estimated to lyse 3.2-16.5% of the standing stock of bacteria at Station ALOHA per hour, resulting in the release of ehD-DNA which was estimated to be 11-35% of the total ehD-DNA production. This research supports the hypothesis that individual components of the D-DNA pool are cycled at different rates and shows that viruses in open-ocean gyre systems may have large impacts on the microbial community there, including viral-induced mortality and subsequent release of cellular contents to the DOM pool.

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BIODIVERSITY AND ECOSYSTEM FUNCTIONING IN MULTI-TROPHIC SYSTEMS: EXPERIMENTAL TESTS IN A BENTHIC MARINE COMMUNITY

Influential research in terrestrial habitats has shown that several ecosystem processes are related to plant diversity, yet these links remain poorly studied in marine ecosystems. Moreover, consumers play central roles in regulating primary production and community structure, but the importance of consumer diversity in mediating plant diversity-production relationships is poorly known for any system. We conducted field and mesocosm experiments to explore the relative effects of macroalgal and grazer identity and diversity on primary production in North Carolina hard-substratum subtidal communities. In contrast to previous results from grasslands and other systems, our manipulations of algal diversity did not strongly support the predicted diversity-productivity relationship. In some cases we found slightly higher rates of primary production in diverse algal assemblages (i.e., 6-8 species), but this was largely due to the presence of highly productive species (i.e., the sampling effect). In manipulations of herbivore diversity, algal biomass was 2x lower in the presence of a mixed grazer assemblage than in grazer monocultures, suggesting dietary complementarity among herbivores and that consumer diversity may play a dominant role in controlling marine ecosystem properties.

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A SHIFT FROM NON-REDFIELD TO REDFIELD NUTRIENT UPTAKE RATIOS INDUCED BY A SOUTHERN OCEAN IRON FERTILIZATION EXPERIMENT

The uptake rate of silicic acid is anomalously high compared to rates of nitrate and inorganic carbon use in the HNLC waters of the Southern Ocean. Fertilization of the high-silicic acid high-nitrate waters to the south of the Southern ACC Front during SOFeX caused a shift from Si:N and Si:C uptake ratios that were significantly higher than Redfield to ratios more typical of nutrient-replete phytoplankton. Fe addition decreased the ratio of integrated silicic acid to integrated nitrate uptake rates by 400% from an average of 8.1 ± 1.5 outside the fertilized patch to a mean of 2.1 ± 0.5 inside. The mean ratio of integrated silicic acid uptake to integrated carbon fixation declined by 160 % from 0.30 ± 0.07 outside the patch to 0.19 ± 0.04 inside. Patterns in specific uptake rates followed these same trends. Fe-induced shifts in nutrient uptake ratios can largely explain the anomalous nutrient depletion ratios observed in the Southern Ocean. Such dramatic shifts in regional biogeochemistry have strong implications for elemental cycling and climate during periods of enhanced Fe supply such as glacial times.

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THE SPECIATION AND SOLUBILITY OF AEROSOL IRON AND ALUMINUM IN THE NORTH ATLANTIC OCEAN: RESULTS FROM THE 2003 CLIVAR A16N EXPEDITION

As part of the 2003 A16N CLIVAR cruise, we collected daily aerosol samples from Iceland to Brazil. The goal was to measure the solubility and speciation of Fe and Al in continental dust, especially in the Saharan dust plume. We also studied the effect of particle size on the solubility and speciation of aerosol Fe and Al. Four replicate samples were collected using an automatic aerosol sampling system. The aerosol samples were collected on both prewashed 47 mm PCTE and polypropylene filters for 24-hour periods, filtering as much as 70 m3 of air through each filter. In addition, we deployed a Micro-Orifice Uniform Deposition Impactor (MOUDI) to collect size fractionated aerosol samples. Surface seawater samples, collected every 60 naut. miles, were processed using cross-flow ultrafiltration to quantify the impacts of soluble aerosol Fe and Al deposition on the formation of colloidal species. The polypropylene aerosol filters were quickly leached with 100 mL of either freshly collected 0.2 micron filtered surface seawater at natural pH or 100 mL of unacidified ultrapure water. The PCTE filters were analyzed for total Fe and Al (and other elements) using EDXRF at the NOAA/PMEL laboratory. Seawater filtrates were analyzed for soluble Fe(II) using the Ferrozine colorimetric method and then acidified and analyzed for total soluble Fe using ICP-MS. The ultrapure water filtrates were analyzed for major anions using ion chromatography.

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COPPER SPECIATION IN SAN FRANCISCO BAY

Total dissolved copper concentrations and the associated chemical speciation were determined at six sites throughout San Francisco Bay in January and March 2003 to compliment the data sets from previous summertime samplings. For speciation analyses, multiple analytical windows were incorporated into an established competitive ligand exchange- adsorptive cathodic stripping voltammetry (CLE-ACSV) method, which employs salicylaldoxime (SA) as the added competitive ligand (Bruland et al. 2000). High analytical windows strongly compete against the natural CuL1 complexes, accurately portraying the ambient Cu2+ concentrations. Lower windows compete less, but define the ligand pool carrying capacity and enable predictions of [Cu2+] as total dissolved copper concentrations change. All results indicate that strong copper-binding L1 ligand concentrations exceed dissolved copper concentrations at each site, with dissolved copper greater than 99.9% complexed by these ligands. Additionally, the [Cu2+] never exceeded 10exp-13 M, a concentration sufficiently below the toxicity threshold for phytoplankton (Brand et al. 1986). Thus, the excess of strong Cu-binding ligands appears to effectively buffer the free Cu2+ at low concentrations and San Francisco Bay is not impaired by the existing levels of copper.

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A NEW TECHNIQUE FOR THE EXAMINATION OF INTERNAL WAVE STRUCTURE

Internal waves have been identified as a source of mixing in both lakes and coastal shelf regions, allowing for an increase in biological activity. In light of the importance of internal waves in the mixing process, a technique is presented for the examination of internal waves. Temperature, pressure and current measurements were collected on the Malin Shelf north of Ireland during July 2002, along with supporting meteorological observations. Temperature records contain periodic bursts of variability at internal wave frequencies characteristic of internal wave generation by tidal forcing over a bank edge. The technique known as empirical mode decomposition (EMD) developed by Huang et al (1998) coupled with the Hilbert transform is applied to the temperature record, yielding an estimate of the time-frequency-energy distribution. Estimates reveal variation in waveform shape as a function of along-track distance, providing researchers a tool in the study of internal waves.

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ESTUARINE TYPOLOGY: PERTURBATIONS AND EUTROPHICATION RESPONSES

Classification of estuaries into functional types that respond differently to perturbation is the first step toward improvement and update of the National Estuarine Eutrophication Assessement (NEEA). Inter-system differences are used to determine thresholds for characterization of the nature and degree of perturbation and to identify and predict differences in response among the different types of systems. This allows for more accurate, quantitative, management-oriented assessment of nutrient over-enrichment (human-induced eutrophication) and will provide a rigorous yet flexible basis for the NEEA update and for management actions at the estuary level.
We show components and preliminary results of a physically based approach to classification of coastal waters. Classification tools such as the geospatial clustering package DISCO will be improved and further developed to provide quantitatively-based objective classifications. Components of the supporting infrastructure such as existing and planned databases, web-based access to tools, data, and outcomes is illustrated, along with examples of initial cluster-based estuarine classifications and an indication of intended future developments.

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DESIGN AND IMPLEMENTATION OF A ROBUST, EXPANDABLE AUV PLATFORM WITH DIVERSE OPERATIONAL CAPABILITIES FOR MULTIPLE END USERS

An Autonomous Underwater Vehicle developed by the Cornell University AUV Group is presented. Designed to encompass a wide range of capabilities in a single platform, the AUV and supported sensory payloads are inherently modular. Vehicle mass is variable between 40kg and 60kg, and operational endurance is variable between 5 and 14 hours. Developed primarily to augment academic and governmental research projects, design of the AUV was also supported by end-users in the offshore industry. The result is a single platform with substantial operational flexibility, including inspection and hover capability. The AUV is designed around multiple onboard processors to isolate vehicle control and navigation tasks from those associated with payload operation and data processing. Primary sensory payloads include passive-acoustics for navigation and tracking, and a real-time optical processing suite for object identification and vision-based decision making. Via standardized power and data interfaces, the AUV can support and operate an almost unlimited array of sensory payloads. An easily reconfigured mechanical platform ensures that desired payloads can be installed on the AUV. The AUV is easily deployed, operated, and recovered with minimal support.

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VERTIGO HERE WE GO

VERtical Transport in the Global Ocean (VERTIGO) is a new mid-size research project designed to address: what are the fates of sinking particles leaving the upper ocean? and what factors influence remineralization length scales for different sinking particle classes? The basic approach is to examine changes in particle composition and flux between the surface and 500-1000m within a given particle source region using a combination of approaches, many of which are new to the field. These include neutrally buoyant sediment traps, particle pumps, settling columns and respiration chambers, along with the development of new biological and geochemical tools for an integrated biogeochemical assessment and improved modeling of the biological pump. Two cruises will be conducted comparing the Hawaii Ocean Time-series site (HOT) and a new moored time-series site in the subarctic NW Pacific (Japanese site K2; 47oN 160oE). The first major VERTIGO field work will begin in the summer of 2004, so this poster is intended as a preview of coming attractions, with the intent to stimulate ideas and more general discussion regarding oceanic studies of the “twilight zone”.

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THE EFFECT OF ZOOPLANKTON ON PARTICULATE CARBON TO THORIUM RATIOS

The carbon to thorium ratio of aggregates is a crucial parameter required for estimating carbon flux from measurements of particulate thorium activity. This ratio
changes with particle size and particle shape and can be affected by particle aggregation. Usually, the ratio is assumed constant within a single particle size class, but interactions between particles as well as interactions between organisms and particles mean that the

carbon-to-thorium ratio continually varies with particle size. This work investigates the additional affect of zooplankton grazing on the particulate carbon to thorium ratio. Zooplankton preferentially remove carbon from the particles, thereby altering the carbon to thorium ratio. This work adds aggregate grazing to a coupled thorium adsorption-coagulation model to examine the effects that zooplankton grazing have on estimates of the carbon-to-thorium ratio on particulate material, and thereby estimate it's impact on estimates of carbon flux derived from thorium measurements.

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QUANTITATIVE DIFFERENCES IN ESCAPE PERFORMANCE IN CALANOID COPEPODS

The ecological success of calanoid copepods can in part be ascribed to high neuromotor performances. Using high-speed video, we compared escape reactions to photic and hydrodynamic stimuli in Acartia hudsonica, Centropages hamatus, Tortanus discaudatus and Temora longicornis. Reactions to sudden light decreases had latencies around 100 msec and often included reorienting turns, producing upward escapes with rapid accelerations to peak velocities. Responses to a flow field created by a suction tube involved reorientation away from the source of suction and vigorous trains of multiple power strokes away from the stimulus. Responses to brief computer-controlled hydrodynamic stimuli had the shortest latencies (a few msec) and consisted of a reorientation followed by a few pereiopod power strokes. Species-specific patterns in escape behavior included quantitative differences in performance to each stimulus type. Their neuromotor systems have evolved different reactions to predatory threat dependent on their ecological situation. Supported by NSF (REU BBI-0139190 to MDIBL; OCE99-06223 and REU supplement to PHL, HI BRIN to DB).

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RELATIVE CONTRIBUTIONS OF FILAMENTOUS CYANOBACTERIA TO NITROGEN FIXATION IN THE TROPICAL NORTH PACIFIC

During several cruises in the tropical North Pacific, we observed three forms of non-heterocystous cyanobacteria in high abundance. Trichodesmium spp. was found in colonies and free filaments. Large filaments of Katagnymene spp. dominated several stations. Richelia spp., as a diatom symbiont, was also present in low abundances. We attempted to quantify the relative contributions of each of these forms to total nitrogen fixation in this region. Free filaments of Trichodesmium had the highest depth integrated nitrogen fixation rates with a maximum of 290 micromoles N m-2 d-1. On average, the colonial form fixed 116 micromoles N m-2 d-1. In contrast to the tropical North Atlantic, which is generally dominated by colonial form of Trichodesmium spp., we find a more diverse flora of filamentous cyanobacteria contributing to nitrogen fixation in the tropical North Pacific.

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THE EFFECTS OF WATER MOVEMENT AND ZOOPLANKTON BEHAVIOR ON PLANKTIVORY BY CORAL REEF FISHES

The interactions between waves and currents with the complex structure of coral reefs produce a wide range of hydrodynamic microhabitats that can have important implications for planktonic predator-prey interactions. Turbulence may interfere with the detection of predators by copepods through habituation to, or masking of, hydrodynamic signals. Acartia tonsa exposed to grid generated turbulence initiated their escape responses significantly closer to the tip of a siphon tube and were captured more frequently than copepods without added turbulence. In tests with tube dwelling coral reef blennies, the capture success rate for highly evasive copepod prey (A. tonsa) increased in the presence of turbulence, whereas the capture success rate of non-evasive Artemia nauplii decreased. Coral reef fish may gain an advantage in predator-prey interactions by choosing habitats with moderate turbulence; coral reef zooplankton may gain an advantage by forming swarms in areas of reduced flow and turbulence. Copepod swarms often form in the lee of branching corals. Swarm forming species are resistant to dispersal by turbulence and swarms make it difficult for predators to track and attack individual prey.

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SPATIAL ANALYSIS OF THE STRUCTURAL CHARACTERISTICS OF PLANKTON SWARMS

Zooplankton have traditionally been viewed as passive inhabitants of their environment, their movements controlled by the fluid in which they live. Consequently, the spatial and temporal patchiness that characterizes plankton distribution has been assumed to result from physical factors acting to concentrate or disperse organisms. It is now recognized that most zooplankton species possess an impressive repertoire of sophisticated behaviors (e.g. directed swimming) that contribute to the formation of the patches, or swarms, observed in nature. Here we examine swarm structure on two dimensions, using radial distribution and pair-correlation functions, an analytical technique traditionally used by physicists to describe inert particle dynamics. This analytical technique is useful because it eliminates the need to track the movements of individuals. The functions were used to describe the behavior of inert particles in random motion over a range of particle densities and the behavior of zooplankton in swarms over a similar range of densities, permitting quantitative comparison across a variety of experimental conditions. Application of the functions to modeling swarms on three dimensions will also be discussed.

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NUTRIENT-BIOMASS EQUILIBRIA, COMPROMISING FOR SUCCESS.

Water-column biomass is set first by the total load of nutrients, and second by the equilibrium between the dissolved and particulate fractions. For dissolved organics the equilibrium is particularly complex because thousands of chemical species are involved. In all cases the equilibrium is determined by the biochemical kinetics associated with the thermodynamically favorable reactions. And for the water column, the key thermodynamic term is concentration. The consumption half of the nutrient cycle is largely set by microbial metabolism of dissolved organics. A quantitative description of this rate requires a term for the nutrient collection ability of the biomass, a term that depends on cytoarchitectural compromises. These compromises weigh nutrient collection and processing ability against maintenance and reproductive costs. Further control is effected by the amount of energy that can be returned to drive transport and metabolism. Specific affinity has been expanded to become a general kinetic theory that can include the balance and activities among cellular components including energy yield. Here we explore this balance in an attempt to understand key features of microbial ecology.

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ABUNDANCE, BIOMASS AND PRODUCTION OF OITHONA SIMILIS IN THE GULF OF ALASKA.

Oithona similis is one of the most numerous and least studied copepod species in the Gulf of Alaska. Abundance, biomass and production rates for O. similis were estimated in coastal and offshore water in the Gulf of Alaska from March through October in each of 2001 and 2002, using 53 µm-mesh plankton nets. O. similis copepodite abundance averaged 1750 m?3 and varied between 620 and 4665 m-3, while biomass averaged 3.11 mg AFDW m-3 and ranged between 0.9 and 10.7mg AFDW m-3, with biomass remaining high from late spring to early fall. Clutch size was relatively stable varying between 10 and 26 eggs per female, with the specific egg production rates averaging 3.03% and ranging from 0.12% to 11.7% per day. Applying this mean rate to all stages, for the upper 100 m sampled, over the entire year, yields a production rate for O. similis of 3.5 g AFDW m-2 yr-1.

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A REGIONAL INTERCOMPARISON BETWEEN TWO SHELF ECOSYSTEMS IN THE NORTH ATLANTIC: A DIAGNOSIS OF THE SEASONAL CYCLE IN THE IRISH SHELF SEAS

A coupled bio-physical model and observations are used to diagnose the seasonal cycle of the Irish Shelf Seas ecosystem, focusing on the ecosystem response to mesoscale processes (namely retention and advection) that may support productivity and the development of marine fish populations. The study lays the foundation for a regional intercomparison of shelf ecosystem dynamics between the Northeast and Northwest Atlantic. It seeks to build upon the extensive bio-physical modeling efforts in the western North Atlantic for the Georges Bank and Gulf of Maine, and use this as the basis for new bio-physical models of the Irish Shelf Seas region. The seasonal cycle circulation is diagnosed using the FUNDY/QUODDY model combination. The biological model is initialized using an analytical steady state solution of an NPZ model to infer the total amount of nitrogen in the system for each season. Preliminary results for three bi-monthly seasons (March-April, May-June and July-August) indicate that the coupled model captures both regional mesoscale bio-physical processes and the evolution of the seasonal cycle.

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MULTIPLATFORM APPROACH TO STUDY ISLAND OCEANOGRAPHY

"Islands are unique worlds within themselves," stated Darwin when referring to the Galapagos Islands. This uniqueness has been previously defined in oceanographic terms as "island mass effect" or "island wakes". Satellite sensors are important tools to identify oceanographic mechanisms present around islands. Temperature and color sensors reveal the sea surface signatures of eddies, fronts and upwelling cells. Synthetic Aperture Radar (SAR) data gives qualitative identification of such processes. Atmospheric processes and their effect in the ocean's surface can also be studied by the use of remote sensing techniques. In situ data can validate the observations and characterize the vertical distribution of such processes. Circulation studies, using numerical models such as POM (Princeton Ocean Model) reveal important quantitative ways of studying island systems. Apart from the complexity of oceanographic phenomena, islands can have important retention / dispersion mechanisms that enhance their biological resources.

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AN ECOLOGICAL CLASSIFICATION OF ALASKAN STELLER SEA LION (EUMETOPIAS JUBATUS) ROOKERIES

The North Pacific Ocean and Bering Sea are dynamic and highly productive ecosystems, which support diverse numbers of fish, marine birds, and marine mammals, including the Alaskan Steller sea lion. As the population of sea lions continue to decline, government managers may place additional restraints on commercial fisheries as protective measures. Currently management decisions regarding rookeries are based on the geographic location of a site and little effort has been made to describe sea lion rookeries in an ecosystem context. We provide a broad ecological classification of rookeries for Alaskan Steller sea lions. Ecological attributes included bathymetry, sea surface temperature, substrate type, orientation, abundance estimates, and diet diversity. Cluster analysis and GIS resources were used to determine the relationship between sea lion rookeries and physical and biological features of the Aleutian Archipelago. Rookeries grouped into six regions based on their relatedness to the ecological factors we defined. Samalga and Unimak passes have distinct properties and were important in distinguishing rookery groups. The structure (temperature, depth, salinity) of the primary ocean currents throughout the Aleutian Archipelago was another important grouping factor.

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COMPOSITION OF ORGANIC MATTER IN SOUTH SAN FRANCISCO BAY: SEASONAL VARIATIONS AND LINKAGES BETWEEN WATER COLUMN PRODUCTION AND SEDIMENT ORGANIC MATTER

Shallow-water coastal and estuarine environments such as South San Francisco Bay provide excellent systems for understanding the benthic response to episodic inputs in the delivery of labile organic matter. In this study, we used lipid biomarker compounds to examine changes in the composition of suspended and sedimentary particulate matter over a bloom event in South San Francisco Bay. The field study was designed around the predictability of the timing of the spring bloom in this system. Using lipid biomarker data, we present a record of changes in particulate matter composition preceding, during and following the Spring phytoplankton bloom. Data collected as part of this study document a rapid coupling between suspended particles and surficial sediments in this shallow estuary and a microbial response to the influx of labile organic matter following the spring bloom. However, over an annual cycle our data indicate a net accumulation of labile organic matter in the southernmost regions.

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GLOBALLY-SCALED ESTIMATES OF TRICHODESMIUM NITROGEN FIXATION

We computed average areal rates of nitrogen fixation by the planktonic cyanobacterium Trichodesmium of 247 umol N m-2d-1 (167 geographically and seasonally diverse observations) for the tropical N. Atlantic and 91 umol N m-2d-1 (80 observations) for the tropical N. Pacific. We assumed ½ these rates for the S. Atlantic and Pacific, respectively, and a rate of 50 umol N m-2d-1 for the Indian Ocean, values consistent with more limited data sets for these basins. We scaled these to the annual average area of waters > 25 C in each basin based on monthly climatologies of SST as a proxy for highly oligotrophic waters. We also considered the interannual variability on the potential areas for nitrogen fixation imposed by ENSO events. Our analysis yielded annual inputs of 23, 5, 22, 7 and 16 Tg N y-1 for the N. Atlantic, S. Atlantic, N. Pacific, S. Pacific and Indian Oceans. Within each basin, Trichodesmium accounted for about one-half the geochemically inferred input by nitrogen fixation. The remainder likely derives from intense Trichodesmium blooms, cyanobacterial symbionts of diatoms and bacterioplankton and cyanobacterial nanoplankton.

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KARENIA BREVIS BLOOMS ON THE WEST FLORIDA SHELF: A BRIDGE BETWEEN OPTICS AND PHYSIOLOGY

Harmful algal blooms of the ichthyotoxic dinoflagellate, Karenia brevis, regularly occur in the Gulf of Mexico, negatively impacting local tourism and shellfish industries and posing a threat to human health. Mitigation of these adverse effects may be possible if an accurate early detection and bloom monitoring strategy can be developed. Since K. brevis blooms discolor oceanic surface waters, ocean color data may be useful for this purpose. Recently, data collected on the West Florida Shelf as part of the EcoHAB (Ecology and Oceanography of Harmful Algal Blooms) program (1999-2001) indicate that K. brevis blooms are optically unique. When cell concentrations exceeded 10,000 cells per liter, significantly lower chlorophyll-specific particulate backscattering and natural fluorescence were observed relative to high-chlorophyll, diatom-dominated estuarine waters containing fewer than 10,000 cells per liter of K. brevis. Optical techniques developed for classifying and quantifying K. brevis blooms using satellite-based ocean color data from MODIS (Moderate Resolution Imaging Spectrometer) are presented. Also, the effects of physiological strategies of K. brevis (i.e. cellular toxicity and photoadaptation) on developing this unique optical environment are discussed.

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DECADAL AND YEAR-TO-YEAR VARIATIONS OF AIR-SEA HEAT FLUXES, VERTICAL CONVECTION AND BIOCHEMICAL PROPERTIES IN THE SOUTHERN ADRIATIC

Inter-annual variations of the heat fluxes were analyzed for the period 1989-2003 using the ECMWF dataset in the Southern Adriatic. One of the most relevant features resulting from the climatological analysis is the presence of an inter-annual signal and a significant intra-annual variability during the whole period considered. Winter convection and dense water formation are determined by the winter heat loss, although the extent of the vertical mixing depends also on characteristics of the pre-conditioning period, more specifically of December. Decadal variability is evidenced in the strong differences between the first half and second half of 1990’s. The heat content in the water column in the first half of 1990’s is smaller than in the second one resulting in the differences of the average temperature of the water column below the seasonal thermocline on the order of a half a degree. The higher heat content in the second half of 1990’s continues in the first three years of this century, maintaining however a prominent year-to-year variability in the vertical convection intensity. New production as estimated from the nutrient content differences in the water column between the pre-conditioning and post-convection situations shows both interannual and decadal variability; the former one being associated with the winter deep convection. Decadal variability, on the other hand, seems to be associated with the Eastern Mediterranean Transient.

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EXPLORING WITH THE VALJEUX EXPERIMENT: PROOF OF METHOD AND INITIAL LARGE-SCALE DEPLOYMENT OF SEEP-SIMULATING SULFIDE BIOGENERATORS

The Francois Valjeux sank in 1979 to a bottom depth of 1160m off Spain. Salvage investigation 11 years later found Vestimentiferan tubeworms growing on decomposing agricultural products. This discovery suggested that tubeworms are opportunists, and that experimental seep systems could be developed to study dispersion and other processes. A prototype device intended to produce hydrogen sulfide through simple anaerobic oxidation of pressed alfalfa pellets (rabbit food) was deployed at 540m in the Gulf of Mexico. Recovered after four years, the device was found to be generating sulfide and had been colonized by 555 living vestimentiferan worms. With support from NOAA's Ocean Exploration Program a large scale deployment experiment was begun in 2003. Seventy two sulfide generators have been deployed in the Gulf of Mexico on the upper slope to test the effects of substrate number and seep proximity on colonization. Ninety six generators were deployed in the deeper Gulf of Mexico and the Atlantic to examine between-region colonization. These deployments constitute the largest long-term experiment undertaken in deep-sea ecology.

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PREDICTING OVIGEROUS BLUE CRAB MIGRATORY TRAJECTORIES AND LARVAL RELEASE LOCATIONS WITH A COUPLED BEHAVIORAL-HYDRODYNAMIC MODEL

Ovigerous blue crabs must successfully migrate from estuarine to coastal regions for their planktonic larvae to be transported to suitable offshore development grounds. During this migration, ovigerous crabs move seaward using a complex form of ebb-tide transport, a series of vertical ascents into the water column selectively during ebb tides. In this study, we use the results of a field tethering experiment that determined vertical ascent patterns relative to hydrodynamic variables, an ultrasonic-telemetry tracking experiment that determined representative migratory trajectories, and a series of laboratory experiments to parameterize ovigerous blue crab migratory behavior. We then couple a drogue-tracking model that includes this behavior to a numerical circulation model of the Beaufort Inlet region of North Carolina to simulate migratory trajectories and larval release locations in the region. Results from this model differ significantly from results using passive or idealized ebb-tide transport behaviors, indicate that the upper estuaries in the Beaufort Inlet region may be population sinks because ovigerous females cannot successfully emigrate from these regions, and show locations that can be effective marine reserves for protecting migratory ovigerous blue crabs.

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PREDICTING DISTURBANCE TO MUSSEL BEDS ON TURBULENT ROCKY SHORES: PUTTING THE BIOLOGY IN BIOMECHANICS

Mussel beds often dominate the midintertidal zone of temperate rocky coasts worldwide. Storm waves commonly dislodge individual mussels, and this form of disturbance to mussel beds can strongly influence intertidal community structure. Combining measured offshore wave heights and mussel attachment strength, a biomechanical model was developed to predict seasonal patterns of mussel dislodgment on Rhode Island rocky shores. The model predicts peak dislodgment during hurricane season (Sept-Oct) when large storm waves coincide with weak mussel attachment. Because mussels increase attachment strength twofold from October to March, storm waves of similar magnitude developed in winter are predicted to incur substantially less damage. This biomechanical model has been field tested at two sites in Rhode Island over the last three years (one with only modest hurricane activity). While the percent cover of mussels in the biweekly photoquadrats were both spatially and temporally variable, dislodgment events were most common during early fall and rare during winter, as predicted by the model. Thus the field monitoring provides a general validation of the biomechanical model for predicting wave-induced disturbance to mussels.

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RIVER-OCEAN EXCHANGE OF TERRIGENOUS SOURCES OF DOC, NUTRIENTS, AND PERSISTENT ORGANIC POLLUTANTS ON THE KARA SEA SHELF, AUGUST 2003

An investigation of supplies and mixing behaviors for DOC, nutrients, and persistent organic pollutants was carried out in August 2003 to evaluate the spatial extent to which river supplies of DOC influence material distributions in the adjacent coastal ecosystem during late summer. In-situ data are used to validate satellite imagery analysis (MERIS and SeaWiFS) in order to map distributions of chlorophyll, sediments and DOC on the shelf. These data sets are complimented with sea surface ultraviolet radiation (UV) and UV attenuation measurements across the shelf. With freshwater fluxes near the annual maximum, DOC concentrations are on the order of 150 uM in near-shore areas. Sea surface light penetration diminishes rapidly on the shelf (< 3 meters below sea surface) and diffuse attenuation coefficients are extremely high; in the range between 7 and 30 at 320 nm, indicating the predominant influence of river supplies of organic and inorganic matter on the Kara Sea shelf during this period of the annual river discharge cycle. These present-day observations are evaluated within the context of expected future climatic changes in land-ocean interactions.

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SPATIAL AND TEMPORAL PATTERNS OF MARINE BENTHIC COMMUNITY VARIABILITY IN ARCTIC MARGINAL SEAS AND POSSIBLE LINKAGES TO CLIMATIC VARIATIONS

Both empirical evidence and models indicate that climate regime shifts occur in the Arctic in decadal scales. These phenomena are accompanied by variations in physical characteristics such as sea ice extent and formation/melting rates, water temperatures, and river-runoff — processes that can strongly affect Arctic marginal seas and the ecological dynamics of organisms. Little is known about the specific bio-physical links that relate atmospheric forcing to marine ecosystems or the inter-regional pattern of ecosystem responses.
Using a comparative approach with historical data from more than 1700 stations spanning from 1924 to 1992 in the Bering and Barents Seas, we examine the spatial and temporal patterns of benthic community structure in relation to past decadal-scale climatic variability. Quantitative data on benthic community parameters suggest regional differences in the relative abundance of different phyla, but biomass was relatively similar. There were variations in overall biomass through time, in the spatial pattern of benthic hotspots, and in the phyletic composition of the benthic communities. Results will be discussed within a climatic framework.

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FECAL CONTAMINATION OF IMPERIAL BEACH – HOW WOULD ONE KNOW IF THE SOUTH BAY OUTFALL IS THE SOURCE?

Routine sampling of surfzone waters off Imperial Beach indicates a recurrent contamination of these recreational waters with fecal indicator bacteria (FIB), i.e., exceedance of state standards (AB411). Following public concern that this fecal contamination is due to the discharge of wastewater via the federally operated South Bay outfall, the EPA requested a study. Specifically, the aim is to determine whether existing monitoring is sufficient to know if the wastewater plume is being transported onto the beach and resulting in FIB exceedances. If not, then how could one design a monitoring system that could achieve this. This paper will outline the various routes by which the wastewater may be transported onshore at Imperial Beach and how these have been evaluated; e.g., plume breaks surface and is blown onshore, sub-thermocline plume waters transported onshore by internal waves. The outfall source of contamination is contrasted with land runoff sources, which are also evaluated. In addition to local runoff, FIB in more distant shoreline sources may be transported alongshore to Imperial Beach, e.g., via longshore surf zone currents.

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REPORT FROM A TEA TEACHER ON THE 2002 SHELF-BASIN INTERACTIONS (SBI) SUMMER CRUISE

Through the Teachers Experiencing Antarctica and the Arctic (TEA) program, K-12 teachers across the United States have taken part in scientific research in polar regions. The goals of the TEA program include: immerse teachers in a research experience as a component of their continuing professional development, inform teaching practices
through the research experience, and bring polar research into classrooms in engaging and innovative ways that underscore the relevance of science to society. I will provide my perspective on the scientific work I was involved in with Dr. Jackie Grebmeier of the University of Tennessee during the Summer, 2002 SBI cruise (http://sbi.utk.eedu) and how it has impacted my secondary school teaching in Essex Junction, Vermont. I will also discuss the mechanisms I used for communicating scientific information off the ship, including daily journals on the TEA website (http://tea.rice.edu/tea_carvellasfrontpage.html#calendar) and two live audio conferences held during the 40-day cruise. Finally, I will provide information on my post-cruise presentations and my work to incorporate polar science into the curriculum and the resulting impact on students from grades 4-12 and my teaching colleagues.

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ORGANIC MATTER BEHAVIOR DURING MESOCOSM INCUBATION OF UNDISTURBED MESOPELASGIC WATERS

Sub-surface and mesopelagic waters (397 m and 687 m depth) from Suruga Bay (Japan) were respectively incubated in Nalgene transparent bacteria free bottles at 25 C outdoor during 15 days. Abundance and composition of phyto and zooplankton, bacterio-plankton, nutrients, POC-PON (particulate organic carbon and nitrogen) and DOC-DON (dissolved organic carbon and nitrogen) Psi (Particulate organic silica) and Chlorophyll a were measured. Initial POC concentrations were 177µgC/L, 31µgC/L and 32µgC/L at surface, 397m and 687m depths respectively. In surface waters POC reached 419µgC/L after two days of incubation. Deep-sea water from 397m depths showed its maximum POC concentration of 1877µgC/L after 9 days of incubation, meanwhile water from 687m POC increased to 3200µgC/L after 11 days of incubation. In deep-sea water, the concentration of living planktonic cells at initial time varied from 20 to 150 cells/L. These values increased to 2.7*106 cells/L (397m depth) and 6.6*106 cells/L (687m depth). As the experiment progressed non-living particles (detritus and dead planktonic cells) and bacterioplankton, nano-flagellates and ciliates began to predominate. This pattern shows a shift from grazing food web to microbial food web.

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USING OPENDAP AND LIVE ACCESS SERVER TO BRING REAL-TIME DATA TO THE CLASSROOM: LESSONS LEARNED IN TEACHER WORKSHOPS

The National Oceanic and Atmospheric Administration's National Marine Sanctuary Program and National Oceanographic Data Center have partnered to establish an educational and scientific framework to bring the excitement of the nation's underwater ecosystems to students using both in situ and satellite-based remote sensing techniques. This initiative will integrate diverse data streams, including both real-time and retrospective data sets. The integration will be achieved through the use of the OPeNDAP data access protocol and the web-based Live Access Server. As part of this initiative, demonstrations of this system have been made at teacher workshops. Several problems encountered, such as bandwidth limitations, data server problems, and web browser incompatibilities, will be presented along with various solutions.

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CONCENTRATION, DETECTION AND QUANTIFICATION OF ENTEROVIRUSES IN MARINE COASTAL ENVIRONMENTS BY REAL-TIME NASBA

Monitoring coastal waters for pathogenic human enteroviruses is important because of their dual role as human pathogens and indicators of water quality. We have adapted a simple membrane filtration technique for enteroviral concentration from marine samples and coupled it with NASBA RNA amplification for specific enterovirus detection and quantification. Enteroviruses were captured on a negatively charged mixed cellulose ester membrane. The membrane was rinsed with 0.5mM H2SO4 prior to elution of viruses with 1mM NaOH. Viral RNA was extracted and purified using a Stratagene Absolutely RNA Microprep Kit. The RNA was then amplified using nucleic acid sequence-based amplification (NASBA), which is an isothermal RNA amplification technique. Real-time detection was accomplished by use of a molecular beacon. Enteroviral primers target a 90nt region of the 5'Untranslated Region (5'-UTR) of the viral genome. Amplification occurred in as little as 20 minutes with a detection limit of 100 viral particles. The combined methods of concentration and detection resulted in average recoveries greater than 50%. This technology is being adapted for use in an autonomous genosensor to be deployed in coastal environments.

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CLONING AND OVEREXPRESSION OF AN IRON STORAGE PROTEIN IN TRICHODESMIUM ERYTHRAE

Iron is an essential element for virtually all life forms on Earth. Yet, in aerobic environments, iron is often unavailable, due to the insolubility of ferric species, and dangerous, due to its facilitation of the formation of reactive oxygen species (ROS). Therefore, cells have elaborated a variety of mechanisms to sequester iron for biosynthesis, while protecting cell components from free iron that would generate ROS. Ferritins, bacterioferritins (which contain heme), and DNA-binding protein from starved cells (Dps) are key parts of this iron-control system and all belong to the ferritin superfamily of proteins. In this paper, we summarize what is known about the structure and function of these proteins in bacteria and describe our recent findings on the marine cyanobacterium, Trichodesmium erythrae, a key nitrogen-fixing organism in the marine environment.

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USING DATA IN THE CLASSROOM-WHAT CAN TEACHERS USE?

For over two years, the National Geographic Society, NOAA's National Marine Sanctuary Program and Office of Ocean Exploration and others have partnered to create new ways to encourage teachers to include oceans in their classroom. One product, "Oceans for Life," has tied key ocean concepts to the National Geographic Education Standards. A 9-month virtual teacher conference, called "Classroom Exploration of the Oceans", was designed to introduce "Oceans for Life" to teachers, provide teachers with supporting lesson plans and a venue to discuss with leading scientists how to include cutting edge research and exploration in the classroom. "Oceans for Life" has now been distributed to over 50,000 teachers; over 2000 educators have registered for Classroom Exploration of the Oceans and over 100 teachers have registered for Classroom Exploration of the Oceans for graduate credit. This paper will present a summary of the success and barriers identified by those teachers to including oceans data in their classrooms.

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FRICTION OF DIFFERENT ROPES IN RIGHT WHALE BALEEN: A STRATEGY TO REDUCE ENTANGLEMENT

Entanglement in fishing gear, particularly lobster trap and gill net gear, constitutes a significant source of North Atlantic right whale mortality. Entanglements may initiate with rope fouling baleen plates before snagging other appendages. Low friction between rope and baleen may minimize the risk of a sustained, progressive entanglement. The friction of various ropes in right whale baleen was examined by measuring the tension of 8 rope types that resulted when each rope was pulled through two baleen plates held underwater. Polypropylene rope generated less friction with the baleen than all other fibers tested, including nylon, polyester, and commercial sinking line (a polypropylene/ polyester blend). Thus commercial floating line (3-strand polypropylene) generated less friction than commercial sinking line, both of which are commonly used in the lobster industry. Other researchers have shown that floating polypropylene vertical line resulted in fewer entanglements than sinking or mixed floating and sinking vertical line. Therefore a sinking line, sheathed in polypropylene, that has lower friction with right whale baleen and avoids floating loops of ground-line may be indicated.

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CARBON LIMITATION OF BACTERIAL PRODUCTION IN DELAWARE BAY

Enrichment experiments were designed to study the influence of carbon and inorganic nutrients on bacterial production and community structure along the salinity gradient in the Delaware Bay. We tested the hypotheses that bacterial growth is limited by inorganic nutrients at high salinity where nutrient concentrations are low and by carbon in the high nutrient, freshwater region of the estuary. Bacterial abundance, production and community composition were examined in incubations with carbon (glucose), ammonium and phosphate additions. Glucose stimulated bacterial production in every experiment and there was never any effect of nutrient addition, demonstrating that bacterial production is carbon limited in throughout Delaware Bay (0 – 26 PSU). Analyses of community composition by fluorescence in situ hybridization (FISH) with rRNA targeted probes for alpha-, beta-, gamma-proteobacteria and Cytophaga-like bacteria revealed that bacterial groups respond differently to the input of nutrients. Proteobacteria responded to inorganic nutrient addition, while the abundance of gamma-proteobacteria was correlated with increased growth in glucose treatments, suggesting that this group of bacteria is important in sugar uptake.

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OPTICAL CHARACTERIZATION OF PHYTOPLANKTON BLOOMS IN THE SANTA BARBARA CHANNEL

Hyperspectral radiometers were deployed on a mooring (Santa Barbara CHAnnel Relocatable Mooring; SB CHARM) in the Santa Barbara Channel (SB Channel) at 25 m water depth between May and October 2003. Ancillary data were collected by the SB CHARM as well as nearby complementary moorings and shipboard sampling as part of the SB Channel Long-Term Ecological Research project. In late August and early September 2003, advection of a cold, nutrient rich water mass resulted in a fall bloom in the SB Channel. In the span of 10 days, the surface water color changed from blue-green to brown and finally to red. The red water mass exhibited intense bioluminescence; bottle sample analyses revealed that it was a red tide bloom of Lingulodinium polyedrum. Cessation of the red tide occurred after just a couple of days. The evolution of this and other phytoplankton blooms in the SB Channel are optically characterized by use of the hyperspectral radiance and irradiance data. Additionally, these data are used to develop remote sensing algorithms to identify phytoplankton blooms by group.

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A REAL-TIME MODELING AND DATA ASSIMILATION SYSTEM FOR THE CENTRAL CALIFORNIA COASTAL OCEAN

Development of a real-time modeling and data assimilation system off the central California coastal ocean is described. The model is based on the Regional Ocean Modeling System (ROMS) using a three-level nested configuration for the U.S. West coast, central California coast, and Monterey Bay with a spatial resolution of 15-km, 5-km, and 1.5-km covering, respectively. ROMS uses the real-time blended wind product from satellite scatterometer measurements (QuikSCAT) and mesoscale atmospheric model simulations (COAMPS). ROMS has the capability of assimilating both in situ and remotely sensed observations through a 3-dimensional variational (3DVar) method. ROMS modeling and data assimilation system was run in real-time during August of 2003 and results are available through an interactive web interface. We will describe our sceintific results as well as experiences and lessons learned from this real-time operation.

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THE CENTRAL CALIFORNIA OCEAN OBSERVING SYSTEM: CENCOOS

A number of federal, state and private institutions along the central California coast have been operating coastal observing efforts for almost 15 years. These efforts began with individual institutions, but over the last 10 years have become increasingly multi-institutional. CenCOOS now seeks to coordinate this large number of coastal observing efforts including state and federally supported programs such as the Center for Integrated Marine Technology (CIMT) (http://cimt.ucsc.edu/), the CSU Center for Integrative Coastal Observation, Research and Education (CI-CORE) (http://www.mlml.calstate.edu/cicore/), the Network for Environmental Observations of the Coastal Ocean (NEOCO) (http://es.ucsc.edu/~neoco/) and the Sanctuary Integrated Monitoring Network (SIMoN) (http://montereybay.noaa.gov/research/simon.html)). The CenCOOS area extends from approximately Cape Mendocino in the north, to Point Conception in the south. These coordination and planning efforts are intended to increase the value of the observations beyond the sum of the parts.

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USE OF THE IN-SITU OPTICAL PLANKTON COUNTER IN CALCOFI 1998 TO PRESENT

A modified, in situ Optical Plankton Counter (OPC) has been deployed on most quarterly cruises of the California Cooperative Fisheries Investigations (CalCOFI) from February 1998 to the present. This OPC is self-powered, logs data internally, and is mounted in one side of the bongo frame that is deployed routinely on the 66 standard CalCOFI stations in the southern California Current Region. Deployments are during oblique tows in the upper 215 m. To date, more than 1,100 successful deployments have occurred. Data acquisition and processing will be described and results, including comparisons with ancillary data, presented. Preliminary analysis shows such patterns as (a) integrated biovolume varying more than two-fold by season (spring > summer > fall > winter), 2.5-fold by distance offshore (0-40km > 40-250km > 250-700km), and a two-fold increase from 1998-2001, and (b) mean size of a particle varying more than two-fold by season (summer > spring > fall > winter), 1.5-fold by distance offshore (0-40km > 40-250km > 250-700km), and a three-fold increase from 1998-2001.

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INTRODUCING MIKE MULLIN

Mike Mullin was a gentleman and a scholar. He was shaped, in part, by his associates. His professional legacy, in turn, includes those he lent shape to, especially his students. Here, I briefly describe his varied associations and accomplishments, and threads common to these. I begin with his youth, during which he was a quiz kid, consider his graduate education at Harvard and WHOI, and end with his tenure at Scripps, as researcher, professor, administrator, and editor. His interest in webs, including species, and scales, including size, is cited. I discuss what may have contributed to his professional success, and what might have been different. To conclude, I distinguish Mike from others and ask what might be learned not only from his discoveries but also from his actions.

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A NEW COASTAL AND ESTUARINE MANAGEMENT MODEL SYSTEM: APPLICATIONS TO ESTUARIES IN THE SOUTHEASTERN US COAST

A management model system has been developed for estuaries in the southeastern US coast. This system includes 4 components: 1) meso-scale meteorological model (MM5), 2) unstructured grid finite-volume coastal ocean model (FVCOM), 3) water quality model (modified WASP5), and 4) computer interface GUI system. MM5 model, driven through nested approaches by the National Weather Service ETA model, provides a forecasting field of wind stress, heat flux, precipitation/evaporation over a time domain of every 5 days, with hindcasting calibration using the real-time wind measurement data. FVCOM is driven by tidal and meteorological forcings, freshwater discharges, and groundwater sources. A wet/dry point treatment in FVCOM is capable to simulate the flooding/drying process over estuarine-tidal creek-salt marsh intertidal complex. A nudging data assimilation method is used to calibrate the model prediction using the real-time observational data. The modified WASP5 includes the bottom re-suspension process to link the water column and benthic ecosystem dynamics. The interface GUI system allows managers to visualize the distribution and animation of selected physical, biological and chemical state variables. A 3-D Lagrangian program is built on the interface GUI system, which allows managers to trace the trajectories of tracers for the evaluation of impacts of point or non-point pollutants on environments. The management model system successes in applying to the Satilla River, Georgia.

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TROPHIC TRANSFER OF METALS IN INTERTIDAL FOOD WEBS OF THE GULF OF MAINE.

Intertidal food webs in coastal wetlands are known to be important in the transfer of carbon, energy, and contaminants vertically up the food web, as well as horizontally from the intertidal to subtidal habitats. Trophic transfer of metals in intertidal food webs in the Gulf of Maine has not been well-studied. A pilot study was conducted to characterize metal bioaccumulation (Hg, Cd, Zn, As, and Pb) in intertidal food webs in three different Gulf of Maine sites (Great Bay, NH, Webhanett Estuary, ME, and Salisbury Cove, ME) which differ in physical and chemical characteristics. In each site, we investigated the bioaccumulation and trophic transfer of metals particularly in the resident and transient benthic, epibenthic, and nektonic species inhabiting the intertidal and subtidal portions of these systems. We measured metal bioaccumulation in multiple trophic levels and estimated trophic position using stable isotopes. Results of the study show different patterns of bioaccumulation and trophic transfer depending on the metal and the site. Relationships are drawn between metal bioaccumulation in biota and physical and chemical characteristics of each site.

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BATHYMETRY RETRIEVALS FROM PHILLS FLOWN OVER TURBID WATERS

Hyperspectral aircraft imagery offers a rapid means of mapping bathymetric changes assuming that the bottom provides at least 15% or so of the signal leaving the water, and the spectral albedo of bottom constituents is known with a reasonable degree of accuracy. For mid-atmospheric (e.g. 10,000 m) imagery of the ocean collected from an aircraft, vibration and thermal stress can change the responsivity of a sensor. To insure that the sensor calibration during the flight is consistent with the solar spectral curve used in the atmospheric-correction code, the sensor should be vicariously calibrated. This contribution applies vicarious calibration and atmospheric correction methodologies to PHILLS hyperspectral aircraft imagery collected by over the dark, turbid waters of Charlotte Harbor, FL. The scenes are then inverted using a genetic algorithm along with a predictor-corrector scheme to derive bottom depth and albedo maps for the vicinity of Caya Costa Key. Bathymetric comparisons with NOAA charts and field data are then discussed.

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CHROMOPHORIC DISSOLVED ORGANIC MATTER (CDOM) IN THE HUDSON RIVER ESTUARY

Chromophoric Dissolved Organic Matter (CDOM) was measured in the Hudson River Estuary in June, 2003 on the RV Oceanus using the Integrated Coastal Observation System (ICOS). High resolution CDOM measurements were made using a SeaTech CDOM fluorometer and a Chelsea UV Aquatracka Hydrocarbon fluorometer aboard the ECOShuttle, an undulating vehicle deployed behind the ship operating from 3 to 8 meters depth. Water pumped continuously from the ship's surface pumping system was collected for discrete dissolved organic carbon as well as CDOM fluorescence measurements. Seawater pumped from the ECOShuttle was measured by a ship-mounted AC-9 multi-spectral absorption detector. CDOM appeared to have two different apparent endmembers, one from the freshwater in the Hudson, the other apparently 30% higher with a source located within the estuary. These high resolution measurements show non-conservative mixing in another major estuarine system supporting evidence that many estuaries act as local sources of CDOM to coastal waters. Possibilities of this CDOM coming from salt marshes, sewage treatment plants or other sources will be discussed.

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AN INQUIRY-BASED MIDDLE SCHOOL ACTIVITY BASED ON CHROMOPHORIC DISSOLVED ORGANIC MATTER (CDOM) RESEARCH

The National Science Standards and Benchmarks recommend inquiry-based lessons for K-12 students to most effectively learn science. While many Ocean Science researchers commonly practice inquiry-based science, they generally do not know how to apply their expertise to the broader context of K-12 education. This demonstration of an inquiry-based lesson appropriate for middle school students is based on current research on Chromophoric Dissolved Organic Matter (CDOM). Hopefully, researchers attending this presentation will be able to use this activity as an example of how they might translate their own seemingly complex research to engaged and interested middle school students. Come to this session and have the pleasure of DOING science for a few minutes. Share the excitement that middle school students enjoy when engaged in inquiry and current research. We will discuss how this activity was developed by a researcher and several middle school teachers, was implemented in the classroom, and was evaluated for its impact on students. Learn how to create broader impacts of your research.

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EFFECTS OF EL NINO-SOUTHERN OSCILLATION EVENTS ON FECAL COLIFORM LEVELS IN MISSISSIPPI SOUND

Information on the effects of inter-annual variations in climatic factors on fecal coliform levels in coastal waters is scarce. We used eleven years (1990-2001) of rainfall, temperature, Pearl River stage and water quality data to assess the effects of El Nino events on fecal coliform levels in Mississippi Sound. The geometric mean fecal coliform number differed among years (P = 0.0001), being highest during the El Nino period of 1991-1992 (14.22 per 100 ml). Mean salinity varied among years (P = 0.0001) from 9 ppt (1991-1992) to 21 ppt (1999-2000). Mean water temperature was also lowest in 1997-1998 (14.5 oC) and highest in 1998-2000 (19.4 oC). Inverse relationships were observed between fecal coliform levels and salinity (P = 0.001) and water temperature (P = 0.001), whereas positive relationships were obtained with total rainfall (P = 0.013) and Pearl River stage (P = 0.0001). These relationships are useful for evaluating the potential effects of climate change on water quality and shellfish harvest in the Sound.

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FACTORS CONTROLLING ECOSYSTEM PRODUCTIVITY AND LAND-OCEAN INTERACTIONS IN OLIGOTROPHIC UPSIDE-DOWN ESTUARIES OF THE FLORIDA EVERGLADES

The Florida Coastal Everglades (FCE) LTER Program includes too many people to show here as co-authors. We focus on connectivity of the freshwater, estuarine, and coastal ocean systems of the Florida Everglades; specifically, on the oligohaline zone where P-limited fresh water mixes with more N-limited coastal ocean water. These "upside-down" estuaries are unique because the ocean is the source of the limiting nutrient (P). We originally hypothesized an ecosystem productivity peak only in the system with a direct freshwater-ocean connection. I address this hypothesis by synthesizing our data on primary production, plant biomass, soil nutrients, waterborne nutrient and organics transport, microbial processes, and fish standing stocks. Along "one upside" down estuarine transect, the productivity peak occurred at the marine endmember (the P source) rather than at the freshwater ecotone (the freshwater organic matter source). Along the other transect, an unexpected productivity peak occurred far from the ocean. We suspect this peak is a function of oligohaline estuarine residence time. Based on this hypothesis re-assessment, we are adaptively redirecting our future long-term coastal and estuarine research at the FCE LTER.

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FORMATION MECHANISMS OF MARINE SELF-ASSEMBLED MICORGELS

Dissolved organic carbon (DOC) consists of a heterogeneous mixture of different organic macromolecules from marine and terrestrial sources. Our previous studies indicate that DOC polymers can spontaneously self-assemble forming microscopic gels (SAM). However, the low micromolar DOC polymer concentration yields estimated assembly kinetics much slower than those observed experimentally leaving the formation mechanism of these SAMs unexplained. We used Brewster angle microscopy, confocal fluorescence microscopy, digital deconvolution and atomic force microscopy to investigate the physicochemical mechanisms of microgel formation. The present results show that due to their amphiphilic properties, DOC polymers can concentrate in the air-water interface forming rafts with their poly-anionic hydrophilic tails cross-linked by Ca2+. When rafts reach critical size they collapse forming hydrophobic-core nanogels that move to the bulk of seawater. The hydrophilic tails of nanogels can then anneal to each other forming microgels. These results are consistent and have been successfully modeled as a second order kinetics process. Based on the observation, we propose that interfaces including the air-seawater or solid surface-seawater must play a critical role in microgel formation.

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BACTERIOPLANKTON DYNAMICS IN INTERMITTENTLY ANOXIC FJORDS OF VANCOUVER ISLAND, BRITISH COLUMBIA

Bacterioplankton production rates were measured in various inlets of Barkley and Clayoquot Sounds on the outer coast of Vancouver Island, British Columbia. Studies were conducted during the summers of 2002 and 2003, when the bottom waters of many of these inlets were hypoxic or anoxic. Trends in the spatial distribution of bacterial production were correlated with information on bacterial species composition, chlorophyll concentration, and physical/chemical properties of the water column. Bacterial production in surface waters, as estimated by thymidine and leucine incorporation, was within the range commonly observed in coastal waters. Generally, there were strong gradients in production, with highest rates at the mouth of inlets and lowest near the head. Bacterial growth was positively correlated with chlorophyll concentrations. High rates of bacterial production also appeared to coincide with zones of high bacterial species diversity. Deep, dysaerobic water showed much lower rates of production indicating either lower bacterial activity or the inability of anaerobic bacteria to effectively assimilate thymidine or leucine.

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PHYLOGENETIC DIVERSITY OF RIBULOSE-1,5-BIPHOSPHATE CARBOXYLASE/OXYGENASE GENES OF MICROBIAL COMMUNITIES FROM MOBILE DELTAIC SEDIMENTS

Autotrophic CO2 fixation via the Calvin cycle was studied by amplification and cataloging of the genes for ribulose-1,5-bisphosphate carboxylase/oxygenase (RubisCO, forms I and II) for 10-20 and >50cm depth intervals from tropical suboxic, deltaic muds along French Guiana and in the Gulf of Papua. Here, we report the results of comparative sequence analysis of RubisCOs form I and II genes from closely and distantly related autotrophic organisms. Sequence analysis showed that retrieved sequences have the characteristic RuBisCO amino acid motif that exists in other RuBisCOs. The phylogenetic affiliation of the most common cbbL and cbbM sequences were closely related to forms I and II of cultured and uncultured chemoautolithotrophic alpha-, beta- and gamma proteobacteria. RuBisCO genes closely related to Thiobacillus spp. appear to be dominant in this environment. The presence of RuBisCO genes in microbial communities from suboxic sediments indicates a net production of CO2 and the probable bacterial participation in the sequestration of CO2.

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SEDIMENT-WATER EXCHANGE OF TOTAL MERCURY AND MONOMETHYL MERCURY IN THE SAN FRANCISCO BAY-DELTA

Five field trips were conducted in the San Francisco Bay-Delta between May 2000 and October 2001 to investigate the sediment-water exchange of total mercury (Hg) and monomethyl mercury (MMHg). Solid-phase Hg did not show any significant variability, whereas solid-phase MMHg showed considerable amounts of vertical, temporal and spatial variabilities, suggesting that MMHg production was largely controlled by temperature and habitat type. In porewater, both Hg and MMHg concentrations were generally elevated near the sediment-water interface during warm months. Total benthic fluxes, determined using benthic chamber deployments, ranged -92 to 850 pmol/m2/d with an average of 64 pmol/m2/d. In most cases, diffusional fluxes of Hg and MMHg, estimated using interfacial concentration gradients, constituted only a minor portion of the total fluxes. Measured benthic fluxes of MMHg were generally higher in May than other seasons. Wetland and marsh regions appeared to be major sites for MMHg production within the Delta. The exchange flux of MMHg into the water column from the sediments was a major source of MMHg to the Delta only during low flow conditions.

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UNMIXING OF HISTORICAL RECORDS OF PARTICLE-ASSOCIATED SUBSTANCES IN LAKE SEDIMENTS

Historical records of particle-associated substances in dated lake sediments provide information about the temporal input of pollution, including the effect of bans or source reductions of priority pollutants. Examples include maxima for lead (1969), Cs-137 (1963), PCBs (early 1970s), and PAHs (1950 and and 1970). Mixing in the upper sediment layers broadens these peaks, and shifts the maxima towards earlier times, typically 3 –7 years, depending on mixing and sedimentation rates. Original input records can be restored using a discrete interval deconvolution method, frequency domain deconvolution, or first- or second order correction methods, based on the Berger-Heath model or the second order advection-diffusion equation for sediment pollutants. It is shown that the inverse Berger-Heath model with mass based variables and input records approximated with cubic splines is effective in restoring the original input flux. As an example, in the average PAH record for a Lake Michigan basin, based on seven sediment cores, maxima in 1930 and 1977 are restored that appear as shoulders without reconstruction.

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DIVERSITY AND VERTICAL DISTRIBUTIONS OF NITROGEN-FIXING BACTERIA IN THE OLIGOTROPHIC NORTH PACIFIC OCEAN

The diversity of upper ocean nitrogen-fixing bacteria was examined using RT-PCR amplification and sequencing of the dinitrogenase gene (nifH) at Station ALOHA in the oligotrophic North Pacific Ocean. Expression of nifH by upper ocean plankton revealed that diverse diazotrophic bacteria, including various members of the cyanobacteria and proteobacteria, might influence nutrient cycling and productivity in this ecosystem. The vertical distributions of two unicellular nifH cyanobacteria and a Cluster III nifH phylotype (presumably anaerobes) were evaluated using quantitative PCR. The gene abundances of all three nifH phylotypes investigated had distinct vertical profiles; the unicellular cyanobacteria accounted for approximately 200 nifH gene copies ml-1 in high irradiance, nitrate-depleted upper ocean, while the Cluster III nifH phylotype accounted for approximately 100 nifH copies ml-1. The combined abundances of the unicellular nifH cyanobacterial phylotypes were equivalent to roughly 5% of the depth-integrated (0-100 m) Synechococcus abundance at station ALOHA. These results reveal that diverse diazotrophic plankton play important biogeochemical and ecological roles in oligotrophic ocean ecosystems.

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RESULTS OF A LARGE-AREA FISH LIDAR SURVEY IN THE NE PACIFIC

In July 2003, the NOAA Fish Lidar flew a survey off the Oregon and Washington coast. The lidar measures the density of fish and plankton in the water. In this region, it penetrated to depths of almost 50 m. The most striking features in the lidar data were thin plankton layers extending for kilometers along the flight track. Overall, the structure is seen to have a fractal nature over 3-4 decades of spatial scales, except right at the surface. The lidar transects were timed to fly over a ship surveying sardines with a 38 kHz split-beam echosounder and a pelagic trawl. Sound scattering from an extensive zooplankton layer, 20-50 m deep, was

confirmed over much of the surveyed area. During the daytime, individual and schooling fish were primarily observed near the continental shelf and at depths between approximately 25 and 350 m. Completion of 46 surface tows revealed adult sardine (Sardinops sagax) schools within 5 to 20 nautical miles of the coastline. Demonstrated is the utility of combining lidar, echosounder, and trawl data for surveying epi-pelagic fish species.

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REDUCING UNCERTAINTIES IN THE MEASUREMENT OF APPARENT OPTICAL PROPERTIES USING AN ROV FIBER OPTICALLY COUPLED SPECTROMETER

Acquiring accurate spectroradiometric measurements of the apparent optical properties within the marine environment over large spectral ranges is a challenging task. Instrument self-shading and appropriate depth sampling can introduce major uncertainties when making these measurements in spectral regions where attenuation is dominated by absorption processes. To reduce these uncertainties, we developed a system, which utilizes the double spectrometer system and fiber optic components developed for the Marine Optical BuoY (MOBY) system, and integrated it with an ROV. The MOBY double spectrometer is remotely coupled to radiance and irradiance collectors mounted on the ROV and ship via fiber optic cables. The ROV is positioned away from the ship in an orientation which will minimize the effects of self-shading. Radiance and irradiance spectral distributions are measured at sub-nanometer spectral resolutions over the spectral range from 350nm to 1100 nm with depth accuracies maintained at +/-2cm. A complete description of this prototype system is presented. Additionally, preliminary observational results of the near surface upwelled and water-leaving radiances, reflectance, and diffuse radiance attenuation coefficients for eutrophic and oligotrophic waters are presented.

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REMOTE TRACKING OF THE MANTA RAY (MANTA BIROSTRIS) IN HAWAII

The manta ray has come under increasing threats in the last four years due to a demand for dried manta ray gill filaments for a medicinal market in China. Given the long life, late maturity, and low fecundity of mantas, populations are highly susceptible to over-fishing unless the population being fished is very large. Acoustic tags were placed on twenty-eight mantas on the Big Island and Maui to investigate the home range of mantas in Hawaii. Tagged mantas were remotely tracked via an array of acoustic receivers along the Kona coast of the Big Island and on Maui. To date, no manta has been recorded migrating between the two islands. On the Big Island, tagged manta rays were detected along a 5 km stretch of coastline in over 80% of detections, with only occasional detections outside of this key area. Two locations where mantas showed exceptionally strong site fidelity are a known feeding area and a cleaning station. These data suggest that manta rays have a closed population in Hawaii, with little or no migration between neighboring islands.

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COMPARING IMPACT OF PHOTOOXIDIZED AND UNPHOTOOXIDIZED PETROLEUM ON MARINE BACTERIA COMMUNITIES USING TERMINAL RESTRICTION FRAGMENT LENGTH POLYMORPHISM

T-RFLP was used to determine the temporal effects of petroleum on communities of bacteria selected from pristine and oil-contaminated marine sites. Subsequent to incubation with photooxidized and unphotooxidized petroleum, bacterial DNA was extracted. The 16S rDNAs of the phylotypes in the communities were PCR amplified using fluorescently labeled 8F Hex primer that targets the 5-prime conserved region of the gene. Purified amplification products were digested with Hae111, a 4-base cutter restriction endonuclease. Terminal restriction fragments were precisely measured using an automated DNA sequencer. Species richness was estimated by the number of ribotypes in the sample digest. The number of ribotypes detected in the unphotooxidized treatments inoculated with bacteria from the contaminated and pristine site were 17 and 16 respectively indicating low diversity. Variation in diversity between communities was minimal. Exposure to photooxidized petroleum reduces the number of ribotypes detected in the samples inoculated with bacteria from the contaminated and pristine site to 6 and 2 respectively. The diversity of both communities changed temporally with exposure to petroleum. However, photooxidized petroleum had the greater impact, especially on the pristine community. It is concluded that petroleum pollution can change marine microbial community diversity, which may have adverse effects on ecosystem functions such as food web dynamics and nutrient cycling.

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PIGMENT COMPOSITION IN HIGHLY OLIGOTROPHIC AND EUTROPHIC CASE 1 WATERS : TRENDS AND NUANCES

In the open ocean, the biooptical properties of highly oligotrophic (surface Chla ~ 0.05 mg m-3) and eutrophic (surface Chla > 1 mg m-3) waters are admittedly the less studied. With the aim of addressing the pigment composition peculiarities of these extreme trophic situations that might ultimately affect their bio-optical status, a HPLC pigment database was assembled and analyzed. On the oligotrophic side, we show that the four sub-tropical gyres present very similar pigment composition, dominated by prokaryotic pigments. However, the ratio of non-photosynthetic pigments (mainly zeaxanthin, but also diadinoxanthin and diatoxanthin) to Chla is significantly higher in the Southern hemisphere gyres than in the Northern ones. On the eutrophic side, high Chla biomasses are associated with high concentrations of fucoxanthin (diatoms) in temperate areas. For southern latitudes, however, this rule is challenged ; high biomasses can be associated either with fucoxanthin or with 19'-HF (Phaeocystis, Emiliania). This pigment variability within both trophic regimes is likely at the origin of part of the variability in phytoplankton absorption coefficients, and subsequent other IOPs.

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OXYGEN IS THE OXIDANT OF MN(II) IN THE BLACK SEA SUBOXIC LAYER

In the Black Sea, biological Mn(II) oxidation occurs in the suboxic zone where oxygen and sulfide concentrations are below 3 micromolar. Suboxic zone biogeochemical models suggest that nitrate, not oxygen, is the oxidant of Mn(II). Anoxic Mn-54 uptake experiments performed during the 2003 Black Sea cruise did not detect Mn(II) oxidation with nitrate, nitrite or nitrous oxide, however, Mn(II) oxidation occurred at very low levels of oxygen. At seven Black Sea stations, the half-saturation estimates for oxygen ranged between 290 and 2500 nM (median = 560 nM). Maximum Mn(II) oxidation rates were 1.5-330 nM/h (median = 9.5 nM/h). The oxygen concentration measured using HDME voltammetry on a sample from the Mn oxide maximum collected by in situ pumping was 164 nM, below the typical detection limits for oxygen. These data indicate that Mn(II)-oxidizing microbial populations produce Mn(III/IV) oxides at very low oxygen levels and that inorganic nitrogen does not stimulate Mn(II) oxidation anaerobically. We conclude that gradients of oxygen at nM levels are critical for explaining the biogeochemistry of the suboxic layer in general and Mn cycling rates in particular.

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OCEAN CIRCULATION AND EXCHANGES THROUGH THE NORTHERN BERING SEA – 1979-2001 MODEL RESULTS

Vast, seasonally ice-covered shelves, narrow and/or shallow passages, and limited access across political boundaries complicate field and modeling investigations in the Bering Sea. We have developed a high-resolution coupled sea ice-ocean model with a domain encompassing all of the sea ice covered northern hemisphere seas. Our goal is to improve understanding of Bering Sea circulation, inter-basin exchanges, and variability in response to prescribed and realistic atmospheric forcing. We focus on the northern Bering Sea (NBS) as the region upstream of the Chukchi Sea and Arctic Ocean, which controls the Pacific Water inflow via Bering Strait. Results show that ocean circulation is highly variable, both seasonally and interannually. Model output in the Bering Strait region is compared to moored observations of water mass properties. Comparison with observations of near bottom salinity from late winter through autumn shows good agreement with major water mass properties, although some sharp transitions such as fronts are not optimally resolved. The model adequately represents anomalous events, such as one from winter 2001 with very low sea ice cover and reversed flow in some areas to the north. High eddy and total kinetic energy in the NBS implies intense mixing of nutrient-rich waters advected from the Gulf of Anadyr. The time-mean total and eddy kinetic energy fields suggest significant correlation with the distribution of high productivity in the Bering Sea.

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REGIONALIZATION OF THE HAWAII OCEAN TIME-SERIES (HOT) OBSERVATIONS

The HOT program has made monthly measurements for 15 years at Station ALOHA (22o45'N, 158oW). Data from this Eulerian ocean observatory have been supplemented by several transects of opportunity aimed at detecting spatial variations of key biogeochemical properties, including nutrients (N, P, Si), chlorophyll, DIC/alkalinity/pH, dissolved and particulate organic matter, pico- and nanoplankton biomass and activity, nitrogenase gene expression, and bio-optical characteristics to name a few. The most recent HOT transects, from Hawaii to Alaska and return (April and October 2003, respectively), allow a comparative analysis of relevant biogeochemical properties across the gyre and its northern boundary. For example, P begins to accumulate (>0.2 umol P/l) in the surface waters at about 34oN; this boundary also marks the switch from surface water phototroph dominance by Prochlorococcus in the south, to Synechococcus and eukaryotic phytoplankton in the north. While heterotrophic bacteria are more abundant in the north (>1 x 10e6/ml vs. 5 x 10e5/ml), bacterial production (leucine incorporation) is greater in the south. These, and other, patterns in habitat and microbial community structure provide invaluable insights into ecosystem processes and function.

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SOUTH SAN FRANCISCO BAY: AN HNLC MARINE ECOSYSTEM SURROUNDED BY SILICON VALLEY

South San Francisco Bay is a marine lagoon bounded by San Francisco, Oakland and Silicon Valley. For three decades, academic and government researchers have used the South Bay as a study site to learn how natural processes and human actions regulate water quality, biological communities and ecosystem functions in urban marine systems. Early hydrographic measurements revealed the South Bay as a high-nutrient low-chlorophyll (HNLC) marine system during most of the year, interrupted by episodic algal blooms during spring. Syntheses of observational data suggested hypotheses: (1) spring blooms result from salinity stratification that develops as a response to weak tidal stirring and inputs of freshwater as a source of buoyancy; and (2) the HNLC state occurs when stratification breaks down and allows strong top-down control of phytoplankton biomass by benthic suspension-feeders. These hypotheses were the foundation of two decades of research designed as iterations between field and modeling studies. This talk will develop the original guiding hypotheses, and the session will illustrate a mode of ecosystem science that integrates results from environmental monitoring, process measurements, retrospective analyses, and modeling.

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CSU CENTER FOR INTEGRATIVE COASTAL OBSERVATION, RESEARCH AND EDUCATION (CI-CORE)

The CSU Center for Integrative Coastal Observation, Research and Education (CI-CORE) (http://www.mlml.calstate.edu/cicore/) is a distributed coastal observatory dedicated to applied coastal research and monitoring in the nearshore (<100 m water depth) environment along the entire 1200 miles of California coastline. The observatory specializes in three technologies: high resolution in situ temporal time series at all participating CSU coastal campuses and two high resolution spatial observatories, high resolution hyperspectral imaging from aircraft-flown sensors and high resolution seafloor habitat mapping.
This presentation will focus on our progress to date in all three technology foci as well as the organizational structure and outreach efforts. Our two hyperspectral data collects in the Monterey Bay National Marine Sanctuary are proving the utility of hyperspectral imagery for routine analyses of, among other monitoring, time-dependent change analysis of shorelines, water quality, harmful algal bloom (HAB) distribution, seagrass and kelp distributions, and shallow water benthic habitats. The seafloor habitat mapping has focused on developing the data necessary to implement a successful marine environment GIS tool for research and regulatory needs. The in situ monitoring implements recommended core measurements by Ocean Observing Systems and Ocean.US, supports site-specific local observations, and provides a framework for the fusion of the three technologies. All of the data and derived products are served to the public through our web sites.

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OPEN OCEAN IRON ENRICHMENT EXPERIMENTS: WHAT THEY HAVE TOLD US, WHAT THEY HAVE NOT.

The development of open ocean iron enrichment experiments has transformed our understanding of open ocean food webs and provided powerful insights into the workings of pelagic ecosystems and the cycling of carbon and nutrients in the upper ocean. Since the first experiments over a decade ago several international and private groups have successfully attempted such experiments and some consistent results have emerged: phytoplankton production and biomass in HNLC systems are limited, in a bottom-up manner, by the availability of iron. Iron enrichment accelerates the uptake of carbon and increases the uptake of nitrate thus fueling new production. Dramatic shifts in ecosystem structure result, favoring larger diatom species. Other results are not as clear. Complexities of these experiments consistently point to the variable and dynamic role of microzooplankton grazing. Yet, even some of the questions these experiments have been designed to address, do not have answers. The behavior and exact effect of iron on these ecosystems is differentially expressed. The cycling of iron itself is not well constrained and little is known regarding the fate of carbon exported below the mixed layer. This talk will focus on that which is known and that which remains a mystery regarding open ocean iron enrichment experiments.

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SENSITIVITY OF A 1-D COUPLED COHESIVE SEDIMENT ENTRAINMENT AND BIOTURBATION MODEL TO ENVIRONMENTAL FORCING

The entrainment of cohesive sediments involves coupled sediment-bottom boundary layer processes forced by waves and currents and complex physical, biological, and chemical processes (e.g. consolidation, bioturbation, geochemistry) that occur within the seafloor sediments. This study uses a system of coupled models to simulate the physical and biological processes that affect entrainment and, through various parameterizations, determine the entrainment rate under a range of wave, current, and biogeochemical forcing. An active layer approach is used to examine the erosion and deposition of fluid mud at the seafloor. The fluid mud layer determines bottom boundary layer dynamics, geochemical fluxes, and sediment transport at the water-seafloor interface. The sensitivity of the entrainment rate and suspended sediment profile to changes in seafloor bed elevation, bed density, bioturbation and biogeochemistry are investigated. In addition, the time-dependent response of feedback loops existing between biological production, bioturbation, and entrainment rate parameters are examined. The temporal and spatial distributions of dissolved oxygen and reaction rates of primary and secondary chemical reactions in the seafloor sediments are evaluated as well.

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ENHANCEMENT OF NEW PRODUCTION DURING THE SOUTHERN OCEAN IRON ENRICHMENT EXPERIMENTS (SOFEX)

New production was substantially enhanced during two iron enrichment experiments conducted in HNLC waters north and south of the Antarctic Polar Front Zone in the Southern Ocean. Absolute uptake rates of nitrate (using the N-15 tracer technique) increased by ca. 15-fold in the northern patch and ca. 25-fold in the southern patch relative to the un-enriched (control) waters. Biomass (particulate nitrogen) specific uptake rates of nitrate increased by ca. 5-fold and up to 10–fold in the northern and southern patches, respectively, whereas specific uptake rates of ammonium and urea did not increase as a result of Fe enrichment. Consequently there was a clear change in the relative utilization of new and regenerated nitrogen; the daily f-ratio (f-ratio = nitrate uptake/total nitrogen uptake) increased from ca. 0.1-0.2 to 0.5-0.6 (ratio uncorrected for isotopic dilution and DON effects) in the southern patch and to 0.3-0.4 in the northern patch. Unlike previous mesoscale experiments, the size-structure of the southern phytoplankton community did not change, and the potential inhibitory effects of increased concentrations of ambient ammonium on nitrate uptake rates were assessed.

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MEDFLUX: RELATIONSHIPS AMONG BALLAST, PARTICULATE ORGANIC CARBON AND TH-234 ACTIVITIES AND FLUXES IN THE UPPER WATER COLUMN

The use of 234Th as a proxy for the export flux of POC from the euphotic zone requires knowledge of the POC/234Th ratio of sinking particles and the relationship between the POC/234Th ratio on sinking and filterable particles. Swimmer-exclusion IRS sediment traps deployed at 200 m at the DYFAMED site (western Mediterranean) were operated in the normal mode, collecting sequential samples of flux, and in a sinking velocity mode, in which particles of differing sinking velocity were collected in each cup. Specific activities of 234Th in the trap samples varied between ~40 – 80 Bq/g, with no clear relationship to flux. Two traps operated in the sinking velocity mode showed that ~40% of the 234Th flux was in the fraction sinking at ~200 m/d. Similar results were observed for particles collected at 200 m by means of a net trap and processed through an elutriator to separate them into fractions corresponding to sinking velocity— ~49% of the 234Th was found in the fraction sinking at least 230 m/d. These results will permit comparison to POC and ballast measured on the same samples.

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OPTIMIZING TECHNIQUES FOR GROWING AND PRESERVING THE CYANOBACTERIUM PROCHLOROCOCCUS

Prochlorococcus is the smallest and most abundant marine primary producer in the oceans, found distributed throughout the euphotic zone from 40ºN to 40ºS. Most laboratory studies of Prochlorococcus have suffered from three major limitations. First, cultures have been primarily maintained in supplemented natural sea water, which is sometimes difficult to acquire and chemically define. Second, transportation of cultures has been limited to metabolically active cultures, which are extremely sensitive to light and temperature changes and often do not survive shipment. Lastly, maintaining stocks by serial transfer can lead to the selection of mutants and can therefore change the genetic makeup of the stocks. To resolve our dependency on natural sea water for maintaining our Prochlorococcus culture collection, all stock isolates and a representative strain from each of the six clades were tested with variations of artificial sea water media to determine optimal nutrient and metal concentrations. Growth was achieved for all Prochlorococcus isolates with the final modified artificial sea water medium. Cryopreservation techniques were developed and optimized, and successful revival was achieved with all strains.

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NEARSHORE TRANSPORT RATES IN SAN PEDRO BAY DERIVED FROM THE DISTRIBUTION OF RADIUM ISOTOPES

The distribution of naturally-occurring radium isotopes in San Pedro Bay, CA, was used to evaluate mixing rates in the coastal ocean, and terrestrially-derived groundwater inputs. Surface water samples were collected at the shoreline and in offshore transects. The distribution of short-lived isotopes (Ra-223, Ra-224) show that the system is in steady-state over days to weeks; however, variability exists over longer time scales. Exponential 1-D model fits to each profile generate scale lengths less than 2km, 10x less than those measured further offshore from South Carolina (Moore, 2000). Based on the Ra-228 distribution, an increase in eddy diffusivity with distance was calculated. Absolute diffusivities were calculated by model fits to the short-lived isotopes. For the calculated diffusivities, Ra-223/Ra-224 scale length ratio is sensitive to small advection rates (< 1 cm/sec). With calculated diffusivities that vary by a factor of 6, the shoreline concentration of a hypothetical contaminant can vary by a factor of 3. Nearshore enrichments of Ra-226, which may indicate terrestrially-derived groundwater inputs, were not observed. Based on sampling sensitivity and mixing models, groundwater advection rates are <1cm/day.

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DOES TERRESTRIAL C FUEL THE AQUATIC FOOD WEB IN SMALL LAKES? FURTHER RESULTS FROM WHOLE-LAKE 13C ADDITIONS.

Ecosystem respiration exceeds primary production in many lake ecosystems, This “net heterotrophy” is driven by inputs and subsequent degradation of incoming terrestrial organic C. Does this terrestrial C merely fuel microbial respiration or does it subsidize the entire food web? We have performed a series of five, whole-lake experiments in which we manipulated the 13-C level of dissolved inorganic C, thereby creating strong contrasts between terrestrial inputs and in-lake (autochthonous) primary production. Two independent modeling approaches (statistical process models and mechanistically rich dual isotope flow models) used to interpret the results converge on similar answers. In the absence of added nutrients, terrestrial organic C supports from 25 to 60% of the production of zooplankton and small fishes, and that 5 to 10% of the standing stock of dissolved organic C in these humic lakes is derived from in situ primary production. Further, conventional models of isotopic fractionation during photosynthesis, largely from marine studies, greatly overestimated fractionation in these lakes. Finally, the addition of exogenous N and P greatly lowers the importance of terrestrial inputs to the food web.

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AN ENHANCED, UNDULATING TOWED VEHICLE FOR PHYSICAL, CHEMICAL AND BIOLOGICAL MONITORING OF COASTAL ECOSYSTEMS: REAP WHAT YOU TOW.

We have developed an enhanced version of the Sea Sciences Acrobat towed, undulating vehicle. This vehicle has been towed nearly 5,000 km to study the upwelling of nutrient rich waters along the Central California Coast. The performance and capabilities of this towed vehicle have been significantly enhanced by several modifications. The addition of an Ethernet based telemetry system using SDSL MODEMS allows data from multiple sensors with serial data streams to be accessed in real-time using only a single pair of conductors. Improved power delivery and regulation significantly expanded both the quantity and types of sensors that could be deployed and greatly improved vehicle control. This vehicle is now towed with a payload that includes CTD, multiple fluorometers, OBS, ISUS nitrate sensor, bioluminescence photometer and LISST laser particle size analyzer.

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UREA-DEGRADING MICROORGANISMS IN CHESAPEAKE BAY

Urea is an important natural component of aquatic nitrogen cycles and is a contributor to anthropogenic nitrogen pollution of aquatic ecosystems. To investigate the diversity and distribution of microorganisms capable of degrading urea, we have developed oligonucleotide primers that direct PCR amplification of an approximately 560 bp fragment of most, if not all, genes encoding the nickel-requiring enzyme urease (which most organisms use to decompose urea into two molecules of ammonia and one of carbonic acid). As part of a Biocomplexity project, we have used these primers to examine samples collected in Chesapeake Bay and the Choptank River by both TRFLP analysis and sequencing libraries of cloned amplicons. The approximately 400 clones sequenced to date reveal that ‘real world’ ureases are more diverse than, and not closely related to, those currently available in GenBank. It seems likely that most of the Chesapeake amplicons originate from phytoplankton that could use urea as a nitrogen source. Patterns in the diversity of urease amplicons among different samples and in the distribution of particular urease sequences will be summarized.

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NUTRIENT LOADS AND ELEMENT RATIOS FROM SUBURBAN LAND INPUT OF NUTRIENTS CONTRIBUTED BY GROUND-WATER DISCHARGE TO COASTAL EMBAYMENTS, NORTHEASTERN USA

Saltwater embayments bounded by barrier beaches are common coastal features of southern Rhode Island; Cape Cod, Martha’s Vineyard, and Nantucket Island in Massachusetts; and Long Island, New York. These embayments are set in hydraulically transmissive glacial outwash sediments on islands, peninsulas, or the seaward sides of glacial moraines. Typically the primary source of freshwater to these coastal waters is from ground-water discharge. The embayments are threatened by increased nutrient loads to the land in the areas that contribute ground-water recharge to them, as evidenced by decreased seagrass and increased macroalgal growth. A transient reactive-solute-transport analysis of the ground-water discharge to Nauset Bay, Cape Cod indicates N ground-water loads have increased 40 fold from background, whereas P and Si loads are controlled by reaction with the sediments and are near background. N loads to Nauset Bay will double in the next 60 years from N already disposed to the subsurface but not yet transported along deep aquifer flow paths to the coast. Ratios of the elements in loading indicate plant growth will not be N limited in the coming decades.

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OCEANS AND HUMAN HEALTH: A SYMBIOTIC RELATIONSHIP BETWEEN PEOPLE AND THE SEA?

Oceans have become conduits for several environmental threats to human health. At the same time, oceans harbor diverse organisms that show great promise for providing new drugs to combat cancer and to fight infectious diseases. To guard against such health threats and to take advantage of the medicinal benefits that oceans might provide, the impacts of the seas on human health must be more fully explored, and new research efforts directed to this area.

Disease-causing organisms harmful to human health can be spread by several different marine processes. Coastal and estuarine circulation patterns influence the frequency and geographic pattern of harmful algal blooms, for instance. Nutrient loading from heavy runoff also poses problems of anoxia and contributes to proliferation of algae. Circulation of waters through estuaries and coastal areas plays a role in determining where and when the risks of human pathogens are highest. Pathogens from human or animal waste enter coastal and estuarine sites via freshwater runoff from sewers, rivers and streams. Viruses and bacteria of fecal origin can concentrate in filter-feeding shellfish, such as oysters and clams. Pathogenic bacteria and harmful algal species can arrive in new areas in the ballast water of ships. Harmful algal species also can be transported great distances by major ocean currents. International trade, as well, transmits algal toxins and pathogens through commerce in seafood. And climate and ocean tides can play a role in epidemics of water-borne diseases, e.g., cholera.

Yet, plants, animals and microorganisms have provided sources of and concepts for more than half the pharmaceuticals currently on the market. Due to the diversity of life within the world’s oceans, marine organisms offer a promising source of novel compounds with therapeutic potential. Despite continued and more sophisticated searches for new bioactive agents, there has been a decreasing return in development of new drug compounds; the oceans may hold new answers to this problem.The subject of the oceans and human health presents two halves of the same coin: what can harm, can also benefit. Someday, we may find answers to the most intractable diseases of our time, including cancer, in the still-mysterious substances produced within an animal, plant or microbe living in the sea.

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VARIABILITY OF PHYTOPLANKTON BLOOMS IN THE ARCTIC AND PERIPHERAL SEAS: RELATIONSHIPS WITH SEA ICE, TEMPERATURE, CLOUDS, AND WIND

Satellite data of ocean color, sea ice concentration, surface temperature, and clouds, as well as ECMWF/winds for the period 1998 to 2002 have been compiled and analyzed to quantify regional and temporal variabilities of phytoplankton blooms in the Arctic and peripheral seas and evaluate their relationships with environmental variables. Large asymmetry in phytoplankton chlorophylls is consistently observed in the Arctic basin with data in Eastern Arctic having about fivefold higher concentration than those of the Western Arctic. Monthly-average chlorophyll concentrations also show large seasonal and interannual variability with 2002 and 2001 having higher values than previous years. Environmental factors that influence phytoplankton growth were examined, and results show relatively high correlations of pigments with sea ice retreat and sea surface temperature (SST) during early and late spring periods and an apparent preference by planktons of SSTs near 277K. The correlation with clouds is significant in some areas but negligible in other areas, while the correlations with wind and its components are relatively weak. Weak stratification, upwelling of nutrients, and unpredictable effect of winds may explain unexpected observations.

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INVESTIGATION OF AIR-WATER EXCHANGE OF MERCURY IN SAN FRANCISCO ESTUARY

In order to accurately characterize the air-water exchange of mercury in South San Francisco Bay, the concentration of surface water dissolved gaseous mercury (DGM) and total atmospheric total gaseous mercury (TGM) were measured at three sites in the estuary in April, May, and August 2003. The concentration of DGM averaged 0.150 ± 0.09 pM, which is similar to that observed in other contaminated estuaries, but nearly an order of magnitude lower than the previously reported average for San Francisco Bay. In addition, the data showed no distinct spatial variation or a temporal trend between months. Concentrations of TGM were supersaturated with and average of 2.1 ± 0.2 ng/m3 and showed little variation across the estuary. The resulting flux of mercury from the South Bay to the atmosphere is, therefore, estimated to be relatively constant at ~5 kg/y, at least during the spring and summer months.

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INFLUENCE OF DISPERSAL, GROWTH, AND HERBIVORE SUSCEPTIBILITY ON THE ABILITY OF THREE NON-INDIGENOUS ALGAL SPECIES TO DISPLACE NATIVE COMMUNITIES IN HAWAI'I

In the past 50 years, over 20 species of non-indigenous marine macroalgae have successfully established in Hawai'i. While many of these species pose minimal threats to Hawaii's marine ecosystems, several species can have devastating impacts on coral reef communities. This study evaluates the potential threats that three of the most common invasive algae pose to Hawaii's reefs by comparing dispersal capabilities, growth rates, and herbivore susceptibility. Dispersal abilities and growth rates most strongly determine the geographic extent of the invasive algae. Sexually reproducing and fast-growing Acanthophora spicifera has established throughout the main Hawaiian Islands, while vegetatively propagating and comparatively slow-growing Gracilaria salicornia and Kappaphycus spp. have much more restricted distributions. Susceptibility to herbivory seems to be the most important trait in determining the threat posed to coral reef communities. A. spicifera is highly preferred by native herbivorous fishes and only attains significant biomass in areas where herbivores are scarce. G. salicornia and Kappaphycus spp. are less preferred species and consequently can overgrow and kill corals even in areas where herbivorous fishes are abundant.

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SEASONAL CDOM DISTRIBUTION ON THE SOUTHWEST FLORIDA SHELF

Colored Dissolved Organic Matter (CDOM), a ubiquitous pool of organic matter and the major controlling factor governing light penetration in the ocean remains mostly uncharacterized. An ideal tracer for water mass circulation, CDOM may also play an important photochemical role as a link between the detrital and microbial pools, especially in subtropical regions. Due to regional variability and complexity of this material, source discrimination and understanding biogeochemical pathways becomes ever more challenging in river-dominated coastal margins such as the southwest Florida region of the Gulf of Mexico. CDOM distributions in this region are influenced by a variety of freshwater inputs ranging from Everglades influenced rivers to both gated and natural agriculturally influenced rivers as well as western Florida Bay waters. These differing allochthonous inputs result in spatially and temporally distinct nutrient fields, microbial distributions and optical properties (e.g. high-resolution 3-D fluorescence, absorption, fluorescence efficiencies, and peak ratios). The source dependent nature of these optical properties on the southwestern Florida Shelf during a spring flushing event will be discussed, with special focus on the relationship between gelbstoff and DOC, DON, DOP, chlorophyll a and nutrients.

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TOWARDS UNDERSTANDING SHELF-BASIN INTERACTIONS: SEASONAL VARIABILITY IN THE OXYGEN ISOTOPE COMPOSITION OF ARCTIC WATERS IN CONJUNCTION WITH OTHER TRACERS

The use of stable oxygen isotope variations in Arctic water masses to study temporal mixing processes in surface waters is incompletely resolved because there has been only limited sampling outside of summer. We report here the results of several research sampling programs that are providing data on the isotopic composition of Arctic rivers (PARTNERS), shelf and deep basin regions of the Chukchi and Beaufort Seas (SBI), and flow through the northern Bering Sea and Bering Strait in late winter (Bering Strait Environmental Observatory). Combining these isotope ratio data with other variables, including terrestrial markers, nutrients, salinity, and denitrification indicators provides new insights on the timing and mechanisms of shelf-basin interaction. These findings include observations of runoff-influenced waters that remain geographically separated over-winter from brine-influenced shelf and slope waters. Apparent source differences in lignin contents of runoff components were also observed, as was subsurface ventilation as brine-injected shelf waters flowed down Barrow Canyon. In the center of Bering Strait an increasing sea ice melt signal was advected through Bering Strait in April 2003 as ice melt commenced to the south.

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ALEUTS, URCHINS AND OTTERS: SIX THOUSAND YEARS OF ECOSYSTEM INTERACTIONS IN THE WESTERN ALEUTIAN ISLANDS, ALASKA

Faunal remains in prehistoric sites offer a means for detailed reconstruction of the near shore ecosystem. Quantitative temporal and spatial analysis of prehistoric Aleut archeological sites spanning 6,000 years reveals strong patterning in the reconstructed biotic environment. The overall picture of stability masks subtle changes over time. These include a decrease in the average size of gadids and nearshore fish, mixed patterns of presence and abundance of on-shore, near shore and pelagic feeding seabirds, and changes in breeding range for Northern fur seals. The evidence for other sea mammals is less clear but at least some researchers see episodic lows in sea mammal populations, especially sea lions. These changes can be linked to patterns of exploitation by Aleut hunters and fishermen. Sea otter remains are of particular importance for understanding the history of near shore ecosystems. The dynamic interaction of sea otters with sea urchins largely determines the character and productivity of near shore kelp forests. The role of humans as a predator on sea otters is poorly understood. Archaeological data and historical records are beginning to yield important evidence on the role of humans in the Aleutian near shore ecosystem.

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COLD SEEP TUBEWORMS MEET THEIR HIGH SULFIDE DEMAND BY ENHANCING MICROBIAL ANAEROBIC METHANE OXIDATION AND DEGRADATION OF HYDROCARBONS

This study presents evidence for a coupled sulfur cycle among symbiotic vestimentiferan tubeworms and microbial consortia at hydrocarbon seeps in the Gulf of Mexico. All vestimentiferan polychaetes rely on sulfide-oxidizing bacterial endosymbionts for their nutritional requirements. Lamellibrachia luymesi differs from most species of tubeworms in that it is capable of using posterior extensions of its body and tube, the "root", to acquire hydrogen sulfide from hydrocarbon seep sediments. Previously, a population growth model including laboratory measured sulfide uptake rates estimated sulfide demand of L. luymesi aggregations to be in excess of 30 mmol•hr-1. Here, this model is coupled to a 3-dimensional steady state diffusion/advection model to estimate sulfide supply. Sources of sulfide include deep sulfide and sulfide produced through reduction of seawater sulfate by microbial consortia. These sources can support the sulfide demand of an aggregation for only 10-15 years. Models including the hypothesized release of sulfate by L. luymesi roots indicate that this additional supply of sulfate could increase the rate of sulfide production through anaerobic oxidation of methane and large-chain hydrocarbons, meeting the demand of large vestimentiferan aggregations.

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ESTIMATION OF PHOTOSYNTHETIC ACTIVITY, AS DETERMINED BY FAST REPETITION RATE FLUOROMETRY (FRRF), IN THE NORTH SUBTROPICAL GYRE (NSPG).

Time-series FRRf measurements were made in the NPSG (Station ALOHA, 22 45 N, 158 00 W), over a complete year. The efficiency of Photosystem II (PSII), derived from normalized variable fluorescence (FV/FM), was high through the water column at all time (FV/FM=0.50-0.60). A constant maximum (FV/FM=0.65-0.85) occurred below the Deep Chlorophyll Maximum Layer, between 120 and 150 m. We defined this depth range as the High Efficiency Area (HEA). The effective absorption cross section of PSII showed similar patterns as FV/FM. Variability on short (seconds to minutes) and long (weeks) time scales in both parameters decreased with depth, reaching a minimum in the HEA. Fluorescence-derived photosynthetic parameters confirmed the presence of surface, high light-adapted populations and deep, low-light adapted assemblages. Our results suggest high photosynthetic efficiency in this oligotrophic region, despite the supposed-chronic nutrient limitation affecting surface populations. Surface variability may, however, reflect more flexible physiological adaptations due to irregular nutrient supply. These findings highlight the potential use of optical measurements to further understanding photo-autotrophs dynamics in pelagic environments, across a high spatial and temporal resolution.

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THE HYGEIA PROGRAM FOR HYPERSPECTRAL IMAGING FROM THE INTERNATIONAL SPACE STATION

The Hyperspectral Sensor for Global Environmental Imaging and Analysis (HyGEIA) program is a collaboration between the Naval Research Laboratory and the Boeing Company. The program objective is to install the NRL Ocean Portable Hyperspectral Imager for Low Light Spectroscopy (Ocean PHILLS) in the Window Observational Research Facility on the International Space Station, to image the coastal ocean and littoral zone, forest areas, and crops. The PHILLS will image over the band 400 to 1000 nm, and is designed to provide a signal to noise greater than 200 to 1 over the visible wavelengths, even when viewing the relatively dark ocean or forest radiances. Ground sample distances of 25 m and 130 m will be available. This paper will describe the Ocean PHILLS implementation on the Space Station, the modeled on-orbit performance, the operations plan, and potential areas to be imaged.

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MARINE MAMMALS AS OCEANOGRAPHERS

Tag-bearing animals can be used as autonomous ocean profilers to provide oceanographic data in key regions. We deployed 17 ARGOS linked tags on crabeater seals that produced 4895 bathythermographs. Each seal completed 279 (30-893) casts that covered 59 (7-201) days. We documented the depth of the Circumpolar Deep Water, and followed the annual degradation of the Antarctic surface water to winter water with a calculated heat flux (31.7 W/m3).
We have recently obtained temperature and salinity data by using Alec Electronics CT tag on Northern Elephant seals and Star Odi CTD tags on Australian sea lions. Female elephant seals offer a great platform to obtain CTD data in the North Pacific and Southern Oceans. Females during the spring migration would produce 69 CTD profiles to at least 600m a day for a total of 4830 CTD profiles over the 70-day migration.
This approach allows oceanographers to obtain data from rarely or difficult to sample areas, while marine biologists can obtain fine scale information on animal movements relative to oceanographic features that could not be obtained with other remote sensing systems.

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HYPERSPECTRAL REMOTE SENSING OF THE FRASER RIVER PLUME, BC, CANADA

The main goal of this pilot study is to provide baseline information and models to effectively use optical remotely sensed imagery to evaluate changes in water quality of coastal waters, and contribute to our ability to separate natural versus anthropogenic inputs and impacts on water and ecology. Compact Airborne Spectrographic Imager (casi) acquired imagery over the main plume of the Fraser River, BC, Canada, on August 2003. casi acquired imagery at a sun position of approximately 43o zenith on spectral mode – 36 bands between 400-900nm – with a 3 x 3 m spatial resolution. The imagery were mosaiced, and the following correction were applied: geometry, atmosphere and air-water interface (ACORN), and across-track intra-calibration. After correction, the image mosaic was converted to remote sensing reflectance and subsurface irradiance reflectance. Parallel to the casi acquisition, 18 surficial water samples were collected along a transect from the mouth of the river to the Strait of Georgia. The water samples were filtered and analyzed for inorganic/organic suspended matter (TSM) and dissolved organic carbon. The results showed a clear gradient from high TSM towards a typical case II coastal oceanic waters. Preliminary analysis of simulations with the Hydrolight model and casi imagery with the water optical constituents showed saturation of reflectance at lower wavelengths for high TSM and sensitive correlations at longer visible wavelengths.

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PRIMARY PRODUCTION IN THE WESTERN ARCTIC OCEAN

Primary production was measured on four cruises in the Chukchi-Beaufort Seas over the last decade with spring and summer cruises in 2002. Productivity is modest. The highest biomass and productivity occur in open waters on the shelf or near the shelf-break, while low values are observed in the largely ice-covered basin waters or early in the spring. Phytoplankton production is highly dependent upon biomass and integrated chlorophyll explains 88% of the variability in particulate organic carbon (POC) production. There is additional production and release of dissolved organic carbon (DOC) which can be ~30-40% of POC production. Large phytoplankton tend to dominate open water blooms, whereas in ice-covered areas small cells predominate. Property distributions confirm the patterns observed, as does ocean color imagery in open waters.

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MAJOR DISSOLVED ORGANIC CARBON FLUXES MEDIATED BY MICROBES IN LAKE MICHIGAN

We examined whole water column water dissolved organic carbon (DOC) demand of heterotrophic bacteria in southern Lake Michigan. Research in this and other Great Lakes has demonstrated that heterotrophic bacteria are the dominant remineralizers of organic carbon through respiration. Bacterial growth efficiency (BGE) relates bacterial respiration to bacterial production. We found a negative correlation between temperature and BGE in Lake Michigan (BGE=26.1-1.4 x T, where T is lake water temperature), indicating that respiratory losses increased with increasing temperature of the surface waters. Bacterial production was related to temperature with a second order polynomial. We used these microbial-temperature relationships and remotely sensed estimates of surface temperatures to estimate whole water column DOC-demand in surface and deep waters. These results indicate that upper 10 meters of the water column represent only about 10% of the volume of the basin but about 50% of the DOC demand. Furthermore, climate change projections of increased surface water temperatures are expected to increase DOC-demand by over a factor of five.

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THE BALANCE BETWEEN AUTOTROPHY AND HETEROTROPHY IN THE WESTERN ARCTIC OCEAN

The balance between autotrophy and heterotrophy is a key feature of ecosystem function that could serve as an indicator of environmental change, such as that suspected to be underway in the Arctic Ocean. Data on microbial processes in the Arctic are sparse and few studies have examined autotrophic and heterotrophic metabolism together. In order to examine the metabolic balance in the Western Arctic Ocean, we measured bacterial production, community oxygen consumption and photosynthetic oxygen production during the summer Western Arctic Shelf-Basin Interactions (SBI) process cruise of 2002. Rates of community oxygen consumption and photosynthetic oxygen production varied greatly over the sampling area, which included shelf, slope and basin environments. Low rates prevailed with substantial rates of community oxygen consumption and production in only about 30% of the samples. On average, bacteria seem to account for about 50% of community oxygen consumption, but this percentage varied greatly. The analysis of light and dark bottle oxygen experiments suggests a dynamic balance between autotrophy and heterotrophy with overall autotrophy in the SBI study area during summer.

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METABOLIC ADAPTATIONS (AND THE LACK THEREOF) TO OXYGEN LIMITATION IN A BURROW-DWELLING CRUSTACEAN

The mantis shrimp Hemisquilla californiensis routinely encounters hypoxia or anoxia in its burrows, which it often enters and caps for hours at a time. Given this environment the species should exhibit adaptations for living in low oxygen conditions that are not generally observed in crustaceans. In this study I compared the aerobic metabolism of H. californiensis with that of the spot shrimp Pandalus platyceros, which lives on the aerobic surface of the sediment rather than in hypoxic burrows. As expected, P. platyceros was a poor oxyregulator with a moderate anaerobic survival time of a few hours. Aerobic metabolism at 20-30 mm Hg O2 was depressed by a factor of 2.5 from metabolism at 110-130 mm Hg. Unexpectedly, H. californiensis is also a poor oxyregulator. Aerobic metabolism of H. californiensis at 20-30 mm Hg O2 was depressed 2.3-fold from that at 130-140 mm Hg. H. californiensis, therefore, which routinely encounters hypoxic conditions, is little better at oxyregulating than is P. platyceros, which inhabits a nearly normoxic environment. However, H. californiensis has dramatically greater anaerobic survival of 24-48 hours or more.

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BRINGING OCEAN SCIENCES TO UNDERREPRESENTED POPULATIONS

Are you searching for ways to reach underrepresented populations of learners, as well as the general public? Explore approaches by which ocean scientists have made connections with instructors and learners in adult basic education programs. It is estimated that 44 million adult Americans, or 23% of the population, function at low skill levels in reading, writing, and mathematical problem solving. These adults are workers, consumers, voters, parents, and grandparents. Many of them are enrolled in federally-funded formal educational programs to improve their skills and/or study for the certificate of General Educational Development (GED).

This presentation will provide specific examples of how adults develop their reading, writing, and numeracy skills through the use of ocean sciences as a context for learning. Learn about the existing education and information distribution systems that have been used to reach this broad audience of underrepresented learners, adult basic education instructors, and the public.

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THE ECOLOGICAL IMPLICATIONS OF PERSISTENT THIN LAYERS OF PLANKTON IN AN INTERMITTENTLY MIXED UPPER OCEAN

Finescale (1 m to 3 m) and microscale (0.01 m to 1 m) observations of the vertical structure of plankton reveal local maxima of phytoplankton and zooplankton within narrow layers (0.5 to 2 m thick). These layers often persist over ecologically relevant time intervals (6-24 hrs), and extend many kilometers horizontally. How do thin layers persist on these time scales? We have documented thin layers with a free-fall profiling system that provides centimeter-scale resolution of hydrographic properties, bio-optical properties, and the vertical shear. We also have data from a multi-frequency towed bio-acoustical system (38, 120, 200, 420 KHz) as well as from a moored 500 KHz ADP. Data from all systems confirm that steep concentration gradients at the boundaries of layers correspond to local maxima in vertical shear. High-resolution bio-optical profiles through a dye patch have revealed thin dye layers along shear interfaces, with the same vertical and horizontal structure as planktonic thin layers. We suggest that these ecologically important features result from a combination of local stratification, steep vertical shear gradients, and infrequent small-scale turbulence events.

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ZOOPLANKTION DISTRIBUTION, ABUNDANCE AND BIOMASS RELATIVE TO WATER MASSES IN THE EASTERN AND CENTRAL ALEUTIAN ISLAND PASSES

As part of an interdisciplinary study of the marine ecosystems of the eastern and central Aleutian Archipelago, comparisons were made of the distribution, abundance and species composition of zooplankton and micro-nekton between Unimak Pass in the east and Tanaga Pass in the west. Acoustic, CalVET and MOCNESS sampling revealed that the eastern Aleutian shelf sustains dense aggregates of the euphausiid Thysanoessa inermis and shelf copepod species, which are rare or absent from the middle Aleutian passes, where populations are dominated by oceanic copepod species and the euphausiid Euphausia pacifica. Physical aggregation of zooplankton by tidally-generated eddies and fronts in or near the passes is a major mechanism for concentrating zooplankton, particularly in the central Aleutian region, where euphausiids concentrations are lower.

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THE EFFECT OF SEDIMENT RESUSPENSION ON THE ESTIMATION OF INFECTION RISK AT RECREATIONAL COASTAL SITES

Laboratory-based microcosm survival studies using intact sediment and water cores, in combination with in-situ measurements, were used to determine the persistence of faecal indicators (Escherichia coli, Enterococcus faecium and coliphage) and pathogens (Salmonella typhimurium and S. derby) in a range of coastal sediment types and waters. These results were incorporated in a quantitative microbial risk assessment (QMRA) to estimate the impact of sediment resuspension on exposure risk during coastal recreation. Microorganisms were observed to persist longer in the surface sediment layer compared with overlying water, particularly for sediments of small particle size and high organic carbon content. Temperature was found to have an inverse relationship with survival, with greatest effect observed in overlying water. Survival of enterococci and coliphage were significantly greater in both matrices compared with other organisms investigated. Results from QMRA modelling demonstrated the change in infection risk over time following a simulated faecal contamination event. Increased survival rates of microorganisms (particularly viruses as modelled by coliphage) in the sediment, led to increased duration of likely infection period if resuspension occurred following a contamination event.

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HOW MESOSCALE OCEAN PROCESSES INFLUENCED THE SERIES PROGRAM IN THE GULF OF ALASKA.

The SERIES program observed enhanced phytoplankton growth following iron enrichment of the ocean surface layer at Ocean Station Papa (OSP) in July-August 2002. OSP lies at 50N, 145W within the HNLC region of the northeast Pacific Ocean. Our observations of the surrounding Gulf of Alaska reveal that OSP lies southwest of the region into which mesoscale Sitka Eddies normally carry iron from the eastern continental margin, and south of the normal influence of dust storms from Alaska. However, Sitka Eddies occasionally drift to the southwest all the way to OSP, creating naturally occurring, iron-enriched, non-HNLC patches in mid-gulf. During SERIES, mesoscale eddies were located to the northeast and southwest of OSP, and the iron injection site was carefully placed to avoid both eddies. The eddy velocity field advected the fertilized patch along a clockwise trajectory, and also distorted its shape, but, fortunately for SERIES, did not alter its surface iron content.

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MEASUREMENT AND MODELING OF DISSOLVED ORGANIC CARBON IN FRESHWATER LANDSCAPES

A significant portion of the dissolved organic carbon (DOC) present in freshwater landscapes is of allochthonous origin. Within these landscapes, wetlands, ranging from small cryptic wetlands hidden underneath a forest canopy to large open wetlands along shorelines of lakes, are often the principal source of DOC. We developed a hydrologically based model that explicitly links terrestrial and aquatic systems to estimate DOC fluxes from these landscapes. The model is based on (A) a DOC loading model, with automatically detected wetlands related to DOC loading to lakes; and (B) a DOC mass balance model for the lakes. The model was developed using headwater catchments (<1 km2) where long-term monitoring data were available. The model was then applied to a regional watershed (5,000 km2), with about 1000 lakes, and resulted in good agreement between measured and modeled DOC in the lake near the mouth of the watershed despite the large number of lakes upstream. This study suggests that significant DOC sources within landscapes can be easily identified and that the fate of these DOC sources can be modeled at scales ranging from the catchment to the region.

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THE MEDWATER PROJECT: METHODOLOGY AND PRELIMINARY RESULTS

The MedWater project aims at studing the mechanisms responsible for the evolution of the Mediterranean basin climate with a focus on the hydrological cycle and water budget for periods ranging from a season up to a few decades. The project includes the Black Sea region which is strongly connected to the Mediterranean. The water budget is the most sensitive climate variable affecting the environment, the human society and its economy. Emphasis will thus be given on the rainfall, river discharge, land vegetation, desertification, thermohaline circulation of the Mediterranean Sea and their relationships and interactions. The variability of the associated marine ecosytem will be also investigated. Efforts of the project will be concentrated on the dynamics of the climate which is the most relevant point to explain the regional climate variability.

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TURBULENT ENHANCEMENT OF BROADCAST SPAWNING EFFICIENCY

The broadcast spawning reproductive strategy relies on turbulent stirring processes in the flow to bring together gametes previously released by adult males and females. The subsequent fertilization rate depends on the product of co-occurring concentrations of egg and sperm. Turbulent mixing produces a strong average dilution in these concentrations, suggesting that an increase in turbulence would reduce the average local fertilization rate. However, turbulent dilution occurs at time scales that may be long compared to those associated with fertilization. Therefore, the instantaneous structure of egg and sperm filaments at shorter time scales must be considered. A mechanism is proposed whereby coherent turbulent structures in the velocity field cause coalescence between high-concentration filaments of egg and sperm, significantly enhancing the average fertilization rate. Simple analytical and numerical models are used to demonstrate how the mechanism works, and to make qualitative estimates of its effect on the resulting fertilization rate. The results suggest that the efficiency of broadcast spawning is a consequence of features in the instantaneous turbulent field.

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EVOLUTION OF THE EAST MEDITERRANEAN BIOCHEMICAL BUDGETS AFTER EMT

The EMT onset, development and fate has been a major transient signal in the general circulation of Mediterranean Sea. Its implications on the variability in the biogeochemical properties and processes are the subject of this study. An overall synthetic description of the most relevant effects experimentally observed is obtained from the analysis of the thermohaline fields, dissolved oxygen, and macronutrients (re)distribution. This synthesis is compared and critically assessed against the hypotheses presently invoked to explain EMT and its consequences. Simplified numerical models are used to give a tentative dynamical description of biochemical budgets in Eastern Mediterranean. We present also evidences and interpretation of post-EMT evolution of dissolved oxigen and macronutrients distributions, and of the biotic part of the ecosystem providing basic estimates and constraints for the implementation of more refined three-dimensional coupled eco-hydrodynamical models.

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THE MID-LAKE REEF COMPLEX OF LAKE MICHIGAN: A MAJOR FISHERIES RESOURCE UNDER INVASION BY QUAGGA MUSSELS.

The Mid-Lake Reef Complex (MLRC) rises above the 100-150m Lake Michigan abyssal plain to shoal at 40-50m, and covers a large portion of the south-central basin. Believed to have been an active fishery when the MLRC was islands 7000 years ago, its steep slopes and large plateaus have supported several modern commercial fisheries. Clear evidence of topographic effects include thermocline doming and concentration of pelagic fish at the leading edge of slopes as seen in sonar images. Slimy sculpin, normally denizens of small coldwater streams, are primary benthic consumers of abundant mysids. Because of its depth it was immune to Zebra Mussel effects. In late 2001 the first Quagga Mussels were observed, and they have increased in population steadily since then. It is likely that Quagga Mussels will affect nutrient cycling and habitat structure through (pseudo)feces deposition, plankton removal from passing currents, and water clearing in the open lake habitat. The leading edge of the invasion is documented through remotely-operated vehicle visuals and slurp samples, along with vessel-based hydrographic and benthic grab samples.

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OPTICAL PROXIES OF BIOLOGICAL PROPERTIES FOR ASSIMILATION INTO MODELS OF ECOSYSTEM DYNAMICS

Advanced models of ecosystem dynamics predict the abundance of phytoplankton in categories corresponding to taxa, size classes and/or ecological functional groups. Differential influences of environmental conditions on growth rates of phytoplankton groups result in changes of community structure. Consequently, measures of community structure and physiological status of phytoplankton, along with information on light, temperature and nutrients, are needed to develop and validate advanced ecosystem models. Real-time data assimilation models will require autonomous measurements. Presently available remotely sensed data products include temperature, chlorophyll concentration and solar irradiance at the sea surface, and an estimate of light penetration. Hyperspectral imagers and instruments on moorings, profilers and autonomous vehicles can potentially provide much more: measures of dominant phytoplankton size class or taxonomic group from ocean color and attenuation; estimates of photoacclimation and possibly nutrient status from observations of sun-induced and stimulated chlorophyll fluorescence; and a measure of the attenuation of photosynthetically utilizable radiation derived from ocean color. All of these optical proxies have limitations, but it is likely that each will find use in advanced models of ecosystem dynamics.

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CHARACTERIZATION OF PICORNA-LIKE VIRUSES FROM A VARIETY OF MARINE ENVIRONMENTS

Recently, based on analysis of conserved sequences amplified from marine virus communities, we have discovered that a diverse array of picorna-like viruses exists in the ocean. Furthermore, we showed that an isolate belonging to one of these groups is a lytic pathogen of Heterosigma akashiwo, a toxic bloom-forming alga responsible for severe economic losses to the finfish aquaculture industry. This study suggests that a diverse, unexplored community of picorna-like viruses exists in the ocean that potentially infects economically and ecologically important hosts. Here, primer sets were used to target picorna-like viruses in a variety of marine environments, including the Arctic, the Strait of Georgia and the Gulf of Mexico.

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EUTROPHICATION OF COASTAL WATERS: A LARGE LAKE PERSPECTIVE

Like the Gulf of Mexico and Chesapeake Bay, Lake Erie's hypoxic "dead zone" has caused concern since 1970. Harmful algal blooms occur in both coastal marine waters and large lakes, although toxic marine dinoflagellates and diatoms are replaced by Cyanobacteria in lakes. Both water types undergo eutrophication primarily from non-point sources of nutrients, although in lakes phosphorus is more important than nitrogen in stimulating algal growth. To date, models of lake and marine coastal eutrophication have focused on the role of external and internal nutrient loading on algal growth, but have largely ignored the role of direct algal loading from rivers on hypoxia. However, Landsat-7 images from 18 August and 10 September 2003 show huge plumes of algae entering Lake Erie from both the Maumee and Sandusky Rivers, and these riverine algae can continue to grow after mixing with waters in the lake. Here, we use our extensive Lake Erie algal abundance and nutrient loading data from 1970 to 2002 to further compare and contrast patterns of eutrophication in large lake and marine coastal waters.

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ACCURATE AND PRECISE ANALYSES OF PRIMARY BIOLOGICAL ELEMENTAL POOLS TO SUPPORT ESTUARINE MESOCOSM EXPERIMENTS.

In performing relatively short time incubations with simple shipboard mesocosms, we analyze multiple pools of carbon and nitrogen as well as stoichiometric balances with oxygen, phosphorus, and silicon. Paired 300L mesocosms have been used to contrast different regimes of the estuary, different nutrient amendments, and manipulations of microbial populations. Incubations are monitored with precise measurements of dissolved inorganic carbon, dissolved oxygen, particulate matter, dissolved organic matter, and nutrients. Tracer additions of inorganic 13C and 15N are used to estimate the elemental uptake and transfer though the different biological size classes. Accurate and precise measurement of all parameters listed above allows detection of small changes within the mesocosm. Constant monitoring of manipulations made to the mesocosm can prove essential to the effectiveness of various treatments against contamination. A specific mesocosm study investigating NO3 vs. NH4 as primary growth substrate is discussed with emphasis placed on our ability to focus on microbial biogeochemistry.

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CAUSES AND IMPACTS OF EUTROPHICATION IN THE PECONIC RIVER ESTUARY, LONG ISLAND, NY

The brackish, riverine portion of the Peconic River Estuary (Long Island, NY) receives anthropogenic inputs from multiple point and non-point sources of contaminants, including a sewage treatment plant. A multi-year study revealed chlorophyll (up to 100 ug/L) and nutrient concentrations (> 50 uM DIN) in this region were elevated relative to the rest of the Peconic Estuary. Algal communities in this region were typically nutrient replete and dominated by a variety of potentially harmful phytoplankton such as Prorocentrum sp. Despite high levels of productivity in surface waters, poorly lit bottom waters were often net heterotrophic, potentially contributing to seasonally hypoxic conditions there. The severity of hypoxia in this chronically halo-stratified portion of the estuary increased during summer months and automated, hourly measurements of dissolved oxygen indicated that portions of the system can remain consistently hypoxic for week-long periods. Comparative analysis of inputs to this system revealed that the freshwater river may be an important source of pathogenic microbes, while nutrients originate from a mid-river source. Levels of toxic trace metals in shellfish from this system will also be presented.

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UPWELLING GENERATED HARMFUL ALGAL BLOOMS: A MODELING APPROACH

Harmful Algal Blooms (HAB) of the red-tide dinoflagellate Karenia brevis Davis (formerly Gymnodinium breve) routinely affect the typically oligotrophic Gulf coast of Florida, reaching densities of up to 2x10^6 cells/l, with resulting shellfish closures and fish kills. The cause of these explosive toxic alga growth events has been the subject of much speculation, from Saharan dust events, associated cyanobacterial blooms or intermittent upwelling. We utilize the Regional Ocean Modeling System (ROMS), a sophisticated, open-source physical oceanographic model to test for upwelling as the likely source of bloom initiation. We introduce a simplified modeling approach with very little site specificity, and a minimal imbedded biological model parameterized with K. brevis physiology that captures not only the typical location of bloom initiation, but also the spread rates as well. Furthermore, the extent of the wind generated upwelling is fundamental to the subsurface mixing, spread of the bloom, and the resulting scaling properties of the bloom pattern.

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CONNECTING DIMENSIONS: THE CHALLENGE OF HORIZONTAL AND VERTICAL SAMPLING OF PELAGIC FISH EGGS

Knowledge of the distributions of planktonic organisms is central to estimating their abundance and understanding their ecology. Study of the horizontal pattern in the eggs of northern anchovy (Engraulis mordax) and Pacific sardine (Sardinops sagax) on the scale of 100's m to km motivates questions about structure on finer scales, for which current in-situ video sampling systems do not suffice due to insufficient concentrations. Describing the vertical component of these highly aggregated distributions is even more challenging due to the inadequacy of traditional net sampling for separating vertical and horizontal elements of spatial structure. A physically based one-dimensional model is used to describe the vertical distribution of sardine and anchovy eggs. Its validation with samples from the California Current region is complicated by patchiness of the eggs of these species, calling into question the applicability of spatially simple models. Automated identification and counting of fish eggs in high-volume pumped flow while underway and an elaboration of this system to sample vertically are briefly described and may eventually help address the sampling problems posed here.

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RECORDS OF BIOGENIC FLUXES IN THE WESTERN ARCTIC OCEAN OVER THE LAST 10,000 YEARS

In order to understand present day changes in the oceanographic conditions of the western Arctic Ocean shelf, one must consider past changes and likely processes controlling them. As part of a paleoceanographic reconstruction of environmental conditions in the Chukchi Sea shelf, biogenic tracers were determined in a 4 m long piston core and companion box core from 201 m depth covering the entire Holocene. These parameters included organic carbon and nitrogen, sulfur, and biogenic silica, and Cd/Ca in benthic forams as a tracer of nutrient inputs. Near the Pleistocene-Holocene transition, organic C concentrations were quite low and C/S ratios suggest very low salinities. After this presumed large melt water input, organic C and biogenic Si record large biogenic fluxes (ca. 8 ky BP). For the next 4 ky, biogenic fluxes were relatively constant, suggesting stable environmental conditions in the water column. In the last millennium, pulses of biogenic Si, and org. C and N indicate large changes in productivity; some of these are associated with nutrient inputs (as recorded by Cd/Ca in forams). In comparison to the previous 9 ky, organic carbon fluxes were highest during this period. However, in the last 300-400 y, organic fluxes decreased to the present. Processes likely controlling these biogenic fluxes will be examined.

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ARSENIC AND PHOSPHORUS IN THE WESTERN ATLANTIC: NEW DATA FOR AN OLD PROBLEM

The toxicity of dissolved arsenic to marine phytoplankton is controlled not only by its concentration and speciation (i.e., AsV, arsenate), but also by the As/P ratio. If hypotheses that many ocean regions are becoming P limited are correct, then the As/P ratio will increase and potentially affect the abundances of phytoplankton that cannot either tolerate or detoxify arsenate (via reduction or methylation). Interestingly, the detoxification byproducts, arsenite (AsIII), and mono- and dimethyl As (MMAs, DMAs), could also act as indicators/integrators of P stress depending on their surface residence times. Data obtained in the western North Atlantic, including the Sargasso Sea, in Aug-Sept 2003 show that surface arsenate is 8-18 nmol/L, the same as or exceeding that of phosphate. The resulting As/P ratios are well into the toxic range, and indeed arsenite, DMAs, and MMAs (0.4-5.6 nmol/L) are ubiquitous in these surface waters. Vertical profiles revealed greater surface water depletion of arsenate than that found in other oligotrophic waters, while the corresponding production of arsenite and methyl As was restricted to the upper 100 m. Interestingly, the production of arsenite had a diel behavior, with highest concentrations just after sunrise. The implications of these results for phytoplankton communities in the Sargasso, and the time periods over which this As/P stress is integrated by reduced and methyl As, will be discussed.

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NUTRIENT SOURCES AND FATE IN THE COASTAL ZONE

We use a global ocean biogeochemistry model and observations to assess the relative importance of different nutrient sources and their fate in the coastal zone. We consider river inputs of N/P, Si, and Fe, vertical mixing/upwelling, and nutrient resuspension. We estimate the potential for each of these sources to sustain the high primary production observed in the coastal zone, and to influence the air-sea CO2 fluxes. Our estimates are based on a comparison between elemental budgets based on limited observations and model results for different nutrient input scenarios. Preliminary results suggest that high primary production in the coastal zone itself can be sustained by river Fe, nutrient resuspension and/or mixing/upwelling, but the influence of the coast does not spread to the open ocean when mixing/upwelling is dominant. We also present model results for scenarios of river input of N/P for a world population of 5 to 12 billion people. These simulations help to gain insight on the potential feedback on ocean biogeochemistry and CO2 that may result from anthropogenic influence in the coastal zone

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PREDICTION OF ZOOPLANKTON COMMUNITY STRUCTURE FROM OCEANOGRAPHIC DATA IN ARCTIC-ATLANTIC WATERS

We investigated the relationship between physical properties of water masses and the mesozooplankton community structure in waters around Svalbard. The physical parameters we focused on were average temperature and salinity over sample depth, spiciness as a function of salinity and temperature, as well as sea surface temperature. A regression analysis between these parameters and the relative abundance of Calanus finmarchicus, C. glacialis and C. hyperboreus, the three main mesozooplankton species in the North Atlantic and Arctic Ocean, indicated that variations in water temperature and spiciness can explain up to 60 percent of the variability in the distribution of C. finmarchicus and C. glacialis. Salinity, although a good indicator for water mass, was a weak parameter to account for variations in the relative abundance of the three Calanus species. For C. hyperboreus these parameters seemed to have little predictive value. No relationship between sea surface temperature and Calanus species composition could be established. Large-scale distribution patterns of Calanus spp., constructed from own data and data available from the literature coincided with water mass distribution and major current systems in the area.

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MODELING ANAEROBIC OXIDATION OF METHANE IN MARINE SEDIMENTS

Anaerobic oxidation of methane (AOM) is a widespread microbially-mediated process in marine sediments which acts as a sink for methane diffusing upward toward the sediment surface. As part of the METROL project (Methane Flux Control in Ocean Margin Sediments), we investigated AOM using a bioenergetic modeling approach combining kinetic and thermodynamic constraints. Microorganism ATP requirements and yields were estimated from the low amounts of Gibbs free energy available. Initially, we employed a zero-dimensional model to asses the parameter sensitivity and how biomass growth is affected by spatial constraints in the AOM region of marine sediments. Encouraging results at this stage showed that microorganism biomass was most sensitive to the mortality term, which had a large affect on the position of thermodynamic equilibrium, and was thus not spatially constrained. Presently, we are incorporating these findings into a fully diagenetic reactive-transport model using data collected from METROL cruises to European continental margins. The ultimate role of the modeling studies is to underpin the main controls of methane flux to the oceans and the consequent impact on the global carbon cycle.

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ALGORITHM FOR CHLOROPHYLL ESTIMATION IN CASE 2 PRODUCTIVE WATERS: THEORETICAL DEVELOPMENT, SENSITIVITY TO INTERFERING FACTORS, AND VALIDATION

For case 2 turbid productive waters, we describe the theoretical basis of an algorithm to retrieve chlorophyll-a (Chla) from reflectance spectra. The method is based on the following hypothesis: the parameter f/Q is a spectral constant and the backscattering coefficient is spectrally independent in the 650 – 750 nm range. The approximation obtained uses reflectance at three wavelengths: in the red, in the red edge, and in the near-infrared spectral regions. The analytical development presented and the hypothesis adopted, provide also a physical framework for the interpretation of band ratio algorithms that can be seen as a special cases of this model. To calibrate and validate the model, a large dataset was collected in order to cover an as wide as possible range of optically active constituents. Through sensitivity analysis and calibration we show how to increase the accuracy of Chla prediction by minimizing interferences due to variations in quantum yield of sun-induced Chla fluorescence and in Chla specific absorption coefficient. The validation results obtained using an independent dataset (r2=0.94 and mean percent error < 35%) corroborate the soundness of our initial hypothesis and the reliability of the model.

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AN EPIDEMIOLOGIC STUDY TO EXAMINE THE EFFECTS OF THE AEROSOLIZED FLORIDA RED TIDE TOXINS ON PEOPLE WITH REACTIVE AIRWAY DISEASE.

The Florida red tide, Karenia brevis, is a harmful algal species responsible for Neurotoxic Shellfish Poisoning in people. When the organism releases its toxins into the water column, the combination of wind and surf cause the toxin to enter the marine aerosol. When inhaled, these toxins cause itchy eyes, cough, and rhinorrea. When toxins are aerosolized in animal models, there is significant increase in airway resistance at picogram levels. An epidemiologic study is underway to identify the impacts of aerosolized toxins in people. One hundred and thirty people with the diagnosis of asthma or chronic lung disease perform a series of tests at the beach prior to exposure to marine aerosols and again after a one hour exposure. These field studies have been conducted during a Florida red tide and with no red tide. Preliminary results reveal a decrease in airflow and an increase in respiratory symptoms after only one hour exposure to the airborne toxins. Results of the study may provide improved information to the public, especially those with lung disease, when on shore red tide occurs.

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MESOZOOPLANKTON-INDUCED TROPHIC CASCADE EFFECT ON PICOPLANKTON IN THE NORTHEAST ATLANTIC

Understanding the complex dynamics and feedbacks of planktonic food webs is essential for the study of oceanic production. In principle, both bottom-up forcing (nutrient availability), which constrains the upper limit of plant productivity, and top-down forcing (grazing pressure), which keeps this productivity from reaching its maximum, control primary production. While there is plenty of evidence of top-down control in lakes, such evidence is less clear in the ocean. Apparently, cascading trophic effects dissipate at the zooplankton-phytoplankton link. However, the manifestation of trophic cascades depends on the number of steps in the food web, the size structure of the predators and prey, and food selectivity of the consumers. In this talk, we will present hypotheses that illustrate when trophic cascade effects should be clearly manifest. We will also present empirical evidence from a shelf region (Gulf of Maine, USA) and a slope region (120 nautical miles southwest of Nantucket, USA), of indirect trophic cascade effects induced by mesozooplankton on picoplankton.

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PHOTOPRODUCTION OF LABILE SUBSTRATES FROM DISSOLVED ORGANIC MATTER PRODUCED BY TRICHODESMIUM

The nitrogen-fixing cyanobacterium Trichodesmium spp. releases labile dissolved organic compounds that are potential nitrogen substrates for the surrounding plankton. One process that may be key to converting this dissolved organic matter (DOM) into labile forms is photochemical breakdown by UV light. In July 2003, rates of photoproduction of ammonium, nitrite, dissolved primary amines (DPA), and phosphate were measured in the oligotrophic waters of the Gulf of Mexico off St. Petersburg. Two sets of experiments were conducted with bulk water from the chlorophyll maximum with and without DOM produced by Trichodesmium added. Samples in quartz tubes were exposed to ambient sunlight with photoproduction rates measured at 3 hours and 12 hours. Ammonium and phosphate photoproduction was observed with rates being higher when Trichodesmium DOM was added. In contrast, significant decreases in nitrite concentrations was observed. No consistent pattern was seen in DPA concentrations. These data indicate that photoproduction is one mechanism converting DOM into labile nutrient forms in the Gulf of Mexico.

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NON ALGAL PARTICLES IN EXCESS MAY EXPLAIN SEA COLOR ANOMALIES IN SUBTROPICAL GYRES ROSSBY WAVES SYSTEMS

Sea-color anomalies in the oligotrophic subtropical gyres have been tentatively explained by nutrients supply through Rossby waves dynamics. In the South Pacific Sutropical Gyre, the anomalies are in warm water in convergences at the leading (trailing) edge of downwelling (upwelling) Rossby waves. We argue that these anomalies result from light retrodiffusion by non algal particles, rather than phytoplankton growth triggered by nutrients inputs. The blue to green reflectance ratio used to estimate chlorophyll indeed decreases when retrodiffusion increases. Convergence can concentrate buoyant particles near the surface. A model coupling a convergent mixed layer, floating particles dynamics, reflectances simulation, and the SeaWiFS algorithm, shows that even small amounts of floating particles generate a bias in SeaWiFS estimates of the same range as the anomalies. Two observations support this hypothesis. First, co-occurence of Rossby waves and chlorophyll anomalies fades out when wind is strong, as if turbulence mixed the particles into the water column. Second, chlorophyll measurements from 12 cruises in the South Pacific show that the difference SeaWiFS minus in situ chlorophyll is correlated with convergence of surface current.

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INVERSE MODEL ANALYSIS OF PLANKTON FOOD WEBS IN THE NORTH ATLANTIC AND WESTERN ANTARCTIC PENINSULA

We are investigating relationships between food web structure and function across different oceanic biomes using an inverse method to recover snapshots of food webs from sparse data. Specifically, we focus on how food web structure, as defined by the relative magnitude of C and N flows in a generic food web, influences particle export, nutrient regeneration, and dissolved organic carbon (DOC) cycling. Comparisons are made between inverse solutions for a North Atlantic food web, using data from the NABE (North Atlantic Bloom Experiment) study and for a western Antarctic Peninsula food web, using data from the Palmer Station LTER (Long Term Ecological Research) site. In the North Atlantic inverse solutions, the microbial food web, defined as the sum of flows of C or N that lead to recycling is much more significant than the short food web, defined as the sum of flows of C or N that lead to export from the surface ocean. In the western Antarctic Peninsula solutions, the short food web and microbial food webs process an equal amount of

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ADVANCEMENTS IN THE USE OF A NUCLEIC ACID HYBRIDIZATION BASED CAPILLARY WAVEGUIDE BIOSENSOR FOR MARINE MICROBIAL PROCESS STUDIES

The capillary waveguide biosensor (CWB) is a novel, fiber optic-based sensor for measuring the abundance of specific gene products (e.g. rRNA, mRNA), using nucleic acid hybridization. The CWB is composed of a laser light source that excites fluorescently-labeled oligonucleotide probe and target hybrids attached to the internal surface of a glass capillary tube. A low background (1:100 dilution) of fluorescent probe on the sensor surface provides an internal calibration for probe loss and day-to-day tube variations. The capillary provides a reaction chamber for hybridization under controlled, optimized conditions. We have been able to perform a successful series of competitive hybridizations using 16S rRNA extracted from Long Island Sound and Alexa 532 labeled synthetic target (E. coli Universal C sequence). The natural and synthetic targets have identical sequences and compete for available complementary probe sites. By measuring the fluorescence decrease relative to the varying ratios of natural to synthetic target, we could quantify the amount of natural target. The use of natural 16S rRNA provides the framework necessary for future field studies.

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SPECTRAL CHARACTERISTIC OF THE LIGHT BACKSCATTERING COEFFICIENT IN THE CASE 2 WATERS (BALTIC SEA) ESTIMATED FROM THE IRRADIANCE AND REFLECTANCE MEASUREMENTS.

The knowledge about inherent optical properties of the water like absorption and backscattering is necessary for effective remote sensing of plankton related parameters. The sufficient knowledge, especially regarding backscattering, is relatively poor in coastal waters or semi-enclosed seas – where the Baltic is a typical example.
Such situation results from difficulties in direct measurements of the backscattering function both with in situ and in vitro techniques. The study presents an indirect estimation of the backscattering coefficients, where vertical profiles of the diffuse attenuation coefficient for downwelling irradiance and remote sensing reflectance were used. The used data were collected on 27 cruises in the years 1993 – 2002, mainly in the southern part of the Baltic Sea, under various environmental conditions and in different seasons of the year. Nearly 1000 spectra of backscattering coefficients were calculated and analyzed.
Spectral characteristic of the backscattering coefficient related to the water constituents as well the range of seasonal and spatial variability is presented.

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SAND FILTERS FOR THE SHELF

The effects of permeable sediments on the biogeochemistry of coastal marine systems are becoming increasingly evident. Advective transport in such permeable beds supplies substrates and reactants at accelerated rates relative to molecular diffusion controlled, high-porosity, low permeability muds. This serves to increase the efficiency of carbon and nutrient cycling in these beds and the overlying water.

Marine ecosystem modeling has advanced substantially from the early days of N-P-Z (Nitrogen – Phytoplankton – Zooplankton) models. Today's ecosystem simulations deal with multiple nutrient sources, spectral optics, multiple phytoplankton functional groups and bacterial effects as well as 3-dimensional ocean circulation. Still, the sediments are not adequately treated. Research in continental shelf environments has shown that sediments can be significant sources of recycled nutrients and production. Still, it is difficult to parameterize centimeter scale processes in permeable sediments to kilometer scale grid boxes within a large-scale ecosystem simulation.

This study examines a method for such parameterization and presents the results of a benthic primary production simulation relative to measurements made in the water-column over the course of several months.

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CHARACTERIZATION OF A CELL-SURFACE PROTEIN ASSOCIATED WITH THE GIRDLE BAND REGION OF THE DIATOM THALASSIOSIRA PSEUDONANA

Copper pollution is increasing in the coastal marine environment. Although copper is required by organisms in trace amounts, at elevated concentrations it is a potent toxin. We have characterized a cell surface protein induced by exposure to elevated copper concentrations from the marine diatom Thalassiosira pseudonana. Originally identified as being greatly up-regulated in response to copper stress, this protein also has a low level of constitutive expression and is moderately up-regulated during silicon starvation. Under conditions of Cu toxicity and Si starvation the cells are observed to elongate in the girdle band region, and, based on immunofluorescent analysis, the induced protein is localized to this region. The protein has an apparent molecular weight of 150kDa, is glycosylated, and is predicted to contain three chitin-binding domains. The 150kDa protein likely plays a role during normal cell division and its localization suggests some involvement in valve formation or cell separation. The cell-surface protein complement of a diatom changes with exposure to environmental stress; as a result, cell surface-proteins can be used as markers that reflect the organism's physiological state in the environment.

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HYPERSPECTRAL IMAGING AS PART OF A COORDINATED SAMPLING OF COASTAL ENVIRONMENTS

The coastal ocean is a complex and dynamic environment. To obtain a coherent picture in three dimensions over time requires a coordinated sampling strategy involving ships, moorings, coastal radars and satellite remote sensing. Additional insight is gained by integrating the observations into physical and bio-optical models of the region. There is currently a focused effort towards building an Integrated Coastal Ocean Observing System (ICOOS). Much attention is being given to the in situ and land based measurement systems, and to the data system and modeling infrastructure. Here I address the satellite remote sensing needs for the coastal ocean. The primary issues are the need for temporal resolution sufficient to resolve currents from tidal and local wind forcing, and the need for spatial resolution compatible with the scale of coastal features. A planned geostationary hyperspectral imager could meet the coastal remote sensing needs in a timeframe compatible with the goals and schedule of ICOOS.

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GETTING SIZE SCALE FROM A SINGLE MOVING UNDERWATER CAMERA

Unmanned underwater vehicle (UUV) technology is increasingly being used for ocean research and exploration. UUVs include remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs). One of the opportunities this technology offers is the rich use of video and imagery for qualitative assessments of marine life. But there is also a growing future need for cost-effective tools for quantitative assessment of ocean resources in support of better resource management. A particular challenge is the development of cost-effective tools to provide 2D size information about objects imaged or recorded during mid-water survey transects by UUVs. In this paper we describe a simple, practical, and accurate algorithm for determining the size scale of mid-water organisms during transects by such systems using a single moving camera.

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SUBTERREANEAN GROUNDWATER, A POSSIBLE SOURCE OF MICROBIAL POLLUTION AT HUNTINGTON BEACH, CA, A RADIUM ISOTOPES STUDY.

Since the summer of 1999, Huntington State Beach, located in Orange County, CA, has been plagued by elevated levels of fecal indicator bacteria (FIB) causing beach closures and presenting a potential human health threat. Previous efforts to identify the source of the FIB have focused on watershed outlets to the south, a treated wastewater plume offshore, and a thermal outfall. All fail to show an obvious, direct link to FIB levels along the shoreline. One potential source, that has not been extensively studied, is subterranean groundwater discharge (SGD).

In this study, we use radium-223 and radium-224 activities as proxies for SGD, in conjunction with FIB levels in the surf zone at Huntington State Beach, to investigate the relationship between surf zone groundwater discharge and FIB abundance. Preliminary results show a correlation between Ra activities and FIB levels. In addition, significant spring-neap tidal variation in both records is detected. These data suggest that there might be a connection between water discharge from the unconfined coastal aquifer in Huntington Beach and FIB. The exact mechanism for such a relationship is being investigated.

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PERIPATRIC SPECIATION AND EVOLUTIONARY RADIATION OF MASTIGIAS (SCYPHOZOA) IN MARINE LAKES DURING THE HOLOCENE: AN ISLAND BIOGEOGRAPHY FOR THE SEAS?

Exceptions to the long-held belief that marine species are widespread and well-mixed are commonplace but still explained vaguely, often in terms of limited dispersal ability and hard-to-see barriers to gene flow that are poorly quantified. In many marine contexts it is difficult to ascertain a priori the likely connectivity between populations over evolutionary time. Consequently, extreme cases may illustrate particularly well the potential of evolution in marine organisms. Golden jellyfish (Mastigias) inhabiting land-locked marine lakes for approximately 10,000 years are behaviorally, genetically, and morphologically distinct; their population dynamics also differ as do their physiologies. Thus, in physical isolation and novel habitats, marine taxa can evolve extremely rapidly, an heterodox finding that is more typically associated with the evolution of terrestrial taxa on oceanic islands. This suggests the rich theory of island biogeography and associated disciplines, such as metapopulation dynamics, apply to marine taxa and have much to contribute to our understanding of patterns of and influences on marine biodiversity including methods of conservation - particularly marine protected areas.

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CHEMICAL STRUCTURE AND CYCLING OF DISSOLVED ORGANIC MATTER (DOM) IN THE SOUTHERN CALIFORNIA BIGHT

Studies examining the marine DOM cycle are significantly hampered by our limited knowledge of DOM structure. Here we describe the novel application of a solid phase resin to isolate a previously uncharacterized component of marine DOM for chemical studies and radiocarbon dating. Samples from the Southern California Bight were extracted and fractionated to investigate offshore and vertical (down to 1000 m) gradients in chemical structure. Each sample was fractionated based on hydrophobicity and characterized by various NMR techniques. Hydrophobic fractions contained mostly aliphatic resonances and polar fractions contained more heteroatom-substituted carbons and were chemically similar to ultrafiltered DOM. Based on 1H-NMR, surface samples were rich in substituted carbons while deep water samples were more aliphatic and homogenous than surface samples. Average d13C signatures confirmed the predominantly marine origin (-22.0 per mil) of these compounds with lighter values (-24.0 per mil) for lipid-rich fractions. Size exclusion chromatography and chemical degradation techniques were further applied to study molecular weight distribution and identify substructures within DOM. Fractionated samples were radiocarbon dated to determine their residence time in the surface and deep ocean.

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CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE; A NEW PARADIGM TO ENRICH COLLABORATION BETWEEN THE RESEARCH AND EDUCATION COMMUNITIES

Science education benefits from the participation of researchers in classroom and field-based enrichment programs. Given the time demands faced by researchers, and an evaluation system that places little priority on service activities for advancement, a variety of incentives have been used to motivate scientist participation in K-12 science education and public outreach programs. The advent of agency-driven outreach mandates, such as the Broad Impact Statement required by some NSF programs, provides a new incentive for researchers to translate research results to broad-based user communities. Scientists now seek guidance and collaborations to enrich exemplary materials and programs that advance ocean science education. The NSF-sponsored Mid-Atlantic Center for Ocean Sciences Education Excellence provides an excellent mechanism to improve the capacity for researchers and educators to collaborate. Successful collaboration requires an efficient investment of scientist and educator time, approaches that bring real-world science into a classroom setting, and development of mechanisms to sustain communication and interaction between the research and education communities.

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INITIATION OF RESEARCH CENTERS ON OCEANS AND HUMAN HEALTH

Oceans have become conduits for a number of environmental threats to human health. At the same time, oceans harbor diverse organisms that show great promise for providing new drugs to combat cancer and fight infectious diseases. To guard against such health threats and to take advantage of the medicinal benefits that oceans might provide, the impacts of the oceans on human health must be more fully explored and new research efforts directed to this area. Hence, the National Institute of Environmental Health Sciences (NIEHS) and the National Science Foundation (NSF) joined together to bridge their respective expertise in biomedical and oceanographic sciences to address the interplay between marine processes and public health. NIEHS and NSF will support a coordinated set of Centers on Oceans and Human Health, focused on three primary research areas: harmful algal blooms; water- and vector-

borne diseases; and marine-derived pharmaceuticals and probes. These Centers will provide for a national network of investigators and will foster an interconnected research approach dedicated to understanding the physical, chemical, and biological complexities linking oceans and human health.

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DISTRIBUTION AND DYNAMICS OF OXYGEN IN COASTAL SEDIMENTS: STUDY BY IN SITU MICRO-ELECTRODES

In shallow aquatic environments, processes controlling preservation and recycling of organic matter is largely governed by the oxygen cycle. In order to understand aerobic mineralization of coastal sediments, the french National Program on Coastal Environments (PNEC) focuses on the oxygen distribution and dynamics of benthic sediments of the Thau lagoon (Mediterranean Sea, France). During seasonal cruises high spatial resolution measurements (sub-millimetric) by in situ micro-electrodes of oxygen, pH and resistivity profiles where obtained at two different stations: C5 (nearly oyster parks) and C4 (in the middle of the lagoon) situated in a biogeochemical gradient. Oxygen profiles measurements, diffusive oxygen fluxes and consumption calculations show a substantial temporal variability (seasonal and daily times scales) and is significant in oxygen budgets. Oxygen demand appears larger in C5 with a large organic loading due to oyster parks compared to C4 with less anthropogenic impact. They reach maximum values during the spring period of phytoplankton bloom. To improve understanding of the dynamics of biogeochemical cycles and the determination of processes controlling oxygen, a model representing early diagenesis was used which takes into account seasonal biochemical cycles.

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PELAGIC TUNICATES: CONSUMERS AND CONSUMED

Although Mike Mullin is best known for his work on copepods, he also did seminal work on salps. In the ensuing 20 years there has been exponential growth in research on tunicates. We now know something of their role as consumers and prey. Tunicates ingest a wide size range of particles, from large diatoms to sub-micrometre colloids. While the selection of small particles is similar among groups, selection of large particles is dependent upon species-specific differences in body size. However, the ingested ration of most tunicates comes from nanoplankton-sized particles. Recent biomarker work we have done in the Beaufort Sea (BS) indicates that appendicularians consume riverine materials by virtue of non-selective feeding. Tunicates are not a trophic dead end, but are consumed by a variety of invertebrate and vertebrate predators. A stable isotope study by Parsons in the BS suggests separate 'copepod' and 'appendicularian' food webs, terminating in Arctic cod and rainbow smelt, respectively. There is still much to be learned of the retention efficiency of small particles, of population patch scales and of their nutritional significance to predators.

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ORGANIC MATTER CHARACTERIZATION WITHIN HYPOXIC AREAS OF THE NORTHERN GULF OF MEXICO

Because the occurrence of summer hypoxia within bottom waters of the northern Gulf of Mexico is largely an effect of organic matter cycling, a description of the types of organic matter and their relationship to organic carbon is important for the study of hypoxia persistence and onset. Sampling was conducted within and around areas experiencing bottom hypoxia in the northern Gulf of Mexico. Absorption and fluorescence spectroscopy of chromophoric dissolved organic matter (CDOM) and total organic carbon (TOC) concentration were used to contrast organic matter composition within hypoxic areas and non-hypoxic areas. Ratios of TOC to CDOM were examined to determine changes in the source of carbon and, thus, the longevity of hypoxia. Preliminary analyses show that CDOM absorption spectra from samples collected in hypoxic areas differ from spectra of samples collected in areas not affected by bottom-water hypoxia.

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OPTICAL CONSEQUENCES OF CHANGES IN ORGANIC MATTER COMPOSITION IN THE MISSISSIPPI RIVER PLUME

Color remote-sensing can be used to study the biogeochemical processes that control the fate of organic carbon in river-dominated margins. To do so, one must understand how changes in organic matter concentration and composition affect its optical properties. We used data from five research cruises to the Mississippi River Plume to evaluate seasonal variability in optical properties and concentration of organic matter, and how these properties change along the river plume. We also evaluated how these changes affect estimates of remote-sensing reflectance. Results showed that mixing processes controlled concentration and optical properties of organic matter. Seasonal variability appeared to be controlled by river flow. Changes in optical properties of organic matter controlled remote-sensing reflectance over most of the river plume. Strong correlations between organic matter concentration and absorption coefficients allowed to use remote-sensing reflectance to estimate concentrations of organic matter in coastal waters.

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SPATIAL AND TEMPORAL VARIABILITY OF THE OPTICAL PROPERTIES OF CHROMOPHORIC DISSOLVED ORGANIC MATTER (CDOM) IN THE WESTERN TROPICAL ATLANTIC OCEAN

The CDOM distribution was investigated in the western Tropical Atlantic Ocean (Amazon River plume) during winter, spring and summer seasons. The CDOM optical signal was below instrument detection limit during low river flow season (winter) and did not correlate with salinity. Considerably larger signals were observed during spring and summer (increasing river runoff) that showed an inverse linear dependence on salinity. These results strongly suggest a terrestrial origin for CDOM off the coast of South America. Departures from this mixing line were observed that suggested local sinks (photodegradation) as well as sources (in situ production) for this material. A photobleaching model will be applied to these shelf waters to test our hypothesis of sunlight degradation of CDOM in mixed layer. Downward departures from this mixing line were instead coupled to near-surface high chlorophyll regions (< 20 m) due to blooms of colonial diatom Hemiaulus suggesting in situ addition of CDOM despite more work is needed to support this hypothesis. Overall, CDOM distribution indicates that the Amazon River outflows northward parallel to the South American coastline reaching > 1000 kilometers offshore.

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THE IMPACT OF THE GEOCHEMICAL PROPERTIES REDISTRIBUTION IN THE WESTERN MEDITERRANEAN DUE TO THE EASTERN MEDITERRANEAN TRANSIENT

Recent studies definitively evidenced the sensitivity of the Mediterranean to the effects produced by the large-scale atmospheric systems. In fact, interannual variability of the circulation may, in some regions, prevail on the variability embedded in the annual cycle. The exceptional production of deep water in the Aegean straits region, which triggered the Eastern Mediterranean Transient (EMT), is a very good example of the above. The EMT caused a redistribution of hydrographic parameters in the Eastern basin, but the timing and the amplitude of the transfer of the EMT signal in the Western basin has been seldom analyzed to date. The analysis of a bi-decadal time series of TS data in the Sicily channel allowed to trace the effects of the EMT on the water masses crossing the Sicilian straits as well as their characteristics in the Tyrrhenian Sea. The scope of the present study is, instead, to determine to what extent those changes affected the nutrient distributions in the Tyrrhenian sea, and to discuss what could the impact be on the trophic functioning of the western basin.

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BEHAVIOUR OF REDOX-SENSITIVE TRACE METALS IN A FRESHWATER INFLUENCED BACKBARRIER TIDAL FLAT, NW GERMANY

Intertidal areas form the transition between the terrestrial and marine environment and are potential trace metal and nutrient sources for the ocean. Geochemical signatures of the Wadden Sea water column of NW Germany show distinct tidal and seasonal variations, which are controlled by microbial activity. Mn shows highest concentrations in the water column during low tide in summer due to the contribution of extremely Mn-rich porewaters draining out of the sediments during ebb current. A similar but less pronounced behaviour is observed for V, while Mo and U behave conservative and follow salinity. Only during summer Mo changes its behaviour indicating a strong coupling to the Mn-cycle. Particles are also enriched in Mn and Mo due to microbial Mn-oxidation accompanied by scavenging of Mo. During winter the freshwater of small coastal tributaries becomes more significant as evidenced by balance calculations and gelbstoff fluorescence. The freshwater is extremely rich in dissolved organic matter as well as dissolved and particulate metals. Therefore, the freshwater contribution, although of small volume, cannot be neglected when performing elemental mass-balance calculations on the Wadden Sea environment.

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INTERANNUAL VARIATION IN THE PHYSICAL AND BIOLOGICAL ENVIRONMENT OF CAPE COD BAY AND ITS SUITABILITY AS A RIGHT WHALE FEEDING GROUND

Cape Cod Bay is the only known winter feeding ground of the North Atlantic right whale, a seriously endangered species, and is thus a critical habitat for right whales. As with most coastal ecosystems, Cape Cod Bay is very dynamic with a high degree of variability in both physical and biological parameters. However, the spatial and temporal extent of these fluctuations and their effect on the suitability of the Bay as a right whale feeding ground is not known. Data collected over the course of four years, encompassing years when whales exhibited regular use of the Bay (2000, 2001) and years during which their use was limited (2002, 2003) were analyzed. There were significant differences among years in both physical (SST, salinity, depth/strength of thermocline) and biological (fluorescence, zooplankton abundance, composition, and distribution) data. These variations in the physical and biological environment of Cape Cod Bay determine the value of this habitat to right whales and impact their seasonal utilization of the Bay as a feeding ground.

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MODELLING EFFECTS OF COMMUNITY STRUCTURE ON THE BIOGEOCHEMICAL RESPONSE TO IRON FERTILIZATION DURING THE 2002 SERIES EXPERIMENT

During the initial 10 days of the 2002 SERIES iron fertilization experiment in the subarctic NE Pacific Ocean, the smaller size classes of phytoplankton, including calcifying coccolithophorids, dominated the enhanced biomass. Subsequently, diatoms bloomed and dominated the phytoplankton biomass. We simulated the iron enrichment and response with a 1-D coupled ecosystem-mixed layer model that had been developed for Ocean Station P (50N, 145W). The ecosystem model includes two size classes of phytoplankton, microzooplankton, an imposed time-varying mesozooplankton grazing based on long term observations at OSP, sinking particulate organic matter (POM), ammonia and nitrate. Nutrient uptake is regulated according to a preference algorithm calibrated from Canadian JGOFS observations, and bacteria-mediated nitrification occurs via a light dependent algorithm. The intensity and length of the bloom response is regulated by the rate of disappearance of iron. Drawdown of CO2 during the bloom is sensitive to the assumed proportion of the small size fraction of phytoplankton that is coccolithophorids, but long term observations of alkalinity constrain the likely upper limit of coccolithophorids in the population at OSP. The sensitivity of the sinking of POM to diatom aggregation is also explored. It is hoped that analyzing purposeful fertilization experiments can be used to learn more about the interplay between community structure and biogeochemical cycles at regional and global scales.

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DYNAMIC TUNING OF INSECT AND BIRD WINGS AND COPEPOD AND DAPHNIA APPENDAGES

Compressible flow theory suggests, and dimensional analysis and growing empirical evidence confirm that, to aid flight, many insects and some birds, notably hummingbirds, tune their wing-beat frequency to a corresponding characteristic harmonic frequency of air. The same property that governs the physics of acoustics, the compressibility of air and water, helps insects to fly and small aquatic animals to swim and capture food. The basic principle is simple, all the animal has to do to hover, is to beat its wings at exactly half the natural compressive frequency of air, or water. Using insect flight to illustrate, if at the tuned frequency the insect achieves maximum compression below the wing at mid-downstroke, then the elastic properties of air will achieve maximum recoil decompression at the bottom of the stroke followed by maximum compression on the subsequent upstroke. The opposite is true above the wings. Albeit not as great as on the downstroke, the animal gets a free boost on the upstroke. The phenomenological governing variables are identified and the wing-beat frequency is derived from dimensional analysis and physical reasoning.

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OCEAN MODEL SENSITIVITY TO BATHYMETRIC CONDITIONING

The Navy Coastal Ocean Model (NCOM), implemented for the California Current System (CCS) domain (30N-49N), is used to study the sensitivity of a numerical ocean model to bathymetric conditioning. The California-Oregon-Washington coastal region encompasses rich land/sea-floor topography with a variety of unique and prominent features that significantly influence the circulation and ecosystem responses. The NRL NCOM-CCS model has 9 km horizontal resolution and is configured to run either as a sigma or as a hybrid (sigma-z) vertical coordinate model. The model is forced by 9 km COAMPS-Reanalysis surface wind stresses and uses initial and boundary conditions from the ⅛-degree global NCOM simulation. Several simulations were conducted with different pre-conditioned bathymetries, starting with ETOPO5, to study the impact of smoothing and the effects of boundary mismatches. The sensitivity to the choice of the coordinate system is also examined by comparing solutions using sigma coordinates with those using the hybrid (sigma-z) coordinate system.

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BROAD-SCALE PATTERNS OF MARINE NON-INDIGENOUS SPECIES ALONG THE US WEST COAST SANCTUARIES AND RESERVES

Despite the many measured impacts of marine non-indigenous species (NIS), large-scale invasion patterns and their underlying mechanisms remain poorly resolved. To test hypotheses about spatial and temporal patterns of marine invasions, the National Estuarine Research Reserve System, the National Marine Sanctuary Program, and the Smithsonian Environmental Research Center's Marine Invasions Laboratory have initiated a program for standardized field measures to evaluate various patterns of marine and estuarine invasions along the US west coast. We will present an overview of our measures to date and our current efforts now underway focusing on the fouling community. We will consider whether our preliminary data support the hypotheses that a) the number and proportion of NIS are greater in estuaries and embayments than in more exposed marine habitats, b) the number of NIS decreases with increasing latitude, and c) along the marine to estuarine gradient at a given latitude, the percentage, but not number, of NIS increases with decreasing salinity. We will also discuss variation in shipping and the extent to which this explains observed invasion patterns.

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TOOLS TO SUSTAIN THE INTEGRITY OF RAPIDLY URBANIZING ECOSYSTEMS IN THE COASTAL SOUTHEAST

Urbanization of land in coastal regions is occurring at approximately 1.5 times the national average rate (175 acres/h). Rapid development along the Georgia and South Carolina coasts challenges the capacity of managers and planners to protect resources and ecosystems. The Land Use-Coastal Ecosystem Study (LU-CES), a five-year project funded by the NOAA Coastal Ocean Program, is responding to the need for data and tools by which decision makers can address these challenges. After three years, LU-CES researchers have developed a validated finite-volume tidal prediction model, and an eight-county urban growth model for predicting development trends in coastal South Carolina to the year 2035. In addition, researchers are close to completing a landscape-scale, development-scenario model and have identified specific urban land use features that are associated with contamination of salt marshes by synthetic organic compounds. Finally, a model has been developed for a cross-disciplinary portal to make technical information in the LU-CES data bases accessible to non-technical users.

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OXYGEN CONSUMPTION, DENITRIFICATION AND SULFATE REDUCTION IN ARCTIC CONTINENTAL MARGIN SEDIMENTS

We have determined pore-water oxygen and nitrate profiles as well as sulfate reduction on four SBI, cross-margin transects in the western Arctic (Bering-Beaufort seas). At all transects oxygen penetration was less than 1 cm when the overlying water depth was less than 200 m but increased dramatically with increasing water depth to 2-3 cm at 3000 m near Barrow Canyon and 10-20 cm further west. Nitrate penetration depths were comparable to oxygen at shallow stations but became much greater at deeper stations. Diffusive oxygen and nitrate fluxes were calculated from the profiles and varied from 5.5 to 0.6 mMoles/m2/d for oxygen and 0.58 to 0.17 mMoles/m2/d for nitrate. Sulfate reduction rates varied between 2.1 and 0.01 mMoles/m2/d per day and also decreased with increasing water depth. Overall carbon oxidation rates calculated from the three electron acceptor fluxes were between 6.3 and 0.77 mMoles/m2/d. Rates Barrow Canyon sections were similar to those along the productive U.S. west coast and significantly higher than further west. Higher rates near Barrow Canyon may be due to off-shelf transport of organic matter through the Canyon.

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THE MULTI-DISCIPLINARY OCEAN SENSORS FOR ENVIRONMENTAL ANALYSES (MOSEAN PROGRAM

The Multi-disciplinary Ocean Sensors for Environmental Analyses and Networks (MOSEAN) project is developing and testing new technologies for increased observations to solve a variety of interdisciplinary oceanographic problems in the coastal and open ocean. These

include: biogeochemical cycling, climate change, ocean pollution, harmful algal blooms, ocean ecology, and underwater visibility. To accomplish this objective, MOSEAN partners are installing two testbed moorings, and developing, interfacing, and testing new interdisciplinary sensor suites on them. The sensors and systems are being designed for use with a variety of stationary and mobile, autonomous, unattended sampling platforms. The project goal is to provide operational sensors and systems capable of measuring biological, chemical, geological, and optical variables to complement physical data suites on time scales from minutes to months and space scales from a meter to 100's of kilometers. Designed for real-time and/or near real-time data telemetry capabilities, one mooring platform for MOSEAN will be located off Hawaii (HALE-ALOHA) in early 2004 and the other has already been deployed within the Santa Barbara Channel (CHAnnel Re-locatable Mooring, CHARM).

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A DECADE OF HIGH TEMPORAL RESOLUTION INTERDISCIPLINARY OBSERVTATIONS USING THE BERMUDA TESTBED MOORING

The Bermuda Testbed Mooring (BTM) program began in 1994 and continues to present (sponsorhip of NSF, ONR, NOPP (O-SCOPE), and NASA). The BTM has been used for scientific studies, development and testing of new oceanographic instrumentation, and validation of ocean color data. BTM data have been used for investigating interdisciplinary processes spanning minutes to years in time scale. Observed phenomena have included multiple hurricanes (most recently the direct overpass of Hurricane Fabian), eddy and mesoscale feature passages, transient phytoplankton bloom and bust sequences, and zooplankton migrations. A variety of multi-spectral optical, chemical, and biological variables have been sampled by a diverse team of investigators. Several modeling efforts have also utilized the BTM data sets. Some of the key scientific and technological results enabled by the BTM activity are highlighted along with a vision of future observational strategies.

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HYPERSPECTRAL SIGNATURES AND REMOTE SENSING OF A RED TIDE EVENT IN MONTEREY BAY USING AVIRIS AND PHILLS2 AIRBORNE IMAGERY

Multi-channel ocean color sensors can be effective at determining chlorophyll concentrations in the primarily Case 1 waters of Monterey Bay, California. However, large red tides can be prevalent in this region. These events change the optical characteristics of the water column. We present in situ and remotely sensed multi- and hyperspectral data of a non-toxic red tide event (Ceratium) that occurred within Monterey Bay in October 2002. The standard remote sensing algorithms for determining chlorophyll fail under these red tide conditions and chlorophyll can be greatly overestimated. Moreover, the peak of the red tide spectrum occurs in a region (570 nm) that is not characterized with multi-channel ocean color sensors such as MODIS and SeaWiFS. Remotely sensed data collected with the AVIRIS (17 m) and PHILLS2 (1 m) sensor are used to map the extent of the red tide event in Monterey Bay. In addition, the high spatial resolution of the imagery affords much greater detail of biomass distributions and current flow within the bay. The red tide event was preceded by a complete flushing of the bay with less saline water from the north that may have contributed to the red tide bloom formation.

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INFLUENCE OF IRON ON ALGAL COMMUNITY COMPOSITION AND PHYSIOLOGICAL STATUS IN THE PERU UPWELLING SYSTEM

Diagnostic indicators were used to assess the impact of Fe-limitation on algal species composition. Photosynthetic efficiency of PS II and the Flavodoxin-index provided physiological evidence of the effects of variable Fe-concentrations on algal species composition in the eastern Equatorial Pacific Ocean. Algal species composition was determined using Chemtax analysis of HPLC pigment data. Highly dynamic spatial variability in the algal assemblage was observed in this region with cyanobacteria and Phaeocystis populations dominating the low Fe offshore HNLC region. Threshold Fe values inducing Fe-limitation (as evidenced by the Flavodoxin index) were in the range of 0.2 to 0.4 nM and were dependent on the algal species composition. Cryptophyte and haptophyte algal populations dominated in the low Fe waters off the Peru upwelling compared to large diatom blooms in the high Fe region near the Peru coast. Dynamic physical forcing, however, led to significant variability in the algal species composition and physiological health of the population in the upwelling region. Effects of ambient Fe-concentration on the photosynthetic efficiency and Fe nutritional status of algal populations will be presented.

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CIRCULATION AND PROPERTY FLUXES OVER THE CHUKCHI PLATEAU – MODEL RESULTS

Circulation in the western Arctic Ocean and over the Chukchi Plateau is not well understood. Mass and property fluxes in the region are investigated using a pan-Arctic model configured at a 1/12-degree and 45-level grid. Results for analyses are from a 23-year integration forced with realistic 1979-2001 atmospheric data. Velocity at three depth intervals, mean transports and fluxes are investigated to identify the main current pathways and directions. Variability is determined by comparison of results a decade apart. The mean velocity fields describe a cyclonic circulation pattern with increased intensity during the late 1980s and early 1990s. The meander through the Chukchi Borderland Pass is identified as the primary pathway for boundary flow across the Chukchi Plateau. The northern Chukchi Plateau is modeled as a major region of exchanges between boundary flow and the Canada Basin interior and it appears to be an area of net upward heat transport. Northward flow along the eastern side of the Northwind Ridge is identified as a mechanism for freshwater advection from the Chukchi shelves into the interior.

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SIZE VARIATION OF VESTIBULE IN KRITHE GNOMA: CORRELATION OF PHYSICAL-CHEMICAL PROPERTIES AND POTENTIAL TO PALEOCEANOGRAPHIC ANALYSES

The Brazilian continental shelf presents tree association of ostracodes: Southern, Transitional and Northern/Eastern. In shelf, specimens of Krithe gnoma recovered from Holocene sediment collected in Southern region have their vestibule analyzed. Considering that hypotheses of Peypouquet, which establishes a relation inversely proportional between the size of vestibule and oxygen content of sea water masses, the present work deals with a quantitative analyze of this structure. Each sample considered for analyze, it was collected from areas with distinct taxes of oxygenation. Only left valves of adult females were used. As result, the relation proposed by Peypouquet was corroborated. These results are the first to corroborate this hypotheses and, considering the stratigraphic wide distribution of Krithe gnoma (?Late Eocene/Miocene, Pelotas and Santos basins), it is open a perspective of application of this relation for paleoceanographic studies, as indicator for oxygen content.

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NUTRIENT AND SELENIUM DYNAMICS IN A SHALLOW WATER SYSTEM

In September 2001, we conducted a process study in a shallow freshwater "lake" in the San Francisco Bay-Delta—Mildred's Island. We sampled three stations: the northern channel, the north-east entrance, and the south-east corner (Chl max). Steady concentrations of chloride (a conservative mixing tracer) at the Chl max site indicated advection was minimal, and any observed changes in nutrient and trace element concentrations at this location were due to internal processes. With respect to nutrients, nitrate draw-down preceded production of particulate organic carbon and nitrogen and followed Redfield ratios. A similar pattern was also observed for the trace element Se, with dissolved organic Se draw-down preceding an increase in particulate Se. Interestingly, changes in dissolved Se were mainly due to dissolved organic Se dynamics, indicating (1) uptake of organic selenide by the biological community-a first time observation in situ; and (2) rapid recycling of particulate organic Se to dissolved forms. Given our observations, it is clear that such habitats present a unique opportunity for investigating the interconversion of dissolved and particulate constituents, which would otherwise be obscured by water flow.

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QUANTIFICATION OF SULFATE- AND IRON(III)-REDUCING BACTERIA WITH REVERSE TRANSCRIPTION REAL-TIME PCR IN BIOTURBATED AND NONBIOTURBATED SALTMARSH SEDIMENTS

Sulfate and iron(III) minerals are the predominant terminal electron acceptors utilized during organic matter decomposition in southeastern saltmarsh sediments. Depending upon the Fe(III) supply, which is effected by bioturbation, iron(III)-reduction can comprise > 50 percent of total sediment carbon oxidation; however, very little is known about the ecology of marine iron(III)-reducing bacteria (FeRB). FeRB were characterized from bioturbated [iron(III)-rich] and nonbioturbated [iron(III)-poor] sediments by cloning and sequencing of 16S rRNA genes from the highest positive dilutions of a most probable number enrichment culture assay. Gene sequences most closely related to uncultured members of the Geobacteraceae family were predominant amongst sequences retrieved from all iron(III)-reducing enrichments. PCR primers specific for these 16S rRNA genes and other phylogenetic groups of known sulfate and iron(III)-reducing bacteria were designed and tested for reverse transcription real-time PCR. The specificity and efficiency of these primer sets was determined empirically and used to quantify the relative abundance of the different phylogenetic groups in depth profiles of bioturbated and nonbioturbated sediment, as well as in radial profiles from macrofaunal burrows and the root zone of Spartina alterniflora.

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THREDDS (THEMATIC REAL-TIME ENVIRONMENTAL DISTRIBUTED DATA SERVICES): INTEGRATING ENVIRONMENTAL DATA AND ANALYSIS TOOLS INTO DIGITAL LIBRARIES

THREDDS is building the infrastructure for a science data web that will facilitate the publication, discovery, and use of environmental data. This work, which is being conducted as part of NSF's NSDL initiative, will expand the means by which learners—including students, educators, scientists, and the general public—can access and use the vast resources made available by Web publication of multimedia documents to perform their own inquiries. The work is being achieved by providing coherent access to a large collection of real-time and archived data sets from a variety of sources at a number of distributed server sites. The datasets will be conveniently accessible from a wide variety of THREDDS-enabled data analysis and display tools. THREDDS second generation will integrate the current systems with those of the Geographic Information Systems (GIS) community via the protocols specified by the Open GIS Consortium. THREDDS will play an active role in a new Data Services initiative within the Digital Library for Earth System Education (DLESE) by hosting a series of annual workshops in which data providers, technology experts, and educational module developers will employ THREDDS technology to incorporate remote datasets and tools into interactive learning materials as part of the online Earth Exploration Toolbook. This work will insure that the available datasets will be usable by teachers in educational settings to teach specific concepts.

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MECHANISMS CONTROLLING THE DYNAMICS AND IMPACTS OF THIN LAYERS

A series of recent studies have provided evidence that thin plankton layrers can occur in a variety of stratified coastal systems and dramatically affect biological dynamics. Herein we will present a conceptual model that summarizes how a series of biological, physical and chemical processes and their interactions can control thin layer dynamics. Examples from a variety of coastal systems will be used to illustrate these mechanism and their impacts.

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AN EXAMINATION OF SPECTRAL SIGNATURES FROM CASE 2 WATERS USING EMPIRICAL MODE DECOMPOSITION

A relatively new analysis tool, Empirical Mode Decomposition, is used to examine the spectral characteristics of Case 2 waters within and surrounding Mississippi Sound and Mobile Bay. EMD is an adaptive, highly efficient method that can be used to decompose a complicated data set into a finite and often small number of intrinsic mode functions (IMF). These IMFs exhibit sinusoidal character and are defined as follows: Any function is an IMF if (a) in the whole data set, the number of extrema and the number of zero-crossings is either equal or differs at most by one, and (b) at any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima is zero. We employ this method on hyperspectral data collected from hand-held spectrometers and PHILLS II, an airborne hyperspectral imager. The objective of this work is to examine the IMF's for unique signatures that characterize a specific water mass type in terms of its various constituents, such as salinity, organic and inorganic matter components, among others.

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THE SUBTROPICAL NUTRIENT SPIRAL

We present an extended series of observations and more comprehensive analysis of a tracer-based measure of new production in the Sargasso Sea near Bermuda using the 3He flux gauge technique. The estimated annually averaged nitrate flux of 0.84 ± 0.26 mol m-2y-1 constitutesonly that nitrate physically transported to the euphotic zone. The flux estimate is quantitatively consistent with other observations, including decade time-scale evolution of the 3H+3He inventory in the main thermocline and export production estimates. However, we argue that the flux cannot be supplied on the long term by local diapycnal or isopycnal processes. We propose a 3-D pathway whereby nutrients remineralized within the main thermocline are returned to the seasonally accessible layers within the subtropical gyre. The "the Nutrient Spiral", is a sequence of steps where nutrient rich thermocline waters are entrained into the Gulf Stream where enhanced diapycnal mixing or seasonal convection moves nutrients upward onto lighter densities and detrainment and enhanced isopycnal mixing injects these waters into the seasonally accesible layer where become available to biota via eddy heaving and wintertime convection. The spiral is closed when nutrients are utilized, exported and then remineralized within the thermocline.

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THE RELATIONSHIPS BETWEEN SEDIMENT PARTICLE SIZE AND ITS ORGANIC GEOCHEMISTRY IN ESTUARINE SEDIMENTS.

The relationships between sediment particle size and its organic geochemistry and biological reactivity are poorly understood in estuarine sediments. Processes such as hydrodynamic sorting and microbial degradation are likely controls on influencing the ultimate lability and geochemical characteristics of particles in coastal sediments. Knowledge of these relationships will improve our understanding the dynamics of natural and anthropogenic aromatic carbon cycling in estuary.
Particle size fractions of 500-250 µm, 250-125 µm, and 125-63 µm were obtained from freshwater and estuarine sediments in the Chesapeake Bay in September of 2003. Particle size and percent organic carbon seem to be inversely correlated, suggesting that smaller particles are more rich in organic carbon. Because of this relationship, we suggest that bacterial productivity is higher on smaller particles, which may also contain higher proportions of lignin. We propose that, as particle size decreases, more aromatic organic carbon is available for bacteria production,, and we expect high mineralization rates of two anthropogenic aromatic compounds (phenanthrene and trinitrotoluene) found in contaminated sediments.

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NEURAL NETWORK CLASSIFICATION OF FISHES USING HIGH FREQUENCY SIDE SCAN SONAR DEPLOYED FROM A FETCH-CLASS AUTONOMOUS UNDERWATER VEHICLE

Effective fisheries management is directly linked to quality of available fisheries data. We demonstrate a novel approach to improve stock assessment. The technique uses a Radial Basis Function Artificial Neural Network classifier to discriminate and enumerate selected fish species from high-resolution sidescan sonar images acquired with a Fetch-class Autonomous Underwater Vehicle. The classifier was trained to successfully discriminate sharks (Carcharias taurus) and jacks (Caranx hippo) from other species. Sonar data collected using an AUV, rather than a towfish, have several advantages: useful images can be gathered under rough seas, when towfish cable heave distorts imagery; the AUV was immune to artifact-inducing, boat electrical noise; and auxiliary sensors (video, CTD, dissolved oxygen, pH) can be used on the AUV to simultaneously characterize the water column and habitat. Fish avoidance reactions are also lessened with use of AUVs. AUVs equipped with automated species classification tools allow unobtrusive documentation of fish stock behavior and population size, yielding data to better tune stock assessment models. We predict that similar automated classification tools will also be valuable for delineation and characterization of essential fish habitat.

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UNSTEADY BURROWING BY CRACK PROPAGATION

Building on a model of bubble movement through sediments developed by Bernie Boudreau and Bruce Johnson of Dalhousie University, we suggest that many infaunal species burrow by crack propagation. Tellinid and protobranch clams are wedges, but worms likely also use this mechanism. The 'point' d'appui classically considered to anchor a clam or worm exerts moderate radial compressive stress. This force, through linear elastic behavior of the medium, focuses strongly at the tip of the burrow, where cohesive bonds break, propagating a crack for the animal to follow. Gelatin is a realistic analog for muddy sediment, enabling visualization of burrowing and novel application of photoelastic stress analysis. This method estimates forces without edge effects from transducers or walls that have been present in most previous studies. Forces determined call into question the reputed great expense of burrowing as a form of locomotion and invite reinterpretation of body shapes and motions of many burrowers. Incorporating realistic material constraints will improve understanding of burrowing mechanics. New questions raised include geochemical, mechanical and stratigraphic consequences associated with the dynamics of crack propagation and annealing.

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CHARACTERIZING THE RATIO OF ALGAL LOSS TO PRODUCTION: INSIGHT INTO THE STABILITY OF PELAGIC MARINE ECOSYSTEMS AT GLOBAL SCALE

Satellite-based estimates of chlorophyll a and primary production have provided an unprecedented perspective phytoplankton dynamics at the global scale. Only a few studies have used the same satellite data to characterize the loss terms associated with biomass variability. Loss rates are a major gap in our understanding of pelagic ecosystems. The total loss rate (L) is easily obtained from the equation dB/dt=P-L, if the biomass (B) and primary productivity (P) are known. To date a major obstacle in using satellite data to study algal loss rates is that dt has been too large, i.e. typical cloud free global coverage ~ 30 days. With the advent of the SeaWiFS and MODIS sensors, almost perfect cloud free global coverage is obtained within an 5-day period, a more relevant time step for studying phytoplankton loss terms. Based on 5-day calculations, monthly global composites of L were derived, as well as monthly composites of the parameter M =L/P. M has been proposed as an indicator of areas where algal production/loss rates are either dominated by physical or biological processes.

This study provides the first insight into the global distribution and dynamics of these variables over a five-year time series. The resulting distributions are in accordance with published estimates. The products provide insight into the stability of pelagic ecosystems as well as new information for studies of interactions among trophic levels.

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MICROORGANISMS: POTENTIAL INVASIVE SPECIES IN SHIPS' BALLAST-WATER TANKS

Aquatic microorganisms are orders of magnitude more abundant than macroorganisms and are transported in profound numbers around the globe in ships’ ballast water. We evaluated microbial metrics in ballast water of 68 ships arriving to Chesapeake Bay and, in one case, throughout a transoceanic voyage. Ballast tanks provide unfavorable conditions for microorganisms in general, as indicated by their relatively low biomass and abundance quantified at the endpoints of voyages and a temporal decline in these metrics measured during the transoceanic voyage. Several hypotheses may explain these results: uncoupling of the microbial loop; removal of bacteria by microzooplankton grazing; respiration of DOM released from phytoplankton and zooplankton die off at the beginning of voyages; or a combination of these and other processes. Knowing the likelihood of microorganisms surviving in a new location is critical to evaluating the risk of invasion, but little is known in this respect. By examining temperature differences between ballast water and receiving waters, we estimate 50% of vessels arriving to lower Chesapeake Bay contain microorganisms that encounter optimum temperature conditions upon ballast discharge.

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A COMPARISON OF ASSIMILATION EFFICIENCIES BETWEEN SHALLOW AND DEEP LIVING FISHES

In the deep sea food availability is relatively low and meals may be infrequent. Deep-sea fishes may have adapted to these conditions, in part, by utilizing as much food as possible from every meal. We investigated the absorption and assimilation efficiencies of shallow living and deep living zoarcid fishes to determine whether deep-sea species have evolved mechanisms to increase their efficiency of food use. Fishes were placed in experimental chambers and fed a known quantity of food. Ammonia excretion was measured and feces were collected daily. Both food and feces were analyzed for water, protein, lipid and ash to determine specific absorption efficiencies. Preliminary results indicate that there were no differences in absorption efficiency between the species examined. However, post-prandial excretion rates were higher in the shallow water species. This suggests that while the absorptive processes were the same that post absorptive metabolic processing of the food was more efficient in the deep-sea fishes. Additional work is being conducted to examine the digestive morphology of all species maintained in the laboratory and how this relates to energetic processes.

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COUPLING AGENT BASED MODELS AND DIFFERENTIAL EQUATION SYSTEMS: FROM THE INDIVIDUAL TO POPULATION SCALES.

We are interested in the understanding of how marine copepods interact with phytoplankton at the individual level considering the heterogeneous nature of the distributions of those organisms. In this presentation, we introduce an individual discrete based model for the modeling of copepod and phytoplankton interaction. Phytoplankton cells are randomly distributed in a 3D space and copepods are freely swimming towards cells to capture and ingest them. This model is based on a modeling and simulation framework coming from computer science, namely Agent Based Simulation. This technique enable virtual experiments on the model in order to simulate ingestion rate. We show that ingestion rate is strongly linked to the nature of cells distribution. We can go forward showing that our bottom-up model can refine classical functional responses of predators (density and ratio-dependence). This enable the coupling of our agent based model with classical differential equation systems of prey-predator interaction. Then, we give a new tool to study the influence of individual scales on population scales.

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INTERACTIVE EFFECTS OF BIODIVERSITY AND TROPHIC STRUCTURE ON ECOSYSTEM FUNCTIONING IN SEAGRASS BEDS

Experiments in terrestrial systems suggest that eroding biodiversity affects ecosystem productivity and nutrient cycling. Yet most such studies focused on processes within the plant level. In many marine ecosystems, with strong consumer pressure, diversity effects on ecosystems may be complicated by trophic interactions. We tested interactive effects of changing biodiversity and trophic structure on ecosystem development in eelgrass (Zostera marina) mesocosms. We established treatments with each of four crustacean grazer species alone, and all four together; an identical set of treatments was established with juvenile blue crabs as predators. Grazer species composition strongly influenced most producer groups, explaining substantially more of the variance in algal and total plant biomass than did predator presence. Nevertheless, cascading predator influence enhanced biomass of most primary producers, and grazer richness effects on ecosystem properties were all changed by removal of predators. On average, the trophic cascade was weaker at high grazer diversity, suggesting that biodiversity loss may intensify linkages between trophic levels. Thus, interactions within, and among, trophic levels strongly influence one another, and neither process can be understood in isolation from the other.

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IMPACT OF ANTHROPOGENIC AMMONIUM ON PHYTOPLANKTON ECOLOGY IN AN URBANIZED ESTUARY: SAN FRANCISCO BAY

South San Francisco Estuary is subjected to the discharge of high levels of ammonium from sewage treatment plants. Long time-series data measured in South Bay show high chlorophyll concentrations occur only when nitrate is high but ammonium concentrations are <4 uM. 15N uptake measurements show nitrate uptake is held low most of the year due to inhibiting ammonium. Spring blooms occur only when ammonium falls to low levels and diatoms are enabled to rapidly take up and grow on nitrate. SFE phytoplankton cannot reach full potential production without access to nitrate. Dilution of anthropogenic ammonium is necessary to reduce the ammonium concentration to levels where the phytoplankton can further reduce these concentrations to the levels where nitrate uptake can occur resulting in a burst of nitrate uptake and biomass formation. This helps explain the low productivity observed during dry years when dilution of anthropogenic ammonium by runoff is strongly reduced. The long term decline in productivity and fisheries in SFE may have resulted from the switch from primary to secondary sewage treatment and resultant discharge of nitrogen primarily as ammonium.

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COUPLING OF BIOGEOCHEMICAL CYCLES OF THE ELEMENTS THOUGH ECOSYSTEM STRUCTURE WITHIN A GLOBAL OCEAN GENERAL CIRCULATION MODEL

We have developed a multiple element (C, N, P, Si, Ca, Fe) biogeochemical model of marine ecology that includes small, large and diazotrophic phytoplankton as well as explicit ballast-driven sinking and remineralization of detrital organic matter and cycling of dissolved organic matter. Phytoplankton growth is described through a new formulation including co-limitation by N, P, Si, Fe and light to reproduce broad observational trends. Phytoplankton grazing is described through different power laws in the closure terms for small (plus diazotrophs) and large phytoplankton to reproduce observation that large forms augment small ones as production increases. Detritus production is assumed to be a temperature dependent fraction of small and large phytoplankton.
This model has been imbedded in a high resolution (1-degree) global ocean general circulation model (MOM4) forced by observed atmospheric forcing to quantify the relationship between food web structure and biogeochemical cycles on inter-annual timescales. The ultimate goal of this effort is the incorporation of this model in a fully-coupled Earth System Model to predict the biosphere¡Çs response to climate change. Novel aspects in the model structure will be described and the impact of the formulation of ecosystem structure on biogeochemical cycling will be discussed.

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ADVECTION OF CARBON ON THE WESTERN ARCTIC SHELF: IMPLICATIONS FOR BENTHIC-PELAGIC COUPLING

This study explores trophic linkages between the benthos and associated physical and biological processes in the western Arctic. Evidence for the importance of rich Bering Sea waters on the Arctic Shelf is provided by carbon and nitrogen stable isotope signatures used to trace carbon advected onto adjacent shelves and as indicators of trophic links between pelagic and benthic components of the shelf and slope. Preliminary del 13C measurements of POM reveal that values are 2-5 ppt lower (more negative) in late summer compared to spring, especially over the shelf and basin. Based on these results and the isotopic values of ice algae, we estimate that ice algal carbon potentially contributes up to 25% of the POC pool over the Chukchi Shelf during the spring bloom. Overall, benthic organisms become more 13C depleted between the Chukchi Sea and western Beaufort, while 15N ratios remain relatively constant. These data support the hypothesis that carbon advected northeastward along the Alaskan arctic coast is assimilated by benthic consumers, but its relative importance begins to decline east of Point Barrow.

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DISSOLVED AND PARTICULATE THIOLS IN THE NORTH PACIFIC AND BERING SEA: THE POTENTIAL IMPORTANCE IN COPPER SPECIATION

Thiols such as Cysteine, Arginyl-Cysteine, Glutamine-Cysteine, Glutathione, and gamma-Glutamate-Cysteine have recently been demonstrated to be exuded by marine phytoplankton in response to copper stress. It was also shown that some of these exuded compounds form stable complexes with Cu (I), suggesting that this class of compound may be responsible for the high degree of copper complexation in surface seawater. Recently, both particulate and dissolved thiols were measured in the sub-Artic North Pacific and the Bering Sea. At all stations, there was an uncoupling of the concentrations of the particulate thiols and dissolved thiols; that is, the predominant particulate thiols were not the primary dissolved thiols, and the concentrations of specific dissolved thiols were approximately 100-fold greater than those of the particulate thiols. Both particulate and dissolved thiols had depth profiles similar to those of chl a, though measurable concentrations of some thiols were present up to 1500m. Based on these results, it appears that the exudation of specific thiols is occurring in the field and that these thiols have a slow degradation rate. The similarity between the depth profiles of some dissolved thiols and copper-binding ligands also provides further evidence that these compounds are partially responsible for the high degree of copper complexation observed in the open ocean.

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PHYTOPLANKTON COMMUNITY DYNAMICS, ENVIRONMENTAL CONDITIONS, AND MYTILUS SPP. GROWTH AT TWO MUSSEL AQUACULTURE SITES IN NEWFOUNDLAND, CANADA

Two commercial mussel (Mytilus spp.) aquaculture sites in Notre Dame Bay, Newfoundland (Charles Arm and Fortune Harbour) were sampled approximately monthly when accessible (free from ice) for three years (2000-2002) to investigate the relationships among mussel growth, physical and chemical properties of the water column, and the phytoplankton community composition. Water column properties (temperature, salinity, and fluorescence) were determined. Discrete measurements were made of chlorophyll, particulate organic carbon, and nutrients at 4 meters depth, near the middle of the mussel sock. Mussel shell size and tissue wet weight were also measured. Net tows and whole water samples were collected to determine phytoplankton species composition. At each farm site, a more exposed and a more sheltered station were studied and the implications for mussel farm location selection are presented. Phytoplankton species composition and biovolume data are compared to those at the Charles Arm site from 11 years earlier, four years after the mussel farm was first established.

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SPATIAL VARIABILITY OF COPEPODS ON GEORGES BANK IS CONTROLLED BY PHYSICAL PROCESSES AND LIFE HISTORY CHARACTERISTICS.

Georges Bank is a highly productive shallow bank with complex hydrography and circulation patterns, and high abundances of invertebrate predators. During the winter spring period the zooplankton is dominated by a group of copepods including non-resident species which are advected onto the bank from outside (e. g. Calanus finmarchicus, Pseudocalanus spp, Oithona similis, and Metridia lucens), and resident species which are sustained by locally hatching resting eggs (e.g. Centropages typicus, C. hamatus, and Temora longicornis). In addition the species are distinguished between those which carry their eggs (Oithona, Pseudocalanus), and those which broadcast their eggs into the water column. These taxa show different spatial patterns of abundance on the bank during the winter-spring study period. We discuss these patterns with respect to their life history patterns and the dominant biological and physical processes affecting them.

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SENSITIVITY OF AN ECOSYSTEM MODEL TO AEOLIAN FLUXES OF IRON

We investigate the sensitivity of primary production, export production and community structure to changes in the magnitude, pattern and temporal resolution of aeolian dust fluxes of iron in a global ocean biogeochemistry model. The model has an explicit parameterization of the deep water iron cycle including representations of scavenging and complexation. The ecosystem model resolves two functional groups of phytoplankton differentiated by their light, phosphate, silica and iron requirements. The biogeochemistry model is coupled to a coarse resolution configuration of the MIT general circulation model. HNLC regions emerge naturally as a result of explicit iron limitation. The model reproduces well the broad qualitative distributions of observed nutrients and chlorophyll. We perform idealized studies exploring the sensitivity of the system to the aeolian iron supply. Doubling dust fluxes increases the mean global production, but there are significant regions (e.g. Pacific subtropical gyres) which have a decrease in productivity. In regions of low aeolian input, the ecosystem model response differs when supplied with daily dust fluxes rather than monthly means. However, the effect on the total global production is minor.

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PHOSPHORUS SCAVENGING MECHANISMS IN TRICHODESMIUM

Trichodesmium and related diazotrophs are abundant in tropical and subtropical regions and can significantly contribute to carbon and nitrogen fixation in these environments. Studies suggest that phosphorus (P) supply may influence carbon and nitrogen fixation by Trichodesmium, and evidence from field populations indicates that P scavenging may differ among Trichodesmium species. Our goal is to better understand how P acquisition mechanisms may differ between Trichodesmium species, and how P supply may influence the distribution and physiology of these species in the field. With the ongoing annotation of the T. erythraeum genome a number of genes likely to be involved in P acquisition have been identified. Three genes of particular interest, phoA (encoding for a putative alkaline phosphatase), and two copies of pstS (encoding for a putative high-affinity phosphate binding protein), were examined in Katagnymene spiralis and two Trichodesmium species. Sequence data indicates that these genes in T. tenue are about 98% identical to T. erythraeum. Less sequence similarity was observed between these genes in the other species, and this has interesting implications for species-specific P scavenging in the field.

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DUNGENESS CRAB LARVAL AND SETTLER ABUNDANCE IN AN ALASKAN MARINE RESERVE

Commercial fishing of Dungeness crabs, Cancer magister, ended in Glacier Bay, Alaska in 1999. In order to assess the effectiveness of this marine reserve and to gather information about the early life stages of this species in Alaska, I studied temporal patterns of late-stage larval abundance and settlement of Dungeness crab, in Bartlett Cove within Glacier Bay. From 2000 to 2003, I quantified late-stage (megalopae) larval abundance with light traps in the water column and juvenile abundance with settlement bags in the intertidal. Larval abundance varied four- to five-fold inter-annually. Larvae were abundant over a two and a half month period from August to November, with peaks within one week before and after the new moon in September and October. Juveniles were collected in the intertidal during this time period, however no large pulses were observed. The relationship between larval abundance and juvenile abundance was density dependent. Understanding the relationship between larvae and settlers is the first step in identifying how the establishment of a marine reserve may replenish stocks either within or outside the reserve.

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DETECTING AND TRACKING ANIMALS IN UNDERWATER VIDEO USING A NEUROMORPHIC SALIENCY-BASED ATTENTION SYSTEM

MBARI uses high-resolution video equipment on remotely operated vehicles to obtain quantitative data on the distribution and abundance of oceanic animals. High-quality video data supplants the traditional tow net approach of assessing the kinds and numbers of animals in the oceanic water column. Video camera-based quantitative video transects (QVT) are taken through the ocean midwater, from 50 m to 4000 m, and provide high-resolution data at the scale of the individual animals and their natural aggregation patterns. However, the current manual method of analyzing QVT video is labor intensive and tedious. We present an automated system for detecting marine organisms visible in the videos. Video frames are processed with a neuromorphic selective attention algorithm. The candidate locations are tracked across video frames using linear Kalman filters. If objects can be tracked successfully over several frames, they are labeled as potentially "interesting". Based on low-level properties, objects are classified as interesting and marked in the video frames. The system enhances the productivity of human video annotators and/or cues a subsequent object classification module by marking candidate objects.

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OPC SIZE SIGNATURES OF LIVE ZOOPLANKTON

The Optical Plankton Counter (OPC) is capable of measuring abundance and size distribution of meso-zooplankton at high resolution in space and time. No information on species can be inferred, which will limit the ecological applications of such data. Knowledge of the size intervals possessed by different groups and taxa can extend the usability of OPC data. Here, size signatures of some species of live meso-zooplankton as recorded by a field version OPC are reported. The experiments were carried out under controlled laboratory conditions by building a simple device for obtaining and controlling flow of water through the OPC, and handling of the samples used in the experiments. From field samples of zooplankton, various species and developmental stages of species were sorted out and applied as mono cultures of live zooplankton. The current set-up was able to key sized down to copepodide stage I of Calanus finmarchicus. The method and possible applications are discussed.

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IMPACTS OF CONTAMINATED SEDIMENT ON BENTHIC FAUNA IN THE LOS ANGELES URBAN OCEAN AS REVEALED BY SEAFLOOR PHOTOGRAPHY

Continental shelf and slope sediments in the central southern California Bight contain land-based contaminants derived from ocean outfalls, rivers, streams, and coastal industrial discharges. Elevated levels of DDTs, PCBs, and trace metals are known to occur at the seafloor in many areas and also in tissues of benthic and pelagic organisms. Studies have documented changes in faunal assemblages and biological mixing rates in response to contamination levels. We combined 35-mm still photography and color Hi-8 video from four cruises (1992 to 2000) with multibeam EM1000 imagery to document the macrofaunal response to 1) changes in sediment contamination levels and 2) variations in benthic habitats (sediment facies, bedrock exposures, relief). Our data show evidence of ongoing infaunal and epifaunal activity throughout all parts of the area. Even highly contaminated regions such as the Palos Verdes margin (elevated DDTs and PCBs) and the head of Santa Monica canyon (elevated silver) show evidence of pervasive open burrows, tracks and trails and feeding structures, and epifauna indicating robust macrofaunal activity. Muddy, sandy, gravel-rich and bedrock exposures occur throughout the area.

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SEASONAL AND INTERANNUAL VARIABILITY ON THE GEORGIA BIGHT

The South Atlantic Bight Synoptic Offshore Observation Network (SABSOON) comprises a grid of towers outfitted with multiple observational packages designed to capture synoptic activity on the continental shelf in real-time. The database now available from the long record of continuous observations allows the unique opportunity to examine shelf dynamics over a range of time scales, from tidal to interannual scales.
This study focuses on observations at two towers located near the 25- and 32-meter isobaths off the Georgia coast. Three and four year records of near-surface and near-bottom temperature and salinity are available from both towers at six minute resolution. Further, two and three year records of six-minute currents from ADCPs give an unprecedented view of seasonal and interannual variability through the water column. The vertical and temporal structure of the currents described, noting evidence of periodic intrusions of Gulf Stream influence. The seasonal and interannual variability in the structure of the current and density fields is analyzed with respect to what is known about coastal processes at subtidal time scales in the South Atlantic Bight.

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COMPARISON OFJUVENILE SALMON DISTRIBUTIONS, WATER MASS CHARACTERISTICS AND PHYTOPLANKTON BIOMASS IN THE EASTERN BERING SEA DURING FALL 2003

Surveys were conducted on the Eastern Bering Sea shelf during fall 2003 as part of a multiyear international research program, Bering-Aleutian Salmon International Survey (BASIS). Over 150 stations were sampled from a 124 ft trawler, the F/V Sea Storm, during mid-August to mid-October. Juvenile salmon and associated fish species were collected with a surface rope trawl. Vertical profiles of temperature, salinity, chlorophyll a fluorescence, light transmission and photosynthetic available radiation (PAR) were measured with a CTD. Water samples for size fractionated chlorophyll a determinations (> 0.7, > 2, and > 10 micrometers) were collected with Niskin bottles from the surface and below the pycnocline. Along-transect surface temperature and salinity data were measured continuously with a thermosalinograph mounted aboard ship. We will compare juvenile salmon and associated fish distributions, temperature and salinity, and phytoplankton biomass (total and percentages within each size class) across frontal boundaries. This study will provide information on the interactions between the physical and biological oceanographic parameters and juvenile salmon abundances, and add to our understanding of the climatic influences on marine ecosystems in the Eastern Bering Sea.

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MODELLING THE CARBON AND NUTRIENT CYCLING IN THE NORTH SEA USING ERSEM II

This work will assess the evaluation of the transports of inorganic and organic carbon and nutrients in, into and out of the North Sea. A one-dimensional ERSEM II (European Regional Seas Ecosystem Model) coupled to the physical biogeochemical model was applied to the first results of the extended carbon and nutrient data set acquired during cruises (2000-2001) in the North Sea. The ecological model consists on the ERSEM ecological model which describe the biological and chemical processes in the water column and in the benthos. In this work we focuse on the dynamic of the CO2 submodel which is recently coupled to a ERSEM model, and on the annual cycle simulation at some contrasting stations. Validation of the simulations indicates good agreement of results with four seasons data set. The model reproduces many spatial and temporal trends of the biogeochemical variables, both qualitatively and quantitatively and so gives insight into the main mechanisms (i.e. stratification) responsible for the biogeochemical and ecological complexity in the North Sea.

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THE FLUX OF IRON FROM CONTINENTAL SHELF SEDIMENTS: A MISSING SOURCE FOR GLOBAL BUDGETS?

Benthic flux chambers were used to directly measure the flux of dissolved iron across the sediment-water interface over a five-year period along the California coast. Sediment cores were also collected and the flux calculated from pore-water concentration gradients was compared to the observed chamber fluxes. The observed flux of dissolved iron was highest from coastal shelf sediments. These high observed fluxes were 1- 2 orders of magnitude higher than values derived from pore-water iron gradients.

The flux of dissolved iron was significantly correlated with the flux of oxidized organic carbon. This relationship is used to provide an estimate of the contribution of continental shelves to global ocean iron budgets. The resulting flux of dissolved iron from shelf sediments is 8.9 x 10^10 moles per year. This is approximately 10 times larger than estimates of dissolved iron inputs from atmospheric deposition, on a global basis. We estimate that a minimum of 4.4 x 10^9 moles per year of this sediment flux reaches the euphotic zone. This lower limit is still of similar magnitude to the estimated flux from aerosol deposition.

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GLOBAL GENE EXPRESSION ANALYSIS OF NITROGEN AND PHOSPHORUS STRESS IN THE TOXIC DINOFLAGELLATE ALEXANDRIUM FUNDYENSE

Blooms of the toxic dinoflagellate Alexandrium can result in outbreaks of paralytic shellfish poisoning, one of the more serious of the global phenomena referred to as harmful algal blooms. Little is known about nutrient acquisition in this organism, despite the likely influence of nutrients on toxic bloom dynamics. To better understand nutrient physiology and toxin production in Alexandrium, we have employed Massively Parallel Signature Sequencing, a method of global expression profiling that generates a 17-nucleotide sequence 'tag' for one million individual gene transcripts in a cell. Our analysis examined Alexandrium cells grown under nitrogen or phosphorus starvation, conditions that decrease and increase cellular toxin content respectively. Differentially regulated genes should thus include those involved in toxin production, N stress and P stress. The results reveal an unexpectedly large number of unique gene tags in Alexandrium, as compared to other eukaryotes that have been examined. The expression of several thousand tags is significantly different ($p<0.001$) between the two conditions. General features of gene tag abundance, distribution and regulation will be presented, as will ongoing efforts to identify differentially regulated genes.

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PROCESSES BEHIND OBSERVED TRENDS IN OXYGEN CONCENTRATION IN THE GULLMAR FJORD, SWEDEN

A study of oxygen changes and trends in the basin water of the Gullmar Fjord will be presented. The study involved physical, biological and sedimentation processes, as all affect the oxygen conditions in the fjord. The purpose of the study was to reveal the contribution of organic matter mineralized in the basin water of the fjord, by primary production in the fjord and by organic matter imported from the Skagerrak. For this a one dimensional model was used. Complementary data analyses were also done, relating different parameters i.e., chlorophyll_a concentrations in the inner part and outer parts of the fjord, oxygen consumption and oxygen minimum to local primary production. Oxygen concentrations in the incoming new deep water were also investigated.

It was shown that the minimum oxygen concentration in the basin water to a large extent depends on the concentration after an inflow of new water and the length of the stagnation period, and less on the variation in consumption between years. It was also shown that the variation in the mean oxygen consumption rates between years did not depend on variation in the local primary production. This and other results presented in this paper indicated that the greatest source of oxygen consuming matter in the basin water of the Gullmar Fjord was organic matter imported from the Skagerrak and that the contribution from local primary production was small.

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TEMPORAL VARIABILITY IN PH IN THE NORTH PACIFIC: A COMPARISON OF RECENT MEASUREMENTS WITH DATA COLLECTED ON THE WOCE GLOBAL CARBON SURVEY

High-precision spectrophotometric pH measurements were made as a part of the CHALK (Coccolithophorids-Haptophytes-ALKenones) cruise in the North Pacific and the Bering Sea from June through August of 2003. The analytical results in deep water at several stations in the North Pacific indicate that highly precise pH measurements were obtained during the 6 week cruise. Comparison of these data with the data collected on WOCE lines P-14 (July, 1993) and P-16 (February, 1991) also show remarkable consistency at depth. In addition, a careful comparison of pH measurements in surface water, indicate an accumulation of carbon dioxide at a rate of approximately 1 micromole per kilogram per year. Our analysis also shows a decrease in pH to a depth of about 700 m at approximately 45 degrees north and 170 degrees west. This result suggests a relatively deep penetration of anthropogenic carbon dioxide in the North Pacific over the last decade.

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UNDERSTANDING PLANKTONIC ECOLOGY IN A TURBULENT ENVIRONMENT: AN INTERDISCIPLINARY CHALLENGE

Turbulent mixing occurs at a wide range of spatio-temporal scales and is a fundamental characteristic of the aquatic environment. The physical energy provided by turbulence, considered as “auxiliary energy” from a biological point of view, is a key factor controling structure and function in the planktonic ecosystem. Studying the effect of small-scale turbulence on biological processes is an active area of research in which increasing collaboration between physicists and biologists has opened promising new directions. This communication intends to present a brief and necessarily selective introduction to current work in this field. Emphasis is placed on the effects of small-scale turbulence on interactions between autotrophic and heterotrophic elements of the planktonic food web. Some important knowledge gaps and open research questions are discussed.

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OCEANOGRAPHIC PATTERNS IN A GLACIALLY-FED FJORD ESTUARY: IMPLICATIONS FOR BIOLOGICAL PRODUCTIVITY AND HOTSPOTS

Oceanographic conditions within high latitude glacially-fed estuaries are often complex, due to high rates of freshwater input, diverse bathymetry, and high sedimentation rates. Through a long term monitoring program, we have conducted physical and biological oceanographic sampling at 24 stations within Glacier Bay, AK, from 1993-2002. Seasonal patterns of salinity, temperature, stratification, turbidity and euphotic depth are correlated with freshwater input. High rates of freshwater input create strong and persistent stratification of surface waters, contributing to sustained phytoplankton abundance from spring through fall. Spatial patterns of phytoplankton abundance vary throughout the season and are influenced by stratification levels and euphotic depth. Highest levels of phytoplankton abundance exist at regions of physical and bathymetric discontinuities, where shallower mixed zones are juxtaposed with deep stratified basins. Spatial patterns of physical and biological oceanographic parameters suggest that there may be biological hotspot regions within Glacier Bay. These findings further our understanding of physical-biological coupling within fjord estuaries and provide information necessary for making management decisions and understanding the ecosystem properties of high latitude marine reserves, such as Glacier Bay National Park.

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ISOLATION OF DNA FROM ACTIVELY GROWING HETEROTROPHIC BACTERIA USING 5-BROMO-2';-DEOXYURIDINE (BRDU)

In Barkley and Clayoquot Sounds on the outer coast of Vancouver Island, British Columbia, we measured bacterial incorporation of the thymidine analog 5-bromo-2'-deoxyuridine (BrdU). Using immunochemical capture techniques and terminal restriction fragment length polymorphism (t-RFLP) analysis of DNA extracts, we determined the number of operational taxonomic units (OTUs) in a population and the proportion of the population that incorporates BrdU. We also measured bulk community growth rates using 3H-thymidine incorporation. BrdU-containing DNA was found in, on average, half the community, indicating that the growing (BrdU incorporating) bacterial population is only a subset of the bulk population. Differences in bacterial community structure and growth were correlated with bacterial productivity, chlorophyll concentrations, and multiple water column properties. Characterizing the growing heterotrophic bacteria in Barkley and Clayoquot Sounds allows for a better understanding of the environmental, biological and physical conditions that influence the microbial loop.

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CLIMATIC VERSUS ANTHROPOGENIC EFFECTS ON LONG-TERM CHANGES IN SALINITY AND NUTRIENTS IN THE IRISH SEA

The analysis of a long-term dataset for the Cypris station, on the Isle of Man, show that small but significant changes in salinity over the past five decades correlate inversely with the North Atlantic Oscillation. Fresh water inputs derived from rainfall and land drainage cannot alone account for the changes in salinity. A three-dimensional numerical model is employed to demonstrate that the salinity changes are controlled primarily by modulated wind-driven currents, which determine the flux of more saline Atlantic water through St Georges Channel at the southern end of the Irish Sea. In years where winds blow with increased strength and frequency from the west or northwest, the northward flow of relatively saline water into the basin is restricted due to Ekman transport. The modelled fluxes are combined with all data for freshwater input in an attempt to synthesise the salinity time series, which is then compared with observations. This work shows how climatic indices, like the NAO, are related to the long-term dynamics of semi-enclosed shelf seas.

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PREY RECEPTION IN MESODINIUM PULEX, FOCUS ON HYDROMECHANICAL SIGNALING

The predator-prey interactions between the raptorial ciliate, Mesodinium pulex, and three autotrophic flagellates: Heterocapsa rotundata, Gymnodinium simplex, and Rhodomonas salina, was studied with focus on hydromechanical signaling as a means of remote prey detection. Mesodinium pulex was non-responsive to non-motile prey regardless of prey species suggesting involvement of prey-generated hydromechanical signals in prey detection. The critical fluid velocity threshold for attack by Mesodinium pulex to the prey was ~80x10^-4 cm/s for Heterocapsa rotundata, ~45x10^-4 cm/s for Gymnodinium simplex, and ~120x10^-4 cm/s for Rhodomonas salina. Mesodinium pulex showed a strong directional response to prey. An angle >90º between predator and prey was considered an attack; an angle <90 was considered as a non-attack. The average attack between Mesodinium pulex to its prey was 154 . The currently estimated critical fluid velocity threshold for attack by Mesodinium pulex is within the fluid velocity threshold for attack found for metazoans. Our data is the first example showing protists that demonstrate the presence of a hydromechanical component in prey detection.

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EFFECTS OF SMALL-SCALE GRID TURBULENCE ON A TOXIC STRAIN OF ALEXANDRIUM FUNDYENSE

In recent years direct effects of small-scale turbulence on phytoplankton attracted increasing interest as an additional factor controlling phytoplankton proliferation in the sea. It appears that dinoflagellate growth may be affected by varied levels of the turbulent kinetic energy dissipation rate. In the present case, effects of small of small-scale turbulence on a toxic strain of A. fundyense were studied in a series of microcosm assays, covering 5 different turbulence levels generated by vertically oscillating grids. In contrast to the common view that dinoflagellate growth is hampered by turbulent conditions, the gowth rate of A. fundyense in higher turbulent microcosms was distinctly higher within the first 4 days of the experiment. However, neither in cellular chlorophyll a and c, peridinin, diadinoxhanthin, and beta-carotin nor in the PSP components saxitoxin and gonyautoxin 2/3 significant changes were found.

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EFFECTS OF ROUGHNESS SCALE AND FLOW ENVIRONMENT ON NUTRIENT MASS TRANSFER TO CORAL REEF COMMUNITIES: EVIDENCE FROM THE DISSOLUTION OF PLASTER FORMS

The dissolution of artificial plaster (gypsum) forms were used as a proxy for examining the importance of varying roughness scale and flow environment on nutrient fluxes to coral reef communities. All plaster forms were constructed using smooth, rectangular shapes roughly 6x6x12 cm. Additional roughness scales were given to some of the plaster forms by means of cylandrical holes (~1 cm) and rectangular grooves (~1-2 mm) added to each of the faces. Plaster forms were allowed to dissolve in an experimental flume under both steady and oscillatory flow with rms-flow speeds of up to 50 cm s-1 as well as in natural, shallow reef environments dominated by oscillatory flow with rms-flow speeds varying between 2 to 22 cm s-1. Rates of plaster dissolution were positively correlated with flow speed under all flow conditions, but were higher in natural reef environments than in the flume. Calcium mass transfer coefficients derived from dissolution rates were proportional to surface area regardless of the roughness scale from which the area was derived. This suggests that roughness features greater than the thickness of the concentration boundary layer (>200 um) contribute comparably to rates of mass transfer.

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A TUNABLE AUTOMATED NUCLEIC ACID SENSOR

Emerging issues of homeland security and the need for surveillance of microorganisms of public health significance are becoming increasingly important. We are developing an automated microorganism sensor to provide real time monitoring of marine environments. The detection system utilizes the Nucleic Acid Sequence Based amplification (NASBA) method coupled with fluorescently labeled molecular beacons to amplify and detect specific microbial and viral species. Sample collection and RNA extraction is achieved by filtration and chemical lysis. Nucleic acid purification is performed using commercially available solid phase technologies. Reagents for sample preparation and amplification are dispensed from a gas-vented, custom fluidic manifold controlled by a valve timing system. NASBA amplification is detected in real-time by fluorescence of molecular beacons hybridizing to amplified RNA. Excitation of the fluorophore is achieved using a simple LED, while detection is achieved using a low-cost, filter-based, photodiode. Optical and thermal control is automatically maintained and regulated during the reaction for optimum amplification and detection. Power is supply by a custom lithium-ion battery pack. Data collection and transmission is in real-time and wireless.

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LONG-TERM LABORATORY OBSERVATIONS OF EUPHAUSIA PACIFICA FECUNDITY: A COMPARISON OF TWO POPULATIONS.

Euphausia pacifica is the most abundant species of euphausiid found in the waters around the North Pacific. It has long been assumed that they produce multiple broods during their spawning season, but without maintaining gravid females for extended periods in the laboratory, this idea must remain a hypothesis. We have successfully maintained individuals in the laboratory from populations of E. pacifica collected from Oregon coastal waters and from a station near Santa Barbara, California. Through daily observation of females over two to six months periods we have documented the production of multiple, distinct broods, and we are able to determine mean brood sizes, interbrood periods (IBP) and therefore calculate seasonal fecundities. Overall, we found a high degree of variability in spawning with brood sizes ranging from 5 to 800 eggs and IBPs ranging from 1 to 78 days. Despite this variability, there were some distinct patterns as well as noticeable differences between populations despite identical laboratory conditions. Through calculations and observation we have determined that a female E. pacifica can produce in excess of 6000 eggs in a spawning season.

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THE EFFECT OF THE STATISTICS OF OPTICAL-ACTIVE CONSTITUENTS ON MODEL-BASED INVERSIONS OF OCEAN COLOR

To update, three model-based inversion techniques have been widely applied to constituent retrievals for ocean color data. They are non-linear optimization (NLO), principal component analysis (PCA) and neural network (NN) inversion techniques. PCA/NN techniques different from NLO depend usually on a model-simulated ocean color dataset to find a statistical inversion function, a relation that is used to derive optically-active concentrations from ocean color. Naturally, we ask how the statistics of the constituent concentrations used for simulating the ocean color data affects the inversions. For this study, three-component forward models, parameterized in terms of 1367 optical measurements made globally, are used for simulating upwelling spectral radiances just above the water surface. The forward models are run to generate various simulated datasets, representing different ranges, means and variances of the concentrations and co-variances between the concentrations. These simulated datasets are used to derive the inversion functions for the two inversion techniques (i.e. PCA and NN), and then independent simulated datasets are applied for inversion testing. The inversion results will be presented to illustrate the effect of the statistics of constituent concentrations on the inversions.

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NITROGEN AND CARBON BUDGETS FOR THE NE U.S. CONTINENTAL SHELVES – A COUPLED PHYSICAL-BIOLOGICAL MODELING STUDY

A coupled physical-biogeochemical model has been implemented for the continental shelf and adjacent deep-ocean of the U.S. east coast in order to elucidate processes affecting the carbon and nitrogen budgets in the continental shelf region. The biogeochemical model is an adaptation of Fasham's ecosystem model (Fasham et al., 1990) with carbon chemistry added. The circulation model is the Regional Ocean Modeling System (ROMS v2.0) and has been implemented at 10 km horizontal resolution. The shelf region model is embedded within a basinwide North Atlantic ROMS. The embedding procedure imposes external remotely forced mesoscale and seasonal variability with few open boundary artifacts. Coastal freshwater inputs are applied using observed USGS river flow data. Simulations to investigate the fate of riverine inputs of nutrients and organic matter, the magnitude and form of carbon exported from the shelf, the effect of denitrification on the nitrogen and carbon balances have been performed and will be discussed.

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OCCURRENCE OF ENTEROCOCCI IN OCEAN WATER, SEDIMENTS, STORM DRAINS, SOIL AND SEAGULLS AT BABY BEACH, DANA POINT HARBOR, CALIFORNIA

Signs warning the public not to swim at Baby Beach are frequently posted due to levels of enterococci bacteria that exceed California's ocean water quality standards. Enterococci are usually present in human and animal feces and are used to indicate fecal contaminated water that may harbor pathogenic species. However, since enterococci can also be found in the environment, their presence in water may give false indications of risks for human illness. Certain species of enterococci are more commonly associated with plants, while others are more predominant in feces and are considered opportunistic pathogens. Thus, the distribution of enterococci species and numbers of these organisms in marine water, sediments, storm drains, soil (from lawns), seagulls and sewage was compared. This was also done for isolates from beach water collected when enterococci levels exceeded standards. Enterococci isolates (N=794) were identified to species level using API 20 STREP with supplemental biochemical testing. E. faecalis and E. faecium were the predominant species found in marine water and sewage. E. casseliflavus, commonly associated with plants, was frequently found in soil and in storm drain water.

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DIFFERENTIAL EFFECTS OF TURBULENCE ON OLFACTORY FORAGING BY BENTHIC INVERTEBRATES

Benthic foragers benefit from a fixed plane of reference that facilitates odor tracking within boundary layer flows. Decapod crustaceans employ spatially segregated sensors to compare simultaneous concentrations across odor plumes. However, these fast-moving foragers are confused by turbulent mixing of chemicals in rapid flows or over rough sediments. Slower animals might instead rely upon temporal averaging of stimulus concentrations, a strategy that would allow detection of more homogeneous odor plumes and thus permit continued olfactory searching in turbulent flows. We varied current velocity and sediment roughness in a racetrack flume to test the hypothesis that, in contrast to crustaceans, slow-moving gastropods track odors more successfully in fast and turbulent flows. We then monitored patches of bivalve prey in the field to evaluate the effect of experimentally enhanced turbulence on olfactory predation by gastropods within natural habitats. Results of both studies confirm that gastropods can track turbulent odor plumes and suggest that bed-generated turbulence may actually enhance the ability of gastropods to detect and locate prey. These findings suggest that benthic foragers may partition resources as a function of turbulence.

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THE USE OF ASSETS AND PHYTOPLANKTON SPECIES COMPOSITION TO DEFINE TYPE-SPECIFIC REFERENCE CONDITIONS FOR ESTUARINE WATER QUALITY MANAGEMENT

Coastal eutrophication assessment requires the definition of type-specific reference conditions, e.g. elevated chlorophyll a must be defined with reference to natural community metabolism, which varies with temperature and other factors. Both NOAA and the EU Water Framework Directive (WFD) recognise that typological classification is a pre-requisite for a regionally meaningful classification of ecological quality status. A set of estuarine and coastal types were defined using both a heuristic approach and the LOICZ DISCO clustering software. Potential methodologies for establishing type-specific reference conditions and defining thresholds for ecological status classes for phytoplankton abundance, biomass and composition were examined, and tested on an extensive (>50 years) estuarine dataset. The ASSETS eutrophication assessment methodology was used for classification of phytoplankton biomass and abundance, and tested for different types. This approach accounts for pelagic and benthic eutrophication symptoms, allows for the inclusion of key WFD quality elements such as dissolved oxygen, and qualitatively considers species composition, based on the occurrence of harmful and nuisance algae. A complementary, quantitative approach to phytoplankton species composition was tested on different types, combining historical data with physical parameters.

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REMOTE SENSING OF UV DIFFUSE ATTENUATION AND GELBSTOFF (CDOM) ABSORPTION FOR USE IN PHOTOCHEMISTRY

UV diffuse attenuation coefficients (Kd) and coefficients (ag) for absorption of UV radiation by its main controlling factor, gelbstoff (CDOM), are required for models of chemical and biological effects of UV radiation in the ocean. To date, only a few recent studies have established the retrieval of these variables from remotely sensed ocean color. Expanding on these new approaches and incorporating additional features such as a UV domain classification, we developed, tested and validated an empirical algorithm to retrieve Kd and ag from 305 to 400 nm from SeaWiFS ocean color data. Coincident surface reflectance ratios (Rrs), Kd and ag spectra collected from over 300 stations representing various water types are used to develop the algorithm. An independent data set obtained from the SeaBASS database is used to test and validate the algorithm through a rigorous match-up analysis. From the match-up analysis, an average accuracy of +/- 38% is obtained on the retrieval of ag from SeaWiFS normalized water-leaving radiances. Photochemical calculations based on known efficiency spectra and these derived UV optical values produce reasonable production rates in coastal waters.

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NUMERICAL SIMULATIONS OF FLORIDA CURRENT FRONTAL EDDIES WITH IMPLICATIONS FOR MESOSCALE BIOPHYSICAL PROCESSES AND FISHERIES OCEANOGRAPHY

The importance of frontal regions and mesoscale eddies on enhanced biological production is well known. Because of the implications on fisheries and stock assessment, identification and forecasting of such locations is critical. Here, a high-resolution coastal ocean circulation model (EFS-POM, developed within the Southeast Atlantic Coastal Ocean Observing System (SEA-COOS) program) is used to investigate Florida Current frontal eddies as mechanisms for increased productivity from local upwelling, cross-shelf water exchanges, and aggregations of biological organisms. Preliminary analyses have demonstrated the ability of the model to simulate frontal eddy dynamics (recurrence period, translation speed, strength, and characteristic length scales) and have provided validation against observations. To investigate biophysical transport both Eulerian and Lagrangian approaches are used and compared. The numerical simulations have straightforward applications to operational fisheries oceanography as they provide detailed synoptic ocean maps and predict the evolution of biologically important features. Combined with satellite imagery, with HF radar-derived surface current maps, and drifters, coastal ocean model output is expected to improve the understanding of the spatial and temporal variability of fish distribution as it relates to mesoscale ocean circulation.

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DISCRIMINATING THE SOURCE OF FECAL CONTAMINATION WITH PCR MARKERS FROM BACTEROIDETES

Fecal contamination of water poses a threat to human and environmental health worldwide. Exposure risk is usually estimated using standard public health bacterial indicators, yet these do not distinguish among different fecal sources. Pathogen exposure will depend on both fecal concentrations and species of origin. We have developed a PCR-based indicator system, utilizing molecular markers from the Bacteroidetes group of fecal anaerobic bacteria. The method detects marker sequences that are not only specific to fecal bacteria, but are also specific to the host species that produced the feces, allowing discrimination among different sources. PCR primers were designed using T-RFLP and clone library analysis or subtractive hybridization. Real-time quantitative PCR (Q-PCR) demonstrated that Bacteroidetes markers were correlated with E. coli and enterococcus counts. Because this method is quick, reliable, flexible for field handling and storage of samples, amenable to high-throughput, simple to score, requires little specialized equipment, does not require culturing isolates, and does not require a "library" of reference strains, it could be useful for general water-testing laboratories.

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AN OVERVIEW OF THE SHALLOW WATER ACOUSTIC TECHNOLOGY (SWAT) COOPERATIVE RESEARCH PROJECT

SWAT was a joint program of at-sea measurements, data analysis and modeling. The Project was a cooperative effort between the United States and Japan. Under the SWAT Project, a multi-component experiment was conducted in the Mid-Atlantic Bight (MAB) off the east coast of the United States from September 26 through November 2, 2000. The participants from the U. S. included the Naval Research Laboratory (NRL), the Woods Hole Oceanographic Institution (WHOI), the University of Miami (UM) and the Office of Naval Research (ONR). The 5th Research Center of the Technical Research and Development Institute (TRDI) and its contractors participated for Japan. Both U. S. and Japanese participants conducted similar experiments in the East China Sea. The acoustic experiments consisted of geo-inversion experiments to extract geoacoustic parameters, monostatic and bistatic reverberation and low (<1200 Hz) and mid-frequency (5.5 kHz) acoustic propagation and fluctuation experiments. During portions of these exercises, extensive oceanographic and sea floor measurements were obtained. An overview of the project will be given. Although the SWAT project officially ended in January 2003, collaborative research are continuing. Future research directions are outlined.

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MECHANORECEPTION IN MARINE COPEPODS: DETECTING TEMPORAL AND SPATIAL HETEROGENEITY IN MOVING FLUIDS.

Aquatic organisms create spatially and temporally organized fluid signals. To behave in an ecologically appropriate manner, copepods must discriminate between different fluid disturbances to distinguish those important for survival. Understanding behavioral responses of copepods requires investigation into its sensory modalities and their associated structures, how these structures are coupled to the environment, and how the neurological responses code for the particular signals. Using a deep-sea copepod (Gaussia princeps) as our model organism, we investigated the selective tuning of individual seta to determine what aspect of the setal motion drives the depolarization event and how these events are organized to describe fluid structures. Our results suggest that changes in angular acceleration cause a graded neural response. Also different seta show different physiological thresholds that likely enable the copepod to accurately detect spatial heterogeneity in the flow. Furthermore, we found very high interspike frequencies (maximum frequency of 5 kHz) that permit the animal to rapidly compare the timing between closely spaced seta. These results are discussed in light of how relatively simple organisms can differentiate microstructure within their fluid environment.

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METAL MOBILITY AND BIOAVAILABILITY IN WETLAND SEDIMENTS FROM THE INDUSTRIALIZED SOUTHERN SHORE OF LAKE MICHIGAN, USA

The development of wetland nature preserves near industrial areas presents special problems of management that must take into account historical legacies of industrial metal contamination, including the significance of bioavailable phases and the potential mobility of heavy metals should environmental conditions change (for example, associated with restoration). This study focuses on wetlands within the Indiana Dunes National Lakeshore (IDNL) located just downwind of heavy industries along the southern shore of Lake Michigan. Sequential extractions for heavy metals (Cd, Cr, Cu, Fe, Mn, Pb, and Zn) were conducted on sediments from an inundated and a drained wetland site. Results showed metal fractionation to be both metal- and site-specific. The oxidizable fraction was dominant for Cu, Cr, and Fe (>65% of the nonresidual fraction) and overall is most important also for Cd and Pb. Iron/manganese oxides were important for Pb, Mn, and Zn, particularly at the drained site. The exchangeable fraction is significant in the drained site, particularly for Cd, Pb, and Zn; but not for the inundated site. Cr, Cu, and Fe exist in forms not likely to be remobilized, whereas Cd, Mn, Pb, and Zn are potentially mobile if drained wetland sites are reflooded. Mass balance calculations illustrate the potential for the removal of ~85,000 kg of exchangeable Zn if currently drained sites across the IDNL are reflooded, with concentrations in water draining into Lake Michigan as high as 5 ppm.

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METHODS TO MEASURE DISSOLOVED ORGANIC NITROGEN CONCENTRATIONS AND FLUX RATES: THE GOOD, THE BAD, AND THE UGLY-REVISITED

The search for an efficient and reliable method for the isolation of dissolved organic nitrogen (DON) in natural waters is an ongoing process. Measurement of uptake and release rates of DON requires the isolation of DON from dissolved inorganic nitrogen (DIN) and interfering salts. One method that has been employed utilizes an amphoteric ion retardation resin. Ongoing problems with the resin, however, led us to search for an alternative. A new approach has been developed using the strong reductant, titanium (III) chloride, to reduce nitrate to ammonia, which is then removed through volatilization. A series of steps follow, yielding N-15 labeled DON in the form of nitrite. The nitrite is then isolated by solid phase extraction, removing salts and allowing for the analysis of the DON-15 via mass spectrometry. Preliminary results indicate a removal efficiency of DIN of 98% and a recovery of DON of 91.5%. Importantly, all reactions in the method are done at or below room temperature making this approach the least chemically destructive available to date.

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CAN BURROW VENTILATION BY MACRO-INFAUNA ENHANCE POREWATER FLOW: EVIDENCE FROM THE NORTHERN GULF OF MEXICO

Burrowing macrofauna exhibit profound influences on the physical and chemical characteristics of the seafloor by the disruption of the sediment fabric during burrowing and,

for organisms that build semi-permanent burrows, transport of oxygenated waters to subsurface strata during ventilation. Our understanding of water movement through burrows is often one of unidirectional flow from an inhalant opening to an exhalent opening with solutes diffusing radially from the burrow wall. However, several species of thalassinidean shrimp from the Northern Gulf of Mexico build burrows with only a single exhalent opening with no apparent inhalant aperture. From where, then, does the supply of burrow effluent come? We hypothesize that porewaters are infiltrating the burrows leading to enhanced porewater flow through the sediments. With volume flow rates up to 15 L per day through individual burrows and population densities that reach > 500 per sq. meter there is the potential for rapid flushing of the sediments in these habitats. We are investigating this question through a series of field and lab measurements of ventilation behavior, burrow structure, and porewater flows.

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EFFECTS OF INTERNAL GRAVITY WAVES ON ACOUSTIC PROPAGATION IN SHALLOW WATER

In shallow water environments, internal gravity waves in the form of solitary wave packets interact with acoustic fields propagating through the ocean waveguide. These wave packets or solibores are commonly generated by tidal flow over variable bathymetry in water with significant density stratification, and their spatial and temporal structure alter the sound speed distribution in the water column. We have developed a non-hydrostatic hydrodynamical model of internal tide generation and propagation and integrated it with an acoustic propagation model to perform time-dependent simulations of the acoustic/internal wave field interactions. An overview of the changes in the amplitude and phase characteristics of the acoustic field interacting with these sub-mesoscale features will be discussed from the viewpoint of computer simulation. Examples will illustrate the refraction and focusing of acoustic energy from solitary wave packets, as well as the effect on beamforming. Work supported by the Office of Naval Research.

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NITROGEN FIXATION AND PHOTOSYNTHETIC PARAMETERS OF TRICHDESMIUM SPP. IN THE SUBTROPICAL NORTH PACIFIC

Nitrogen fixation by Trichodesmium is a key component in recent oceanic biogeochemical models. However, its basic photosynthetic parameters are thus far inadequately characterized. On separate cruises during fall 2002 and late summer 2003, we collected Trichodesmium spp. in the subtropical North Pacific. We measured dinitrogen (N2) fixation rates (using acetylene reduction) and carbon (C) fixation (with 14C-labelled sodium bicarbonate uptake) at varying light intensities using 21-well photosynthetrons. We then modeled the data to a curve-fitting equation based on Platt et al. (1980) to determine alpha (the increase in fixation rates at low light intensities), beta (photoinhibition parameter at high light intensities), Pbmax (photosynthetic capacity) and Ik (light-saturation parameter). In our preliminary analyses of N2 fixation, we derived a range of alpha = 0.35 – 3.63 during the fall and alpha = 0.33 – 2.26 (pmol N col-1 hr-1)/(uEinst m-2 s-1) during the summer. Pbmax during the fall ranged between 23 – 107 and 44 – 132 pmol N col-1 hr-1 during the summer. All parameters for both N2 and C fixation will be presented.

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ADAPTIVE OCEAN SAMPLING USING COORDINATED AUTONOMOUS UNDERWATER VEHICLE FLEETS: THE AUTONOMOUS OCEAN SAMPLING NETWORK IN MONTEREY BAY 2003 AND BEYOND

The Monterey Bay '03 Field Experiment (MB'03), initiated as part of the Autonomous Ocean Sampling Network (AOSN) project, used a large fleet of autonomous underwater gliders for the purpose of adaptive ocean sampling. AOSN is a multi-disciplinary, multi-institutional project focused on using autonomous underwater vehicles together with ocean forecasting models to improve the ability to observe and predict ocean processes. Each glider carries sensors to measure a number of physical and chemical variables. In this way, each vehicle serves as a mobile sensor and the vehicle network as a mobile sensor array. Our contribution to AOSN is the design and implementation of real-time, coordinated and cooperative control strategies to direct the vehicle network so that measurements are most useful for understanding and forecasting ocean dynamics. One focus is to provide and exploit real-time estimates of gradients in measured fields. During MB'03 we demonstrated maneuvers involving rigid formations, re-configuration (changing the resolution of the mobile sensor array), and coordination with different sensor platforms. We describe results from MB'03 and discuss the ability of the coordinated glider network to estimate meaningful gradients.

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SURFACE VELOCITY AND PROFILING DRIFTERS TRACK POTENTIAL LARVAL PATHWAYS, NORTHWESTERN HAWAIIAN ISLANDS

In fall 2001, six APEX (Autonomous Profiling Explorer) floats and six SVP (Surface Velocity Program) drifters were deployed along the Northwestern Hawaiian Islands (NWHI) to investigate larval dispersion. Floats descended at sunset (based on original deployments) to 100m for 13 hours, profiling water temperature every 2m as they rise. SVPs were drogued to follow water flow at 35m, where previous surveys for spiny lobster larvae showed maximums. Data is transmitted via the NOAA/ARGOS system. All floats and SVPs spent time in mesoscale eddies, primarily anticyclonic, generated near the southern end of the Hawaiian Ridge. Three floats and three SVPs remained very near the islands for weeks to months, suggesting a possible local recruitment mechanism. Four floats moved south/southwest and two were swept around Johnston Atoll. They continued west, passing north and south of Wake Island. Two SVPs eventually traveled south/southwest, one reaching the Philippine Sea and traveling in the Kuroshio beyond 35N 145E. These trajectories have possible implications on larval dispersion and biodiverstiy in the Central Pacific, while changing water temperatures encountered may affect fecundity of any larvae transported.

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EFFECTS OF THE MERIS DESIGN ON THE RETRIEVAL OF WATER-LEAVING RADIANCES BY NEURAL NETWORKS

In February 2003 the European Space Agency (ESA) launched the ENVIronmental SATellite ENVISAT which carries among other instruments the MEdium Resolution Imaging Spectrometer MERIS. The MERIS band setting and its sensitivity were among other things optimized to acquire data over the ocean. The sensor consists of five overlapping CCD cameras which demands special routines for the geometric and radiometric calibration. The water leaving radiances contribute to approximately 5 to 10 percent to the top-of-atmosphere signal. Thus the atmospheric correction has to be done with special care. We present some examples of atmospheric corrections based on the inversion of radiative transfer calculations over case I and case II waters by artificial neural networks. While a multilayer perceptron network yielded good results the inversion by radial basis functions failed during the first tests. A deeper analysis led to an explanation of this behaviour by considering the non-perfect radiometric calibration and the different mathematics of the networks used.

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EXPLORATION, BIOGEOGRAPHY AND BIODIVERSITY OF COLD SEEP FAUNA IN THE GULF OF MEXICO

In 2002 and 2003, we used the Johnson Sea-Link submersibles to explore 15 cold-seep sites on the northern Gulf of Mexico continental slope. We sampled a total of 21 vestimentiferan tubeworm aggregations with our "Bushmaster" collection devices. Over 90 different species of macro- and mega-fauna have been collected in association with the tubeworms, with at least 5 and as many as 12 of these species being new to science. One of the main findings has been a general consistency in the fauna inhabiting vestimentiferan aggregations and mussel beds over an E-W transect of 580 km. Two additional Bushmaster collections of Lophelia pertusa emphasize this result with very different communities found associated with coral habitat at the same sites. Aggregation age has a greater effect on the composition of the associated community than collection site, with younger aggregations containing a greater proportion of endemic species in lower trophic levels. In the fall of 2003, we will be expanding our census of Gulf of Mexico cold seeps to deeper waters between 2100 and 3500m using the Alvin and WHOI towed camera system.

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LEARNING ABOUT SCIENCE THROUGH THE LOCAL MARINE ENVIRONMENT

The GK-12 OCEANS fellowship program is an exciting collaboration between the National Science Foundation, USF's College of Marine Science graduate students, and Pinellas County School District teachers. As part of the OCEANS program, we are developing research activities in which students learn science by inquiring about their own environment. Madeira Beach Middle School is located directly on Tampa Bay, FL, providing a great opportunity for students to study the marine environment in their own backyard. The teamwork between marine scientists and teachers enables us to share our expertise in assisting students to monitor and research the habitats within the vicinity of the school. The students get hands-on experience with scientific equipment to collect their own data sets to analyze and make conclusions. Future students will then be able to use these datasets to compare with their own data. This program allows scientists to share their enthusiasm with teachers and students so that they too can gain an appreciation and awareness of the marine environment through their own hands-on experiences.

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RELATIONSHIP BETWEEN SEDIMENTATION AND REGENERATION IN MONTASTREA SPP. (SCLERACTINIA)

Understanding the relationship between nearshore water quality and incidence of mortality in corals is essential to resource management. Sedimentation and turbidity are generally assumed to stress corals. However, in the Florida Keys, inshore patch reefs often have higher coral diversity and living coral cover than offshore reefs, despite higher sedimentation and turbidity inshore. There also is a need to understand the coral's potential for healing and what conditions would prevent recovery. This study examines the relationship between sedimentation and regeneration rates in Montastrea annularis complex. Sampling was conducted at three patch reefs within the Florida Keys National Marine Sanctuary, near Key Largo, and two patch reefs in Biscayne National Park, along the Northern Florida Reef Tract. Sampling-induced lesions on tagged corals were monitored on a quarterly basis during 2001 and 2002. Sediment traps were placed at each site, in proximity to the corals beings sampled, to quantify sedimentation. The percentage of lesions healed was highest in corals at the site with the highest sedimentation rate, while corals at the site with the lowest sedimentation rate exhibited the highest mortality.

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COUPLING AND DECOUPLING OF PHYSICAL AND BIOLOGICAL DISTRIBUTIONS IN THE SOUTH SAN FRANCISCO BAY SYSTEM IN WET AND DRY YEARS: FRACTAL AND MULTIFRACTAL MEASURES

Multiscale analysis can be used to map differences in spatial structure of biological and physical variables in dynamic environments. Such a mapping strategy allows realistic portrayal of the patch structure observed in the system. USGS data from the monthly monitoring of South San Francisco Bay provides a record of fluorescence, salinity, and temperature that gives insight into spatial structure. Multiscale analysis suggests that wet and dry conditions lead the relation of fluorescence to the two physical variables into distinctly coupled and uncoupled states. In wet years, wavelet-based power spectra have similar slopes for all three variables over the range of 60 meters to 1.5 km. In dry years, the spectral slopes of fluorescence are flatter than for the other two variables. These differences in spatial structure are consistent with expected effects of benthic grazing pressure. Given the complex interplay of oceanic and land-based supplies of water to the basin, the evolution of these two distinct patterns has implications for modelling the system, and for using the relationship between spectral slope (beta) and fractal dimension in generating input fields to be used in ecosystem models of South San Francisco Bay. Multifractal analysis adds the descriptive power of higher order moments characterizing the intermittency of the system, and provides a valuable tool for further distinguishing between cases in which identical power-spectra result from different patterns.

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METAL CYCLES IN SAN FRANCISCO BAY: SOURCES, SINKS AND SPECIATION ON DIURNAL, SEASONAL, ANNUAL AND DECADAL SCALES

While virtually unknown - actually incorrectly reported - a litttle over a decade ago, the biogeochemical cycles of metals in San Francisco Bay are now perhaps known better than those of any other aquatic system. This dramatic shift in knowledge is primarily due to (1) an ongoing, uninterrupted regional monitoring program over the past fourteen years and (2) complementary studies by researchers from several universities, government institutions and industry. These interconnected programs have provided concentration and speciation data that have lead to the establishment of new, more appropriate water quality criteria. They have also provided information on the sources and cycling of contaminant metals within the estuary on diurnal, seasonal, annual and decadal scales. That knowledge is now being used to establish new, more appropriate startegies to reduce contaminant loadings in the estuary. Consequently, research scientists, redulators and dischargers, and the public have all realized the benefits from scientific collaborations in a sustained monitoring program that provides flexibility for evolving scientific investigations.

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PHYSIOLOGICAL AND GENETIC CHARACTERIZATION OF HEMOGLOBIN IN A PHENOTYPICALLY PLASTIC HYDROTHERMAL VENT TUBEWORM

The ability to thrive under extremely diverse environmental conditions sets the hydrothermal vent tubeworm Ridgeia piscesae apart from other vestimentiferan species. R. piscesae occurs as multiple growth forms along the Juan de Fuca Ridge in the Northeast Pacific. These growth forms are genetically indistinguishable. The microenvironments for each phenotype differ in key parameters such as temperature and concentrations of sulfide and oxygen, suggesting that conditions of the surrounding vent water may be driving their phenotypic plasticity. Tubeworm hemoglobins are candidate proteins that may play key roles in the differentiation of these growth forms because they provide an essential link to the external environment by delivering sulfide, oxygen and perhaps inorganic carbon to the chemoautotrophic bacterial endosymbionts. Two of the most extreme morphotypes have phenotype-specific differences in the structure and function of one of the hemoglobins found in the coelomic fluid of R. piscesae. We also present preliminary results from an investigation of phenotype-specific expression levels of genes encoding the polypeptide chains responsible for sulfide binding in the hemoglobins.

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CONSTRAINING A PARAMETERIZATION OF EXPORT PRODUCTION USING A NUMERICAL MODEL AND ITS ADJOINT

We use the MIT ocean circulation and biogeochemistry model and its adjoint to bring modeled and observed distributions of ocean macro-nutrients and oxygen into consistency. The biological export of nutrients is parameterized simply as a maximum export rate modulated by the availability of phosphate, light and iron. This maximum export rate characterizes the unresolved biogeochemical processes in the model and is a function of latitude, longitude and season. We use the adjoint model to estimate the pattern and seasonality of the maximum export rate that minimizes the difference between modelled and observed climatologies of seasonal phosphate and oxygen. Here we demonstrate the application of the model and its adjoint in two experiments: First, we will optimize the maximum export without explicit iron limitation. Secondly, we will include the explicit iron model and optimize parameters such as the bio-availability of the aeolian source. We will assess to what extent the explicit iron cycle can account for the structure of the maximum export rate in the first experiment.

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ORGANIC COMPLEXATION OF SOLUBLE AND COLLOIDAL IRON THE SUBARCTIC NORTH PACIFIC AND BERING SEA

The Fe-binding capacity of organic seawater ligands was determined at 6 stations in the subarctic North Pacific and at a station in the western Bering Sea. Samples (15 m to 1500m depths) underwent ultra filtration to give two operationally defined size fractions, "dissolved" (<0.4 micrometers) and "soluble" (<0.02 micrometers). The technique used was competitive ligand exchange – adsorptive cathodic stripping voltammetry (CLE-ACSV) with differential pulse and the competitive ligand 2-(2-Thiazolylazo)-p-cresol (TAC). We found the highest concentration of total ligands in the surface waters at all stations, with total ligand concentrations in the region of 1.5 to 1.8 nM, with strong L1 ligands contributing around 0.5 nM. The calculated ligand values were always in excess of total Fe by 0.3 to 1.5 nM. The total ligand concentration decreased down through the water column to around 1 nM with a complete absence of the strong L1 ligands. Colloidal ligands were a significant fraction (50%) only in surface waters at the two stations that had the highest chl A. Elsewhere, including deep waters, speciation was dominated by soluble ligands.

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NON-STEADY STATE MODELLING OF DIAGENETIC PROCESSES IN MARINE SEDIMENTS WITH SPECIAL EMPHASIS ON FIELD DATA

Vast numbers of field data are the basis for the parameterization of a novel non-steady state model of diagenetic processes in the sediment of Aarhus Bay, Denmark. These high-resolution field data in both time and depth include in situ degradation rates, fluxes across the sediment-water interface as well as porewater and solid state concentrations. Based on these data this presentation discusses the diagenetic model formulation and shows examples of the model parameterization and verification. Finally, an example is given of how the model can be used to predict biogeochemical changes in a marine sediment caused by an altered environment which accordingly leads to a change in model input.

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A PHYLOGENETIC AND ULTRASTRUCTURAL CHARACTERIZATION OF THE CYANOBACTERIAL PASSENGERS IN AN UNKNOWN TINTINNID SP. AND A SPONGIOSE RADIOLARIAN, DICTYOCORYNE SP.

Cyanobacterial symbionts have been observed forming associations with an unknown Tintinnid species and a Radiolarian, Dictyocoryne sp. from the tropical Atlantic and Pacific Oceans. Individual hosts were isolated for an immuno-cytochemistry assay coupled with Transmission Electron Microscopy. Cyanobiont cell diameters ranged 1.5-2.0 µm and 0.6-0.8 µm in the Tintinnid and Radiolarian hosts, respectively. Symbionts from both hosts were significantly labeled with the phycoerythrin antibody. Thylakoid distribution was peripheral in the symbionts of the Radiolarian, as was the phycoerythrin labeling. The phycoerythrin label was homogenous in the Tintinnid cyanobionts;thylakoids were not clearly visible in the cells cross section. In both hosts, there were several symbionts in the process of cell division. However nitrogenase localization was low. Phylogenetic reconstructions of the Tintinnid cyanobiont 16s rRNA sequences showed high support for two distinct clades. One clade was closely related (96-100%) to Synechococcus sp., whereas the other diverged and was slightly comparable (89-90%) to Prochloron sp. and Pleurocapsa sp. The symbionts of Dictyocoryne sp. showed 99% similarity to Prochlorococcus sp. So far there have been no reports of a Prochlorococcus sp. living symbiotically with open ocean eukaryotes. The low sequence similarity in the Tintinnid cyanobionts' suggests a novel group of cyanobacteria has been unveiled.

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THREE-DIMENSIONAL ANALYSIS OF CORAL GROWTH USING COMPUTER TOMOGRAPHY

Advances in computer tomography (CT) have allowed the creation of high-resolution three-dimensional scans of hard coral skeletons. In contrast to traditional X-ray techniques, CT scans do not require fine slicing of the coral specimen. Also, X-ray techniques give only an average density value through a physical slice, whereas CT scans give density information for a fine three-dimensional grid of points encompassing the entire specimen. Theoretically, a CT scan of a coral skeleton contains a long-term record of the coral's growth patterns and health. Unfortunately, this data is difficult to extract and interpret due to the complex, opaque nature of the volumetric data. To extract information from CT coral scans, we have developed several new techniques in image and volume processing. Our techniques have two goals: (1) to allow the accurate extraction of empirical data, for example, coral growth bands, and (2) to give us an intuitive three-dimensional understanding of coral growth patterns. We will demonstrate our techniques using a CT scan of a large specimen of brain coral, Diploria labyrinthiformis.

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DETECTION OF METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS (MRSA) IN POPULAR MARINE RECREATIONAL BEACHES IN HAWAII

Skin infections with Staphylococcus aureus have been associated with recreational uses of marine waters in Hawaii and these pathogens have been recovered from several marine beaches. Increasing anti-microbial resistance of S. aureus, especially to methicillin, and frequent reports of human skin infections with MRSA is a major problem, particularly for Pacific Islanders. The objective of this study was to determine the incidence of MRSA in all the S. aureus isolated from beach water samples in Hawaii. The CHROMagar Staph aureus method of directly enumerating from clinical samples was modified and up to 124 CFU/100 ml of S. aureus were recovered from beach water samples. Confirmed S. aureus isolates were tested for susceptibility to oxacillin. Ten isolates of MRSA were recovered from three beach sites. They represent approximately 1% of all confirmed S. aureus isolates and this is similar to the nasal carriage rate of MRSA in a local medical clinic. This new monitoring method will allow standardized testing of beach water and will be useful in understanding a link between MRSA in seawater and human infections.

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CLUSTER-BASED CHARACTERIZATION OF OCEAN VARIABILITY

Acoustic propagation can be highly sensitive to specific features in the sound speed structure of the ocean. Short of in situ measurements, it can be useful to characterize an area based on historical and modeled profiles in an area to determine if there are a few dominant modes that occur and how often those modes occur. In many areas, in situ measured profiles are sparse or unavailable. Using measured profiles and certain derived parameters of acoustic relevance, we examine the resulting clusters and compare them with those derived from numerical ocean models and determine if the modes can be determined (or at least limited) using remote sensing.

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SEDIMENTATION AND HABITAT CHANGE IN SOUTH SAN FRANCISCO BAY: 1858 - 1983

Since the Gold Rush, sedimentation patterns and bathymetry of South San Francisco Bay have been altered by both natural processes and human activities. Between 1858 and 1983 more than 80% of tidal marshes were converted to salt ponds, agricultural fields, and urban areas. Loss of marshes has reduced tidal exchange with the bay and, because of this and other factors, tidal flat area has decreased by 40%. South San Francisco Bay has experienced a net loss of sediment from 1858 to 1983; however within this timeframe there have been periods of both deposition and erosion. From 1858 to 1898, net sedimentation was near zero. From 1898 to 1931 and from 1956 to 1983, sediment loss approached 3 million cubic meters/yr. During the intermediate period, from 1931 to 1956, it gained approximately 3 million cubic meters/yr of sediment. This anomalous deposition corresponds to a period of rapid urbanization and may in part be the result of associated land use practices. Sediment dynamics are an essential factor controlling the extent and distribution of habitats and are vital to understanding this complex ecosystem.

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DIVERSITY OF NITRITE REDUCTASE GENES IN THE WATER COLUMN OF PERMANENTLY ICE-COVERED LAKE BONNEY, ANTARCTICA

Lake Bonney is a permanently ice-covered Antarctic lake that is unusual because denitrification occurs in the deep anoxic waters of the west lobe (WLB) but not the east lobe (ELB). Environmental factors that usually control denitrification rates (e.g., DOC, NO3, O2) do not appear to explain its distribution in this extreme environment. To help resolve this mystery, nirS genes (encoding cytochrome-cd1 nitrite reductase) were PCR-amplified from DNA extracted from various depths in both lobes. Sequencing of >100 nirS clones revealed extremely low diversity, from a single sequence type at 16m and 19m in ELB to only 4 to 5 sequence types at 25m in ELB and 16m in WLB. Significant community compositional overlap and greatest diversity occurred at the two depths where maximal denitrification rates were recently measured via the acetylene block method. The dominant nirS sequences were most closely related to Marinobacter sequences. The detection of nirS genes is consistent with the immunofluorescence detection of denitrifiers (including an ELB Marinobacter isolate) in the lake, but only deepens the mystery of why there is no denitrification in situ.

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A TRANSECT OF SILICA PRODUCTION ACROSS THE NORTH PACIFIC GYRE

We measured silicic acid and biogenic silica concentrations and biogenic silica production rates at 12 locations in the North Pacific from 23.6 degrees to 49.2 degrees N latitude, along a transect from Honolulu, Hawaii, USA to Kodiak, Alaska, USA. There were strong gradients in all three properties in the transition zone between the North Pacific subtropical and subarctic gyres, with silicic acid and biogenic silica concentrations and silica production rates increasing from relatively low values in the subtropical gyre to relatively high values in the subarctic gyre. We also conducted 32-Si autoradiography experiments to compare and contrast the contribution of selected diatom groups to silicon cycling in these two very different ecosystems.

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CALIFORNIA COSEE: WHAT'S IN IT FOR SCIENTISTS?

We at CA COSEE make scientists an offer too good to refuse: We'll help you get your proposals funded, and charge nothing for our services. How? By connecting you with professional educators, we'll relieve you of the burden of developing and executing outreach plans that demonstrate the broader impact of your research. Perhaps even better, we'll draft the broader impact sections of your proposal, develop a budget for the outreach component, and work with you to secure additional funds to support your outreach activities.
We'll describe specific CA COSEE-facilitated collaborations between scientists and educators, as well as share lessons we're learning about the catalytic process we've undertaken. The value of the services we provide in terms of leveraging limited resources and forging partnerships that ultimately make ocean research relevant to non-scientists will be reflected in the quality of education resources generated as well as scientists' changing attitudes toward outreach. We invite all those interested, especially ocean scientists (including technical staff and graduate students) and informal science educators to visit www.cacosee.net and click on Engaging Scientists.

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AUTONOMOUS UNDERWATER GLIDER PERFORMANCE DURING AOSN-II

The August 2003 Autonomous Ocean Sampling Networks (AOSN-II) experiment utilized a heterogeneous fleet of 21 underwater vehicles with widely varying capabilities to investigate physical and biological processes associated with coastal upwelling along the central California coast. Central to this effort were two fleets of high-endurance autonomous underwater gliders operated by the Scripps Institution of Oceanography and the Woods Hole Oceanographic Institution. Gliders are torpedo-shaped winged vehicles which maneuver slowly through the ocean in a sawtooth-shaped trajectory. At predetermined intervals the vehicles surface to determine their geographic position, transmit collected data, and receive new instructions from a shore-based control system via satellite phone. During the month-long experiment a total of 15 gliders occupied more than 10,000 km of horizontal trackline in Monterey Bay and vicinity and collected more than 12,000 vertical profiles of temperature and salinity, chlorophyll fluorescence, optical backscatter, and PAR. We will present an overview of glider operations during the AOSN-II experiment, review vehicle and sensor performance, and summarize the resulting oceanographic data set including regional tracer and velocity fields.

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BETA-DIMETHYLSULFONIOPROPIONATE (DMSP) AS A GRAZING DETERRENT IN COASTAL PHYTOPLANKTON COMMUNITIES

While not much is known about the role of chemical defenses in marine planktonic systems, it has been hypothesized that beta-dimethylsulfoniopropionate (DMSP) may act as a signal for the presence of potentially harmful algal cells. Previous laboratory experiments indicate that DMSP can inhibit feeding in some species of protists, but it is unknown whether this holds true when DMSP is present in coastal communities. Using both laboratory experiments and field experiments conducted in Puget Sound, WA, and the Gulf of Alaska, the role of dissolved DMSP as a chemical defense in ambient seawater was examined. DMSP (twenty micromolar) added to laboratory cultures and natural planktonic communities in Puget Sound led to a decrease in protist feeding rates; in natural communities, feeding on phytoplankton greater than twenty microns in size was affected more strongly than feeding on smaller cells.

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CONSEQUENCES OF NON-LINEAR DENSITY EFFECTS ON BUOYANCY AND PLUME BEHAVIOR

Aquatic plumes, as turbulent streams, grow by entraining ambient water. Buoyant plumes rise and dense ones sink, but, non-linear kinetic effects can reverse the buoyant force in mid-phenomenon. The class of nascent-density plumes begin as buoyant, upwardly accelerating plumes that subsequently reverse buoyancy, sinking to a more submerged trapping level or the bottom. Unlike double diffusion, where density adjusts to radiative or conductive temperature changes and salinity, the nascent-density effect is due to the mixing of plume and ambient fluids. A nascent-density example is a freshwater thermal plume discharged to freezing ambient fresh water, or to freezing brackish water up to a salinity of about 14psu. The highly buoyant plume rapidly becomes denser than the ambient fluid as the plume element temperature cools by entrainment. Once the mixture temperature falls below about 8C it becomes denser than the surrounding freezing water, decelerating its acquired upward velocity and ultimately sinking. If the equation of state were linear it would rise to an elevated trapping level or to the surface. The USEPA Visual Plumes software illustrates pertinent concepts with comparative examples.

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INORGANIC CARBON BETWEEN THE SURFACE AND THE ANOXIC ZONE OF THE BLACK SEA

High-resolution profiles of the partial pressure of carbon dioxide (pCO2) and total carbon dioxide (TCO2) between the sea surface and the anoxic zone were collected during the 2001 and 2003 R/V Knorr cruises to the Black Sea. Sea surface pCO2 and TCO2 were also measured continuously during both cruises. Although the general features remained unaltered, sharp contrasts were observed between the two years. The direct influence of the Bosporous inflow on the chemical structure of the sub-oxic zone was much more localized in 2003 than 2001. The cold winter of 2003 allowed deeper mixing to occur that enriched the surface layers with inorganic carbon, but it did not reach deep enough to supply a significant amount of nitrate to the photic zone. As a result sea surface pCO2 over the entire basin was higher than atmospheric pCO2 in 2003 while the reverse was true in 2001. Profiles obtained in the eastern basin allow us to separate some of the influences of the Mediterranean water intrusions into the sub-oxic zone from the effects of vertical mixing and biological processes.

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CROSS SHELF TRANSPORT INDUCED BY INTERNAL TIDES

Using a nonhydrostatic coastal ocean model, we study the influence of internal tides on the cross shelf transport of pollutants originating at the break of an idealized coastal shelf. The conditions we analyze represent those offshore of Huntington beach, where recent studies have shown that internal tides may be responsible for cross shelf transport of discharge from a sewage outfall located 7.5 km offshore at the shelf break. To demonstrate the effects of internal waves on the cross shelf transport of a microbial plume, we force the model with a 1 m M2 tidal signal using idealized two-dimensional geometries and representative density fields, with the waste field represented by a neutrally buoyant microbial contaminant field. The non-conservative behavior of the microbial pollutants is modeled as first order decay using inactivation rates reported in the literature for total coliform, fecal coliform, and enterococci (10^-6 to 10^-4 s^-1). We demonstrate the differences between cross shelf transport with and without the presence of internal tides and show that baroclinic motions result in a net shoreward mass flux of the pollutant field.

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EFFECTS OF INORGANIC AND ORGANIC PHOSPHOROUS ON THE GROWTH AND ALKALINE PHOSPHATASE ACTIVITY OF THE CYANOBACTERIUM TRICHODESMIUM GBRTRLI101

We report the effects of dissolved inorganic phosphorous (DIP) and dissolved organic phosphorous (DOP) (Na-glycerophosphate GP or Glucose-6-phosphate G-6-P) on the growth of the diazotrophic marine cyanobacterium Trichodesmium GBRTRLI101, isolated from the Great Barrier Reef (GBR) lagoon. The maximum specific growth rate increased with DIP medium concentrations up to 3.5 micromolar, and was reduced in media containing over 14.6 micromolar. The lowest concentration of DIP allowing long-term maintenance of the batch cultures was 0.5 micromolar. Growth rates with GP or G-6-P were similar to those in control cultures growing in 3.5 micromolar DIP. In both cultures and natural populations, alkaline phosphatase activity (APA) was inhibited with increasing DIP. The proportion of soluble APA, secreted into the medium, is modified by the availability and sources of P. These results are in agreement with observations of natural populations of this genus in areas of the GBR lagoon with elevated DIP levels, and with reports of P-limitation of N2 fixation in the central Atlantic Ocean. Our results suggest that DOP utilization could be important in supporting the growth of Trichodesmium in some environments.

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SINKING BEHAVIOR OF GASTROPOD LARVAE (ILYANASSA OBSOLETA) IN GRID-STIRRED TURBULENCE

Larvae of coastal gastropods sink at high turbulence intensities, and may use near-shore turbulence as an initial settlement cue. We quantified the relationship between turbulence intensity and the proportion of sinking larvae for competent mud snail veligers (Ilyanassa obsoleta). We exposed larvae to a range of field-relevant turbulence conditions in a grid-stirred tank. Larval movements in still water and in turbulence were recorded on video, and larval velocity measurements were extracted using video image analysis. We also measured turbulent flow velocities independently, using Laser Doppler Velocimetry. To interpret empirical measurements in terms of larval behavior, we developed a 3-component normal mixture model for vertical velocity distributions of larvae in turbulence. The model was fit to observed larval velocities by maximum likelihood, to estimate the proportions of sinking, hovering, and swimming larvae. Over the range of turbulence intensities found in typical coastal habitats, the proportion of sinking larvae increased exponentially with the log of the turbulence dissipation rate. By sinking when they enter turbulent, shallow water, competent larvae could settle more successfully in favorable coastal habitats.

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NITROGEN SPECIES AND ISOTOPES IN THE BLACK SEA

Previous nutrient profiles and recent microbiological studies indicate that the anammox process, in which one ammonium and one nitrite form nitrogen gas, plays an important role in nitrogen cycling in the suboxic zone of the Black Sea. Here we show the distributions of nitrogen species and isotopes and discuss them in terms of temporal variability and nitrogen transformations, including anammox. Analysis of samples collected in 2000, 2001, and 2003 from the Western Gyre of the Black Sea indicates an excess of nitrogen at the density where sigma-t equals 16.0. At that same density, concentrations of both nitrate and ammonium decrease to zero. The maximum of excess nitrogen corresponds to a minimum of 15N dinitrogen gas and both decreased during the 2000 to 2003 period. Over this same time period, the ammonium profiles remained consistent, but the nitrate concentration and downward flux decreased markedly. A reduction in the eutrification of the Black Sea could be affecting amounts of denitrification and anammox activity.

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TEMPORAL AND GEOGRAPHIC PATTERNS OF MARINE BACTERIAL COMMUNITY COMPOSITION

We are now beginning to investigate broad scale patterns of marine microbial diversity with molecular techniques. Through the use of a whole-community DNA fingerprinting approach, automated rRNA intergenic spacer analysis (ARISA), augmented with cloning and sequencing, we have been able to study and compare diversity of whole bacterial communities. ARISA provides the ability to analyze communities with high phylogenetic resolution, near the "species" level. Samples collected monthly from a California site over 3 years show stability over some seasons and changes over others, with a surprising annual seasonal return of particular communities (taxa as well as relative abundance) during some months. Samples collected from around the globe show complex patterns, with certain kinds of environments, such as coral reefs, having similar communities. A gradient sampled from the Brisbane River, Australia, to the Coral Sea showed particular taxa associated with river, bay, or ocean locations, and also revealed a positive relationship between species richness and bacterial abundance.

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HOT-DOGS: A USER-FRIENDLY INTERFACE FOR ACCESS TO THE HAWAII OCEAN TIME-SERIES DATA

The Hawaii Ocean Time-series (HOT) study is an ongoing, 15-year ocean observation program with a large and growing data base of physical, bio-optical, and biogeochemical parameters. On approximately monthly intervals since October 1988, a multidisciplinary suite of environmental measurements has been made, discrete samples collected and analyzed, and experiments performed; all HOT data are freely accessible via the Internet from servers at the University of Hawaii (http://hahana.soest.hawaii.edu/hot/hot_jgofs.html and http://www.soest.hawaii.edu/HOT_WOCE/) and Oregon State University (http://picasso.oce.orst.edu/ORSOO). In order to make these data sets fully available and interactive, we have developed a user-friendly, WWW-based interface called Hawaii Ocean Time-series Data Organizational and Graphics System (HOT-DOGS). Independent modules facilitate: (1) data extraction to obtain a text file consisting of one or more data columns, (2) data display to plot selected variables, (3) comparisons of a selected data set, or depth-integral thereof, in time, and (4) time-series analyses of data grouped by depth, potential density or temperature. We believe that this interface will be invaluable for both research and teaching applications.

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MEASUREMENT OF PHOTOSYNTHESIS-IRRADIANCE RESPONSE CURVE USING FAST REPETITION RATE FLUOROMETRY

The relationship between photosynthesis and irradiance is fundamental for the study of phytoplankton physiology and simulation models of ecological dynamics in the marine environment. Recently, because of its sensitivity and convenience, fast repetition rate (FRR) fluorometry is used to assess phytoplankton photosynthetic activity. FRR fluorometry can measure photosynthetic parameters such as chlorophyll variable fluorescence, functional absorption cross-section, electron transfer rate and photochemical quenching. Photosynthetic rate also can be calculated from the photosynthetic parameters measured as a function of irradiance. In this study, for estimating fluorescence-based photosynthesis–irradiance response curve of natural phytoplankton communities, we measured the photosynthetic parameters as a function of irradiance using FRR fluorometry in the Sagami Bay, Japan. Here, we show the results of experimental studies and discuss the utility of FRR fluorometry for assessing the photosynthesis-irradiance relationships of natural phytoplankton communities.

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COMPARATIVE STABILITY AND GROWTH REQUIREMENTS OF S.AUREUS VERSUS FECAL BACTERIA IN SEAWATER

The most frequent disease associated with recreational use of seawater in Hawaii is skin infection by S. aureus. We previously reported a correlation between concentrations and biotypes of S. aureus in beach water and from skin infections of children using these beaches. Currently, beach waters are only monitored for fecal bacteria. The objective of this study was to determine the comparative stability and growth requirements of S. aureus, E. coli and E. faecalis in filter-sterilized seawater at 25 C. These three bacteria did not grow in seawater and S. aureus was the most stable while E. coli was the least stable. In seawater mixed with 50% sewage, S. aureus failed to grow whereas E. coli and E. faecalis multiplied. In seawater supplemented with 0.05% peptone, all three bacteria multiplied. These results show that these bacteria can multiply in high salinity seawater if their nutritional requirements are met. S. aureus has stricter growth requirements than E. coli and E. faecalis. Thus, in seawater, S. aureus will persist longer than fecal bacteria but is less likely to multiply in polluted water.

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FULL-DEPTH PROFILE OF NANOFLAGELLATES AND THE STRUCTURE OF MICROBIAL FOOD WEBS IN OCEAN'S INTERIOR

Despite increasing recognition that heterotrophic bacterioplankton in meso- and bathypelagic water columns play an important role in oceanic carbon cycles, the fate of bacteria and microbial trophic dynamics in deep oceanic waters are still largely unknown. We examined the full depth profile of the abundance and cell size distribution of nanoflagellates and bacteria, and bacterial production (Leu incorporation) throughout the water column (maximum depth, 3,800 - 6,000 m) of the subarctic Pacific and the Bering Sea. Below the euphotic zone (> 100 m), the depth dependent decrease of the flagellate abundance was well described by a power function, with negative exponents (0.65 - 1.5) which are greater than the corresponding values of bacterial abundance. The cell abundance ratios of bacteria and flagellates (B:F ratio) scattered widely in the range of 10^2 - 10^4 and the ratios were correlated positively with bacterial turnover time. Comparison between this systematic transition of the B:F ratio and the Lotka-Volterra predator-prey model suggests that role of higher trophic levels is a key to explain the observed nanoflagellates and bacteria interaction in meso- and bathypelagic water columns.

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BASIN-SCALE DISTRIBUTION OF DISSOLVED ORGANIC CARBON IN THE DEEP NORTHEAST ATLANTIC: ITS SIGNIFICANCE IN CARBON AND OXYGEN DYNAMICS IN DEEP WATER

Concentration of total organic carbon (TOC) was measured in the mid-latitude Northeast Atlantic Ocean in September-October, 2000. We observed the north-south gradient of both TOC and apparent oxygen utilization (AOU) along the longitude of 18W/20W at 3000 m which corresponds to the lower surface of the Northeast Atlantic Deep Water. TOC decreased 3.7 micro-M C from 44N to 42.5N, whereas AOU increased 9.6 micro-M. Ratio of decrease in TOC to increase in AOU (dTOC/dAOU) was 15% in the mesopelagic zone (100-600 m), whereas ratio of increase in AOU to increase in dissolved inorganic carbon (dAOU/dDIC) was 116%. It reveals that DIC was produced mostly via respiration and mineralization of organic matter, but contribution of TOC (mostly dissolved organic carbon, DOC) to the latter process was minor in the mesopelagic zone. On the other hand, dTOC/dAOU increased to 35% in deep water (3000-5400 m), whereas dAOU/dDIC accounted for 64%. Our results demonstrate the importance of DOC to carbon and oxygen cycles as well as microbial ecosystem in the deep Northeast Atlantic.

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THE POPULATION BIOLOGY OF THE CHAETOGNATH, SAGITTA ELEGANS, IN DABOB BAY, WA, AS MEDIATED BY DIATOM-COPEPOD INTERACTIONS

As a part of a broader field study examining the potential effects of diatoms on planktonic food webs, we examined the abundance, stage composition, and diet of the chaetognath, Sagitta elegans. Our objective is to look for a relationship between phytoplankton blooms and S. elegans recruitment, as mediated by their copepod prey. Zooplankton were collected weekly during February-May, and in mid-summer, of 2002 and 2003 in Dabob Bay,WA . Greater abundances of S. elegans were found in 2003 than 2002, and summer compared to late winter/spring. Stage composition of the population suggests earlier recruitment of larval chaetognaths than previously found, as well as production of pulses of new recruits throughout the season. The proportion of S. elegans containing prey was greater in 2003 than 2002, and showed considerable seasonal (monthly) variability. Gut content analyses of S. elegans will be used to further examine the relationship between feeding and recruitment. The degree to which higher trophic levels such as chaetognaths are affected by phytoplankton and zooplankton blooms generally, and possible deleterious effects of diatoms specifically, will be discussed.

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TERRESTRIAL VEGETATION AND THE SEASONAL CYCLE OF DISSOLVED SILICA IN A SOUTHERN NEW ENGLAND COASTAL RIVER

The Wood-Pawcatuck watershed is located in southern Rhode Island and Connecticut. As part of a larger study of nutrient and sediment exports from the watershed, we measured dissolved silica (SiO2) concentrations at the river mouth between 1/14/02-11/29/02. Annual export of dissolved silica was 40 x 106 mol yr-1 or 50 kmol km-2 yr-1. Dissolved silica concentrations did not vary in a regular way with water discharge or water temperature. Dissolved silica and dissolved inorganic nitrogen concentrations were significantly related over the annual cycle ($p < 0.0001$) and both decreased substantially during the spring. Dissolved inorganic phosphorus did not covary with silica or nitrogen. The spring decline in river silica concentrations may be due to silica uptake by terrestrial vegetation. Model estimates of dissolved silica weathering rates, based on runoff and watershed lithology, estimated the annual flux for this year within 20% of that measured but overestimated the long-term dissolved silica flux by a factor of 2.5. In forested systems, where the influence of terrestrial vegetation is important, basin lithology and runoff alone may not be reliable indicators of dissolved silica flux.

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MULTICOMPONENT INVERSE MODELING FOR DETERMINATION OF DIAGENETIC REACTION RATES AFFECTED BY MACROBENTHOS

The depth-dependent rates of organic matter (OM) remineralization were calculated using a multicomponent inverse model for two sedimentary environments: Saltmarsh of Skidaway Island, Georgia, USA and laboratory mesocosms simulating bioturbated muddy estuaries. The model determined the OM remineralization rates by seeking simultaneous agreements between measured and model-calculated depth-concentration profiles of multiple major redox species while employing the biological transport parameters determined from direct field or laboratory observations. The calculation results confirmed and quantified the previous field and laboratory observations: (1) Fe(III)-(oxy)hydroxides are much more important than sulfate as terminal electron acceptors in the heavily bioturbated part of Skidaway saltmarsh due to their repeated redox cycling; (2) macrophyte vegetation at the saltmarsh stimulates microbial activities and enhances the OM remineralization rates; and (3) the population density of bioirrigating macrofauna has a positive relationship with the OM remineralization rates. In addition, the multicomponent inverse modeling approach highlights our current insufficient understanding of the C/N ratio during OM remineralization as well as the post-remineralization pathways for N.

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ASSOCIATION BETWEEN INORGANIC AND ORGANIC MOIETIES WITHIN INDIVIDUAL PARTICLES (0.2 - 3 UM) SUSPENDED IN SEAWATER STUDIED BY SINGLE PARTICLE MASS SPECTROMETRY

The association of organic matter with inorganic ions and matrices could have important biogeochemical consequences. For example, it has been suggested that dissolved organic matter (DOM) spontaneously aggregates around metal ions to form gels and eventually, particles. To explore such associations, we investigated the organic, inorganic, and metal composition of individual particles suspended in seawater or formed from DOM. The chemical composition and size of individual particles was determined on-line with a novel technique, aerosol time-of-flight mass spectrometry (ATOFMS). Particles, originally suspended in seawater solutions, were directly introduced into the ATOFMS after atomizing the solutions and sending the aerosol through a region of reduced humidity. For each sample, we analyzed between 500-3000 particles and found the presence of distinct metal ions (Ca, K, Mg, Fe), inorganic S, N and P species, and organic moieties (N-containing compounds, saccharides, and lipids). Based on these data, specific particle types with unique chemical associations were identified. This study represents the first on-line mass spectrometric measurements of individual particles from seawater solutions, providing direct evidence of the detailed chemical associations within individual particles.

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CONNECTIVITY OF MARINE POPULATIONS: COUPLING POPULATION GENETIC AND DISPERSAL MODELING APROACHES

Elucidating marine population structures and interactions is increasingly imperative as anthropogenic influences affecting them escalate. Although the science of marine reserves is an important tool for the conservation of marine populations and habitat, surprisingly little is known about the connectivity of marine populations via larval dispersal. An ideal approach is to couple predictions of particle movement made by models calibrated with detailed oceanographic data with empirical tests in field-based studies. Although important strides have been made in estimating dispersal using techniques such as electronic tagging and otolith chemistry, these approaches require large-scale spatial and temporal sampling in a challenging environment. Population genetics offers the advantage of detecting a cumulative signal of gene flow using a fairly simple sampling scheme. While advances have been made in determining appropriate levels of field sampling for genetic studies, developing a theoretical framework for population genetic models incorporating a variety of demographic, life history, and dispersal patterns lags behind. We propose a new way of looking at the construction of such models and suggest methods for directly testing their predictions in the field.

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THE IMPACT ON THE SOUND SPEED FIELD OF INTERNAL BORES AND LARGE AMPLITUDE INTERNAL WAVES IN THE CONTINENTAL SHELF/SLOPE REGION

Barotropic tides can generate internal waves that propagate up the continental slope and force deep water onto the continental shelf. Also dense water formed by winter cooling on the shelf flows down the continental slope to the deep ocean. Canyons are preferred locations for these cross-slope flows because the slopes are steeper than the average, thus accelerating the flows. Since cross-slope flows have an inherent vertical acceleration, they are nonhydrostatic. These flows produce large amplitude internal waves and internal bores. Previous simulations of internal bores over flat topography have demonstrated that nonhydrostatic models are required to obtain the correct dynamics of the head, the mixing region and the large amplitude internal waves of the bore. The organization of the temperature field generated by these dynamics significantly affects the propagation and coherence of acoustical signals. The sound speed field will be constructed from simulations of internal bores on slopes. The effect of the sound speed field on acoustical signals will be assessed particularly with respect to propagation and coherence.

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THE NEXT GENERATION OF IN SITU BIOLOGICAL AND CHEMICAL SENSORS IN THE OCEAN: A WORKSHOP REPORT WITH RECCOMMENDATIONS

The sensors workshop held in Woods Hole, July 2003 documented critical scientific and engineering aspects of existing, emerging, and proposed sensors in oceanography. Among many exciting advances reported were in-situ spectrophotometry, mass spectrometry, and laser induced breakdown spectroscopy (LIBS) for measurement of elemental composition, trace metals, nutrients and dissolved gases. Novel fiber optic-based sensors and DNA probe arrays for measuring abundance of specific genes and gene products (DNA, rRNA, mRNA), and an autonomous microbial sensor were highlighted for species identification. Sensor integration is necessary for measurements at appropriate time and space scales; e.g., optics and acoustics, in combination, become powerful tools for characterizing particulates, plankton, fish and whales. Large area sensor arrays to evaluate signal coherence must be designed for long term, autonomous operation, fast response, high accuracy and precision, wide dynamic range, self-calibration, low power consumption, common interface, and affordability. Rapid advances in miniaturization and sensor integration through micro and nanotechnology will lead to the next generation of sensors. Production of intensively integrated sensor systems will become cost effective for volume deployment on proposed observatories throughout the global ocean.

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FLUXES FROM LAND TO SEA: OPTICAL PROPERTIES AND GEOCHEMISTRY OF INLAND AND COASTAL WATERS IN BRITISH COLUMBIA, CANADA

The optical properties and geochemistry of inland and coastal waters are evaluated to quantify the sources, pathways, and fate of dissolved and suspended constituents (sediment, nutrients, ions) from land to sea for Canada's west coast estuaries. Spectrally active components are correlated with the aqueous geochemistry of the waters to determine fluxes of major and trace substances such as carbon, weathering products, and toxic elements over a one-year period. This is accomplished via simultaneous collection of in-water (135 channel spectral depth profiling), and above-water (hyperspectral airborne) spectral data, and geochemical data for fresh and coastal water environments. Constraining these fluxes provides new insights into a poorly studied yet vital part of Canada's coastal ecology, the Strait of Georgia – one heavily impacted by development,– and will strongly contribute to improving our ability to monitor case II waters regionally and globally.

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EFFECT OF CORTISOL AND RU486 ON CORTISOL CONCENTRATIONS AND ON NA+/K+-ATPASE AND GLUCOCORTICOID-LIKE RECEPTOR IMMUNOREACTIVITY IN JUVENILE SUMMER FLOUNDER

Cortisol is a steroid hormone secreted in response to stress and known to be a seawater-adapting hormone in teleost fishes. RU486 is a synthetic glucocorticoid and progesterone receptor blocker. We quantified effects of exogenous cortisol and RU486, alone or together, on whole-body cortisol concentrations and localized glucocorticoid-like receptors (GLR) and Na+/K+-ATPase using immunocytochemistry in juvenile summer flounder. Flounder were immersed in cortisol (20 mM), RU486 (0.12 mM), cortisol and RU486, with controls, for 5 days. RU486, with or without cortisol, significantly elevated whole-body concentrations of cortisol, confirming uptake by indicating suppression of the negative feedback loop on the cortisol axis. Immunoreactive-GLR and Na+/K+-ATPase were evident in all treatment groups in the primary osmoregulatory tissues (gill, intestine, and kidney). The GLR was more cytoplasmic in the intestine of RU486-treated flounder, whereas in control and cortisol-treated flounder nuclear staining was more evident. Localization of the GLR in the intestine and gills further evidences a direct action of cortisol on the major osmoregulatory organs. The present study also adds to the ability to manipulate the cortisol axis and therefore to understand cortisol's role.

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A NEW METHOD FOR IN-SITU CONTINUOUS DETECTION AND IDENTIFICATION OF MICROORGANISMS

Recent developments in the characterization of particle dispersions have demonstrated that complementary information on the joint particle property distribution (size-shape-chemical composition) of micron and sub-micron particles is available from combined absorption and scattering multiwavelength spectrophotometric measurements. On this basis, new miniaturized instrumentation and novel interpretation techniques have been developed for a variety of optical configurations. Experimental results demonstrate that this technology can be used for

the characterization of the joint particle property distribution in a large variety of on-line and in situ particle characterization applications. In this paper an interpretation model is proposed for the quantitative interpretation of spectral patterns resulting from transmission measurements of microorganism suspensions. It is demonstrated that different organisms give rise to spectral differences that may be used for their identification and classification. The interpretation model based on light scattering theory and spectral deconvolution techniques yields the quantitative information necessary for the detection and identification of microorganisms. Several microorganisms are presented as case studies. It is concluded that spectroscopy techniques coupled with effective interpretation models are applicable to different types of cells found in diverse environments.

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MODELLING THE GROWTH OF BUBBLES IN SOFT SEDIMENTS: DIAGENESIS MEETS FRACTURE MECHANICS

Bubbles grow in soft sediments by a combination of elastic deformation and fracture of the surrounding sediment. We present a mechanistic model for bubble growth by coupling the diffusive supply of gas (generated by methanogenesis or ambient super-saturation) to the mechanics of the sediment. Consistent with our experimental results, we specifically assume that linear elastic fracture mechanics (LEFM) governs sediment behavior. Because fracture events are rapid compared to elastic growth, the model divides growth into separate elastic and fracture phases. During the elastic phase, bubbles thicken by diffusive input of gas, but do not elongate. Conversely, bubbles elongate during the fracture phase, but may exhibit some elastic relaxation. Our model predicts that bubbles in sediments like Cape Lookout Bight (USA) can grow to observed sizes in about 1 week and that they become more and more eccentric with time. We also find that under some circumstances bubbles in an elastic medium can cease to grow, which is not possible in a fluid.

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THE INTEGRATED COASTAL OBSERVATION SYSTEM (ICOS): EXAMPLES OF OBSERVATION CAPABILITIES FROM ITS MAIDEN VOYAGE IN THE HUDSON RIVER AND NEW JERSEY/NEW YORK SHELF

The Integrated Coastal Observation System (ICOS) consists of the ECOShuttle, an undulating vehicle (2-50 meters) carrying multiple hydrographic and chemical sensors and the Mini-Shuttle, a depressor wing carrying a reduced sensor suite (1m depth), both interfaced with a van-based laboratory housing all control, data acquisition and chemical analysis equipment required for the operation of the vehicle. A pump aboard the ECOShuttle provides ~8 liters/minute of seawater to lab-based instruments measuring spectral absorption/attenuation, particle size, total organic carbon and nitrogen, pyrene, nitrate, phosphate and silicate. An optical plankton counter and a video plankton recorder can also be attached to the vehicle to measure zooplankton abundance and distribution. The ICOS system provides intermediate resolution coverage of coastal waters with nearly synoptic coverage of chemical and biological parameters which are generally not possible on moorings, gliders, AUVs or with remote sensing. The ICOS system is ideal for focused, integrated studies of complex coastal systems within a larger observational framework. Initial results from the first deployment of the ICOS system in the Hudson River and the New Jersey/New York shelf will be described.

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DIFFERENTIAL DIFFUSION: AN OCEANOGRAPHIC PRIMER

Even where mean gradients of oceanic temperature T and salinity S are both stabilizing, it is possible for the larger molecular diffusivity of T to result in preferential vertical turbulent transfer of T relative to S, a process known as differential diffusion. It is essential that this process be better understood in the oceanographic context, given potentially serious implications for estimates of diapycnal density diffusivity from ocean microscale measurements or tracer release experiments, as well as observed sensitivities of predictive models of ocean circulation and embedded ecosystems to values of vertical diffusivities. This review will describe the physical origins of differential diffusion and examine the existing evidence of differential diffusion that has been provided by laboratory experiments, numerical simulations, and oceanic observations.

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DO LANGMUIR 'SUPERCELLS' DOMINATE SEDIMENT RESUSPENSION AND TRANSPORT IN SHALLOW SEAS?

Continuous real-time observations with a 5-beam acoustic Doppler current profiler (VADCP) were made over a six month period at the LEO-15 cabled coastal 'observatory', located in 15m of water 7 km off the coast of New Jersey. Measurements of backscatter amplitude and (true) vertical velocity from this data set reveal that the major sediment resuspension events occur as a result of the highly episodic development of Langmuir "supercells", Langmuir cells that have grown in vertical extent to full water column depth. In these conditions, both the bubble clouds that originate at the surface and sediment clouds that originate at the bottom extend over the full water depth. Conditions that determine such events appear to depend more on time extent than magnitude of wind/wave forcing.

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DORADO AUTONOMOUS UNDERWATER VEHICLE OPERATIONS – LESSONS FROM THE FIRST 1000 KM

Monterey Bay Aquarium Research Institute (MBARI) commenced regular hydrographic data acquisition operations with its Dorado class autonomous underwater vehicle (AUV) in March 2003. The vehicle is reconfigurable for a variety of environmental monitoring tasks. It is accompanied by a team of operators and a dedicated support vessel equipped with a novel launch and recovery system. A set of data processing, visualization, and storage tools has been developed.
The standard suite of science instrumentation includes two conductivity sensors, two temperature sensors, two flow sensors, a dissolved oxygen sensor, a nitrate sensor, a turbidity sensor, and a fluorometer. A utility payload bay in the most commonly deployed configuration accommodates 95 liters and 20 kg of additional payload.
Missions are being conducted several times per month in the vicinity of Monterey Bay, California. A description of the operational system and lessons from the first year and 1000 kilometers of routine operations are presented here.

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A NOVEL APPROACH TO TRACKING EQUILIBRIUM AND KINETIC PARTITIONING OF CADMIUM AND LEAD BETWEEN DISSOLVED AND PARTICULATE FORMS IN SOUTH SAN FRANCISCO BAY, CA

Partition coefficients (KD) for six metals in South Bay vary over three orders of magnitude, with Cd and Pb behaving as end-member metals with respect to sorption. Additions of the low occurrence stable isotopes 106Cd and 204Pb are used as tracers to determine the exchange kinetics of these metals in laboratory studies of natural water and suspended sediments from South Bay. Equilibrium and kinetic sorption parameters are quantified according to a general model for metal partitioning assuming pseudo-first-order kinetics. As a result of the dissolved metal isotope additions, partition coefficients for both metals drop and then increase back to near ambient KD values after two weeks. Curve-fitting concentration versus time profiles from dissolved and exchangeable particulate data sets allows determination of kinetic rate constants. The kinetic results predict that sorption equilibria in South Bay should be reached on the order of a month for Cd and a week for Pb. Metal sorption exchange rates calculated using these kinetic results indicate that sorption exchange between dissolved and suspended particulate phases can cause dynamic internal cycling of these metals in South Bay.

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WASI - A TOOL FOR AUTOMATIC ANALYSIS OF SPECTRAL SIGNATURES OF DEEP AND SHALLOW WATERS

A user-friendly software tool was developed for simulating and analyzing optical in-situ measurements in deep and shallow waters above and below the water surface. It supports all major spectrum types which are commonly measured by instruments on ship: absorption, attenuation, irradiance reflectance, remote sensing reflectance, bottom reflectance, downwelling irradiance, and upwelling radiance. Calculation is based on analytical models. For deep water different well-established models are included, for shallow water new models were developed based on simulations using the radiative transfer model HYDROLIGHT. The program is designed as a sensor-independent spectra generator and spectra analyzer with well documented calculation steps and automatic result visualisation. It is suited to generate and analyze large series of spectra. All model constants and input spectra can be changed easily for adaptation to a specific region. The paper focuses on the models and inversion techniques for remote sensing reflectance spectra in shallow waters and gives examples of data analysis and error analysis.

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INTENSE PHYTOPLANKTON GRAZING IN CORAL REEFS SUSTAINED BY STRONG TURBULENCE OVER ROUGH BOTTOM TOPOGRAPHY

Near-bottom layers depleted of phytoplankton are typical in coral reefs, indicating the occurrence of intense benthic grazing. Our objective was to determine the rate of grazing and its relationship with turbulence for a fringing coral reef in the Red Sea. Phytoplankton removal was measured using four vertical pump arrays that defined a control volume. Current profiles and Reynolds stresses were measured at the volume's center. The rough bottom had a dramatic effect: bottom drag coefficients were 3-4 times greater for the reef than at a nearby sandy bottom. Rates of phytoplankton removal were amongst the highest reported for marine habitats, with an apparent clearance rate of 10-20 m/day. Zero grazing was measured when the reef was temporarily covered with a nylon sheet. Abundant grazers included sponges, bivalves, tunicates, polychaetes and micro-fauna inhabiting "bare" rocks. Turbulence effectively counteracted limitations on grazing imposed by the concentration boundary layer. At the same time, a thermal circulation maintained exchange with phytoplankton-replete waters from the open sea. Thus, hydrodynamics appears to play a major role in determining trophic dynamics of this coral reef.

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MODELING CONTAMINANT FLUX IN SEDIMENTS: CONFINING BIOTURBATION TO A SIMPLE EXPRESSION

A variety of mathematical models have been developed in the last two decades to characterize and quantify how bioturbation affects the fate of matter that settles on the sediment surface; most adopt an advection-diffusion formulation where bioturbation is integrated in one overall term. While some take into account nonlocal transport phenomena and can show a good fit to experimental data, most have extremely limited use in predicting the actual effects on sediment contaminant flux.

With the increased interest in "natural recovery" as a sediment remediation alternative for contaminated site cleanup, scientists are applying the flux models of their choice to support records of decision. Results from time-lapse sensors and high-resolution video of microcosms with intact estuarine infaunal communities indicate that integrating bioturbation into one mathematical expression is probably more of a leap of faith than most resource managers would care to admit.

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MATHEMATICAL MODEL OF JUVENILE SALMON SURVIVAL IN COASTAL WATERS OFF OREGON

During the last thirty years, most salmonid populations of the Northeast Pacific ocean have exhibited general declines in the area off Washington, Oregon and California. One of the hypotheses proposed to explain this decline is that poor survival of salmon populations is caused by the poor survival of juvenile salmon in the coastal waters during the time period shortly after ocean entry. Based on the studying the trophic relationships of juvenile salmon, we developed a mathematical model of the juvenile salmon survival in the coastal water off Oregon. Our model reflects the most important links between the juvenile salmon and their environment, enabling insight into relationships in a nearshore oceanic ecosystem. This knowledge provides a theoretical basis for a better understanding of the natural mechanisms controlling juvenile salmon survival. This enables prediction of different scenarios, within the dynamics of juvenile salmon populations.

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CLEARANCE RATES OF SALPA ASPERA

Salpa aspera is a filter feeding pelagic tunicate that can be important exporters of biogenic carbon from the euphotic zone to the deep ocean via fast sinking fecal pellets. This species of salps undertake an extensive diel vertical migration up to 600 m. During June and September 2002, the population of S. aspera extended over 100,000 km-2, from the mouth of Chesapeake Bay to Georges Bank, bounded by the shelf break and the Gulf Stream. The average nighttime biomass in the upper 50 m was 600 mg C m-2. Shipboard experiments were conducted on the grazing rates of S. aspera solitaries (30-90 mm), and aggregates (8-40 mm length), to determine the effects of a wide range phytoplankton concentrations (2x10-3 - 1x10-4 cells/ml) and temperatures (5-23 C) on the clearance and clogging rates. Clearance rates for S. aspera solitaries ranged up to 2000 ml h-1, and aggregates to over 1000 ml h-1. These experimentally determined rates help to quantify the in situ grazing rates for S. aspera and the intermittent importance of salps as consumers.

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REMOTE SENSING OF BENTHIC HABITATS IN SOUTHWESTERN PUERTO RICO

Benthic habitats were characterized in southwestern Puerto Rico using remote sensing techniques. We used IKONOS and Hyperion imagery in order to compare spatial and spectral resolutions. Coral reef, mangrove, seagrass, and sand were detected by using supervised and unsupervised classifications with ENVI. IKONOS proved to have the most appropriate spatial resolution (1 m) for our study site, but it was very limited in spectral information (4 bands). This sensor also showed problems with the atmospheric corrections, which introduced errors in the calibration procedure. The high spectral resolution (220 bands) of Hyperion demonstrated to be excellent for our study area. This sensor provided us with a better atmospheric correction and better calibration. However, its spatial resolution (30 m) presented a limitation for an accurate classification of our benthic habitats. Image classifications were compared with field data in order to evaluate the processing performance. Based on our preliminary analyses the most appropriate remote sensing technique for benthic habitats classification in the southwestern Puerto Rico is merging the data of these two sensors.

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NUTRITIONAL STATUS OF INVERTEBRATE LARVAE IN THE OCEAN

Are populations of larvae in nature surviving under near-starvation conditions, or growing at optimum rates? A series of experiments were conducted to assess the growth potential of larvae in the ocean at an offshore field site, 20 miles off the coast of California (Santa Catalina Island). Absolute rates of protein synthesis were measured in batches of sibling larvae placed in the field and reared, in parallel, under defined nutritional conditions in the laboratory. Larvae of the sea urchin Lytechinus pictus were used in these experiments because of their experimental tractability for studies of protein synthesis. Rates of protein synthesis for laboratory-reared larvae fed with 10 algal cells per microliter were 6-fold greater than starved larvae. In the field, rates of protein synthesis ranged from 50 to 75% of the fed larvae in the laboratory. We conclude that larvae growing under natural conditions were never starving, but were food limited to a variable degree. As food availability affects the time that meroplankton are in the water column, defining larval physiological state is an important component for models of dispersal and recruitment.

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CHARACTERISTICS OF THE REFLECTANCE PEAK AROUND 700 NM IN PRODUCTIVE TURBID WATERS – CONSEQUENCES OF VARIATION IN CONSTITUENT CONCENTRATIONS

The red region of the water-leaving radiance spectrum is important for remote estimation of chlorophyll-a concentration in case 2 waters. The variability of reflectance spectra in the red-NIR spectral region can be explained by the combined effect of pure water absorption, scattering by phytoplankton cells and inorganic particles, as well as by the absorption and fluorescence of chlorophyll-a. Sun-induced chlorophyll-a fluorescence causes a reflectance peak around 685 nm. At chlorophyll-a concentrations above 5-15 mg/m3, chlorophyll-a absorption becomes comparable to water absorption and it causes a minimum in total absorption and a peak of reflectance between 690 and 715 nm. Using simulations and experimental results, we show that under increasing scattering conditions, which are typical of inland and coastal waters, the reflectance peak at 685 nm, that is due to chlorophyll-a fluorescence, gradually becomes masked by the reflectance peak due to the minimum in total absorption, and shifts towards longer wavelengths. HYPERION, MERIS, and GLI provide information on water leaving radiance in red and NIR regions. Thus, the interpretation of the spectral features in this region becomes crucial for improvement coastal and inland water remote sensing.

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TEMPORAL AND SPATIAL VARIABILITY OF THE BLACK SEA SUBOXIC ZONE

We coupled an in situ electrochemical analyzer to a CTD to allow for high-resolution, real-time profiling of redox species across the oxic-anoxic transition zone of the Black Sea. Voltammetry was performed using gold-amalgam electrodes to simultaneously measure soluble oxygen and sulfur species (H2S/HS-, Sx2-, S8) at greater than one measurement per meter resolution. In situ data agree with measurements made in an on-deck flow cell coupled to a pump profiling system, and from water samples collected with conventional CTD rosette bottle casts. We observed much less significant lateral oxygen injection from the Bosporous in 2003 (less than 95 km from Bosporous) than in 2001 (up to 150 km). We attribute this difference to the winter climatic conditions (storms, winds) observed in 2003 compared to the calm summer conditions of 2001. Furthermore, suboxic zone thickness varied basin-wide, with changes in the depth of both oxygen extinction and sulfide onset. Vertical shifts in oxygen extinction and sulfide onset were also observed at the west-central station across a span of 7 profiles within 30 days.

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OBSERVING THE OCEAN FROM THE COOLROOM: RESULTS FROM A DECADE OF COLLABORATIVE PARTNERSHIPS

Scientists supported by research grants have now continuously operated a collaborative coastal ocean observatory on the New Jersey coast for over a decade. The motivation for maintaining the collaboratory is that for many of our science questions of interest, we typically over-sample in time and under-sample in space. In response, a long-term development strategy was adopted to address the need for improved coherent spatial sampling. The strategy is based on science-engineering partnerships where the scientists provide the motivation, the engineers develop the new tools, and the team collaborates on implementation. A phased and parallel implementation plan has progressed through three spatial scales, the 3 x 3 km scale of the early 1990's motivated by questions in sediment transport around ridges and sediment-flow-organism interactions, the 30 x 30 km scale initiated in the late 1990's to study the physics of coastal upwelling, the biological response and its relation to hypoxia, and now the 300 x 300 km scale of the New Jersey Shelf for which ten science-drivers have so far been articulated. The science-drivers were assembled through past and ongoing discussions with scientific, industrial and regulatory users of the collaboratory.
To highlight one example, a key user whose activities will likely evolve into the greatest economic impact for this collaboratory is the power industry. The need to meet the increasing power demands of growing seasonal coastal populations and businesses over a power grid that is already at capacity is driving multi-million dollar investments in local renewable energy studies. Both fixed and floating windfarms have been proposed, and wind resources are being evaluated, with the key engineering issue to overcome being energy storage. Peak demand occurs on the hot, humid and hazy days of summer when the major wind resource is the seabreeze. A better understanding of the seabreeze vertical structure, its horizontal extent in both the offshore and onshore, and how this is modulated by coastal upwelling have been identified as present scientific needs requiring both observational and modeling studies that can, in turn, identify long-term monitoring needs. The political nature of the windfarm debate further highlights the role of observatory scientists as the unbiased interpreters of the data they collect.

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A COUPLED MESO-EPIPELAGIC PARTICLE FLUX MODEL FOR THE BERMUDA ATLANTIC TIME-SERIES STATION (BATS)/OCEANIC FLUX PROGRAM (OFP) SITE: PHASE 3, INITIAL RESULTS

A coupled meso-epipelagic, one-dimensional ecosystem model was developed to model the flux of biogeochemically active constituents (carbon, nitrogen, phosphorus, silica, calcium carbonate and iron) from the surface to 4000 m at the
Bermuda Atlantic Time-series Station (BATS)/Oceanic Flux Program (OFP) Site. In this modeling approach, epipelagic and mesopelagic ecosystem models are combined into a single physical framework to simulate their influence on the sinking detrital pool. The sinking detritus aggregates from and disaggregates into a suspended detrital pool, providing another pathway into the mesopelagic. The
epipelagic primary producers are represented by three phytoplankton classes: diatoms, diazotrophs and small phytoplankton. The primary consumers are represented by passive and active feeding habit zooplankton classes. This configuration allows numerical experimentation into the process of particle remineralization. The model yields a particulate flux that can be sampled at the OFP trap levels allowing a direct comparison to the time-series of deep-water sediment trap data (25+ years) collected at the OFP site. Results of this modeling effort, model-data comparisons, as well as a discussion of the interplay between meso- and epipelagic processes will be presented.

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CHARACTERIZATION OF VIRUSES ISOLATED FROM NEW YORK ESTUARIES CAPABLE OF LYSING THE HARMFUL BROWN TIDE ALGA, AUREOCOCCUS ANOPHAGEFFERENS

We isolated viruses from NY estuaries which are able to lyse laboratory cultures of the harmful brown tide pelagophyte, Aureococcus anophagefferens. Ultrastructural analysis of infected Aureococcus cultures revealed the presence of intracellular viral capsids similar to those found in field populations. Although previous research has indicated there is no genetic variability among clonal Aureococcus cultures isolated from multiple locations over a 12 year period, viral isolates demonstrated the ability to lyse only a portion of these clones, suggesting that there may be a greater degree of diversity within brown tide field populations than has previously been recognized. The experimental additions of laboratory propagated viruses to bottle-incubated bloom waters from NY and MD estuaries demonstrated that additions of some, but not all, viral isolates were capable of significantly reducing the abundance Aureococcus relative to control treatments ($p<0.05$). Preliminary experiments indicate that viral lysis of A. anophagefferens is delayed in the dark and, hence, low light conditions which prevail during blooms may reduce viral-induced mortality of Aureococcus field populations. Pulsed-field gel electrophoresis (PFGE) characterization of viral genomes will also be presented.

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AN EMPIRICAL, GENERAL FORMULATION OF PRIMARY PRODUCTION FOR A MANAGEMENT MODEL OF PELAGIC METABOLISM IN LONG ISLAND SOUND

Decreasing oxygen levels in the bottom waters of Long Island Sound (LIS), attributed to the decomposition of phytoplankton blooms encouraged by high nitrogen loads, lead to hypoxic events during the summer season. We measured net community production and respiration in a Photosynthesis-Irradiance (P-E) series bi-weekly at eight stations ($n = 86$) spanning central and western LIS during the summers of 2002 and 2003. Physiological parameters of these P-E curves were used to calculate integrated rates of primary production in the water column. The empirical relationship between these estimates of phytoplankton production in the field and more routine measurements of phytoplankton stocks, euphotic zone, and incident irradiation is proposed as a formulation for phytoplankton production in an ecological model of oxygen metabolism in LIS. Such corroboration of the new model with local, direct measurements of rate-processes of pelagic primary production not only sets our model apart from those that base their primary production rate processes on temperature and/or tune these rates according to predictions of biomass, but strengthens our proposed general empirical formulation for primary productivity as a modeling approach practicable for management purposes.

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THE ABUNDANCE AND DISTRIBUTION OF BACCHL A IN THE TEMPERATE, SUBTROPICAL AND TROPICAL PACIFIC.

Aerobic anoxygenic phototrophic (AAP) bacteria were recently discovered in the euphotic zone of the open ocean. A proxy for their abundance is their primary photosynthetic pigment bacteriochlorophyll a (BacChl a). The importance of AA-photosynthesis, relative to oxygenic photosynthesis, can be gauged from the ratio of BacChl a to chlorophyll a (Chl a). AAP bacteria are suspected to be ubiquitously present in the world’s oceans; however, their relative abundance and impacts on rates of carbon cycling in the ocean are still open questions. To address these, concentrations of BacChl a were measured in samples from diverse regions of the Pacific Ocean. BacChl a was primarily found in the upper euphotic zone, contributing, relative to Chl a, 0.2 to 1% to primary photosynthetic pigments. Depth-integrated values were substantially lower, since concentration of BacChl a at the subsurface Chl-maximum and in particular at the Prochlorococcus maximum in the Eastern Tropical North Pacific were negligible. These results corroborate the earlier conclusions that aerobic anoxygenic photosynthesis does not have a major impact on cycles of energy and matter in the ocean.

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GENE FLOW AND HABITAT PREFERENCE IN TWO CRYPTIC CIRCUMGLOBAL COPEPOD SPECIES, EUCALANUS HYALINUS 1 AND 2

Circumglobal biogeographic distributions are common among oceanic marine zooplankton. Little is known, however, about the genetic relationships among disjunct populations of globally distributed species. This study examines the population genetic structure of 2 antitropical sister species, Eucalanus hyalinus 1 and 2, on spatial scales ranging from mesoscale to global. Specific goals of the study are 1) to identify the spatial scale on which these oceanic species experience panmixia, and 2) to identify oceanographic features that may act as barriers to gene flow. Mitochondrial cytochrome oxidase 1 (COI) DNA sequences were obtained from ca. 800 individuals collected at >110 locations in the North Pacific, South Pacific, Indian, and North Atlantic ocean basins. I examined genetic structure within and among each of these major populations. I also investigated ecological habitat specificity of the 2 species through an analysis of water mass properties and phytoplankton communities collected at the same location as copepod individuals. Results will be discussed in light of species-specific patterns of population genetic structure.

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PROSPECTS FOR THE USE OF SUBMERSIBLES AND ROV'S IN THE WORLD'S LAKES

Both tethered and remote controlled vehicles and submersibles have become important tools in aquatic investigations, both marine and freshwater. In 1979 the Tahoe Research Group made the first manned submersible dives in Lake Tahoe, reaching a maximum depth of 333 meters in the Pioneer 1. We subsequently acquired the Mini Rover from Deep Sea Systems International. The Mini Rover allowed examination of the lake's depths that were too deep for SCUBA, resulting in discovery and filming of the steamer Tahoe that had been scuttled in 1942. In 2002-03 Deep Sea Systems provided the Global Explorer for marine and lake studies, equipped with a 3-chip digital camera, zoom still camera with flash, four green scaling layers, and HID lights. Capable of reaching 3000-meter depth, it was used at 78 degrees N in the Beaufort Sea on a NOAA-University of Alaska expedition. The same unit, during summer 2003, examined Loch Ness, Scotland, in search of former marine deposits and collected organic growth on submerged basin walls. Further exploration of lakes is planned for 2004.

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TRANSPARENT EXOPOLYMER PARTICLES (TEP) DEGRADE SLOWLY IN LABORATORY INCUBATIONS

Transparent exopolymer particles (TEP) are an abundant, ubiquitous class of marine particles produced by gelation and aggregation of dissolved polysaccharides excreted by phytoplankton and microbes. TEP range in size from <1 to several hundred microns and occur at abundances of several thousand per ml. While TEP production has been quantified in various systems, the degredation of TEP to dissolved form is not well understood. We conducted 2 long-term (up to 6.5 month) experiments monitoring TEP concentration and bacterial abundance in filtered (1) diatom cultures and (2) natural seawater samples (some treatments with added nutrients). In all samples TEP increased dramatically in the first 5 days and generally decreased thereafter. TEP was more rapidly degraded in the replicates with added nutrients. Peak bacterial abundances matched up well with peak TEP concentrations with occasional lag times. By the end of each experiment TEP values had stabilized to roughly 50-150 ug gum xanthum equivalent staining capacity per liter. These values match up well with observed background deep water TEP concentrations suggesting that some TEP are highly resistant to decomposition.

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IMPROVED ESTIMATES OF PHYTOPLANKTON BIOMASS FROM CHLOROPHYLL VARIABLE FLUORESCENCE: A NEW APPROACH TO THE OLD PROBLEM

Chlorophyll-a (Chl-a) fluorescence is routinely used for rapid assessment of phytoplankton biomass and physiological status. However, conversion from in vivo fluorescence to Chl-a concentration is aggravated by remarkable variability in the fluorescence efficiency, which is strongly affected by the efficiency of photosynthetic processes. The mechanisms behind the variability in fluorescence yields have been realized, but the operational use of Chl-a fluorescence is still bordered by the absence of dependable algorithms that would take into account this variability. Here we show that fluorescence per unit Chl-a can be deduced from the knowledge of photosynthetic parameters, thus increasing dramatically the conversion of fluorescence to biomass. An operational algorithm for assessment of Chl-a concentration from variable fluorescence has been developed and parameterized against an extensive field database. Although fluorescence per unit Chl-a varies by a factor of four, it can be predicted from variable fluorescence measurements with the precision of ~15%. The precision of these determinations of Chl-a is comparable with that of analytical chemical methods and several-fold higher than that of passive optical techniques based on remote sensing of ocean color.

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SHIP, SATELLITE, AND AIRCRAFT ASSESSMENT OF COASTAL OPTICAL VARIABILITY IN MISSISSIPPI SOUND NEAR MOBILE BAY, ALABAMA

The highly variable light regime in coastal waters affects, and is affected by, the dissolved and particulate materials in the water. Unraveling the in-water optical properties through the hyperspectral reflectance signature holds promise. Our objectives are to: (1) characterize the spatial optical variability in a dynamic coastal environment impacted by high concentrations of dissolved and particulate materials, and (2) perform an optical water mass classification using satellite imagery and in situ data. During May 2002, we conducted multi-ship surveys in the coastal waters of the northern Gulf of Mexico near Mobile Bay, Alabama. Continuous, underway surface measurements and vertical profiles at 63 stations were collected. Optical properties included hyperspectral remote sensing reflectance, partitioned absorption coefficients (phytoplankton, detrital, and CDOM components), beam attenuation, diffuse attenuation, backscattering coefficient, HPLC phytoplankton pigment concentrations, particle size, volume scattering function, and organic/inorganic particle loads. In addition, SeaWIFS and MODIS satellite imagery and PHILLS hyperspectral aircraft imagery clearly demonstrate the dynamic nature of this environment. A new optical classification system based on the partitioned absorption coefficients is used to distinguish water masses and track coastal features.

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CYANOPHAGE MAY PLAY IMPORTANT ROLES IN TRICHODESMIUM SPP. ECOLOGY IN THE OLIGOTROPHIC OCEAN.

The planktonic cyanobacterium Trichodesmium spp. is a globally important diazotroph; however, the mechanisms of its mortality, and the means by which its fixed N enters upper levels of the food web, are poorly understood. Viral lysis of Trichodesmium spp. was detected both in culture (IMS101) and samples of waters from 6 stations around the Hawaiian Islands in the tropical North Pacific. Calculations from decay rates and burst size of cultures and field samples suggest that 0.3 – 6.5 % d-1 of trichomes are virally lysed, representing the release of 3 – 64 % d-1 fixed N. PFGE demonstrated that mitomycin C-treated IMS 101 culture had a presumed viral genome size of ~ 45 kbp, while field samples subject to the same treatment had up to three virus-like genomes per Trichodesmium sp. population. Viruses were induced from natural Trichodesmium sp. populations, added to Trichodesmium IMS 101 after washing to remove mitomycin C. Significant stimulation of nitrogenase activity was then noted after 2 – 6 days, while the addition of concentrated natural virioplankton had no significant effect on Trichodesmium sp. These results suggest viruses may play an important role in the ecology of Trichodesmium sp. in the oligotrophic ocean.

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MAGNITUDE AND CONTROL OF SEA-ICE ALGAL GROWTH IN THE CHUKCHI AND BEAUFORT SEAS IN SPRING 2002

We measured the biomass, diversity and activity of pack ice algae in the Chukchi and Beaufort Seas in order to assess the impact of nutrient and light availability on algal growth. Measurements included estimates of Chl a, POC, PON, stable isotopes and algal cell counts at a total of 14 stations (mainly first-year sea ice). Algal pigment concentrations were in some cases extremely high, exceeding 1 g Chl a per square meter of sea ice at two stations. As for algal pigments, POC and PON values increased exponentially towards the bottom of the ice floes with a mean C/N ratio (molar) of 16. The d13C ratio ranged between -30 and -10 per mille, exhibiting a positive correlation with POC concentration. The low ambient nutrient concentrations (nitrate and silicate) in the sea ice and photosynthetic yield data determined via PAM fluorometry point towards nutrient limitation of ice algal growth. In addition, new production and algal growth rates were estimated using exponential growth models.

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ALGAL SPORE SETTLEMENT IN THE VISCOUS SUBLAYER STUDIED WITH PARTICLE IMAGE VELOCIMETRY (PIV)

The green alga Enteromorpha is a worldwide fouling organism. This alga grows on a variety of submerged structures e.g., ship hulls. Spores are able to attach and remain attached even at high flow speeds. This study explores the conditions leading to attachment and detachment of spores as a function of flow in the turbulent boundary layer and the viscous sublayer. The instantaneous flow and the behaviour of settling spores in the viscous sublayer close to the bed is measured in a flume tank using Particle Image Velocimetry (PIV). The aims are to describe swimming behaviour and passive transport of spores in this layer and to find the critical flow velocities/forces where spores attach and detach from the substrate.

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SURF ZONE ENTRAINMENT AND LONG-SHORE TRANSPORT OF FECAL POLLUTION FROM TIDAL OUTLETS

This study describes field experiments and modeling studies aimed at characterizing how pollution from tidal outlets is entrained and transported in the surf zone. The field experiments center around two tidal outlets that drain into Huntington State Beach and Newport Beach, popular beaches in southern California. As contaminants flow out of these outlets, a fraction is entrained in the surf zone and the rest is ejected offshore. Pollutants entrained in the surf zone tend to stay close to shore, where they can travel significant distances parallel to the beach before diluting to extinction. These results suggest that pollution from tidal outlets and other shoreline outfalls (e.g., storm drains) can have a large and disproportionately negative impact on shoreline water quality and human health.

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INTERNATIONAL POLAR YEAR 2007-2008

The year 2007/08 will mark the 125th anniversary of the First International Polar Year (1882/3), the 75th anniversary of the Second Polar Year (1932/3), and the 50th anniversary of the International Geophysical Year (1957/8). The IPYs and IGY resulted in significant new insights into global processes and led to decades of invaluable polar research. Planning is underway to hold an International Polar Year (IPY) in 2007-2008. It is envisioned as an intense program of internationally coordinated polar observations, exploration, and analysis, with strong education and outreach components. Coordinated research efforts in both the Arctic and Antarctic are being discussed. Efforts must be multi-disciplinary, including study of human dimensions, and truly international. IPY is envisioned to provide both short-term outcomes and to lay a foundation for longer-term commitments, ultimately attracting and developing a new generation of polar scientists. This presentation will outline current ideas for the next IPY with the objective to inform participants of current plans and to gather input on other ideas and programs that could be integrated into the next IPY.

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BENTHIC CARBON CYCLING AND NUTRIENT EXCHANGE IN THE WESTERN ARCTIC SHELF-BASIN INTERACTIONS (SBI) STUDY AREA

Benthic sediment metabolism studies initiated in 2002 in the Chukchi and Beaufort seas as part of the Western Arctic Shelf-Basin Interactions (SBI) global change program are investigating the seasonal deposition of organic carbon and its transformation. Sediment tracers, such as plant pigment, carbon content, and natural (Be-7) and artificial (Cs-137) radioisotopes are also being measured. In the spring, sediment oxygen uptake (1-17 mM m-2 d-1) and nutrient flux were highest on the Chukchi and Beaufort shelves, with rates decreasing from the shelf to the deep basin. Sediment respiration rates doubled (up to 34 mM m-2 d-1) during the summer at the shelf sites, indicating tight pelagic-benthic coupling, with rates decreasing with depth. Silicate and ammonium fluxes from the Chukchi and Beaufort shelf sediments were high, presumably due to the influence of the nutrient-rich Pacific inflow waters, with plumes of nutrients extending offshore into the Arctic Basin at halocline depths. Dissolved organic carbon was also released from sediments, with implications for both lower food chain productivity as well as carbon sequestration in this region.

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THE FLORIDA CENTER FOR OCEAN SCIENCE EDUCATION EXCELLENCE

We will share how the Florida COSEE is connecting ocean scientists with opportunities to enhance the broader impacts of their research through education and outreach. The mission of FCOSEE is to serve as a source of ocean science information, an active agent for development, distribution and promotion of products, and provider of services to educators, scientists, news media and the public. Goals are to 1) expand the contribution of scientists to education, 2) advance the availability and quality of information about the oceans, 3) improve ocean science competency in K-20 audiences, and 4) keep the public, policy makers, and the media fully informed on ocean issues and discoveries. Florida COSEE serves ocean scientists by connecting their current research with existing education initiatives and providing models for developing new education components to effectively enhance the impacts of their research. A Web Portal will serve as a community vehicle to distribute research results and products developed as part of Criterion II initiatives. Florida COSEE managers serve as advisors to ocean scientists during grant development and implementation of activities.

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HIGH GROWTH EFFICIENCIES IN ANTARCTIC LARVAE

Antarctic sea urchin larvae synthesize protein for 25-times less energy than any other animal. This unique, efficient metabolism might be the basis for high growth efficiency in cold ocean environments. We studied growth efficiency in larvae of the Antarctic sea urchin Sterechinus neumayeri. For five sets of independent cultures, the following series of measurements were made over a total period of larval development and growth of 2 months at 1.5C: clearance rates of algae by larvae; rates of protein growth; and metabolic rates. Clearance rates were 17 ± 1.8 (SE) algal cells/larva/hr; protein growth was 8.1 ± 1.9 ng/larva/day; metabolic rates ranged from 25 to 57 pmol oxygen/larva/hr. Gross growth efficiency for larvae was calculated for each culture – i.e., ratio of protein growth to amount of protein obtained from algae. The mean growth efficiency for five cultures was 99% ± 12. This near-perfect (100%) growth efficiency is exceptionally high for invertebrate larval forms and suggests that these Antarctic larvae, living for most of their life span in food-limited environments, can maximize growth rates by having unique macromolecular synthesis processes.

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A BIOACOUSTIC OCEAN OBSERVATORY ON HAWAI'I ISLAND

Planning is underway to deploy an Ocean Resources and Ecosystems Observatory on Hawai'i Island. It will provide physical, biological, and chemical observations for monitoring the marine living resources and ecosystems of the Big Island. Within this more comprehensive observing system, we plan to construct a Bioacoustic Ocean Observatory. To be located in the central region of the leeward coast, this Bioacoustic Ocean Observatory will be used to acoustically track animals in a volume of ocean running from surface to bottom, out to the 1000 m isobath, and along approximately 150 km of coastline. Within the observatory, a variety of pelagic gamefish (tunas, billfishes), bottom fish, sharks, mantas, and sea turtles will be acoustically tagged and tracked. We also plan to acoustically track humpback whales, spinner dolphins, and other vocalizing cetaceans, which will not be tagged. Our goal is full passive receiver coverage within the observatory so that any tagged animal will be continuously tracked in three dimensions, and any cetaceans that are exhibiting suitable vocalizations will be localized and potentially tracked as individuals or in groups.

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RECENT TRENDS IN GLOBAL OCEAN CHLOROPHYLL

Recent analyses of SeaWiFS data have shown that global ocean chlorophyll has increased more than 5% since 1998. The North Pacific ocean basin has increased nearly 19%. To understand the causes of these trends we have applied the newly developed NASA Ocean Biogeochemical Assimilation Model (OBAM), which is driven in mechanistic fashion by surface winds, sea surface temperature, atmospheric iron deposition, sea ice, and surface irradiance. The model utilizes chlorophyll from SeaWiFS in a daily assimilation. The model has in place many of the climatic variables that can be expected to produce the changes observed in SeaWiFS data. This enables us to diagnose the model performance, the assimilation performance, and possible causes for the increase in chlorophyll.

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DESERT DUST IN EARTH'S ATMOSPHERE: THE IMPACT ON OCEAN AND HUMAN HEALTH

A current estimate of the quantity of dust that is transported some distance in Earth's atmosphere each year is approximately two billion metric tons. Whereas various research projects have been undertaken to understand this planetary process, little has been done to address its impact on ocean and human health. One of the potential impacts of dust on ocean health is change in ecologically sensitive areas (coral reefs) due to the utilization of dust as a source of nutrients by microorganisms. Utilization of dust as a nutrient source has recently been implicated as a cause of harmful algae blooms in coastal environments resulting in marine and human health stress. Desert dust can also deliver pathogenic microorganisms and chemical pollutants such as pesticides and herbicides to downwind ecosystems. Atmospheric delivery of pathogens to marine environments may present risk to both marine organisms and humans. Chemical pollutants impacting marine environments may impact marine health through direct (toxin accumulation) or indirect (immuno-suppression) means. This presentation will cover current and historical research in this emerging field and the implications to downwind ecosystem and human health.

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COUPLING BIOGEOCHEMISTRY WITH BIOIRRIGATION AND BIOTURBATION IN SHRIMP BURROWS

We investigated burrowing shrimp mounds using a profiling laser device and identified two important but often neglected methodological aspects of field measurements of bioturbation rates. Firstly, sediment subduction from the sediment surface can be just as important as sediment expulsion from depth. Conventional sediment trap techniques cannot detect this transport. Secondly, a high sampling frequency is required to estimate accurately the rates of the two-way exchange between sediment and depth.
The nitrogen chemistry in the sediment surrounding an irrigated burrow was modelled using a radially-symmetrical diffusion model. Limitations of one-dimensional representations of bioirrigation were explored via comparisons between one-dimensional models and a full cylinder model. Using a radially-symmetric model we show how measurements of burrow chemistry made in thin tanks may differ markedly from field measurements, simply because of the altered diffusion geometry.

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TEMPORAL AND SPATIAL PATTERNS OF MEROPLANKTON IN MISSION BAY, SAN DIEGO, CALIFORNIA.

Mission Bay is a highly modified Mediterranean estuary in urban San Diego, California. Freshwater enters the bay primarily via two creeks and a network of storm drains located in the eastern (back) portion of the bay. The eastern sections of the bay experience reduced rates of flushing, compared to areas near the mouth of the bay. This study examined temporal and spatial patterns of meroplankton through bi-weekly plankton collections at six sites within Mission Bay during a one-year period. Along with plankton samples, environmental data were collected, including temperature, salinity, turbidity, and concentrations of nutrients (nitrate, phosphate, silica). Results indicated that two types of cnidarian larvae, a bivalve veliger, and a species of Littorina dominated meroplankton populations. Overall, higher densities were observed more frequently near the mouth of the bay than at back bay sites. Sites in the eastern part of the bay displayed maximum meroplankton densities between August and October, whereas sites closer to the mouth of the bay supported high larval densities in April and May.

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THE ROLE OF POSITIVE INTERACTIONS IN THE INVASION OF COASTAL MARINE SYSTEMS

As increasing numbers of non-native species accumulate in coastal systems, there is an increasing opportunity for interactions among invades to influence the dynamics and community structure of heavily invaded habitats. One possibility that has not been widely considered is that changes to a system as the result of recent invasion could rapidly turn an older, previously benign invasion in an aggressive one. This has the potentially to greatly increase the chances of significant declines in ecosystem function or biodiversity. I provide examples of new invaders accelerating the spread and impact of earlier invasions as the result of both direct and indirect interactions and discuss the potential generality of these kinds of interactions for driving change in coastal marine systems. These kinds of positive interactions suggest that we may not only be faced with managing new invasions, but may also need to address an increasing number of management problems resulting from new invasions triggering rapid change in older invasions.

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BACTERIAL DYNAMICS ON PARTICLES: COLONIZATION, INTERACTIONS, AND GROWTH

Organic particles represent micropatches of concentrated particulate and dissolved substrates which are preferential sites of bacterial growth. Rapid enzymatic degradation of organic particles by attached bacteria increases the spatio-temporal heterogeneity of organic matter in the water column. This heterogeneous distribution of particulate as well as dissolved bacterial substrates has profound consequences for transformation and flux of organic matter in aquatic food webs. We have investigated how bacterial colonization of particles is affected by growth and interspecific interactions among bacteria. Long-term incubation experiments using single bacterial strains show that growth dominated over attachment and detachment after a few hours in controlling population density. Changes in colonization rate in the presence of other bacterial strains were detected by fluorescence in situ hybridization (FISH) with 16S rRNA oligonucleotide probes and show either increased or decreased colonization rates. Comparison between an antibiotic-producing strain and its antibiotic-free mutant showed no negative effect on the colonization rate due to antibiotic production. However, colonization rate was significantly increased in the presence of strains with high hydrolytic activities.

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A COMPARISON OF NONPOINT FECAL CONTAMINANTS IN SANTA MONICA BAY

Santa Monica Bay (SMB) receives much urban runoff, delivered through a network of storm drains and contaminated with oil, solvents, trash, and feces. Coastal water quality is routinely monitored by the City of Los Angeles using standardized assays for fecal indicator bacteria (FIB); however, these tests are non-specific and take 18-24 hours. The human-specific Bacteroides-Prevotella (B-P) group is a more useful indicator, and can be detected rapidly by polymerase chain reaction (PCR) targeting a 16sRNA sequence. The standard assays for FIB and molecular-based assays for the human-specific B-P group were performed on 8 costal seawater samples collected near storm drains in Los Angeles. Our FIB assays correlated with those of the County and showed considerable contamination. PCR assays did not yield any positives for the B-P group. This may suggest that FIB assays are not always indicative of sewage contamination, and fecal pollutants in SMB are maybe largely non-human in origin. It will be important to consider the sensitivity of the assay and also how representative our samples are of the year-round situation in various parts of the bay.

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BIOMASS BURNING AS A SOURCE OF DISSOLVED IRON TO OPEN OCEAN?

The Mediterranean sea is strongly influenced by atmospheric inputs into the water column. This is due first to the close vicinity of the Saharan desert, which provides a source for considerable amounts of dust, and second to the strong stratification of the surface water column during a large part of the year which dramatically reduces exchange between surface and deep waters. Surprisingly high (1nM) concentrations of total dissolved concentrations were measured in the Ligurian Sea in August 2003. Only one Saharan event of very low magnitude was recorded during the stratified period, that could not explain the enrichment observed in the mixed layer. Hypothesis of iron input from huge biomass burnings that occurred in South of France/Corsica in summer 2003 was tested by analysing total iron concentration and labile iron (by the mean of dissolution experiment) in aerosols collected in Corsica and in South of France during this summer.

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CLUES TO CORAL REEF ECOSYSTEM HEALTH: SPECTRAL ANALYSIS COUPLED WITH RADIATIVE TRANSFER MODELING

The world's reefs are in peril due to climate change and anthropogenic activity. Reefs respond immediately to environmental change and indicate the health status of the marine ecosystem. An important contribution to coral reef research is improved spectral distinction of reef species' health. Unfortunately, relatively little is known concerning the spectral properties of coral or how coral architecture reflect/transmit light. New insights into optical processes of corals under stressed conditions can lead to improved interpretation of remote sensing data and forecasting of immediate or long-term impacts of events such as bleaching and disease in coral. We are investigating the spatial/spectral properties required to remotely sense changes in reef health by coupling spectral analysis of in situ spectra and hyperspectral data with a new coral-specific radiative transfer model (CorMOD2). Challenges include light attenuation by the water column, atmospheric scattering, and scattering caused by the coral species. We present reflectance and absorption profiles output from CorMOD2 for corals, including Acropora palmata (Elkhorn Coral), and other bottom types of the Long Rock Site at Andros Island, Bahamas.

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ESTUARINE CORALS: PARADOX OR PARADIGM?

Reef-building corals are commonly regarded as obligate marine organisms, unable to survive in environments with high and variable sediment and nutrient loading, reduced salinity, and other estuarine characteristics. In fact, corals are part of the fauna of many coastal systems legitimately classified as estuaries. These habitats are part of the continuum of environments inhabited by near-shore, or terrigenously influenced, coral reef communities. Near-shore communities are common, widely distributed, and systematically different from off-shore (oceanic) reef communities. Differences are in not only community structure and composition, but also function, including the key issue of vulnerability or resistance to bleaching and various environmental stresses. In the present era of concerns about both coral degradation and loss, and eutrophication and modification of estuarine environments, estuarine corals represent case studies of adaptation or acclimatization that deserve serious attention as a possible paradigm for future environmental responses, rather than dismissal as anomalies, outliers, or paradoxes. The presentation will review and summarize the environmental and taxonomic characteristics of 'estuarine corals' and 'coral-containing estuaries,' with an emphasis on systematic relationships worthy of further exploration.

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SEASONAL PATTERNS OF TRICHODESMIUM C-INCORPORATION AT THE BERMUDA ATLANTIC TIME-SERIES (BATS) SITE

Primary production by the diazotrophic cyanobacteria Trichodesmium was investigated seasonally over a two-year period at the BATS site using 14C-bicarbonate. Colonies of Trichodesmium puffs and tufts were collected at monthly intervals in 1995 and 1996 and placed in a deck-board incubator with in situ sea surface temperature and light conditions. In contrast to N2 fixation and N-doubling times, primary production and the corresponding C-doubling times showed a strong seasonal pattern.
Due to spatial scaling, the significance of primary production by Trichodesmium in surface waters may have eluded the standard method of primary production performed at the BATS site. By accounting for the temporal and spatial abundance distribution of Trichodesmium colonies and trichomes, and a PI-curve developed locally, we were able to estimate the amount of C incorporated by the diazotrophs. Seasonal estimates of Trichodesmium primary production are significant in surface waters in summer and the incorporation of C by the cyanobacteria can account for at least half the observed surface draw-down of DIC at the BATS site.

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A COMPARISON OF LIDAR AND ECHOSOUNDER MEASUREMENTS OF FISH AGGREGATIONS IN THE GULF OF ALASKA

An acoustic-trawl survey was conducted during August 2001 near Kodiak Island in the Gulf of Alaska to describe the abundance and distribution patterns of walleye pollock (Theragra chalcogramma) and capelin (Mallotus villosus). Acoustic data (38, 120 kHz) were collected during the day along parallel transects from 15 m below the water surface to within 0.5 m of the sea floor (bottom depth range: 30 - 251 m). Airborne lidar measurements were also collected along the vessel survey track lines during day and night. Although greatest densities of both species were deeper than 100 m during the day based on the acoustics data, large numbers of capelin and juvenile pollock moved into shallower depths, and within range of lidar measurements during the night. Measurements from the two methods were partitioned into 185 m along-transect data bins and compared to determine whether aggregations of these fishes were detectable with lidar. The value that novel technologies, such as lidar can bring to similar studies in terms of increased survey speed, and the elimination of fish avoidance to survey vessels are discussed.

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DISTRIBUTION OF BIOLUMINESCENCE AND ZOOPLANKTON IN MONTEREY BAY, CALIFORNIA

During the AOSN-II sampling program of 2003, we used a variety of ship-based platforms to sample the distribution of bioluminescence (BL) and other biologically related oceanographic

parameters across Monterey Bay, California. On consecutive nights, an autonomous underwater vehicle (AUV) measured CTDO, BL, OBS, fluorescence and nutrients to depths of 100 meters across six 22km sections. Along these same tracks, zoo- and phytoplankton, chlorophyll, nutrient and pigment samples were collected. Data revealed several interesting patterns in the onshore/offshore and vertical distributions of the biological parameters. Typically, bioluminescence maxima occurred below the subsurface chlorophyll maxima, and got deeper with greater distance offshore where zooplankton sources became more prominent than phytoplankton (dinoflagellates). Exceptions to these trends occurred when frontal processes disrupted the patterns, causing accumulation of biological material at the offshore edge of newly upwelled water. Further analyses of the correlations and large-scale (tens of km) trends are currently underway.

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RISING GAS BUBBLES – A MODEL FOR MIXING POREWATER

Pore water profiles from the Sakhalin shelf, Sea of Okhotsk, associated with gas hydrates and large methane plumes in the overlying water column, show effects of irrigation over the uppermost 3 metres of the sediment. Rising methane gas bubbles are believed to cause this mixing. Applying Aller's bioirrigation model, a non-local exchange rate of >0.1/year is necessary to reproduce the measured data. In surface sediments, gas bubbles can fracture the sediment while they ascend. In the wake of a rising bubble, pore water is mixed within the bubble tube and hence, an eddy diffusion coefficient, Keddy, can be assigned to this effect. A 2D numerical transport-reaction model in cylindrical coordinates was developed to investigate the 'gas bubble mixing' as a function of e.g. Keddy, time, bubble rise frequency, ratio of tube radius to tube distances, rate of internal sources. A minimum Keddy of 10^5 cm^2/a, for example, is necessary to mix bottom water sufficiently to about 3 metres down as observed by field data. Using Prandtl's mixing length theory, this translates into a bubble rise velocity of 0.3 mm/s.

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DEVELOPMENT OF AN OXYGEN SENSOR BASED ON QUENCHING OF PORPHYRIN PHOSPHORESCENCE

A method of preparing oxygen sensors with the use of luminescent porphyrin compounds covalently attached to silica gel particles or optical fibers and phosphorescence data analysis is described. By calculating phosphorescence lifetimes in transient signals it is possible to acquire data that is insensitive to the amplitudes of the measured signal, making the measurements insensitive to porphyrin concentration or bleaching. Data integration produces high resolution enabling assessment of primary production in real time and constitutes a novel approach toward measurements of benthic respiration. The long term goal is to develop in situ methods of studying Aerobic Anoxygenic Photoheterotrophs (AAPs). AAPs of the two marine genera Erythrobacter and Roseobacter have been found to be prevalent in the open ocean and thus may contribute to global carbon balance. AAPs are capable of switching between respiration and photosynthesis in response to physical conditions. Advances in the understanding of their biochemistry would likely lead to improved culture rates of AAPs. More generally, improvements in small scale technology would greatly increase the amount of information regarding local environmental conditions and individual biological response to such.

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OPTIMIZATION OF DNA EXTRACTION FOR QUANTITATIVE MARINE BACTERIOPLANKTON COMMUNITY ANALYSIS.

The establishment of a coupling between the presence of predominant bacterial species and their function in the environment is of primary interest in current microbial ecology. Molecular methods such as microarrays and real-time PCR may be used to estimate presence or expression of different genes (e.g., 16S rDNA and nifH) in environmental samples; however, in order to be quantitative these methods require a reproducible and efficient DNA extraction protocol. Using Picogreen DNA quantification, real-time PCR and an internal DNA standard, we step-wise examined and optimized a protocol for DNA extraction from seawater samples (vol. 2 – 300 ml). Sample volume had a pronounced effect on DNA extraction efficiency showing that comparison of samples with different volumes is problematic. The duration of enzyme treatment (lysozyme and proteinase K) significantly influenced the DNA extraction efficiency. Dissolved DNA contributed significantly to total DNA when extracted from small filtering volumes (<10 ml). Addition of a co-precipient (yeast tRNA) improved the precipitation of low-concentration-DNA from a few % to 90-100 %. When tested on various seawater samples as well as on isolates the optimized extraction protocol was found to be highly reproducible with an average extraction efficiency for seawater samples of 92% and for isolates of 96%.

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BACTERIAL RESPONSE TO A MESOSCALE IRON ENRICHMENT IN THE NORTHEAST SUBARCTIC PACIFIC

Here we report on the response of the mixed layer microheterotrophic community to the addition of Fe, during the Subarctic Ecosystem Response to Iron Enrichment Study (SERIES) conducted in July 2002. Inside the patch, bacterial abundance decreased 4-fold over the first 12 days following the Fe addition, and then increased 9-fold by day 16. Similarly, bacterial production decreased 3-fold over the initial 8 days and then increased 13-fold to 5.51 mg C/m^3/d, by day 18. Bacterial growth rate remained constant until day 4 and then increased 8-fold to 0.81 /d by day 12. Outside the patch, bacterial abundance, production and growth rate remained constant. Bacterial dynamics were controlled by top-down (grazers) rather than bottom-up (resources) processes. Bacteria were released from grazing pressure on day 14, when microzooplankton switched from ingesting mainly bacteria to ingesting mainly picophytoplankton and nanophytoplankton. We propose that the addition of Fe into the patch changed the dynamics and structure of the microbial food web, and that this has important implications for remineralization of Fe, and the cycling and export of carbon in the upper ocean.

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REPRODUCTION AND RECRUITMENT OF CALANUS PACIFICUS AND PSEUDOCALANUS NEWMANI DURING TWO PHYTOPLANKTON BLOOMS IN DABOB BAY, PUGET SOUND (WA)

Copepod secondary production has traditionally been linked to the spring diatom bloom in temperate and high latitudes, while laboratory studies recently have challenged this view and have shown either reduced fecundity or viability of the offspring when copepods were fed high concentrations of diatoms. However, field evidence that diatoms affect copepod reproduction still is scarce. We compare abundance and reproduction patterns of two common copepods of the boreal Pacific, Calanus pacificus and Pseudocalanus newmani, during two spring blooms in Dabob Bay, a semi-enclosed fjord of Puget Sound, WA. The two copepods differ significantly in size, distribution, and reproductive strategy and, since inhibitory effects of diatoms are species-specific, bloom conditions may affect reproduction and recruitment of the two species differently. We examined abundance patterns, egg production rates, and nauplii viability from February to early May 2002 and 2003. The results suggest that reproductive output of P. newmani is more negatively affected by certain bloom conditions than that of C. pacificus. Hatching success and nauplii survival of the former were reduced following a peak of toxin producing Thalassiosira species.

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PHYTOPLANKTON PRODUCTION AND CHEMICAL COMPOSITION OF EXTRACELLULARLY RELEASED ORGANIC CARBON IN THE CHESAPEAKE BAY AND DELAWARE BAY

Phytoplankton production of 14C-labled particulate organic carbon (POC) and released dissolved organic carbon (DOC) were tracked in samples obtained along the salinity gradient of the Chesapeake Bay, the Delaware Bay estuary and the Potomac River estuary, a major tributary of the Chesapeake Bay during 2002 and 2003. Particulate primary production (PPP) averaged 0.020 mg C l-1 h-1 and dissolved primary production (DPP) averaged 0.110 mg C l-1h-1 in samples from all locations. During this study, the mean portion of total primary production (TPP) (TPP = DPP + PPP) in the functionally dissolved (filterable) state (DPP) was approximately 60% in samples taken within the Chesapeake Bay, but significantly lower in those from the Delaware Bay estuary. High DPP frequently coincided with pulses of monosaccharides, dissolved free amino acids, and to lesser extent polysaccharides. Elevated DPP was significantly correlated with heightened bacterial metabolic activity. These data demonstrate that particulate indicators of phytoplankton activity considerably underestimate carbon subsidy to the DOC pool from in situ processes and do not link closely with labile organics driving bacterial metabolism in the Chesapeake Bay.

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SUBTIDAL TRANSPORT PROCESSES ON THE SAN PEDRO SHELF DURING SUMMER, 2001

The Huntington Beach, Phase III, study into the transport pathways of the effluent from the OCSD outfall, deployed a total of 16 moorings across the San Pedro shelf from near the surfzone to the upper-slope. On the middle and outer shelf, the currents flowed strongly down-coast (towards San Diego) at the surface and had large vertical shears through the well-stratified water column. In the deeper water near the shelf break, the shears were such that lower-layer flows were up-coast, and related to the poleward undercurrent over the upper slope. Mid-shelf currents and upwelling over the shelf appear to be driven by the larger-scale, upper-layer slope flows of the Southern California Bight. Inner shelf alongshore currents were significantly correlated with the alongshore wind at the shelf break, and a CEOF analysis gives two modes, with the first mode dominant over the outer and middle shelf. The second mode connects the inner shelf to the poleward undercurrent over the slope such that increases in the poleward flow over the slope are correlated with increases in down-coast current inshore of the 15-m isobath.

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ORBIMAGE'S OPERATIONAL FISHERIES OCEANOGRAPHY AND VESSEL MONITORING SERVICES FOR FISHERMEN, FLEET MANAGERS AND RESOURCE MANAGERS

Operational Fisheries Oceanography has been shown to be beneficial to both fishers and resource managers. Information should flow both to and from fishing vessels. Fishermen and fleet managers require historical and near-real-time information on weather and ocean conditions to assist in making both tactical (short-term, within fishing trip scale) and strategic (medium to long-term, seasonal or interannual scale) decisions. Resource managers need timely information on vessel location and catch to better manage stocks and reduce by-catch, and to support research on how fishing effort and environmental changes affect interannual population variability.
ORBIMAGE has been providing worldwide Operational Fisheries Oceanographic services since late 1997 after the launch of its OrbView-2 satellite carrying the SeaWiFS sensor. To enhance interpretation of changes in pelagic fish distribution, information on a suite of meteorological and oceanographic conditions is included with our global ocean color imagery. Decision-making tools allows the user to combine information layers in a way that optimizes each layer's relationship to fish distribution, while taking into consideration other operational constraints.

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THE NEWEST GENERATION OF DEEP SEA EXPLORATION

In response to the Presidential Panel report, Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration, NOAA has initiated a $14M program which supports projects, expeditions, and innovative applications of technology which focus on exploring the many still unknown regions and characteristics of the ocean as well as the marine life within it. OE strives to support path-finding ocean exploration and research that is, or may become, important to NOAA within the context of its mandated responsibilities as the Nation's premier civilian ocean agency. The now three-year-old NOAA Ocean Exploration (OE) program is envisioned to be the initial phase of an eventual, larger, multi-agency program. Presentations within this session, some of which have been supported wholly or in part by the OE program, are all examples of some (although not all) of the diverse, and typically interdisciplinary, scientific endeavors and subject matter that the OE program embraces. Other major emphases of the OE program include exploration of global marine cultural heritage, discovery of the impacts of the Earth's largest volcanic system on the ocean, and a firm commitment to communicating the results of all its efforts through an ongoing program of education and outreach.

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COSEE-WEST: INSERTING OCEAN SCIENCE INTO LARGE SCHOOL DISTRICTS

K-12 educators teach subjects with which they are familiar. COSEE would increase literacy in ocean sciences, yet few K-12 teachers have taken a University course in marine science or oceanography. University Extension programs can provide adult education classes in ocean science, and we proposed that K-12 teachers would be more attentive if Extension instructors were Research Oceanographers rather than outreach educators. Accordingly, NSF's Teacher Enhancement Program funded adult education programs in Marine Science at UCLA from 1992 to 2003, taught by University faculty oceanographers. Some 480 K-12 teachers in the Los Angeles Unified School District were trained in ocean science, but LAUSD is very large (780,000 students) and 480 teachers are only a fraction of the whole. But by leveraging these NSF-TE educators as in-service mentors for elementary teachers, COSEE-West is inserting ocean science into the entire science curriculum of LAUSD from the bottom up. UCLA and USC through COSEE-West support these teachers with research lectures by oceanographic faculty and a rich array of instructional and classroom exercises for elementary and middle schools as freeware through the COSEE-West web site.

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THE USE OF REAL-TIME DATA IN THE UNDERGRADUATE INTRODUCTORY OCEANOGRAPHY LABORATORY

Since August 2001, the Department of Oceanography at the University of Hawai'i at Manoa has been offering an introductory Oceanography laboratory to undergraduate science and non-science majors of the university. The laboratory is offered as an optional accompaniment to the department's very popular lecture course titled Science of the Sea. We describe the use of real time data in the instruction of basic oceanographic and atmospheric processes and concepts. We focus on our use of the NOAA TAO/Triton array real-time data plots and model forecasts of the Climate Prediction Center to help students construct and test hypotheses on El Nino/La Nina cycles, and to compare their findings with those of experts. We discuss the reasons behind the efficient and successful use of these applications, and the potential of other sources of real time data to be used in introductory laboratory courses such as ours.

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NON-CONSERVATIVE BEHAVIOR OF TERRIGENOUS DISSOLVED ORGANIC CARBON IN THE WESTERN ARCTIC OCEAN

DOC was measured at the Chukchi/Beaufort Sea shelf break during the Shelf-Basin Interaction project. Evident from DOC/salinity relationships was a fresh water intercept indicating low terrigenous DOC (155 microM), and not the commonly high values in Arctic rivers and the Eurasian Basin (~600 microM). This low intercept results from the long residence time (~20 years) of surface waters in the Beaufort Gyre, allowing significant degradation of terrigenous DOC. 228Ra/226Ra indicated the surface gyre water we sampled had an age of 13 years since being over the shelf. With this age and terrigenous DOC decrease (396 microM), a terrigenous DOC decay constant of 0.097 year-1 and a half life of 7.1 years results. In contrast, in the Eurasian Basin, where the freshwater DOC intercept is high, surface waters have a much shorter residence time. Terrigenous DOC transferred from the Eurasian shelves into the Eurasian Basin via the Trans Polar Drift apparently has insufficient time to significantly degrade before being exported out of the Arctic Ocean. The different ocean pathways of Arctic rivers draining North America and Eurasia impart different fates for terrigenous DOC.

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UPTAKE OF ADENOSINE AND PHOPHATE RELEASED FROM ADENOSINE-5'-TRIPHOSPHATE (ATP) BY FRESHWATER BACTERIOPLANKTON ASSEMBLAGES

Dissolved organic phosphorus compounds (DOP) have traditionally been thought of as a source of P for bacteria and algae in natural fresh water environments; the significance of DOP as a C-source has largely been ignored. The purpose of this study was to follow the assimilation of the P- and C- moieties of the 5'mononucleotide, adenosine-triphosphate (ATP), by a natural plankton assemblage drawn from a hardwater glacial kettle lake (East Twin Lake, Portage County, Ohio). Uptake of 3H-adenosine and 32P-phosphate from equimolar quantities of 32P-ATP and 3H-ATP, ranging from 10 to 80 nM (total conc.), was followed by filtering aliquots onto 1.0 micron and 0.2 micron polycarbonate filters at 5, 30, 60, and 90 after addition of labeled ATP; formalin-fixed controls accounted for non-specific binding of labeled materials to seston. We found that both bacteria and phytoplankton assimilated the phosphoryl moiety in preference to the adenosyl moiety. Bacterioplankton but not phytoplankton also assimilated a significant fraction of adenosine released from ATP. The study was supported in part by NSF-REU OCE-0139280.

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BIOPHYSICAL MODELLING OF BALTIC COD LARVAL GROWTH AND SURVIVAL AND ITS USE FOR RECRUITMENT PREDICTION

A coupled hydrodynamic-trophodynamic individual based model of drift and feeding was utilized to analyse the intra- and interannual variability in growth and survival of cod larvae in the Central Baltic Sea. The model results suggest the necessity of co-occurrence of peak prey and larval abundances and favourable oceanographic conditions for high survival rates. Larval survival is altered by the variance of prey availability, circulation patterns and temperature, reflecting the strong influence of seasonal variations of atmospheric warming. The model was able to predict with a high degree of confidence relatively high levels of recruitment from 1986 to 1991 as well as the strong decay of recruitment from 1993 onwards. The validity of the coupled biophysical model results have been independently evaluated by relating recruitment success of Baltic cod to the availability of P.elongatus nauplii. Both recruitment and availability of this copepod stage/species showed general declining trends towards the end of the

1990's, with extraordinarily high values at the end of the 1970's. The same coupled biophysical model has been utilized for the year 1999 to consider larval survival success with respect to mesoscale horizontal patchiness and a realistic description of the vertical distribution of prey. According to seasonally resolved data on egg and larval abundance the model allows to specify time periods within the spawning season which mainly contributed to recruitment.

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FATE OF DOC IN THE DEEP OCEAN: INSIGHTS FROM RADIOCARBON ANALYSIS OF PROKARYOTIC NUCLEIC ACIDS

Little is known about the cycling of DOC in the deep ocean. One possible sink for DOC in this environment is heterotrophic consumption, but the types and sources of carbon fueling bathypelagic prokaryotic production have not been identified. The distinct radiocarbon ages of carbon pools in the deep ocean (DIC, total DOC, and POC/new DOC) make 14C an ideal tracer for addressing this question. The radiocarbon age of nucleic acids (NA) and other cellular components of prokaryotes should reflect the 14C signature of their primary carbon source. But low prokaryotic abundances in the deep ocean have precluded such compound specific radiocarbon measurements. Here we describe a procedure to sample and extract large quantities of bacterial NA from a single filter. NA were released from cells using inorganic lysis agents and precipitated before processing for radiocarbon analysis. Denaturing gradient gel electrophoresis was used to assess the quality of the NA and biases associated with the extraction procedure. Data from several globally distributed surface ocean sites and one 600 m site in the North Central Pacific will be presented.

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PREDICTIONS OF PHYTOPLANKTON BIOMASS AND PRIMARY PRODUCTIVITY USING DATA FROM IN-SITU AND REMOTE SENSING OBSERVATIONS IN CHESAPEAKE BAY, USA

We have examined seasonal and inter-annual variability of phytoplankton chlorophyll (chl-a) and primary productivity (PP) using data from shipboard observations and aircraft remote sensing in Chesapeake Bay (CB) that span nearly two decades. Depth-integrated models (DIMs) calibrated and validated with shipboard observations were applied to chl-a retrievals from remote sensing to estimate PP. Data from >60 cruises and >300 flights have given improved spatial and temporal resolution of PP to support simple models of intra-annual variability based on hydrographic properties. We found that flow from the Susquehanna R., the major source of freshwater and dissolved inorganic nutrients to CB, explained much of the variance of chl-a and PP. Recent efforts have focused on the roles of synoptic climate, regional precipitation, and freshwater flow that underlie phytoplankton dynamics, expressed as anomalies of chl-a and PP and forcing of floral composition in CB. We describe the application of these findings to forecasts and hindcasts of these important measures of ecosystem function, aimed at resolving long-term trends from variability that dominates the recent several decades.

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EXPERIMENTAL DETERMINATION OF CLIMATE CHANGE EFFECTS ON BERING SEA BIOGEOCHEMISTRY AND PHYTOPLANKTON COMMUNITY STRUCTURE

A shipboard continuous culture system was used to examine shifts in Bering Sea phytoplankton communities and elemental cycling under predicted year 2100 climate change conditions of +4C and 750 ppm CO2. In a 4 treatment matrix of temperature and pCO2 (ambient and increased), total Chl a was relatively unaffected by temperature but was lower at high pCO2. Increasing pCO2 decreased the abundance of all algal groups counted, with the exception that dinoflagellates increased in abundance in the "greenhouse ocean", i.e. high CO2: high temperature treatment. Maximum photosynthetic carbon fixation rates (Pmax) were 2.5-times higher in this treatment, suggesting the possibility of negative feedbacks on atmospheric CO2. Both temperature treatments were dominated by small pennate diatoms and small flagellates at ambient pCO2, but higher pCO2 resulted in growth of larger diatom species. Consequences for biological C, N, P, S and Si production ratios will be presented. These results suggest that under currently predicted climate change scenarios, Bering Sea phytoplankton community structure could change significantly in the next 100 years, driving simultaneous changes in and feedbacks to nutrient and carbon biogeochemical cycles.

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DRIFTERS FOR REAL-TIME INTERDISCIPLINARY OCEANOGRAPHY

An instrumentation package, control unit, and telemetry system were developed and integrated for use on moorings and on free-floating drifters. Scheduling, data acquisition, processing, and power management are accomplished with a Tattletale Model 8 controller. Serial and analog ports were made available for instrumentation and sensors. Telemetry is accomplished via the Orbcom satellite network in near-realtime or power saving burst mode. The initial instrumentation included a conductivity and temperature sensor, a combination scattering meter and fluorometer, and a CO2 gas analyzer. CO2 sensing is accomplished by a low-power, low-cost version of infrared CO2 instrumentation that has been deployed on moorings for the past decade. During each sample cycle, a headspace analysis is performed with a simple non-fouling equilibrator; in addition, an atmospheric sample and an absolute zero are obtained. O2 is measured in the same gas stream with a galvanic O2 senor, utilizing atmospheric O2 as a reference gas.
Original testing and short-term deployments were scheduled to coincide with the Autonomous Ocean Sampling Network (AOSN) initiative (July and August 2003). A long-term system is designed to operate for up to one year with current deployments off Peru. With batteries, the instrument module has a diameter of 15 cm and a length of about 80 cm and can be launched from a vessel of any size. Various components and subsystems of the drifters have been deployed as part of other moorings and integrated into other drifters.

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COPPER REQUIREMENTS OF FE-LIMITED COASTAL AND OCEANIC DIATOMS

Recent findings in our laboratory indicate a potential interaction of copper (Cu) and iron (Fe) nutrition in Fe-limited diatoms. To explore this interaction, two marine diatoms - Thalassiosira oceanica, an oceanic isolate, and Thalassiosira pseudonana, a coastal isolate- were grown in Fe-limiting media under either Cu-sufficient or Cu-limiting conditions. Cellular growth rates, cell size and intracellular Fe:Cu concentrations were determined. Our results show that, under Fe-limitation, the coastal and oceanic diatoms respond differently to Cu-deficiency. The Fe-limited oceanic species showed a strong Cu-dependence of growth rates, whereas the Fe-limited coastal species was unaffected by low Cu. These results suggest that under Fe-limiting conditions, T. oceanica has a higher requirement for Cu than T. pseudonana. To test this hypothesis we are currently examining intracellular Fe and Cu quotas using graphite furnace atomic absorption spectrometry. In addition, particulate Fe:Cu ratios of indigenous phytoplankton communities from two Fe-limited regions, the Subarctic Pacific and the Southern Ocean, will be presented. Our results highlight the important role that Cu may play in Fe-limited oceanic regions.

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PHYTOPLANKTON RESPONSE TO IRON ENRICHMENT IN THE SUBARCTIC NE PACIFIC OCEAN

We report results from the SERIES (Subarctic Ecosystem Response to Iron Enrichment Study) experiment in which large-scale Fe enrichment led to a shift in phytoplankton community structure from picoplankton to one dominated by large pennate diatoms in waters of the subarctic Pacific. The phytoplankton community response to added Fe was monitored for 26 days following two infusions into a 64 km2 patch of seawater. Phytoplankton chlorophyll a increased from ambient concentrations of 0.3 mg m-3 to a peak of 6 mg m-3 18 days after the initial addition of Fe. The bloom was divided into two phases based on contributing microalgal size fractions. In phase one, from the initial infusion to day 9, all size fractions increased in biomass as indicated by increased chlorophyll a. In phase two, from days 10 to 18, the bloom was dominated by the >20 micron size fraction, with a concomitant decrease in smaller phytoplankton. The bloom duration and succession in phytoplankton composition illustrate the variations in this biological response to Fe when compared to ecosystems of other HNLC regions.

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TOXICITY, DUE TO PERMANONE31-66, TO THE INLAND SILVERSIDE, MENIDIA BERYLLINA AND MYSID, MYSIDOPSIS BAHIA

Communities along the Southwest Florida coast have implemented the use of pesticides to control mosquito populations for decades. This investigation details the results of laboratory studies used to evaluate the potential environmental impact of a mosquito adulticide, Permanone31-66, on Charlotte Harbor Estuary, FL. The acute toxicity of Permanone31-66 to the inland silverside (Menidia beryllina) and mysid shrimp (Mysidopsis bahia) was measured using both static (constant) and flow-through experimental design methods, and mean lethal concentrations (LC50) values were calculated. Results indicate that the 96hr LC50 value for M. beryllina under static conditions is 10.20ug l-1 and in a flow-through environment, 80.92ug l-1 (95% CL: 74.4-87.97ug l-1). The 96h LC50 value for M. bahia under static exposure is less than 4.45ug l-1 and less than 1.94ug l-1 in flow-through conditions. This indicates that Permanone31-66 is more lethal to M. bahia than to M. beryllina. Also, based on known application rates around Charlotte Harbor (0.33 fl.oz. acre-1), these findings suggest that Permanone31-66 is not at lethal limits for M. beryllina, but could reach them for M. bahia.

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MOLECULAR BIOMARKERS AS TRACERS OF ORGANIC CARBON CYCLING ALONG THE SHELF-BASIN BOUNDARY OF THE WESTERN ARCTIC OCEAN

A suite of lipid biomarkers in particles and sediments from Arctic rivers and shelf to basin transects in the western Arctic Ocean was examined and combined with radiocarbon dating to determine the sources and exchange of organic carbon between the shelves and basins. Riverine particles contained high concentrations of a number of terrestrial biomarkers, including beta-amyrin, friedelin, and 24-ethylcholest-5-enol. Offshore particles from the chlorophyll maximum contained the polyunsaturated fatty acids 20:5 and 22:6, low concentrations of 24-ethylcholest-5-enol, and were modern based on 14C values. Particles from halocline waters contained predominantly marine signatures, but ranged in age from 300-400 years indicating the presence of an older, recalcitrant carbon pool overlain by fresh marine material sinking from the spring bloom. Basin sediments were, on average, greater than 6000 years old and contained low concentrations of algal biomarkers, suggesting that marine production provides the fuel for carbon cycling while the recalcitrant terrigenous carbon pool is slowly recycled.

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CONNECTING THE DOTS: ECOLOGICAL LINKAGES IN LARGE MARINE ECOSYSTEMS

Ecosystem-based management is predicated on practical understanding of connections among targets of management (exploited populations, essential habitats, etc.). Processes linking such units in marine ecosystems comprise the complex interplay between advection and directed movement of biomass and materials. Quantitative prediction of trajectories and statistics of dispersal at the scales of large marine ecosystems might be achieved through a combination of numerical models and suitably-scaled empirical measurements for model verification. Our multi-disciplinary program of research uses a nested set of numerical, bio-physical, and transition matrix models to predict the pattern and pace of larval fish dispersal from designated sources to all possible sinks within a coral reef province. Simultaneously, we try three tools to test predictions of inter-reef connections generated from the models. Measures of genetic distance between putative source and sink populations using microsatellite and MHC sequencing; measures of spatially-traceable variations in the chemistry of larval fish otoliths using laser ablation ICP-mass-spec technology; and temporal patterns of habitat-specific settlement of fish to reefs may permit accurate calibration of models. Outputs can identify modes and magnitudes of connectivity, assess effectiveness of networks of MPAs and map land-based inputs of pollutants.

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AGGREGATE FORMATION OF THE DINOFLAGELLATE CERATIUM TRIPOS CAUSED BY TURBULENCE – IMPLICATIONS FOR PREDATOR:PREY INTERACTIONS.

Increasing turbulence resulted in a decreased growth and an increased aggregate formation of Ceratium tripos. Even at a turbulence level corresponding to storm (epsilon = 1 cm2 s-3) no dead or damaged C. tripos cells were observed in the aggregates and the growth of C. tripos was still positive. Growth of the predator, Fragilidium subglobosum, in food-saturated conditions (prey density > 10 C. tripos cells ml-1) was not affected by turbulence. At < 7 C. tripos cells ml-1, however, the growth of F. subglobosum increased significantly with increasing turbulence. Not because of an increased predator – prey encounter rate with increasing turbulence, but because of an increased aggregate formation of the prey in response to turbulence. When F. subglobosum grazed on aggregates of C. tripos it was not food-limited.

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A EUTROPHIC ASSESSMENT OF LAGOONAL POND SYSTEMS IN SOUTH CAROLINA COASTAL WATERS: HAVE WE OVERLOOKED THEIR IMPACT ON COASTAL DEVELOPMENT?

South Carolina's coast is one of the fastest growing regions in the United States, prompting concern for the potential effects of coastal development on estuarine eutrophication. We present results from monitoring efforts relating nutrient, chlorophyll and phytoplankton properties from brackish-to-marine lagoonal SC systems. Following the classification scheme of Bricker et al.'s (1999) NOAA Eutrophication Assessment, we found that in lagoonal systems, which include storm water detention/retention ponds, chlorophyll levels were high in the fall/winter and spring, and hypereutrophic in the summer, while nutrients were high throughout the year. Also, harmful algal blooms were prevalent in these systems, and increased from the spring to fall periods. By extending Bricker et al.'s assessment to include lagoonal systems not previously considered (e.g. detention ponds), highly eutrophic-to-hypereutrophic conditions were commonly found. Consideration of high tidal exchange between lagoonal ponds and estuarine creeks stresses the need to include the former systems when assessing the effects of coastal development on estuarine eutrophication. This study emphasizes the importance of considering coastal system type (typology) in assessing state and regional eutrophication conditions.

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A CLOUD-FREE, SATELLITE-DERIVED, SEA SURFACE TEMPERATURE ANALYSIS FOR THE WEST FLORIDA SHELF

Clouds are problematic in using Advanced Very High Resolution Radiometer (AVHRR) imagery for describing sea surface temperature (SST). The Tropical Rainfall Measuring Mission Microwave Imager (TMI) observes SST through clouds, providing daily, ¼ maps under all weather conditions except rain. A TMI limitation, however, is course resolution. Optimal interpolation (OI) is used to generate a cloud-free, 5-km, daily SST analysis for the west Florida Shelf (WFS) by merging the high-resolution (cloud-covered) AVHRR with coarse-resolution (cloud-free) TMI SST products. Comparisons with in-situ data show good agreements. Given large spatial gradients by coastal ocean processes, this regional analysis has advantage over the global, weekly, 1 Reynolds SST. A 5-year (1998-2002) OI SST analysis is diagnosed using Empirical Orthogonal Functions. The first two models represent annual cycles, one by surface heat flux and another by shelf circulation dynamics.

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CORAL AND SPONGE HABITATS OF THE ALEUTIAN ARCHIPELAGO

A unique feature of the benthic environment of the Aleutian Archipelago is the presence of a highly diverse and abundant coral and sponge community. Summaries of historical survey data and recent direct observations with an occupied submersible indicate that this area may harbor the highest diversity and abundance of cold-water corals and sponges in the world. These corals and sponges likely provide important habitat for a variety of fish and invertebrate species. The incidental mortality of corals and sponges is a challenging problem in the area's fisheries that use bottom contact gear. Here we provide an overview of new research focusing on these communities. Focus is on the development of a statistical model to predict coral and sponge distribution as a function of environmental characteristics (i.e., geologic, oceanographic, bathymetric, and geographic features). In addition, this research will provide estimates of the relative abundance of corals and sponges, their importance to commercially valuable fish and invertebrates, and the degree to which these communities have been disturbed, including disturbance by fishing gear.

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PHOSPHORUS DYNAMICS IN THE EASTERN GULF OF MEXICO: PHOSPHORUS UPTAKE AND REGENERATION RATES WITHIN TRICHODESMIUM AND KARENIA BREVIS BLOOMS

The west Florida shelf region of the eastern Gulf of Mexico is characterized by a gradient from nearshore elevated PO4 concentrations (attributable to phosphorus mining in central Florida) to oligotrophic, undetectable PO4 and DOP concentrations within 5 km of shore. Phosphorus uptake and regeneration among size fractionated (<1.0, <3.0 and < 64.0 um) phytoplankton populations was examined along a onshore-offshore gradient which included a nearshore Karenia brevis bloom and offshore populations of the N2 fixing cyanobacteria Trichodesmium. The contribution of regenerated phosphorus to measured uptake requirements ranged from 14% nearshore to 98% and 100% at the 50 m and 200 m isobaths respectively. Only 4% of the K. brevis bloom uptake requirements were met by regeneration, while 100% of measured

uptake rates of Trichodesmium populations were met by measured regeneration rates. Despite these differences, all populations exhibited alkaline phosphatase activity and were characterized by the highest phosphorus regeneration rates in the 1-3 um size fraction. This suggests that both inorganic and organic P sources were used and that the microbial loop plays a significant role in P dynamics.

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SEASONAL MASS-TRANSPORT LIMITED GROWTH OF THE GIANT KELP MACROCYSTIS PYRIFERA

Rates of nutrient transport to seaweeds, and hence seaweed growth and production rates, are thought to be reduced in slow flows, but there is little field evidence supporting this hypothesis. We examined the influence of hydrodynamic environment on growth rates of Macrocystis pyrifera at eight sites in the pristine Paterson Intlet, Stewart Island, New Zealand, each season during 2002. Seawater velocity varied between sites while concentrations of nitrate and ammonium were similar at all sites. In winter, M. pyrifera growth was light-limited and water motion had no effect on growth rates. In summer, growth was nitrogen-limited but because inorganic nitrate concentrations in seawater were low at all sites, water motion had no influence on M. pyrifera growth rates. In late summer, however, there was a significant correlation between water motion and blade and stipe growth rates, with rates at wave-exposed sites being 6-fold greater at than those at wave-sheltered sites. Water motion influences the growth rates of M. pyrifera at only specific times of year; when growth is N-limited but inorganic N is available in the water column.

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TWO GENERATIONS OF THE OPTICAL PLANKTON COUNTER: EVOLUTION, APPLICATIONS AND FUTURE DIRECTIONS

Optical Plankton Counters (OPCs) have been in use by the scientific community for about 12 years while deployed on a wide variety of platforms such as SeaSoar, AquaShuttle, Batfish, Scanfish, MOCNESS, BIONESS, V-fins, ARIES, LHPR, ROVs, and integrated with BONGO and ring-nets. OPC applications have evolved from measuring zooplankton size distributions which could be related to taxa, to measuring biomass distributions and more recently size-based biomass spectra as ecological indicators. The OPC could provide high spatial and temporal resolution while being towed over large areas without the need of recovery or servicing and measurements could be made continuously, rapidly, in real-time simultaneous with other environmental parameters. The OPC design, deployment platforms and measurement capabilities will be discussed along with an account of its deficiencies, the latter leading to the development of the second generation Laser-based OPC. The new LOPC design is discussed with emphases on its new measurement capabilities, ie. coincidence reduction, size detection, flow speed measurement, overall size and finally its measurement of shape profiles leading to some taxanomic identification capability. Potential directions in data analyses of LOPC data are discussed and data consisting of measured zooplankton distributions from Scotian Shelf waters are presented.

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LASER-OPC AND NET SAMPLE INTERCOMPARISON OF MONITORING STATIONS IN THE GULF OF ST. LAWRENCE.

An Laser Optical Plankton Counter (LOPC) mounted on the inside mouth of a ring-net is an effective method for intercomparing LOPC measurements with collected zooplankton samples. Flow interference is minimal since the LOPC frontal cross-section occupies only 5% of the net-mouth area while the LOPC is directly sub-sampling the zooplankton caught by the net. Such intercomparisons were made on 17 & 41 monitoring stations during the spring of 2002-3 respectively in the Gulf of St. Lawrence using vertical hauls of a 0.5m net with a 75 micron mesh. Intercomparisons of plankton densities and biomass over the various sizes ranges were made to establish correlations between net and LOPC. Shape profiles of large copepods, Calanus spp. will be shown and methodology for calculating biomass from all size measurements will be discussed. A newly-developed index for measuring relative plankton transparencv will also be presented.

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DIEL MODELS OF LARVAL FISH VERTICAL DISTRIBUTIONS IN STRATIFIED-HYPOXIC VS. WELL-MIXED WATERS IN THE NORTHERN GULF OF MEXICO

In the northwestern Gulf of Mexico, a combination of nutrient loading, increased phytoplankton production and summertime hydrographic stratification result in a hypoxic zone along bottom shelf waters. Resulting ecosystem effects can include changes in larval fish survival due to direct mortality, changes in prey and predator fields, and altered vertical distributions, which may affect larval transport to estuarine nursery areas. In an effort to describe and predict the effects of seasonal hypoxia on the vertical distribution of larval fishes, diel vertical distribution models were developed using data from depth-discreet ichthyoplankton samples collected off the coast of Louisiana (USA). Differences in the vertical distributions of dominant taxa (primarily engraulids and sciaenids) were compared between samples collected from a stratified water column with a bottom hypoxic layer and a well-mixed water column. These vertical distribution models, when coupled other biological, physical and chemical models, will assist in linking the population dynamics of the region's diverse and abundant marine fishes to the effects of variable river discharge, nutrient input, eutrophication and hypoxia.

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THE "ISLAND EFFECT" IN THE CANARY ISLANDS: FROM ZOOPLANKTON TO FISHERIES

Zooplankton biomass, feeding and metabolism, fish larvae and fish distribution were studied around the island of Gran Canaria (Canary Islands) during the most characteristic periods of the annual cycle. In general, zooplankton biomass showed a high variability around the island but it was lower in the core of cyclonic eddies induced by the island as a consequence of the divergent effect produced by these physical structures. In contrast, high zooplankton biomass was observed within the anticyclonic eddies. Cyclonic eddies showed higher values of the index of feeding in their boundaries while indices of respiration and ammonia excretion were higher in the core. No increase of those indices were observed in the anticyclonic structures. Higher concentrations of zooplankton and neritic ichthyoplankton were observed immediately upstream of the island, around the stagnation point, and downstream in the warm lee region, particularly in the convergent anticyclonic boundary of the lee, showing that both regions are retention areas for ichthyoplankton. It is suggested that these oceanographic structures are partially responsible for the relatively high abundance observed for fish larvae. The distribution of the fish biomass around the island using acoustics showed a similar pattern during the different cruises carried out in the area. Their distribution will be compared with the biomass of zooplankton and discussed in relation to the flow field around the island.

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PHOTOCHEMICAL REACTIVITY OF LOW AND HIGH MOLECULAR FRACTIONS OF MARINE DOM

Photochemical degradation is known to be an important sink for dissolved organic matter (DOM) in the upper ocean, but little is known about the chemical moieties responsible for the photochemical reactivity of marine-derived DOM. To examine the role of chemical structure in the photochemical cycling of chromophoric DOM (CDOM) of truly marine origin, we conducted several experiments with samples isolated from the surface and 1000 m depth in the Pacific Ocean. Study sites included station ALOHA, the California Current and coastal San Diego (SIO Pier). CDOM was isolated using a novel solid phase extraction protocol, performed either on whole seawater or following ultrafiltration (>1 kDa), and exposed to natural sunlight for several hours. Changes in DOC concentrations, UV-vis spectra and molecular weight (MW) were used to monitor the extent of photoreactivity. LMW CDOM (<1 kDa) from the deep Pacific is highly colored and initial results suggest that it is extremely photoreactive relative to the HMW fraction. This is in contrast to CDOM studies in freshwater systems, where the HMW fraction has been shown to be rich in photoreactive chromophores.

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THE MINIMAL GENOME FOR PHOTOSYNTHESIS: ON THE FUNCTION OF PHYCOERYTHRIN IN PROCHLOROCOCCUS

Prochlorococcus, one of the dominant cyanobacteria in the world's oceans, comprises an unusual pigment composition. It uniquely possesses Divinyl-(DV) Chl a and b that are bound to PCBs, the major antenna proteins of Prochlorophytes and does not have phycobilisomes. However, recent total genome analyses of three different strains of Prochlorococcus have confirmed that genes encoding a particular form of phycoerythrin have selectively been retained during the evolution of Prochlorococcus. Within the Prochlorococcus group ecotypes have been defined that are adapted to either low or high light. Low light-adapted strains are capable to build a functional form of phycoerythrin, whereas in the totally sequenced genome of the HL-adapted strains only remnants of this gene cluster are left. In this ecotype, all phycoerythrin genes are lacking except a single, highly sequence-derived beta phycoerythrin gene. We show this gene to be expressed and to bind phycoerythrobilin in vivo. To investigate whether the presence of this particular phycoerythrin form in high light-adapted ecotypes of Prochlorococcus can be generalised, different laboratory cultures and field samples from the Red Sea were screened. Additionally, chromophorylation of recombinant phycoerythrin with bilin chromophores demonstrated autoassembly in vitro. We speculate the phycoerythrin of high light-adapted Prochlorococcus might act as a green light photoreceptor.

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LINKED FLUXES OF DISSOLVED ORGANIC CARBON, NITROGEN AND SILICA IN NORTHERN WATERSHEDS

The correlation between dissolved organic carbon (DOC), nitrogen and silica was assessed in a large number of lakes and selected rivers over a latitudinal gradient in Scandinavia and Siberia. In general, strong links were found between concentrations and fluxes of C, N and Si, where dynamics in the DOC-pool have strong bearings also for N and Si, and the correlation between DOC and total N increase with DOC concentrations. Catchment properties, climatic fluctuations and nitrogen deposition all have strong bearings on riverine export to estuaries and fjords, and especially warm winters aim at shifting the major flux of N to coastal waters from spring to winter. Focusing the major rivers Ob and Yenisey, this presentation will also provide data on the major role of riverine DOC export for productivity and underwater light climate in the Arctic marine areas.

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USING REMOTE ACOUSTIC SENSORS TO MONITOR THE LONG-TERM MOVEMENT PATTERNS OF SHARKS IN TWO FLORIDA ESTUARIES

Arrays of acoustic receivers were deployed in two estuaries along the Gulf coast of Florida (Terra Ceia Bay and Pine Island Sound). Acoustic receivers recorded the presence of individuals fitted with acoustic transmitters and were used to monitor the long-term movement patterns of sharks within each study site. Data collected from monitoring efforts were used to define home range, habitat use, movement patterns and factors affecting movements. Environmental factors appeared to play an important role in dictating habitat use by sharks. In Terra Ceia Bay barometric pressure appears to have altered shark movement patterns as a tropical storm approached. In Pine Island Sound high rainfall caused salinity declines that led to bonnethead sharks leaving the study site. In both cases changes in habitat use occurred at the population level. These results could not have been obtained without the use of remote sensing technologies to continuously monitor the movements of individual fishes. Details of how environmental factors affected movement patterns and implementation of acoustic technology to monitor these populations will be discussed.

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VIRAL INFLUENCE ON BACTERIOPLANKTON COMMUNITIES IN THE NORTH PACIFIC GYRE

Community dynamics of bacterioplankton in the North Pacific gyre in September 2002 and July 2003 was determined using a DNA fingerprinting approach (automated rRNA intergenic spacer analysis) that targeted 1.2 > bacteria > 0.2 micron. There was no significant difference in the Simpson diversity index between 0 m and 100 m communities, which contained 63 – 125 phylotypes and a mean Simpson's index (D) of 18.2 ± 2.0. Virus impacts upon bacterial communities were investigated by concentrating native viruses and adding these back to whole bacterioplankton communities in small (4.5 L) incubations. Viruses significantly stimulated the diversity of some communities (e.g. base of euphotic zone; Control D = 11.2 ± 1.8, +Virus D = 14.5 ± 0.4), but inhibited the diversity of others (e.g. immediate surface; Control D = 9.8 ± 0.3, +Virus D = 7.4 ± 0.2). High variability between replicate incubations obscured changes in community caused by elevated virus abundance. These results demonstrate that viruses may be responsible for a considerable fraction of bacterioplankton mortality in the North Pacific but their roles in structuring pelagic communities remains unclear.

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EYES ON THE BAY BRINGS MARYLAND'S CHESAPEAKE AND COASTAL BAYS TO THE CLASSROOM

Eyes on the Bay, www.eyesonthebay.net, brings real-time monitoring data to the classroom through a network of continuous monitoring instruments in Maryland's Chesapeake and Coastal Bays that collect water quality data and broadcast it to our website. On-line lesson plans are coupled with these real-time data, monitoring stories and other useful links to illustrate how water quality information is used to assess environmental issues such as harmful algal blooms, essential fish habitat, SAV restoration and the impacts of episodic storm events. By creating a more dynamic, web-based experience, it is hoped that students will become more engaged in learning about the complex environmental processes of the Chesapeake Bay, its tributaries and the Coastal Bays.

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VIRAL PRODUCTION RATES IN THE ANTARCTIC SUBTROPICAL CONVERGENCE: ESTIMATES OF FE REGENERATION

Viral activity in marine systems has been demonstrated to be an important process in the recycling of carbon biomass as well nutrient elements. During the recent FeCycle expedition, we carried out experiments to quantify both the turnover of viruses as well as the viral burden within an SF6-labelled HNLC patch of water in the subtropical convergence southeast of New Zealand. Viral production estimates by a dilution technique were undertaken in parallel with sampling for transmission electron microscopic analysis of natural populations in order to estimate the regional viral burden. Virus particles in the region were released from infected cells at rates of 1.3 – 4.9 particles mL-1 h-1 with mean burst sizes of 29.8 ± 10.9 viruses per infected cell. Visibly infected cells ranged across stations from 1.25 – 2.75 % of the total bacterial community. Taken with bacterial abundance and production data, the results infer that viral activity in this region recycled Fe at a rate of 18 – 43 pM d-1 in this region. When examined in consideration of Fe requirements and turnover, these results demonstrate that viruses-mediated Fe recycling may be critical to the maintenance of population growth and abundance in this region.

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GRAY WHALE FEEDING IN THE CHUKCHI SEA

Gray whales, long thought to feed primarily on infaunal amphipods in the northern Bering and Chukchi Seas, have recently shown signs of food deprivation, including a significant decline in numbers. In 2002/3, very few whales were observed at the traditional feeding grounds in the Bering Sea. NOAA aerial surveys revealed whales present near the Convention Line in the Chukchi Sea. We studied the location using a series of N-S transects between 67 and 68 10'N and 168 to 169W. Satellite data indicate high productivity there. In scans conducted every 10 min, >1000 gray whales were recorded and most were distributed along an east-west oceanographic front as determined by CTD casts. Approximately 50% of whales observed closely produced mud plumes when surfacing, indicating bottom feeding. Infaunal amphipods were not present in the sediments. However, epifauna and shallow infauna composed of juvenile snow crabs, shrimps, seastars, brittle stars, bivalves, moon snails and sea cucumbers were abundant. Gray whales appear to have shifted their major feeding activities farther north where they have a significantly different diet than in the northern Bering Sea.

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CLONING AND FUNCTIONAL CHARACTERIZATION OF DIATOM AMMONIUM TRANSPORTERS

I report the cloning and functional characterization of ammonium transporters (AMTs), from the diatom Cylindrotheca fusiformis. Both cDNA and genomic clones were isolated. Based on sequence differences, two classes of AMT genes were identified (AMT1 and 2), with multiple copies of each. AMT mRNA levels were not tightly regulated by the N source in the medium, in contrast to the C. fusiformis nitrate transporter. AMT mRNA levels were induced most highly in N- and NO3 conditions, and at lower levels in ammonium or after the transition from nitrogen starvation to replenishment. These results were consistent with a general preference for ammonium by phytoplankton. Under all conditions, AMT1 mRNA levels were much higher than AMT2. Substantial mRNA degradation was observed, suggesting that mRNA turnover could be a regulatory factor affecting AMT protein synthesis. AMT1 and 2 were cloned in a yeast expression vector and were able to complement a Saccharomyces cerevisiae mutant deficient in its native AMTs. Data from these experiments indicate that AMT1 is a high affinity transporter and AMT2 a low affinity transporter.

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SEASONAL SUCCESSION OF PHYTOPLANKTON IN THE CHUKCHI SEA

Distribution of pigments (spatial and seasonal) in the Chukchi-Beaufort Seas during the 2002 SBI field program was analyzed from HPLC measurements. Spring communities are characterized by large diatoms (>5um) over the shelf, while over the slope and basin smaller (<5um) chlorophyll b containing cells, most likely prasinophytes were more abundant. In summer, populations in the low nutrient surface waters of the shelf are succeeded by smaller chlorophytes and prasinophytes. Diatoms remained dominant in higher nutrient conditions deeper in the water column. Slope and basin areas are usually dominated by small (<5um) chlorophyte and prasinophyte cells. Phytoplankton from the shelf are advected through Barrow Canyon to the adjacent ice covered basin explaining similar populations to the ice free shelf. The pigment differences between populations are manifested as visible differences in algal absorption and the remote sensing reflectance spectra.

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IRON ELEVATES PHOTOSYNTHETIC EFFICIENCY OF MOST, BUT NOT ALL, PHYTOPLANKTON: IMPLICATIONS FOR SOUTHERN OCEAN IRON ENRICHMENT AND PRIMARY PRODUCTION ALGORITHMS

We tested the iron limitation of three size classes of phytoplankton: picoplankton (<5µm), nanoplankton (5µm-20µm), and microplankton (>20µm). Photosynthetic efficiency, maximum quantum yield, was measured within two different high nutrient, low chlorophyll regimes in the Pacific Sector of the Southern Ocean. Repeated in situ iron addition resulted in an increase in the maximum quantum yield of photosynthesis; however the response within size fractions differed between the two sites. Within the Subantarctic Zone (~56 S, 172 W) picoplankton and nanoplankton showed very little response to iron addition while the maximum quantum yield of the microplankton increased 2-fold with iron addition. But within the Subpolar Regime (~66 S, 172 W), south of the Southern Boundary of the Antarctic Circumpolar Current, all three size classes of phytoplankton responded to iron addition with a 2-fold increase in maximum quantum yield. Strategies for primary production algorithms and primary production forecasting for the Southern Ocean will be discussed.

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SPECTRAL REFLECTANCE OF CORAL, ALGAE AND SAND AND IMPLICATIONS FOR CORAL REEF REMOTE SENSING

The most commonly stated rationale for developing coral reef remote sensing techniques is to assess and/or to monitor the status of these ecosystems. The most important parameters for such assessment are the relative bottom covers of hermatypic corals, various algae and sediments. We demonstrate the basis for discrimination of coral, algae and sand using a library of ~15,000 optical reflectance spectra for bottom-types measured in situ on reefs worldwide. Examination of full-resolution spectra, with 301 contiguous 1-nm wavebands, reveals (1) that carbonate sand has brighter reflectance that either coral or algae at all visible wavelengths and (2) that corals exhibit a unique spectral reflectance feature near 570 nm that algae do not possess. These spectral characteristics are not subtle; modeling results indicate that they are useful for remote discrimination between the bottom-types to water depths of 5 m under typically clear oceanic water conditions. Ultimately, knowledge of these reflectance characteristics provides the foundation for design of remote sensing missions with the purpose of reef ecosystem assessment and monitoring.

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SPRING BLOOM DYNAMICS IN AN ARCTIC FJORD

The spring phytoplankton bloom in Kongsfjorden, Svalbard, was studied in April and May 2002. This is the first study from the Svalbard area where the spring bloom is followed from the beginning to the end. Primary production, nitrate, silica acid, biogenic silica, chlorophyll a, POC and PON were measured. Samples of phytoplankton were analysed and potential grazers were noted. The diatom dominated phytoplankton bloom started in mid-April and ended in mid-May. Combined with earlier observations, it was calculated that primary production during the spring phytoplankton bloom contributed at least 19 % to the total annual primary production in Kongsfjorden. Nutrients were exhausted in the upper 20 meters by the beginning of May but were re-supplied in mixing events with deeper water at several occasions. The concentration of chlorophyll a was low in the whole period due to sedimentation of large diatom cells. Mesozooplankton were not observed in the beginning and middle of the bloom. In the end of May, cirripedia-larvae were seen in large concentration which could have controlled any further phytoplankton blooms.

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USING MOLECULAR APPROACHES TO EXAMINE SPECIES' PHYSIOLOGICAL RESPONSE TO CHANGES IN ENVIRONMENTAL TEMPERATURE

In marine ecosystems, the impact of predicted increases in global temperature may be mediated by direct effects on resident species, indirect effects on community-level biotic interactions, or via the influence of temperature on biological invasions. Common to all these mechanisms is the need to understand the physiological performance and tolerances of the marine organisms in question. However, we currently have a limited view of the physiological status of marine organisms across their distribution, and of what aspects of organismal performance might be ecologically significant, and temperature-responsive, across a species range. For example, are organisms more stressed at the 'edges' of their biogeographic distributions? If so, species-specific data would provide insight into whether populations will expand or contract in response to climate change. Increasingly, molecular approaches are being used to assess the physiological response of marine organisms to environmental temperature changes. In this presentation, I will describe studies in my laboratory that have used molecular and biochemical techniques to profile gene expression, as a diagnostic of physiological status, to assess the responses of marine invertebrates to changes in environmental temperature.

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NITROGEN FIXING FILAMENTOUS CYANOBACTERIA IN A SWEDISH BALTIC BAY, HIMMERFJAERDEN, AFTER REDUCED NITROGEN LOAD

Himmerfjaerden, a Swedish bay in the northwestern Baltic Sea, receives discharges from a modern sewage treatment plant (STP). New efficient nitrogen reduction (> 85 %, P and BOD reduction > 95 %) in the STP since 1997 have resulted in nitrogen rather than phosphorus limitation of phytoplankton growth and an increased summer abundance of filamentous nitrogen fixing cyanobacteria in the bay. Since nitrogen fixation is an energy demanding process compared to the use of dissolved inorganic nitrogen (DIN), nitrogen fixing species would be expected to preferentially use DIN when available. We used stable nitrogen isotope ratios in filamentous cyanobacteria, mainly Aphanizomenon sp. but also some Nodularia spumigena and Anabaena spp., collected in a gradient of increasing delta 15 N in DIN (measured as delta 15 N in seston < 10 micrometer) and total nitrogen concentration, to study to what extent atmospheric nitrogen was used for growth. Despite differences in available DIN and its delta 15 N we found no significant differences in delta 15 N in heterocystous cyanobacteria, indicating they only used fixed nitrogen for growth.

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EVIDENCE FOR THE PRESENCE OF CIGUATOXIN (CTX) IN CRUDE CTX EXTRACTS OF CIGUATERA IMPLICATED FISH: IMMUNOLOGICAL, TOXICITY, CELL CULTURE, AND PHYSICAL-CHEMICAL

The difficulty in obtaining purified ciguatoxin (CTX) and its commercial unavailability has led to using crude lipid extracts from fish tissues implicated in human ciguatera poisoning as a standard for immunological assays in our laboratory. Presented in this abtract are the procedures used to assess the presence of CTX from fish mplicated in ciguatera poisoning that were obtained from the Department of Health, State of Hawaii (DOH) and designated, DOH CTX standard extracts. All ciguateric fish samples were initially tested by the Membrane Immunoassay (MIA) procedure. Tissues testing positive were pooled and etracted by previously established techniques. Total exracts were purified by silica gel G and reverse phase C18 silica column chromatography. Partially purified extracts were subjeted to competitive binding experiment using a synthetic JKLM fragment of CTX as the competitor by the MIA procedure. The partially purified fractions were further tested by the followin gmethods: mouse toxicity assay, neuroblastoma (NB) tissue culture assay that tests for sodium channel action, and further characterized by proton magnetic resonance (PMR), fast atom bombardment (FAB) mass spectrometry, and UV-Vis spectrophotometry. The physical-chemical data strongly suggest the presence of ciguatoxin, CTX-3C, that has previously been shown to be associated with Gambierdiscus toxicus in the DOH CTX standard extracts used in this study. Taken together with the immunological/competitive binding assays, mouse toxicity, neuroblasoma cell culture asays, and physical-chemical analyses, it is concluded that the DOH CTX standard extracts taken from fish implicated in the clinincl ciguatera poisoning contain a CTX associated with G. toxicus.

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CHARTING THE COURSE OF HUMAN WASTE MIGRATION, FROM WATERSHEDS THROUGH COASTAL WATERS

The introduction of human waste into the coastal zone is an undesirable threat to human and ecosystem health. Human waste origins in watersheds are diffuse and often unknown, but may include community waste collection and treatment systems, as well as illegal activities. Effective markers of human waste will be stable and traceable throughout the system. Microbial markers are used to detect and trace waste, but many issues surround their use. Specifically, which microbes are suitable? What are their fates in the natural environment, particularly when moving between environmental compartments including freshwater, saltwater, and sediments? How do climate and biology interact to amplify or attenuate the pollution? How could coastal outlet conditions influence the magnitude of impacts? Are there other markers or suites of markers that could also be effective for tracing waste? These and other issues surrounding the emigration and efflux of human waste into and along the coastal zone will be discussed.

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SONIC TELEMETRY IN MARINE FISHES: PAST, PRESENT AND FUTURE

The advent of sonic (acoustic) telemetry techniques has allowed unprecedented insights into the behavior and physiology of marine animals as they move around in their natural habitats. Sonic tracking can be conducted 24 hours/day thereby revealing diel changes in habitat use and behavior. The previously mysterious world of large open ocean species has particularly benefited from the development of sonic telemetry techniques but methods are now available for tracking small animals in shallow waters. Three general categories of acoustic telemetry can be distinguished: active tracking (pursuit of the tagged animal), passive tracking (the use of fixed detectors/data loggers) and archiving communicating tags that store and then download data through the water column. Future directions will probably include "ecology tags" and "physiology tags" that telemeter not only the position of the animal but also information about its social milieu and internal physiological status. Examples of the various types of tracking and possible future directions will be given.

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EARLY ONSET AND EXPRESSION OF GREEN FLUORESCENT PROTEINS IN THE LARVAE OF THE MUSHROOM CORAL, FUNGIA SCUTARIA.

Green fluorescent proteins (GFP's) have been described in a variety of scleractinian corals by a number of researchers. Several of these studies have resulted in identifying the genes responsible for encoding various GFP's. Other studies have been performed that quantify the concentration of GFP's in adult corals. Little has been done, however, to understand the early onset and expression of GFP's in developing coral larvae. This study documents the temporal onset and expression of green fluorescent proteins in the larvae of the mushroom coral, Fungia scutaria, using fluorescence microscopy, SDS-PAGE, and immunoblotting with commercially available anti-GFP antibodies. Fungia scutaria larvae exhibit intense green fluorescence relatively early in their life history (within two to three days after spawning). This expression of fluorescence occurs before larval uptake of symbiotic zooxanthellae and is apparently stimulated after fertilization since neither eggs nor one-day-old larvae fluoresce intensely. Studies of the expression of GFP's in coral larvae correlated with other ecological, physiological and behavioral observations may help elucidate the functions of these proteins in scleractinian corals.

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HORIZONTAL DISPERSION OF EGGS OF CUBERA SNAPPER, LUTJANUS CYANOPTERUS, AT A REEF PROMONTORY IN BELIZE

Cubera snappers aggregate and spawn at promontories along the Meso-American reef around full moons March-June. Fertilized eggs are positively buoyant and quickly rise from 5-30 m to the surface, where the eggs become subject to dispersion by currents, wind stress, and wave drift similar to oil spill dispersion. Our objective is to understand and quantify the horizontal dispersion characteristics of cubera snapper eggs at the Gladden Spit reef promontory along the barrier reef at N16.5 latitude in Belize. We have tracked the drift of egg clouds, released surface drogues, measured horizontal currents, and applied a numerical oil spill trajectory model to simulate egg cloud advection and dispersion. Eggs are alternately transported towards the reef and into the barrier reef lagoon by waves and trade winds or entrained into the along-reef flowing surface currents. These currents are a manifestation of circulation gyres on different scales - from small locally generated gyres due to the flow interacting with the promontory to larger transient cyclonic eddies arriving from the east as a part of the general circulation of the western Caribbean.

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INTEGRATED SEDIMENT MODEL: SIMULTING ADAPTION PROCESSES AND STRUCTURE FORMATION IN DYNAMIC ENVIRONMENTS

In order to investigate the interdependencies of physical, biological and chemical processes in the sediment and the sediment-water interface under fluctuating boundary conditions a new modelling frame was developed.
The model features a two-dimensional resolution of spatial heterogeneities, adaptive strategies of microorganisms, coupled microbial kinetics with geochemical transformation rates, non-uniform transport processes such as bioturbation or pore-water advection and accounts for transient and lag mechanisms.Validation of the model dynamics was performed using data sets derived from series of experiments with different carbon loads carried out in a tidal flat of the Wadden Sea. After a separate data assimilation for each experiment, comparison of the respective best fitting parameter sets points to variation in few parameter values which are interpreted as structural changes of microbiological or geochemical characteristics of the sediment system when subjected to different amounts of carbon load.
Finally, we investigate to what extend the horizontal heterogeneity in near-shore or shelf sediments may also be increased by Turing instabilities.
We will highlight some results on the relevance of instabilities in complex sediment systems under fluctuating forcings.

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BRIDGING THE GAP BETWEEN COASTAL OBSERVATION RESEARCH AND THE COMMUNITY

Members of the Coastal Observation Technology System (COTS) are now more than ever committed to the collection, management, collaboration, and educational use of coastal ocean data. The University of New Hampshire's Center of Excellence in Coastal Ocean Observation and Analysis (COOA) is a northeast based observation member contributing to the development of technologies, research, and education and public outreach in the realm of coastal observation science. Examples of current research within COOA include, 1) the study of how carbon is exchanged within an ecosystem using remote sensing and in-situ measurements, 2) the production of weekly composited chlorophyll and sea surface temperature maps using MODIS data hosted on a publicly accessed website called WebCOAST, and 3) the development of anti-fouling polymers to be used on underwater observation stations. Here we present a variety of approaches COOA utilizes to bridge the gap between data and the variety of educational users it serves in both formal and informal settings.

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CHEMICAL COMPOSITION AND BIOAVAILABILITY OF DISSOLVED ORGANIC MATTER (DOM) IN A RIVER / ESTUARINE SYSTEM

Factors influencing seasonal changes in DOM in the river/estuary continuum have received relatively little attention. Results will be presented from monthly surveys conducted between July 2001 and December 2002 of dissolved organic nitrogen (DON) and carbon (DOC) at a number of sites throughout the Test river/estuary in southern England. DOC showed strong seasonal changes in the river as did nitrate, particulate carbon/nitrogen (POC/N) and chlorophyll, whereas DON and ammonium showed no clear temporal variability.
Maximum concentrations of nitrate in the river were measured in February, immediately prior to the spring bloom in March characterised by peaks in POC/N and chlorophyll, with reduced DOC concentrations in April. Estimates of riverine inorganic and organic nitrogen fluxes to the estuary will be presented. Evidence of point sources of ammonium and DOC/N have been identified from fish farm and sewage effluent inputs at various positions along the river. In addition, estimates of bioavailability of DOM using ultrafiltration and bacterial bioassay techniques will be given, with the aim of testing the hypothesis that DON/C assimilation is dependent on molecular size.

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MODELING THE IMPACT OF IRON AND PHOSPHORUS LIMITATION ON TRICHODESMIUM GROWTH IN THE TROPICAL ATLANTIC OCEAN

Recent revised estimates suggest that open ocean N2-fixation is globally significant, i.e., on the order of 80 - 110 Tg N yr-1, and comparable to inputs of NO3 from the deep ocean in subtropical waters. The conspicuous marine cyanobacterium, Trichodesmium, is believed to be the most significant N2-fixer in the open ocean. The factors that control Trichodesmium growth are thought to include temperature, vertical mixing/light availability, competition with other phytoplankton species, and the availability of iron and/or phosphorus. In this paper we model the distribution of Trichodesmium and rates of N2-fixation in the Atlantic using a coupled physical-biological model. In previous efforts we have assumed that Trichodesmium's fundamental physical, chemical and ecological niche is defined by high light intensity, relatively weak vertical mixing, and low DIN concentrations, where the latter prevents the growth of other, faster growing, phytoplankton species. These modeling efforts have been successful, predicting observed distributions and rates remarkably well. However, there is evidence that Fe and/or P limitations may place constraints upon Trichodesmium growth and N2-fixation in the Atlantic. Here we examine the effects of imposing these limitations on Trichodesmium growth in our model system.

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VARIABILITY AND PREDICTION OF PRODUCTION DYNAMICS IN THE NORTHERN CALIFORNIA CURRENT ECOSYSTEM: WHAT CAN THE COPEPODS TELL US ABOUT FISH PRODUCTION?

Our zooplankton collection time series from the upwelling zone off Newport, Oregon has produced a species-specific copepod biomass index that captures inter-annual and inter-decadal variation in ecosystem productivity. The index is based on biomass anomalies of Pseudocalanus mimus, Acartia longiremis and Calanus marshallae, seasonally abundant species that are representative of coastal sub-arctic waters. These cold-water species are larger and bio-energetically distinct from copepod species common to less productive offshore waters, and therefore are likely to be a more valuable food resource for planktivorous fish. This "cold-water index" is indicative of high production ocean conditions and has been correlated with the survival of coho salmon (Peterson and Schwing, 2003, GRL Vol. 30, No. 17). Two additional indices, also based on species-specific copepod biomass anomalies, reveal the influence of ocean condition variability on upwelling zone productivity. We show correlations with salmon, sablefish and whiting recruitment, suggesting that managers can apply our indices to stock assessment projections of key fish stocks of the Northern California Current.

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PARTICLE SIZE-SPECTRA IN MESOPELAGIC WATERS OF MONTEREY BAY, CALIFORNIA

We deployed an OPC on the ROV Ventana and ran 300 m horizontal transects from the surface to 1000m at 100m depth intervals. Twenty such profiles were collected at approximately monthly intervals within the Monterey Submarine Canyon. On most occasions, a small 200 um plankton net, attached to the back of the OPC, funneled the water passing through the OPC tunnel into a carousel sampler that captured and isolated the zooplankton from each transect. On average, particle abundance and total volume declined by only a factor of 2 from the upper mixed layer to 500 m and then increased 2 fold toward 1000 m. Mean particle size was greatest in the upper 400m and smallest in the lower 400m. Seasonal patterns, and the degree to which the OPC and plankton net agree, are presented and discussed.

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LIGHT PRODUCTION BY SULFIDE-OXIDIZING BACTERIA? A POSSIBLE LIGHT SOURCE FOR CHLOROPLAST-SEQUESTERING FORAMINIFERANS

Functional chloroplasts are sequestered in foraminiferans inhabiting the benthos well below the euphotic zone. The foraminiferans Nonionella stella (Santa Barbara Basin, 600 m) and Virgulinella fragilis (Cariaco Basin, 550 m) live within Beggiatoa spp. mats, a genus of sulfide-oxidizing bacteria, and sequester chloroplasts (Bernhard and Bowser 1999, Bernhard 2003). V. fragilis also harbors sulfide-oxidizing bacterial endosymbionts. In the absence of sunlight at these depths, the benefit of the chloroplasts is unclear, although they have been implicated in helping the foraminiferans meet nitrogen requirements (Grzymski et al. 2002). The close association of Beggiatoa spp. mats and bacterial endosymbionts to sequestered chloroplasts, together with the fact that bioluminescence evolved at least once in bacteria (family Vibrionaceae), lead us to the hypothesis that sulfide-oxidizing bacteria may emit light that can be a source of photosynthetically active radiation. To begin to test this hypothesis, we assayed for indicators of bacterial bioluminescence using pure cultures of sulfide-oxidizing bacteria. Light production was measured directly under multiple culture conditions, and the presence of the luxA gene, necessary for bacterial bioluminescence, was tested by molecular techniques.

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THE EFFECTS OF TEMPERATURE AND PH ON CALCIFICATION AND QUANTUM-YIELD EFFICIENCY OF MADRACIS MIRABILIS

The climate change predictions of rising sea temperature and elevated pCO2 may have important interactive effects on reef coral health through the pathways of calcification and photosynthesis. We tested for a temperature x CO2 interaction on these traits by exposing branches of Madracis mirabilis to temperatures of 26.4, 28.3 or 30.0 C, pH 8.03 or 7.82, and using growth and dark-adapted quantum yield as response variables. pH manipulations indirectly altered pCO2 to simulate present day and year 2100 levels. Growth was significantly depressed by 28% at low pH compared to high pH and there was a trend towards maximum growth at 28.3 C, but there was no significant temperature x pH interaction. In contrast, there was a significant temperature x pH interaction for quantum yield. These results suggest that the negative effects of elevated CO2 on coral growth appear to be independent of temperature across the range investigated, and that the interactive effects of temperature and CO2 on photosynthesis are probably uncoupled from the contemporaneous effects on calcification.

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USING REAL TIME ENVIRONMENTAL DATA FOR EDUCATION

Real Time Data provides students with an authenticity and investment in science concepts that no book or historical data ever could by engaging students in the scientific process and using technology the ways researchers do: analyzing real data, formulating and testing hypotheses and refining ideas to account for the collected evidence. Since the "majority of teachers use textbooks as their principal curriculum guide and source of lessons" (Eisenhower National Clearinghouse) there is a need for instructional materials that tap into uniqueness of the Internet to deliver real world data. Although the Internet is available in all secondary schools in the United States (Cattagni & Westat, 2001) only 20% of secondary teachers use computers to "solve problems and analyze data" to a large or moderate extent (Rowand, 2000). Over the last decade, CIESE (the Center for Improved Engineering and Science Education) has helped educators realize the benefits of integrating technology in order to effectively engage students in learning particularly in science and mathematics. This session will provide participants with an understanding of using real time data to improve science education.

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LARGE-SCALE, MULTI-CHANNEL VIDEO MOSAICS OF A CORAL REEF AUTOMATICALLY CONSTRUCTED FROM IMAGERY ACQUIRED USING AN AUTONOMOUS UNDERWATER VEHICLE

Large-scale mosaic images were created from individual video frames obtained from three, narrow-band video channels (460, 520 and 575nm) acquired using a multi-channel, intensified video camera (Xybion IMC-301) onboard the autonomous underwater vehicle (AUV) ROVEX during the CoBOP 2000 field campaign. The large-footprint, pseudo-colored mosaics of a spur-and-grove coral region approximately 3.5x36 m2 near Lee Stocking Island, Bahamas will not only help to identify targets on the ocean floor, but also provide detailed stereographic bathymetric information over the sampled area that, because of the complex topography of the scene, is superior to even precision acoustic bathymetry. The approach is based entirely on scene-content-tracking and allows automatic construction of continuous mosaics for each channel. The effects of wave focusing on the imagery and the future inclusions of a solar-stimulated bottom fluorescence channel (685 nm) are also discussed.

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ANALYSIS OF DIFFERENTIALLY EXPRESSED PROTEINS IN PFIESTERIA PISCICIDA IN SEARCH OF GROWTH-RELATED PROTEINS

Pfisesteria piscicida is a heterotrophic dinoflagellate, whose physiological and ecological characteristics are under intense investigation. Recent studies show that this species can be an important grazer and regulator of phytoplankton population dynamics, but its role as a grazer remains to be assessed taking into consideration of its population size and growth rate. Toward developing molecular markers for growth studies, we analyzed protein expression profiles associated with different growth conditions. P. piscicida cells were harvested under starved (hence not growing) and well-fed (hence actively dividing) conditions. Proteins were extracted, purified, and separated using two-dimensional protein electrophoresis. Results revealed the protein profiles were very different from those of Prorocentrum minimun in which several proteins were highly abundant, likely to be Rubisco and other photosynthetic proteins. P. piscicida lacked proteins of very high abundance, and some relatively abundant cellular proteins were found under both starved and well-fed conditions. Some proteins were detected under well-fed condition but not under starvation, while some others appeared only during starvation. Potential of these differentially expressed proteins for studying molecular regulation of cell division will be discussed.

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HINDCASTING AND PREDICTING BAY ANCHOVY RECRUITMENTS IN CHESAPEAKE BAY

Understanding variability in recruitments of bay anchovy(Anchoa mitchilli), an important forage species, is an important goal for multispecies fisheries management. Recruitments in Chesapeake Bay varied nine-fold from 1995-2003. Abundances declined since the 1970s, but have stabilized in recent years. Most spawning occurs in the seaward third of the Bay where early-life stages are most abundant. Larval growth rates and feeding incidence (FI) varied annually and were correlated with zooplankton abundances. Larval FI is strongly correlated with young-of-the-year (YOY) recruitment level. A bioenergetics model suggested that years deficient in larval prey were associated with poor recruitment. Recruitment of YOY bay anchovy was inversely correlated with subpycnocline mean dissolved oxygen (DO), a probable indicator of interannual variability in pelagic productivity. Modified Ricker stock-recruitment models that include measures of seasonal migration of anchovy spawning stock or of subpycnocline DO levels, explained much of the observed variability in recruitments from 1995-2000. Forecasts of recruitment were successful in 2001, but poor in 2002.

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THE IMPORTANCE OF SWIMMING BEHAVIOR IN MAINTAINING PATCHES OF LARVAL CRABS: CAN BIOCHEMICAL CUES HAVE AN EFFECT?

Generally, larval forms are considered weak swimmers that are unable to overcome advection in the horizontal plane. Regardless, crab larvae may influence their horizontal distribution, at least on a small spatial scale (mm – m), by overcoming effects of turbulent diffusion—and this in turn may be important in formation and maintenance of patches. For example, crab larvae have been found in discrete patches in the water column, even in areas where aggregative physical processes (e.g., fronts, pycnoclines) are rare or absent. One possible reason for this observation is that larval crabs may alter their swimming behavior in response to biochemical cues in the water. To test this idea, the behavior of fiddler crab megalopae (Uca pugnax) was observed in a laminar-flow flume while introducing putative cues into the flow field. Swimming behavior of megalopae was video recorded under far-red light, and the resulting tapes were analyzed to determine changes in orientation and displacement of megalopae. Megalopae have shown responses to exudates produced by adult fiddler crabs and by conspecific megalopae. The results provide insight in answering some broader research questions.

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FLUORESCENT IN SITU HYBRIDIZATION WITH OLIGONUCLEOTIDE PROBES TO IDENTIFY ALEXANDRIUM TAMARENSE AND GENUS ALEXANDRIUM

This study was laid out to develop oligonucleotide probes that can be coupled with fluorescent in situ hybridization (FISH) to specifically detect the bloom-forming Alexandrium spp. and the species A. tamarense, respectively. Multiple probes were designed based on the sequences of 5S, 28S rDNA, and 18-28S internal transcribed spacer region, respectively. Three complementary probes (Tama28s01, Tama5s01, Tamaits01) specific for A. tamarense and one (Alex24s01) specific for genus Alexandrium, labeled with fluorescein, were tested on several different algal species using FISH method. The hybridization results were detected by both flow cytometry (FCM) and epifluorescence microscopy (EFM). The three A. tamarense-specific probes could discriminate A. tamarense from other species. The hybridization signal of each probe was affected by the growth stage of algae. Probes Tama28s01 and Tama5s01 yielded much brighter hybridization signal than probe Tamaits01. Targeted cells and negative control cells were well separated using FCM. Three auxiliary probes were designed to enhance the efficiency of hybridization. The probes and protocols developed here can be used to monitor in situ distribution of Alexandrium spp. and specific species of A. tamarenser.

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RAPID ESTIMATION OF PHOSPHATE AT PICOMOLAR CONCENTRATIONS

We have modified a recently developed 24-hour radiobioassay with a 15-minute radiobioassay for the measurement of steady state phosphate (ssPO4). This shorter procedure exploits a published empirical relationship between nutrient regeneration and total phosphorus (TP) based on data from 20 lakes, and only requires the measurement of total phosphorus (TP) and the uptake constant for phosphate (k). We applied this approach to a new set of lakes (n =34). Total phosphorus concentration ranged from 0.058 to 7.64 micromolar across all lakes (n=54). Uptake constants (n= 52, 0.016 to 1.1 per min, mean 0.345) indicated that the phosphate pool was turning over rapidly in most systems. Steady state phosphate ranged between 27 and 16,838 pM. Predicted ssPO4 concentrations (range 28 to 19,155 pM) were very similar to observed ssPO4 concentrations, indicating that the model provided a good estimate of ssPO4 with much less effort. With a small modification to correct for high dissolved organic phosphorus concentration in marine systems, the empirical model also provided useful estimates of PO4 in the P-limited Mediterranean and South Pacific Subtropical gyre

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EDDY-CORRELATION MEASUREMENTS OF DMS FLUXES AND EXCHANGE COEFFICIENTS ON THE NOAA-TAO CRUISE 2003

The emission of dimethylsulfide gas (DMS) is thought to be a major factor in the production of aerosols that control cloud reflectivity in the marine atmosphere. Until now the sea/air flux of DMS has been constrained mostly by budget methods that rely on assumptions about the fate of DMS in the ocean or atmosphere. Area-averaged parameterizations of these fluxes in terms of wind speed alone cannot explain all of the variability, because a) wind speed is only one factor affecting the exchange velocity (roughness, surface films, bubble spectra, and mean-square wave slope are others), and b) the parameterizations are based on observations that cannot resolve fluxes on time scales of less than a day.
We measured the flux of DMS on an hourly time scale in the Eastern Equatorial Pacific from the NOAA ship R/V Ronald H. Brown, using an atmospheric pressure ionization mass spectrometer (APIMS) with an internal isotopically-labeled standard. Both standard and ambient concentrations were measured at 20 Hz. We also measured the seawater DMS concentration with a purge and trap system, so that we could compute the DMS exchange coefficient (flux/interfacial concentration difference). We will compare our transfer coefficients with those from three commonly used parameterizations and with those reported from the GASEX data sets.

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SPATIAL MODELING OF FISH DISTRIBUTION AND ABUNDANCE: RESOLVING BEHAVIORAL RESPONSES OF FISH TO CHANGES IN THE INSHORE MARINE ENVIRONMENT.

Spatial models that simulate fish stock distribution in relation to oceanographic features can be used to interpret catch data or evaluate management measures. Accounting for fish behavior in response to oceanographic processes may make model predictions of spatial dynamics more robust. However, identifying fish behavior in response to oceanographic processes is sufficiently complex. Incongruity of movement and environmental datasets makes it difficult to form causal links between behavior and environment. Studies that examine these processes also encounter practical limitations for data collection - from the manual rigors of sampling at high resolutions to technical and fiscal constraints on methods and equipment. We present a study of bonefish (Albula vulpes) movement as an example of recent research in this field. The data provide inferences on response patterns of bonefish, but lack conclusive evidence for proximate mechanisms. When empirical support for behavioral hypotheses is not available, management models often rely on minimalist or phenomenological approaches. Emerging methods fitting behavioral models to empirical data provide opportunities for progressing beyond minimalist structure in fish movement models. Strong collaboration between biologists and physicists will be critical to future advances in spatial models that link movement and behavior at the level of individuals to shifts in fish distribution and abundance.

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ACID POLYSACCHARIDES IN MARINE COLLOIDAL ORGANIC MATTER AND MARINE MICROORGANISMS

Carbohydrates are among the most reactive compounds in the marine carbon reservoir. Acidic polysaccharides (APS) are an important surface-reactive component of the carbohydrate and hydrocolloidal pool that have roles in gel and marine snow formation, biofilm colonisation, and trace metal regulation. However, we currently know very little about the molecular composition of APS produced in natural environments. We used GC-EI-MS to measure neutral and acidic polysaccharides in marine colloidal matter extracted by ethanol precipitation, and in suspended particles. The results showed marine colloidal matter consisting of a number of neutral and acidic polysaccharides (arabinose, rhamnose, xylose, fucose, glucose, mannose, galactose, galacturonic, mannuronic or glucuronic acids). For suspended particles, the sum of galacturonic , mannuronic acid, and other unknown APS, accounted for 27% (on average) of the total uronic acid concentration, as assessed by spectrophotometry. Currently, we have successfully purified bacterial APS, produced by Sagittula Stellata, using a combination of techniques including ultracentrifugation and repeated alcohol precipitation, with a polysaccharide content that is about 17% of the organic carbon content. The molecular level composition of APS, determined by retention times and GC-EI-MS fragmentation patterns, will be reported for Sagittula Stellata, along with that of two marine phytoplankton, i.e., cyanobacteria and Emiliania huxleyi.

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BERING ECOSYSTEM STUDY PROGRAM (BEST)

We present information on a new research program being planned for the eastern Bering Sea, the Bering Ecosystem Study Program (BEST). In recent decades, components of eastern Bering Sea marine ecosystems have shown unexpected changes in abundance or distribution that, in many cases, correlate with climate-associated physical variability. Thus, the overarching question to be addressed in BEST is: How will climate change affect the ecosystems of the Bering Sea? Areas of inquiry will include the role of external forcing factors, biophysical coupling and forecasting the effects of changes in climate on the productivity of eastern Bering Sea marine ecosystems. It is important to resolve these questions because the eastern Bering Sea supports stocks of commercial fish that generate more than 40% of all United States' fish and shellfish landings, is the source of subsistence foods used by Alaska residents, and is home to vast numbers of marine birds and mammals. Understanding the underlying processes responsible for ecosystem responses to climate variability is essential for providing good stewardship and effective management of the Bering Sea's riches.

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SEASONAL DYNAMICS AND ECOSYSTEM IMPACT OF ZOOPLANKTON IN THE OLIGOTROPHIC PACIFIC OCEAN, ESTIMATED FROM OPTICAL PLANKTON COUNTER

We routinely surveyed waters in a 600 km2 region encompassing Station ALOHA using a towed Optical Plankton Counter (OPC) during 18 successive cruises of the Hawaii Ocean Time series (HOT) program. Our data set of zooplankton size structure and abundance together with other physical and biological variables covers a two-year period from February 1995 through January 1997, with sampling generally at one month intervals. The OPC was towed at 8 to 10 knots at a constant depth of 45 m. Numerous intermittent, multi-hour deployments were made during each 3 to 4 day cruise. Here we present time- and space-averaged biomass spectra for each survey. Post-processed data include particles ranging in size from 4 to 1,800 micrograms C, encompassing zooplankton from small copepods to euphausiids. Integrated biomass showed a marked seasonal cycle with winter minima and summer maxima. The 1996 summer maximum was greater than 1995; minima were similar in three successive winters. We estimate upper and lower bounds of primary production required to sustain observed zooplankton. We also estimate boundary contributions of zooplankton to dissolved nitrogen and fecal production.

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VARIABILITY IN SUN-INDUCED CHLOROPHYLL FLUORESCENCE IN SURFACE WATERS: PHYSIOLOGY OR BIOMASS?

Twenty-six years ago, Neville and Gower showed a tantalizing correlation between chlorophyll concentration and sun-induced chlorophyll fluorescence, which to this day is still showing great potential that has yet to be realized. The two key variables in this problem are light absorption by phytoplankton and the quantum yield of fluorescence. If the quantum yield of fluorescence is known, fluorescence is a useful measure of phytoplankton biomass. Similarly,

if light absorption can be specified, then the quantum yield of fluorescence can be retrieved, which provides information about phytoplankton physiology or species composition. In the past, the retrieval of both phytoplankton biomass and physiological indicators has met with variable success. The quantum yield is particularly difficult to estimate, as biases can arise across optical and ecological gradients when using simple algorithms; in addition, the quantum yield is a difficult parameter to validate. We use recent lab and field data, MODIS measurements and literature results, to describe quantitatively sources of environmental variability in sun-induced fluorescence measured at the sea surface. We address the question: "When is physiology and when is biomass the prime factor influencing variability in satellite measurements of sun-induced fluorescence?"

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SIMULATING NATURAL IRON INPUTS TO THE SOUTHERN OCEAN USING A SHIPBOARD CHEMOSTAT SYSTEM

Established grow-out iron addition methods provide strong diagnostic evidence of phytoplankton iron limitation, but cannot be considered prognostic indicators of community responses to natural iron inputs in HNLC systems. Single large inputs of iron followed by batch-mode growth do not accurately reflect natural supply processes. We used a shipboard continuous culture system to more realistically mimic iron inputs by upwelled sources and by stochastic events in two parts of the iron-limited Southern Ocean. The shipboard chemostat was used in HNLC waters at the high nitrate, high silicate SOIREE site to examine the biogeochemical and biological consequences of continuous low-level inputs, such as those originating from vertical advection. The chemostat was also used during the FeCycle cruise in high nitrate, low-silicate Subantarctic waters to mimic pulsed injection of iron from below the thermocline by periodic storm events. Results of these shipboard chemostat experiments indicate that natural iron inputs can result in profound changes in community composition and biogeochemical cycles. This method offers an alternative to grow-outs that can more realistically simulate ambient iron inputs in the Southern Ocean.

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THE EVOLUTION OF OUR UNDERSTANDING OF THE MARINE IRON BIOGEOCHEMICAL CYCLE

Manipulative experiments demonstrate that iron is one of the fundamental controls on marine productivity, but give only limited information about in-situ biogeochemistry. In this tutorial I will trace the evolution of our thinking about the natural marine iron cycle. Early paradigms focused on atmospheric deposition, total dissolved concentrations, and direct effects on algal growth and biomass. Conceptual and methodological advances added to this relatively simple picture by giving new insights into organic complexation, upwelled and regenerated sources, and taxon-specific requirements. Accelerating research efforts yielded progressively more detailed and realistic iterations that included multiple functional groups and trophic levels, interactions with other nutrients, and effects in regions other than HNLC regimes. Current research is bringing iron biogeochemistry into much sharper focus by investigating topics such as redox and photochemistry, sources and characterization of organic ligands, molecular diagnostic tools, export fluxes, the roles of bacteria and viruses, and quantitative biogeochemical modeling. Our emerging picture is that iron is comparable to nitrogen in the complexity and global significance of its marine biogeochemical cycle, but significant unknowns remain in critical parts of current models.

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COUPLED IRON AND PHOSPHORUS CYCLING AT THE OXIC/ANOXIC INTERFACE

Field evidence points to oxidative precipitation as the probable pathway for the formation of iron phosphate (Fe-P) phases in sediments of the eutrophic Scheldt estuary (NW Europe). Oxidative precipitation of Fe-P was studied in the laboratory at neutral pH. The P/Fe ratio of the precipitates decreases as a function of the Fe(II)/Fe(III) ratio of the solids. The latter ratio, in turn, depends on the oxygenation rate during precipitation. In the sediments, variable Fe(II) incorporation into Fe-P also depends on diagenetic uptake of Fe(II) from anoxic pore water. The presence of Fe(II) decreases the availability of Fe-P phases to iron reducing microorganisms, and may therefore account for the preservation of predominantly ferric Fe-P in the highly reducing sediments. In systems characterized by high phosphorus loading (estuaries, lakes, coastal zones, upwelling zones and highly productive oceanic basins), formation of ferric Fe-P may be an overlooked sink for phosphorus.

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MIGRATION AND ABUNDANCES OF BIGEYE TUNA (THUNNUS OBESUS) INFERRED FROM CATCH RATES AND THEIR RELATION TO VARIATIONS IN THE OCEAN ENVIRONMENT

Bigeye tuna catch rates are observed on a variety of scales, including interannual, associated with ENSO; seasonal, associated with the annual temperature cycle; and mesoscale, associated with eddies. Interannual variations between 1990 and 2003 indicate very high catches in 1998 near Palmyra during upwelling in the 1997-1998 ENSO, followed by a period of reduced CPUE. Bimonthly averages of latitudinal variation in effort, catch, and catch rate (CPUE) are compared with ocean temperatures from the ECCO model. The results suggest a broad annual migration primarily driven by the preferred surface layer temperature range. The region of maximum abundance migrates from subtropical waters in September when these waters are warmest, to tropical waters in March when subtropical waters are coldest. The inferred migration is supported by north-south annual migration of the CPUE center of mass (COM). However, the latitudinal CPUE variations also indicate that the fish inhabit regions outside their preferred thermal ranges for short times to feed at the subtropical convergence front or to spawn close to Palmyra. The SPC and Japanese Pacific data sets indicate similar Pacific-wide variations. The CPUE COM variations suggest significant annual migrations for albacore, bigeye, and marlin, but not for yellowfin tuna and swordfish. We aim to compare the actual latitudinal movement of tagged bigeye in the Pacific with the expected migrations over the tag release-to-retrieval periods.

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THE EFFECT OF THIN LAYERS ON THE VERTICAL DISTRIBUTION OF THE ROTIFER BRACHIONUS PLICATILIS.

Microscale patches of resources occur in both the horizontal and vertical dimension, and in the latter case are referred to as thin layers. These layers may affect ecological processes like behavior, predation, growth and reproduction in phytoplankton and zooplankton. The objective of this study was to determine possible effects of biological and physical thin layers on the vertical distribution and diel migration of the rotifer Brachionus plicatilis. We used four, 2-meter tall, experimental tanks with video cameras which panned the vertical extent of each tank. The treatment tanks consisted of a thin layer of Nannochloropsis sp., whereas control tanks consisted of homogeneously distributed algae. Rotifers initially aggregated in the thin layers of Nannochloropsis sp., but after depleting the algae, rotifers became evenly distributed. No signs of diel vertical migration were noted. We also examined the response of rotifers to a choice of food (Skeletonema costatum vs. Nannochloropsis sp.). Preliminary results suggest preferential feeding on Nannochloropsis sp. over S. costatum. These data suggest that rotifers are capable of locating and taking advantage of concentrated food sources in thin layers.

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DATA ASSIMILATION AND MODELING OF SOURCE-SINK RELATIONSHIPS AND FISHERY PRODUCTION OF HOMARUS AMERICANUS IN THE GULF OF MAINE.

The general cyclonic circulation of the Gulf of Maine and a well-defined coastal current system (mean subtidal flows of 10-30+ cm/s) assures some degree of connection, via larval transport, between Canadian and U.S. portions of the population of the American lobster, Homarus americanus. We are developing a multi-scale model of biological and coupled bio-physical processes to quantify the effects of along- and across-shelf transport dynamics on the patterns of fishery production in the northwestern Gulf, determine the roles of retention and transport to various segments of the population, and suggest how external forcing by nature or management efforts might alter the patterns. The types of data available and the finite resolution of circulation models (particularly near the complex coastline) mandate a multiple grid-scale approach that combines spatially-explicit (at different scales) and non-explicit modeling (with results later spatially re-apportioned). Part of the project is built around elements of the Gulf of Maine Ocean Observing System, so important system (model) attributes will be monitored into the future.

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BIODIVERSITY PATTERNS OF MARINE PHYTOPLANKTON

Phytoplankton blooms are unique events in nature where plant biomass may increase by up to 3 orders of magnitude over a time scale of days. The species composition of these blooms plays an important role. Toxic dinoflagellates may form harmful algal blooms, blooms dominated by diatoms contribute substantially to the global biogeochemical cycles, and blooms dominated by haptophytes like Phaeocystis sp. or Emiliania huxleyi are important sources of DMS, a biogenic gas affecting cloud formation and albedo. Here we present biodiversity and species composition data for marine phytoplankton assemblages from 11 different areas of the world. Our results show that, similar to terrestrial vegetation, the relation between phytoplankton diversity and phytoplankton biomass fills a triangular area with minimum diversity during massive blooms. Using microzooplankton biomass data and a shading index we suggest that the observed triangular relation in marine phytoplankton diversity is a result of the interplay between nutrient limitation, grazing, and competition for light.

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OCEAN PRODUCTIVITY THROUGH TIME AS REVEALED THROUGH STABLE ISOTOPE ANALYSIS OF ARCHEOLOGICAL MIDDEN MATERIALS IN THE GULF OF ALASKA: INITIAL RESULTS

Ocean productivity and temperature of nearshore environments in the Gulf of Alaska over the past 6,300 years are being examined through natural stable isotope analysis of bivalve material from an archeological site. The Katmai National Park island site in the Shelikov Strait was occupied from approximately 350 to 2,000 years before present (BP) and from approximately 4,000 to 6,300 years BP. Bivalves figure prominently in the midden materials and are well preserved. Results of delta carbon-13 and delta oxygen-18 isotope analyses of Saxidomus giganteus shells are being contrasted to available climate data to suggest how ocean productivity has varied with climate in the nearshore marine environment.

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VOLATILE ORGANIC COMPOUNDS IN THE OCEAN AND THE MARINE ATMOSPHERE IN THE EQUATORIAL PACIFIC

The upwelling of nutrient-rich water was observed in the eastern region of equatorial Pacific (upwelling region) and the higher sea-surface temperatures, and the lower nutrient concentrations were also observed in the western region (warm pool region). Volatile organic compounds (VOCs) such as dimethylsulfide (DMS), halocarbons, and isoprene in the water and air samples were measured in the equatorial Pacific (145 E-160 W) in January 2002 and 2003. For example, average concentration of DMS in the surface seawater is 6.28 nM in the upwelling region, in warm pool region: 3.77 nM (2002). In the upwelling region average concentration of DMS in the sea-to-air flux is 5.50 µmol m-2 day-1and in the warm pool region, flux is 4.62 µmol m-2 day-1 (2002). Positive relationships between primary production and VOCs such as bromomethane and DMS were observed in the upwelling region. Positive relationships between the picoeukaryotes and DMS were also observed in the upwelling region (r2=0.95, 2002). Phytoplankton speciation and physiological diferrences between the two regions are probably related to the difference of the distribution of VOCs between the upwelling region and warm pool region.

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3D-STRUCTURE OF FRESHWATER RED-TIDE UROGLENA AMERICANA EVALUATED BY AUTONOMOUS UNDERWATER VEHICLE

It is not easy to predict where noxious algal blooms will develop in a large lake. Especially for phytoplankton species that are unlikely to accumulate on the water surface, an Autonomous Underwater Vehicle (AUV) equipped with a submersible microscope might be helpful for monitoring the microbiological water quality. In Lake Biwa (area 670 km2, mean depth 44 m), Japan, water quality has deteriorated and freshwater red-tide has occurred in almost every spring since 1978. The red-tide consisted predominantly of Uroglena americana (Crysophyceae). In May 2003 we investigated the spatial phytoplankton distribution in a 100 m (H) x 100 m (W) x 20 m (D) water body using an AUV. Digital video images from a submersible microscope mounted in the AUV were analysed by computational image processing software, and the detected numbers of the target species were plotted for each 3D spatial position. Using this automated monitoring system we were able to determine the 3D structure of Uroglena patches separately from other phytoplankton.

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IMPACT OF SUPERSATURATED IRON ON IRON UPTAKE AND GROWTH OF A COASTAL MARINE DIATOM

The growth and iron uptake of a coastal marine diatom, Chaetoceros sociale, were experimentally measured in culture experiments which high concentrated acidic Fe(III) solution was added directly into culture media containing C. sociale. The direct input of Fe(III) into the culture media induced the highest iron uptake rate by C. sociale during the first day of incubation, resulting from the supply of supersaturated bioavailable inorganic Fe(III) species. In the present study, the further iron uptake by C. sociale from external iron in the direct Fe(III) input media was prevented by adding hydroxamate siderophore deferriferrioxamine B (DFB) during cultivation. Without any additional iron uptake by addition of DFB during cultivation, the highest specific growth rate of C. sociale in the direct Fe(III) input media was remained for a few days after DFB treatment and was independent of the amount of intracellular Fe uptake. However, the maximal cell yields appeared to be relatively dependent on the amount of intracellularly stored Fe. The high iron uptake and storage capacity in C. sociale allows this species to accumulate excess iron at high concentration of supersaturated bioavailable inorganic Fe species and to divide at least a few times without any additional iron uptake.

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ZOOPLANKTON USE OF CHEMODETECTION TO FIND AND EAT PARTICLES.

The ability of raptorial zooplankton to find large particles such as marine aggregates is crucial to their use of the particles as food and to the fate of the particles. Kiørboe and Thygesen (2001) developed a numerical approach to describe particle detection by chemosensory zooplankton. In this paper, we develop and test a simplified mathematical description of the process and explore the ecological implications of chemosensory particle detection. Our results suggest that chemosensory particle detection is more efficient than hydrodynamic detection. The exact extent depends greatly on the sensitivity of chemodetection in zooplankton, a process that has not been well studied experimentally.

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EFFECT OF BED ROUGHNESS ON SCALAR MIXING AND ODOR PLUME NAVIGATION IN TURBULENT BOUNDARY LAYER FLOWS

The fluctuating properties of odor signals in turbulent boundary layer flows are used by animals to navigate towards a source. Turbulent mixing is the dominant physical process that disperses odor in environments inhabited by large marine invertebrate predators (e.g., blue crabs), and in fact, turbulence decreases the rate at which blue crabs successfully locate prey. We coupled laser-induced fluorescence (LIF) measurements of odor plume structure to behavioral analysis of search kinematics of crab predators to determine why increased turbulence produces signals that are less easily tracked by foraging crabs. Bed substrates of different roughness (grain size) created smooth, transitional, and fully rough flow conditions. Substrate manipulations effectively alter turbulence, but are environmentally relevant since foraging crab frequently traverse different substrates enroute to prey. For each case, we challenged blue crabs to locate a stimulus source, and the characteristics of odor signals in horizontal planes were analyzed using LIF. Generally, increasing turbulence causes greater mixing, decreases concentration and concentration variance, and increases the plume integral length scale. We will discuss the impact of these changes on search kinematics of foraging crabs.

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TOWARDS A SMART FAD: MONITORING PELAGIC FISH WITH A SCANNING SONAR

Associative behavior is a major component of the life of pelagic fishes. Tropical tunas and other fish species are frequently found in association with a variety of floating objects. With the increase in catch rates occurring at FADs the standard methods for fishery stock assessment and management have been significantly impacted. These changes require the development of new technologies for stock assessment and fishery management that take into account these structure associated aggregations and their importance to the fishery. In order to provide information to scientists interested in studying the abundance and behavior of these fishes around FADs, we are building a scanning sonar system. The system consists of several "side scan like" transducers capable of localizing animals and estimating their target strength out to several hundred meters. Hourly scans will permit knowledge of animal abundance and position as a function of the time of day. Characterization of reflections holds potential to provide information about taxa. Autonomous operation in conjunction with large data storage capability will permit the system to operate over periods of weeks.

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SPATIAL PATTERNS OF SEABIRD DISTRIBUTION, ABUNDANCE AND DIETS IN THE CENTRAL AND EASTERN ALEUTIAN ISLANDS

We examined the hypothesis that spatial patterns of seabird distribution, abundance and diets along the Aleutian Islands are an indirect response to (1) water masses that determine planktonic food webs and (2) physiography and tidal interactions that determine prey availability. We tested these hypotheses on two research cruises conducted in June 2001 and May-June 2002. At large spatial scales, composition and abundance of seabirds showed marked differences between the central and eastern Aleutian Islands. At smaller scales, narrow shallow passes had higher densities of seabirds than wide, deep passes. Seabird diets in the central Aleutians were dominated by oceanic copepods and shelf-break species of euphausiids, and in the eastern Aleutians by coastal species of euphausiids. Seabird foraging habits partially reflected patterns of zooplankton abundance. Our study reflects major zoogeographical differences in the marine environment between the central and eastern Aleutian Islands and expands our understanding of the mechanisms responsible for the formation and persistence of seabird foraging aggregations in the Aleutian passes.

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ENRICHMENT OF THE SEA SURFACE MICROLAYER AND MARINE AEROSOLS BY VIRUSES AND BACTERIA

The sea-surface microlayer (200-400 mm thick) is a unique physical, chemical, and biological environments serving both as a source and sink for materials in the atmosphere and water column. It is enriched compared with subsurface waters by several mechanisms including bubbles transiting the water column and carrying organic compounds, viruses, and bacteria. This project examined the enrichment of aerosols, produced from microlayer material and material adsorbed to bubble surfaces during scavenging through the water column when bubbles burst and eject droplets into the air, Collections of microlayer and aerosol samples were coupled with epifluorescence microscopic counts of DAPI stained bacteria and SYBR Gold stained viruses (Viral-Like Particles). Microlayers were enriched with VLPs and bacteria about 1.2-8 times compared with subsurface water. Aerosols collected at 10 cm above the surface were enriched even more: 2.5-25 times for bacteria and 2.7-13 times for VLPs. Concentrations varied with boating activities, breaking waves, storms, and proximity to land. Many known viral and bacterial pathogens able to survive drying in aerosols and could potentially impact human populations given the pressures of development in coastal areas.

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EVIDENCE OF HYDROMECHANICAL SIGNALING BETWEEN THE CILIATE MESODINIUM PULEX AND ITS PREY

The raptorial ciliate Mesodinium pulex feed while motionless. In this fashion it obviously cannot move along prey generated chemical gradients. Instead; the prey generated hydromechanical signal is used in localizing prey. Mesodinium pulex respond only to motile prey with either an attack or an escape. Non–motile prey is ignored. Both the attack and escape response were associated with a strong directional component by Mesodinium pulex. The critical threshold fluid velocity generated by various prey species required to initiate an attack by Mesodinium pulex was ca. 80X10^-4 cm/s which is similar to what is found marine metazoan. In some of the predator prey encounters Mesodinium pulex escaped. The escape response in Mesodinium pulex is associated with fast swimming prey such as in Gymnodinium simplex. The prey generated fluid deformation signal perceived by Mesodinium pulex at the point of escape is about 9.8s^-1. Microscopical observations also suggest that the equatorial cirri Mesodinium pulex is the principal site of detection of prey generated fluid mechanical signals and our data is the first example of its kind in a protist.

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IMPLICATIONS OF CIRCADIAN CYCLES IN HETEROTROPHIC PROTISTS

Growth and feeding rates of planktonic marine heterotrophic protists showed pronounced circadian cycles. Rates were higher during the day and lower at night in most tested species. However, inverse exceptions were found. Also in the fast growing ciliate Balanion comatum circadian growth and feeding cycles was not apparent. Higher rates of feeding and growth during the light period, when phytoplankton are photosynthetically active, may strongly influence predator-prey cycles in the ocean's euphotic zone. The heterotrophic dinoflagellate Oxyrrhis marina maintained a circadian cycle at irradiances as low as 2.6X10-3 micromol photons m-2 s-1, but not at 3.1X10^-4 micromol photons m-2 s-1. Growth and feeding were also studied in transition from complete darkness to culturing in a day:night light cycle in the dinoflagellate Oxyrrhis marina. We found that resetting the circadian cycle in Oxyrrhis marina temporarily arrested growth and feeding. Turbulent mixing across the critical irradiance threshold of 3.110-4 mol photons m-2 s-1 occurs in coastal environments. Our data suggest that mixing across this threshold may temporarily arrest growth and feeding in heterotrophic protists, hence reducing grazing on phytoplankton.

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HYDROTHERMAL PLUME DETECTION WITH AN AUTONOMOUS UNDERWATER VEHICLE

Sensors aboard autonomous underwater vehicles (AUVs) can detect deep-sea hydrothermal venting, and with the addition of data-driven behaviors, AUVs have the potential to significantly improve the efficiency of plume search. Before we can capitalize on this potential we must understand how the chemical and physical anomalies associated with the presence of a hydrothermal plume map to sensor outputs aboard an AUV. Our experience with the Autonomous Benthic Explorer (ABE) indicates that the local bathymetry and hydrographic setting play a decisive role in determining that mapping, and must be considered in any automated detection scheme. We apply a model-based hypothesis test to scalar temperature, conductivity, optical backscatter, and depth measurements collected by ABE during dives at the varied settings of the East Pacific Rise (9 N and 18 S), the Juan de Fuca Ridge, Galapagos Rift, Explorer Ridge, and Lost City (MAR). A hypothesis test reduces multiple measurements and prior information to a single scalar value, which when appropriately thresholded could be used to trigger alternate survey behaviors. The plume model employed is that of Speer and Rona (1989).

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DIFFERENTIAL AFFECTS OF NUTRITIONAL STRESS ON CLOSELY RELATED SPECIES

Zooplankton diversity is driven by differential responses by species to environmental variables. In this study we compared the responses of Acartia clausi and A. tonsa to stressed nitrogen limited Rhodomonas, and Rhodomonas in the exponential phase of growth, to determine the affects of algal blooms on life history parameters. Egg production, egg size, egg hatching, naupliar viability and resting egg production were measured. Early results suggest that the two species respond differently to the differing food qualities. A. clausi increased egg production with nitrogen limited algae, but hatching success and naupliar viability were lower, whereas A. tonsa decreased egg production but produced more resting eggs. As climate induced changes in zooplankton abundance and distribution are mediated by their responses to phytoplankton, these species specific responses could ultimately affect the persistence of a species at a particular location.

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LAKE MICHIGAN YELLOW PERCH: A POND FISH'S RECRUITMENT CHALLENGES IN A MESO-OCEANIC ENVIRONMENT

Yellow perch are a demersal small lake fish that, in Lake Michigan, have an early life history similar to many marine coastal species. In small bodies of water larval yellow perch swim out of the weedy littoral zone where the eggs incubate, to the limnetic zone. They return to become demersal after about 40 days. In Lake Michigan, however, the much stronger currents quickly transport the larvae from preferred rocky spawning habitat to well offshore. Sampling and physical modeling show that cross-Lake Michigan transport, i.e. transport in excess of about 120 km, is real, rapid, and to be expected. Daily transport typically exceeds the dimensions of the yellow perch's typical lakes. The transport, which tends to be from west to east, combined with dreisennid mussel related loss of soft-bottom nursery areas, appears to have transformed the Lake Michigan yellow perch recruitment situation to one of sources and sinks. Proposed sources are the abundant rocky areas along the western shore and proposed sinks are the food-barren, soft bottom sediments along the eastern shore.

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COMPLEXITY IN MARINE BENTHIC POPULATION DYNAMICS

Processes governing the population dynamics of nearshore benthic species can be categorized as those that influence the supply of larvae to adult habitat (i.e. larval production, transport, and settlement), and those that influence adult performance (i.e. disturbance, predation, and competition). It has become apparent that these processes interact across categories yet because they are nonlinear, operate on different spatial and temporal scales, and are traditionally investigated by different disciplines, studies continue to focus on individual processes. Our collaborative, cross-disciplinary study addresses this problem by examining key phenomena, across appropriate spatial and temporal scales, that impact barnacle population dynamics at two sites along the Southern California/Northern Baja California coast. Adult Chthamalus fissus in La Jolla, CA, USA are larger and grow faster than adults in Las Olas, Baja California, Mexico yet size specific fecundity is larger and size at first reproduction smaller for the Chthamalus population in Las Olas. Our data on population density, larval concentration and distribution in the two sites show higher adult abundance and larval concentration in La Jolla than in Las Olas.

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STABLE ISOTOPES AND FATTY ACIDS AS BIOMARKERS IN A SEAGRASS ECOSYSTEM

Stable isotope analysis has been widely used to establish trophic level of invertebrates and fishes in marine food webs and to distinguish the contribution of different primary producers to ecosystem carbon flux. Analysis of fatty acid composition is another approach to understand marine trophodynamics. In our study we combined both methods to establish the main food sources in a seagrass ecosystem. Carbon and nitrogen stable isotope ratios, as well as fatty acid composition of main consumer species and potential food sources were determined monthly for one year in a subtidal eelgrass meadow (Zostera marina) in the Kiel Fjord, Germany. The main sources of organic carbon in the community exhibited a wide range of carbon isotope ratios, varying from -35.2‰ for the macroalgae Delesseria sanguina to –12.5‰ for epiphytes and –10.2‰ for Zostera marina. The dominant mesograzer, the omnivorous isopod Idotea baltica showed seasonally varying d15N values, that indicate a more herbivorous nutrition in springtime and early summer. The d13C values suggested that at first chiefly epiphytes and then macroalgae were consumed. This is supported by the fatty acid composition.

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SOLAR INDUCED DNA PHOTOPRODUCTS ACROSS A LATITUDINAL GRADIENT IN THE EASTERN PACIFIC OCEAN

DNA damaging solar ultraviolet radiation (UVR) varies due to zenith sun angle, ozone and day-length affecting both the quality and quantity of UVR. Latitudinal position may result in UVR differences of an order of magnitude or more. UVR induced DNA damage was examined in surface water samples collected and incubated under full sun during a transect between approximately 30 S to 30 N in the Eastern Pacific Ocean. Samples were collected pre-dawn and incubated in UVR transparent incubators at in situ temperatures until late afternoon at which time they were filtered and the DNA extracted. DNA damage measurements in marine plankton were accomplished using radioimmunoassay, HPLC-EC, and HPLC-MS/MS technologies. This enabled a comprehensive report of photoproducts to include thymine dimers , thymine-cytosine dimmers, (6-4) photoproducts, Dewar isomers of the (6-4) photoproducts, and oxidative damage as 8-oxo-deoxyguanosine. In general, total damage levels were proportional to incident irradiance levels, although the range in irradiance intensities implies that there may be a threshold response below which damage is lower. We are also provided with new insights into damage induction and repair kinetics.

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DIVERSITY OF NITROGEN ASSIMILATION GENES IN NATURAL CYANOBACTERIAL POPULATIONS

Genes for nitrogen assimilation can be used as phylogenetic markers for populations of Prochlorococcus and Synechococcus to study their N utilization strategies in the environment. Glutamine synthetase is a gate for assimilation of nitrogen into amino acids, regardless of the nitrogen source. Thus, this molecular marker can be used to characterize all cyanobacterial populations. The presence and expression of nitrate reductase can be used to identify cyanobacteria that use nitrate as a nitrogen source. We amplified glutamine synthetase (glnA) and nitrate reductase (narB) genes from a number of cultivated cyanobacteria and a variety of marine environments, including the Chesapeake Bay, Monterey Bay, and the Pacific Ocean. The glnA tree topology is similar to phylogenetic trees generated with sequences from the small subunit of 16S rRNA. Oceanic cyanobacteria form one major, distinct phylogenetic group with divisions between Synechococcus and Prochlorococcus. There is resolution within this group that is similar to phylogenetic clustering in trees constructed with the 16S-23S spacer region. Assimilatory nitrate reductase sequences also resolve into major cyanobacterial clades and indicate phylogenetic groups of organisms with the potential to assimilate nitrate.

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PRESENCE OF BACTERIAL AND VIRAL INDICATORS AND HUMAN ENTERIC VIRUSES IN MICHIGAN WATERWAYS

Surface waters in the state of Michigan are used for multiple purposes including source waters for drinking and those used for recreation. Microbial pathogens and fecal contamination are emerging as significant threats to these waterways; however, they have not been adequately addressed in terms of presence. In this study, nine major tributaries in the lower portion of the state were tested for the presence of fecal coliforms, Escherichia coli, enterococci, coliphage, and human enteric viruses. Of these, seven exceeded the allowable limits set for recreational waters for E. coli and enterococci and three tested positive for the presence of human enteric viruses by tissue cell culture methods. The presence of human enteric viruses and elevated levels of microbial indicators suggest that these waters pose a threat to the health of individuals using them for recreation. These results illustrate the need for the establishment of a more comprehensive water microbiological program in the state of Michigan.

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USING A FISH AS A RHEOMETER: FLUID-MUD FLOW OVER GILLS AS A FUNCTION OF PARTICULATE ORGANIC MATTER CONCENTRATION

Some blooms and cultures of phytoplankton, such as the ichthyotoxic Karenia mikimotoi, show the physical properties of a gel. In such cultures, cystein compounds, which fluidify mucus by breaking S=S links, diminished measured yield stress (YS) and lethality to fish (Jenkinson & Arzul, 1998, 2001). The intertidal Anse de l'Aiguillon (W. coast of France) is a nursery ground for young sole (Solea solea), but it also supports intensive culture of oysters and mussels, whose defecations contribute to a surface layer of highly organic "crème de vase" (mud cream, MC). The sole burrow into the MC to escape predatory birds. In freshly killed sole, we measured flow through the gill-ways as a function of hydrostatic pressure difference (HPD) across the gills. In pure water, flow rate was directly proportional to HPD, while in MC, the flow was proportional to (HPD - YS). YS was itself proportional to (organic matter concentration - 4.5 g/L). Above 8-10 g OM/L, the YS reached 50 Pa (0.5 cm water) which would theoretically kill the young fish as this is the maximum HPD they can produce.

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RELATION OF BEHAVIOR OF COPEPOD JUVENILES TO POTENTIAL PREDATION BY OMNIVOROUS COPEPODS: AN EMPIRICAL-MODELING STUDY

An empirical-modeling study was carried out to examine the motion behavior of copepod nauplii to their potential predation by omnivorous copepods. First, video observations were made on the encounters of nauplii of Centropages velificatus, Paracalanus aculeatus, P.quasimodo and Temora stylifera with free-swimming adult females of C.velificatus. Through examining each female's behavior, the observed encounters were arranged under three categories: (1) quasi-steady, (2) unsteady, and (3) unsteady with body turnabout/rotation. We conclude that a wide spectrum of motion behaviors contributes to the generation of hydrodynamic signals. Then, a hydrodynamic model was developed to analyze the encounters under the quasi-steady category. The model quantifies flows at both the female copepod's body scale and the nauplius' body scale. The model is able to estimate the tip-base velocity differences as well as the averaged-deformation-rates over the length of A1 (first antennae) setae of the nauplii, resulting from the flow disturbances generated by a steadily approaching C.velificatus female. The results demonstrate that nauplii moving intermittently are more sensitive to hydrodynamic signals than those moving continuously.

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INTEGRATION OF MOLECULAR BIOLOGY, PHYSICAL OCEANOGRAPHY AND REMOTE SENSING TO ILLUMINATE THE SOURCES AND TRANSPORT PATHWAYS OF URBAN COASTAL POLLUTION

Locating and mitigating urban coastal pollution is complicated by the multitude of potential sources and the complex fate and transport processes that control regions of impact. In this investigation we incorporate information from molecules to satellites for illuminating coastal pollution problems. Periodically during the summer, the surf zone at Huntington Beach, California receives inputs of sub-thermocline water. These upwelling events extend over a broad region of the southern California Bight (>200 km), and manifest in shoreline waters as a drop in temperature (3-5ºC), phytoplankton blooms, and the appearance of fecal indicator viruses and hepatitis A virus. Urban runoff appears not to be the major source of viral contamination. However, it can be an important source of fecal indicator bacteria. The results demonstrate the power of an integrative approach to solving coastal water quality problems, challenge current paradigms for the offshore disposal of treated sewage, question the use of fecal indicator bacteria as an index of coastal water quality, and illuminate the complexity and non-linearity of processes that control the cross-shelf exchange of mass in the coastal ocean.

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REDOX CONTROL ON SPECIATION AND REMOVAL OF TRACE METALS IN A PARTLY ANOXIC ESTUARY

The Danshuei River Estuary, located in northern Taiwan and flows through a metropolitan area of 6 million people, is under sub-oxic to anoxic condition because, the system 1) is a macro-tidal estuary; 2) has anthropogenic inputs; 3) has limited water exchange with coastal water. Under different climate conditions, behavior of trace metals changed dynamically while transporting to the coast. Using detailed physical (0.1 and 0.4 micron cut-offs) and chemical (labile, organically bound, and inert) separation techniques, distribution patterns of trace metal speciation were investigated, and distinct behavior of trace metals was revealed. In general, high river flow conditions would result in metal species mostly being in the labile and <0.1 micron fractions. As the redox state of the estuarine waters shifted from oxic during high flow condition to anoxic in low flow condition during dry season, the inert fractions were more pronounced, metals had higher percentages presented in larger size fractions (0.1-0.4 micron), and the magnitudes of removal of trace metals were greater. These distribution patterns of different metals indeed reflected various reactivity of specific elements.

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DYNAMICS OF AEROBIC ANOXYENIC PHOTOTROPHIC BACTERIA IN THE EAST CHINA SEA

Aerobic Anoxyenic Phototrophic Bacteria (AAPB) are unique functioning bacteria that can use sunlight for photosynthesis as needed in accordance with environmental conditions. Dynamics of AAPB in a wide geographic range (from the Yangtze Rive estuary to the oceanic Kuroshio Current area) of the East China Sea, a typical marginal sea characterized by diverse physical-chemical and ecological conditions, were investigated during April 2002 to September 2003. The results showed great variability in abundance of AAPB ranging from 104 to 105 cells/ml, and in the ratio of AAPB to the total heterotrophic bacteria from less than 1% to more than 10% over environmental gradients. Remarkable seasonal patterns were observed: AAPB were highest in spring either in terms of abundance or in terms of ratio to the total bacteria. In the other seasons, however, abundance and the ratio did not match, suggesting differences in controlling mechanisms for AAPB and other bacteria. Geographically, the abundance declined in off-shore directions while the ratio increased in off-shore directions. Affecting factors of the distribution patterns are also discussed.

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LIGHT UTILIZATION IN 13 DIFFERENT PIGMENT GROUPS OF BLOOMFORMING PHYTOPLANKTON

Spectral (400-700 nm) in vivo chl a specific absorption coefficients and the corresponding PSII scaled fluorescence excitation spectra of high light and low light acclimated cells of 33 species, 10 phytoplankton classes from Bacillariphyceae, Dinophyceae, Prymnesiophyceae, Prasinohyceae, Euglenophyceae, Chlorophyceae, Chrysophyceae, Raphidophyceae, Cryptophyceae, and Cyanobacteria are presented. These classes comprises 13 pigment-groups which have been used to gain information of: Pigment-group specific differences in light harvesting and utilization (both chl a and C biomass normalized) and relate these to differences in package effect, the fraction of cellular chl a associated with PSII and the fraction of light received by PSII for taxonomic, phylogenetic, ecological, and photo-physiological information.

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RADIOMETRIC STRAY LIGHT CHARACTERIZATION AND ITS SIGNIFICANCE TO OCEAN COLOR SCIENCE

To obtain the accuracies required for useful data products, ocean color satellites are calibrated vicariously against reference instruments. A primary reference instrument for recent ocean color satellites is the Marine Optical System (MOS) on board the Marine Optical Buoy (MOBY). A ship-board deployable instrument called the MOS Profiler is used in the development of bio-optical algorithms. These instruments are calibrated against incandescent sources with a spectral distribution that peaks in the near-infrared, while the radiant flux from the ocean peaks in the blue to green. Because of the different spectral
distributions between the calibration source and the ocean color, the effect of stray light on the instrument response must be considered. In this presentation, we discuss the characterization and stray light correction of the MOBY/MOS and the MOS Profiler. The impact of the MOBY/MOS stray light correction on satellite sensor calibration coefficients and resultant bio-optical products are discussed pertinent to SeaWiFS and MODIS. Similarly, we discuss the impact of stray light in the MOS Profiler on bio-optical relationships.

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GROWTH OF METHANE BUBBLES IN NATURAL SEDIMENT BY THE MECHANISM OF FRACTURE

We have studied the mechanical behavior of natural and surrogate sediment samples by injecting bubbles. We have injected gas through a fine capillary and have monitored pressure during bubble growth to provide information about stress and strain. Injection of gas into natural sediment and surrogate gelatin samples typically produces a saw-tooth record of pressure. The resulting bubbles are disk shaped with long axis oriented vertically. The stress and strain results and the observed bubble shape are consistent with a mechanism of bubble growth by fracture. We show that our data can be interpreted with Linear Elastic Fracture Mechanics (LEFM) and have applied this model to determined the critical stress intensity factor, K1C, a geotechnical property of the sediment that is the principle determinant of fracture. We suspect that our results will also have important implications for some forms of infaunal movement in sediments.

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THE SEASONS OF MONTEREY BAY OBSERVED WITH MOORED CHEMICAL AND BIOLOGICAL SENSORS

Dissolved nitrate absorbs light in the deep ultraviolet and its concentration can be determined directly by measuring the UV spectral properties of seawater. Optical nitrate sensors (In Situ Ultraviolet Spectrophotometers – ISUS) have been deployed for much of the past two years on the MBARI M1 and M2 moorings at 20 and 50 km offshore Monterey Bay. These moorings are also equipped with PCO2 sensors and spectral radiometers to estimate phytoplankton biomass. Shipboard visits to the moorings are made at approximately 21 day intervals to sample additional ecosystem properties. The continuous observations of chemical and biological properties provide an unparalleled view of biogeochemical processes in the coastal ocean. Perhaps most surprising, the nitrate concentrations in this system are very seldomly depleted to near zero values. This suggests that other parameters are regulating ecosystem process. Measurements of dissolved iron concentration, which are made on the shipboard visits, demonstrate that this metal plays a strong role in regulating the ecosystem.

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PHYTOPLANKTON, FATTY ACIDS AND SECONDARY PRODUCTION OF DOMINANT COPEPOD SPECIES IN THE NORTH SEA.

Most studies on biochemical controls of food (food quality) on zooplankton growth have been conducted in the laboratory. Those studies have shown that correct ratios of some essential fatty acids in the food are essential for successful growth of zooplankton. During 4 cruises from March to July in the North Sea, detailed sampling of phytoplankton community, pigments and fatty acid composition of seston was conducted to evaluate the food quality available for zooplankton growth. Concurrently egg production and hatching measurements were conducted on 6 most dominant copepod species in the area. Reproductive responses differed between the species. Egg production rates appear to be dependent on food availability while hatching success seems to be more dependent on the quality of the food available. Hatching success correlated significantly with the presence of the essential fatty acids 22:6n3 and 20:5n3 in the seston.

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OCEAN OUTFALL PLUME VARIABILITY AND OCEAN DYNAMICS OFF HUNTINGTON BEACH, CALIFORNIA

The variability of an ocean outfall plume was mapped during an intense physical dynamics experiment on the San Pedro Shelf off of Huntington Beach, CA during the summer of 2001. Intensive sampling focused on periods of spring tides when bacterial contamination of beaches was most likely to occur. The plume was observed under varying conditions of stratification and current variability. Cross-shelf motion of the plume could in some instance be associated with cross-shelf currents, but on other occasions there was no clear indication of cross-shelf transport. The plume was always submerged, trapped by the seasonal pycnocline, but variations in the depth of the plume were observed. These variations were associated with variations in stratification and variations in the pycnocline depth. Several mechanisms were proposed that could transport the effluent plume to the surf zone have been proposed. Components of the physical processes associated with these mechanisms have been observed, but there were no observational connections between the effluent plume and surf zone.

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APPLICATION OF AN AUTONOMOUS UNDERWATER VEHICLE TO STUDIES OF BENTHIC PELAGIC COUPLING

The bio-physical field experiments conducted with Stanford's recently acquired REMUS AUV represent some of the first applications of a commercially available AUV to studying environmental flows. The REMUS was equipped with high-resolution fluorescence, turbidity, conductivity, temperature and depth sensors, upward and downward looking acoustic Doppler current profilers (ADCP) and side scan sonar. Preliminary experiments at Frank's Tract, San Francisco Bay Delta, CA and Conch Reef, Key Largo, FL highlight some of the benefits and challenges of using REMUS in bio-physical experiments. Successful deployment of REMUS in Frank's Tract, a shallow (3m) tidal lake, provided high resolution bathymetry data and side scan images, enabling the density of aquatic vegetation and the presence of other underwater features to be identified. "Snapshots" of fluorescence and temperature indicate REMUS will be able to detect spatial variation in these parameters during future control volume experiments measuring phytoplankton feeding by clams. However, ADCP velocity data collected in opposite directions along the same transect indicate a significant bias in the direction of the vehicle's motion, similar to the problems found with boat mounted ADCPs.

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MAKING WATER FLOW: THE HYDRODYNAMIC CHARACTERISTICS OF DIFFERENT BIOLOGICAL FLUME TANKS

Flume tanks are becoming important research tools in aquatic ecology. There is no such thing as a "standard" flume tank, and no flume tank is suitable for every type of research question. BioFlow is a European network, comprising 18 institutes with benthic biological flumes. Within the framework of this network experiments have been carried out to characterise and compare the hydrodynamic characteristics of twelve different flume tanks, most of which have been designed specifically for biological research. The flumes are divided into four basic design types: straight, racetrack, annular and field flumes.
Turbulence was fully developed in all channels. Straight and racetrack flumes generally produced boundary layers with a clearly definable logarithmic layer, comparable to measurements in the field taken under very steady flow conditions. The two annular flumes produced relatively thin boundary layers. In the field flumes, situated in a dynamic tidal area, the profiles were highly variable. Different designs impose different constraints and provide different possibilities for research. Cooperation between labs with different facilities can open up research areas that cannot be tackled by an individual institute alone.

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THE BAY ANCHOVY: DO THEY EXHIBIT NATAL HOMING?

The bay anchovy is a seasonal species in estuaries at the northern extent of its range with abundances peaking inshore during the summer months. The anchovy undergoes large inter-annual variability in abundance. Over-winter survival and return migration patterns likely play a major role in the inter-annual variability. The extent to which the bay anchovy show fidelity to their natal spawning estuary is being investigated using chemical signatures of otoliths of young-of-the-year (YOY) and adults. The specific objectives are to determine if there is significant variation in the trace element signatures of YOY from three different estuaries (Narragansett Bay, RI, Niantic Bay, CT, and Hudson River Estuary, NY) and then to classify adults to natal estuaries based on these chemical signatures. Otoliths were analyzed using laser ablation inductively coupled plasma mass spectrometery (LA-ICPMS) for concentrations Sr, Ba, Mg, and Mn. Preliminary data indicate there are significant differences in elemental signatures between estuaries and among sites within each estuary. The chemical signatures will be used to determine the degree to which YOY return to the same estuary the following season to spawn.

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ADVANCED INSTRUMENTATION IN AN UNDERGRADUATE PROGRAM IN OCEANOGRAPHY

The Sea Education Association (SEA) is a non-profit academic institution located in Woods Hole, Massachusetts. Since 1971, SEA has offered multidisciplinary academic programs in ocean education to undergraduates, K-12 teachers, and high school students. Many of SEA's more than 5,500 alumni have continued in science and engineering graduate programs and are now active in professional fields. SEA has recently upgraded a multi-component system of sampling and analytical gear that enables users with a wide range of technical backgrounds to participate in modern oceanographic research. New, computer-controlled equipment with graphical interfaces is proving itself both more reliable, and easier for a wide student population to use and understand than the equipment it replaces. Our faculty are able to instruct students in the operation of very sophisticated instrumentation. The data is now more accessible and more easily understood than was often the case with the earlier, electro-mechanical equipment. The high quality data produced by these instruments is both easier for students to understand and use, and is becoming the basis of research projects by SEA scientists and associated researchers.

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PHYTOPLANKTON GROWTH AND MICROZOOPLANKTON GRAZING RATES IN A GULF OF MEXICO ESTUARY

Dilution grazing experiments measured microzooplankton grazing (g), phytoplankton gross growth (mu-o), and nutrient-replete gross growth (mu-n) in Santa Rosa Sound (Florida, USA). Each rate was measured for several phytoplankton groups; bulk, large (> 5 micrometers), and small (< 5 micrometers) eukaryotic phytoplankton, and cyanobacteria. For all phytoplankton groups; mu-o < mu-n, indicating nutrient limitation. Strong correlations were found for each phytoplankton group between both growth rates and the respective grazing rates. However, correlations between g and biomass of the phytoplankton groups were mostly non-significant, indicating that g related more to phytoplankton growth rates than standing stocks. Microzooplankton grazing accounted for essentially all in situ growth (mu-o) for all phytoplankton groups, allowing no net phytoplankton increase at ambient nutrient concentrations. However, with increased nutrient availability, grazing could not compensate for increased phytoplankton growth (mu-n). Increased nutrient availability led to greater dominance by larger eukaryotic phytoplankton because of high mu-n, despite high g. Temperature had a strong effect on cyanobacterial rates, however, temperature was not significantly correlated with any rates for eukaryotic phytoplankton.

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SOLUTE FLUX IN STEADY AND UNSTEADY FLOWS AROUND PHYTOPLANKTON CELLS

Because molecular diffusion times depend nonlinearly on diffusion distances, places where – and times when – diffusive boundary layers thin produce disproportionate increases in nutrient fluxes. Treatments invoking flow effects on solute fluxes around phytoplankton have treated primarily steady, linear shear produced in Couette flow or have modeled steady translation of cells through a stagnant medium. Here we use a number of different numeric and analytic approaches to demonstrate that (contrary to our 1996 review paper) steadily swimming cells will in general experience more shear thinning than sinking cells at the same speed of translation. In addition, cell rotation produces higher fluid inertia and outward flow at the equator, contributing to thickening there and shear thinning at the "nose." Much more generally, time-varying accelerations in turbulence and in the rapid decay of Kolmogorov-scale vortices produce short-lived but repeated shear thinning of diffusive boundary layers. Shape- and orientation-specific effects also arise, but shape-orientation-flow interactions in unsteady shear thinning at low Reynolds numbers are as yet difficult to generalize. Some of them may also be important in particle encounter and capture by suspension feeders.

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ECOLOGICAL CHARACTERISTICS OF WALLEYE POLLOCK EGGS AND LARVAE IN THE SOUTHEASTERN BERING SEA DURING THE 1970'S REGIME SHIFT PERIOD

Environmental effects on the spawning and early life history of walleye pollock, Theragra chalcogramma, in the southeastern Bering Sea was investigated based on the patterns of egg distribution and larval growth between 1976~1979. Egg stages were grouped into 6 steps, and the measured larval lengths were adjusted by a shrinkage rate of 9~12 % for the last 20 years. The peak spawning season and place was identified by the presence of the youngest eggs (<1-day old). The high spawning intensity appeared in April near the Unimak Island where a strong thermocline divided the water mass into two layers. Eggs were slowly advected (5~10 cm/sec) to the northwest by the current over the outer shelf. Larval distribution expanded to the east and north as they grew. Due to the high temperature in spawning ground in 1978, the pollock spawning occurred earlier than in 1976. Warm temperatures might be beneficial to larval growth, so growth was higher in 1979 (0.23 ㎜/day) than in 1977 (0.12 ㎜/day). Consequently, larval length in 1976, the coldest year during the study period, was much smaller.

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NUTRIENTS, CLIMATE AND HYPOXIA: PREDICTING WATER QUALITY TRENDS IN THE NEXT 50 YEARS

It is generally believed that coastal eutrophication is controlled primarily by the magnitude of anthropogenic nutrient loading and that this cause-effect relationship provides a common explanation for the global eutrophication of the second half of the 20th century. Nevertheless, superimposed on this long-term eutrophication trend we find strong climatic signals, and there is also a compelling paleoevidence suggesting that climate variability has greatly influenced coastal and estuarine ecosystems in the past. Because of large uncertainties in the climate system, and also at different levels of biological control, it is difficult to predict future eutrophication trends. Model simulations for the Gulf of Mexico hypoxic zone, for example, suggest a number of possible outcomes, ranging from a 58% decrease to a 63% increase in the frequency of hypoxia. This uncertainty emphasizes the need for adaptive management of coastal eutrophication, where intimately coupled monitoring and modeling efforts provide a base for continuous policy adjustments over time.

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BODY SIZE STRUCTURE OF THE BENTHOS: MODELLING THE BENTHOS

Biological modelling of the benthos lags far behind that already achieved for planktonic communities. This largely reflects the lack of quantitative information on many benthic processes. One promising approach to modelling the benthos is using the underlying size structure. Although some attempts have been made to construct body size spectra for benthic assemblages, the limited availability of adequate sample material has hindered the process. The relative simplicity of body size-based modelling is nonetheless attractive and offers the prospect of significant advances in this underdeveloped field. With access to appropriate sample sets, we have erected reliable body size spectra for benthic communities. The results from the Fladen Ground, North Sea have served as a foundation for a simulation model. Both the compartments and the equations governing the transfer of material in the model have been primarily defined in terms of individual body size. The model aims to provide additional insights into benthic ecology by highlighting some of the key dynamics responsible for maintaining the observed body size distribution.

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EVALUATION OF SHELF-BASIN INTERACTION IN THE WESTERN ARCTIC BY USE OF SHORT-LIVED RADIUM ISOTOPES; EVIDENCE OF THE IMPORTANCE OF JETS AND EDDIES

Rapid shelf-basin exchange in the western Arctic was evaluated by use of the first ever measurement of the short-lived 224Ra (3.64 d half-life) in this region. Radium-224, generated in shelf sediment by decay of its parent 228Th, subsequently diffuses into the overlying water. There, the 224Ra (in excess of the parent) is transported to the extent that its decay-time allows thus providing a measure of short-timescale transport. During the 2002 SBI program, excess 224Ra was measured over the shelf but extended less than 20km beyond the shelf-break. Similarly, the 228Ra/226Ra ratio dropped rapidly across the shelf-break. Bering Strait inflow is constrained by the earth's rotation to follow local isobaths and does not easily move into deeper water. Possible mechanisms that can generate cross-shelf currents that break the topographic constraint to follow isobaths, and thereby transport water (and associated properties) off the shelves include meandering jets and eddies. Evidence of a jet was found during the ICEX project in April 2003 when excess 224Ra measured over 200 km from any shelf source corresponded to a high velocity feature (measured by ADCP) within the upper 300m of the ocean.

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THE ECOLOGY AND ECOLOGICAL IMPACT OF A HIGHLY INVASIVE MARINE INVERTEBRATE IN HAWAII'S CORAL REEF COMMUNITIES

Carijoa riisei, a shallow-water soft coral species native to the Atlantic, is the most invasive of the 287 nonindigenous marine invertebrates in Hawaii. In 2001, deep-water surveys near Maui discovered it killing 75-90% of black coral colonies at depths of 80-110 m. This bioinvasion threatens the $30 million precious coral industry in Hawaii with wider ecological implications throughout the Pacific. Despite this emerging notoriety, little is known about C. riisei and the process of invasion in tropical coral reef communities. The Carijoa research project was launched in 2002 to determine the ecology and ecological impact of this highly invasive alien in Hawaii. Preliminary results reveal not only traditional r-selected characteristics commonly associated with opportunistic invaders but also k-selected traits typical of dominant competitors. Analysis of distribution & abundance imply that viable habitat results from both the paleoceanography of the Hawaiian Islands and modern anthropogenic activity. Management of the proliferation and dispersal of C. riisei presents a challenging ecological problem. In the Western Pacific, several populations of Carijoa have been identified. However, taxonomy has not been resolved at the species level, and whether these populations also represent alien invasions is unknown. The Carijoa project has recently expanded to incorporate molecular genetic techniques to determine the phylogenetic origin and dispersal history of Carijoa in the Pacific.

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LONG-TERM TRENDS IN SATELLITE-DERIVED OCEAN COLOR: VALIDATION OF VARIOUS ALGORITHMS IN THE CALIFORNIA CURRENT

The ability to use satellite-derived ocean color data in assessing long-term trends in ocean bio-geochemistry is dependent on the accuracy and validity of the data from the first and still the longest ocean color mission, the Coastal Zone Color Scanner (CZCS, 1979-1986). Recent efforts by several groups (Gregg and Conkright, 2002; Antoine et al., 2003) have produced new versions of the historic CZCS dataset (Feldman et al., 1989) using different algorithms and assumptions. We evaluate those new data sets as well as various other versions produced from the water-leaving radiances of the original CZCS data sets in the California Current. We use chlorophyll a data from various programs (CalCOFI, SCBS) to evaluate the satellite data sets and show significant discrepancies between satellite and in situ data.

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USE OF DYES IN CALIBRATING AND DIAGNOSING DRIFT OF IN-SITU ABSORBTION AND ATTENUATION METERS

A dye dilution series can be used to calibrate and diagnose WET Labs' ac-9 absorption and attenuation meter. Currently air and "pure" water calibrations are used to track meter performance between factory calibrations. Over time, a meter's calibration can drift -due to changes in light source, degradation of filters, or damage during deployment. In the field, it is often difficult to obtain high-quality water for calibrations, making it difficult to distinguish between meter drift and water contamination. We used a dilution series of a dye with a broad visible absorption spectrum to characterize small changes in a meter. We measured absorption of a working stock of a non-toxic dye in a bench-top spectrophotometer; the stock was diluted to a low-concentration series (~ 0.05 – 0.2 m-1) and run through in the ac-9. The slope and intercept can provide diagnosis of drift within a single instrument and be used to compare different instruments. An automated modification of this technique, with direct injection of dye into the ac-9, could be developed for self-calibration protocols for long-term deployments envisioned for the Ocean Observing System.

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SIZE STRUCTURE STABILITY OF PHYTOPLANKTON IN A MESO-EUTROPHIC SUBTROPICAL LAKE

The study was aimed at analysis of seasonal and inter-annual variability, and the stability of several parameters describing the size structure of the phytoplankton assemblage of Lake Kinneret (Israel). Phytoplankton biomass size spectrum (BSS) patterns were analyzed using biomass data based on microscopic counts of samples collected biweekly over 4 years (1996-1999). The study included all phytoplankton greater than ca. 2 µm diameter, which comprise nearly all of the lake's autotrophic biomass, and phytoplankton alone. A typical pattern of Lake Kinneret phytoplankton BSS emerged, as being quasi-stable in spite of unprecedented man-induced lowering of the lake's water levels, atypical phytoplankton biomass dynamics, and inter-annual variations in phytoplankton species composition. Statistical descriptors of separate size classes elucidate two zones of pronounced variability within Kinneret BSS and a zone of stability near BSS center, which may parallel marine 'small nanoplankton background'.

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A NOVEL, EMERGENT PARADIGM FOR THE ECOLOGY OF MARINE PICOPLANKTON

Microorganisms, including bacteria, archaea, and eucarya, are the foundation of life in the biosphere and the key to Earth's habitability. As microbiologist Louis Pasteur noted more than a century ago, "The very great is accomplished by the very small." It has been estimated that there may be 10e10 globally distributed bacterial genes – many residing in the global ocean – Earth's largest biome. The recent proliferation of cultivation-independent molecular and biochemical identification techniques has resulted in the discovery of numerous novel groups of microorganisms, some – like the aerobic anoxygenic phototrophs – with implied physiologies that were not expected from the habitats of origin. Furthermore, the discovery of novel genes in those few microbial genomes that have been sequenced to date suggests that additional diversity in cell function exists, and this may have important implications for the field of marine microbial ecology. We are literally "hidden in a sea of microbes" and we should expect additional surprises in the future. The challenge now is to link genomics with biogeochemistry, and to develop a capacity to scale from molecules-to-cells-to-ecosystems.

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EFFECTS OF BOTTOM INTRUSION AND KYUCHO ON PHYTOPLANKTON ABUNDANCE AND COMPOSITION IN THE UWA SEA

In the Uwa Sea, there are two intermittent physical events, bottom intrusion and Kyucho, both of which are respectively intrusions of cold nutrient-rich water from the shelf slope region and warm water from surface layer of Pacific Ocean. Changes in phytoplankton abundance and composition in relation to occurrence of bottom intrusion and Kyucho were studied from May to July, 2003. We also conducted in situ incubation experiments to evaluate nutrient limitation on phytoplankton growth. Chlorophyll a concentrations in <2 and >2 um fractions were separately determined. Bottom intrusion occurred on 4 and 26 June, and Kyucho on 12 June. Chlorophyll a concentrations in >2 um fraction in the euphotic zone varied from <0.5 ug/l to 2.6 ug/l. Higher values were detected during bottom intrusions, and the lowest value during Kyucho. By contrast, chlorophyll a concentrations in <2 um fractions were relatively constant. In nutrient enrichment experiments, significant nitrogen limitations were detected only in >2 um fractions. Thus, we demonstrated differences in response to the two intrusions between phytoplankton in the two size-fractions.

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A METHOD FOR INVESTIGATING INTERACTIONS AMONG CHEMICAL SPECIES IN SEDIMENTS: APPLICATION TO SULFATE-ASSISTED PHOSPHORUS MOBILIZATION

The usefulness of diagenetic models stems partly from their ability to quantify phenomena that were previously understood only at some qualitative level. With proper calibration, models allow exploring conditions that are inaccessible experimentally, as well as establishing a basis for comparing observations across systems. In order to calibrate and explore batch and box diagenetic models, we developed a visual "real-time slider" method. For example, several mechanisms were previously suggested to explain the observed increase in phosphorus mobilization from sediments in the presence of dissolved sulfate. Using recent experimental data for homogenized lake sediment, we use our method to quantify the relevant phosphorus release mechanisms and determine their relative roles. We identify P release characteristics that only weakly depend on the model's input parameters and therefore, consistent with observations, can be used across a range of systems. We discuss parameter identifiability and compare the results of our simple model with reaction-transport simulations that provide a more complete description of vertically stratified sediments.

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THE INFLUENCE OF SEAMOUNTS ON SMALL- AND MESOSCALE DISTRIBUTION OF PHYTOPLANKTON – A CASE STUDY OF TWO SUBTROPICAL, NORTH-EASTERN ATLANTIC SEAMOUNTS

In a multidisciplinary approach, Ampere and Great Meteor seamounts, located in the subtropical North-East Atlantic Ocean, were investigated in April 1996 and September 1998, respectively, to detect the influence of these seamounts on the distribution of plankton and nekton. Measurements of the oceanographic conditions combined with a numerical model lead to the conclusion that mainly two physical processes are responsible for the observed biogeochemical patterns. These are Taylor cap formation through a steady impinging flow and non-linear flow rectification through tidal forcing. On Ampere Seamount, a topographic following flow also played a large role. For most of the variables measured a slight uplift of the isopleths above the seamounts could be detected. Nevertheless, no significant upwelling of nutrients and also no significant enhancement of phytoplankton biomass could be detected. Different methodological approaches clearly indicated the numerical dominance of cyanophytes (Prochlorococcus and Synechococcus) in the phytoplankton community. In terms of biomass, however, picoeucaryotes dominated over the cyanophytes. The distribution of these picoplanktonic organisms showed clearly isolated patches over the seamounts. Patch formation was also confirmed by modelling of particle trajectories.

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TEMPORAL AND SPATIAL VARIABILITY OF MEIOFAUNAL COMMUNITIES IN MISSION BAY, SAN DIEGO, CALIFORNIA

Mission Bay is a modified, shallow estuary fed by three freshwater creeks and numerous storm drains that channel inputs from a highly urbanized watershed. Physically, the bay can be separated into two regions, a well flushed front bay and a poorly flushed back bay. The back bay experiences elevated temperatures and salinities during the summer and cooler, fresher water during the winter, relative to the front bay. Winter rains bring runoff and organic-rich sediments from the creeks to the back bay, creating gradients of sediment grain size and organic content from the back bay to the ocean. Sediments and meiofaunal communities were sampled monthly at six sites throughout Mission Bay over a complete annual cycle. Sediments were characterized physically and chemically, and quarterly toxicity assays also were performed. Overall, sediments in the back bay were finer; contained more organic matter and anthropogenic contamination; and displayed greater toxicity to bioassay organisms than sediments in the front bay. Back bay meiofaunal communities were dominated by low densities of nematodes, while those near the mouth of the bay included high densities of foraminifera.

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THE DETECTION OF SARGASSUM WEED DISTRIBUTIONS IN THE NORTH ATLANTIC OCEAN USING MODIS IMAGERY

The abundance and distribution of drifting Sargassum weed in the North Atlantic Ocean have always been very uncertain due to the extreme difficulty of the detection and monitoring of the weeds on any large scales. In contrast, the importance of Sargassum weeds to the regional ecosystem in the North Atlantic Ocean is becoming more clear. These weeds act as a nursery for a large number of fish species, including swordfish, marlin, and tuna, and the abundance and distribution of the weeds will have significant impact on fish stocks and the dependent economies. The weeds themselves have been proven to have economic value and the harvesting of Sargassum weed may be a viable business, which has led to the recent regulation of the Sargassum fishery. However, this resource is being managed before the simplest questions about Sargassum weed – how much is there, where is it, and how are these changing – have been adequately answered. We have begun to answer these questions by utilizing the ocean color imagery gathered by the highly-sensitive Moderate-resolution Imaging Spectroradiometers (MODIS) aboard NASA's Terra and Aqua satellites. Initial laboratory and field tests indicate that floating Sargassum weed has a sufficient spectral signature for detection and identification by MODIS. Though these early results are pending proper verification studies, preliminary assessments of MODIS imagery in the Sargasso Sea and adjacent waters indicate that weed detection is possible.

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A COUPLED COHESIVE SEDIMENT ENTRAINMENT AND BIOTURBATION MODEL

The cohesive sediment entrainment rate (EB) can be represented by an excess shear stress formulation with linear coefficients that represent physical, biological, and chemical processes; for example, EB = AB*AC*A0*(TAU/TAUC-1)**M, where: TAUC = critical shear stress for entrainment; TAU = the bottom shear stress; and A0 and M are empirical constants. The parameters AB and AC represent biological and physical processes, respectively. The values of AB and AC have been estimated with an entrainment model using published data from sediment slurries at different shear stresses. These physical and biological processes are being studied using hydrodynamic, sedimentation, and bioturbation models that predict the seafloor biogeochemical and physical changes that accompany the activity of infauna, as well as consolidation and hydrodynamic forcing by waves and currents. This paper reports on initial efforts to couple the individual models for physical, chemical, and biological changes to a 1D model of near-bottom hydrodynamics and cohesive sediment entrainment at the seafloor.

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ENHANCING ENVIRONMENTAL LITERACY THROUGH NOAA OCEAN EXPLORATION

The National Oceanic and Atmospheric Administration's (NOAA's) Office of Ocean Exploration is bringing current ocean science discoveries to educators and students using a new Ocean Exploration curriculum and a CD-ROM of the Ocean Explorer website (http://oceanexplorer.noaa.gov). Both the curriculum and CD-ROM interpret multidisciplinary ocean discovery voyages to explore life and earth science throughout the ocean using daily web logs and activities formulated by scientists and educators. The inquiry-based curriculum is designed for use in biology, earth and/or marine science courses to connect students to the excitement of NOAA Ocean Exploration as they travel from the Galapagos Rift to the Arctic Ocean, from Alaskan seamounts to those in the Hawaiian Islands. Additional program efforts to build capacity and reach out to new ways to stakeholders to improve the ocean literacy will be addressed.

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APPLICATION OF THE SEAWIFS OC4 CHLOROPHYLL ALGORITHM TO THE WATERS OF NARRAGANSETT BAY, RHODE ISLAND

The Ocean Chlorophyll 4 (OC4) algorithm is currently used to derive chlorophyll concentrations from SeaWiFS spectral data. The OC4 model is a modified cubic polynomial that relates a band ratio to chlorophyll concentration based on whichever remotely sensed reflectance (Rrs) ratio, Rrs443/Rrs555, or Rrs490/Rrs555, or Rrs510/Rrs555 is the most dominant. The determination of chlorophyll a using OC4 in turbid and shallow estuarine (Case 2) waters has been very limited because the atmospheric correction scheme used to process satellite ocean color data generates erroneously high concentrations. In this study, the ability of the algorithm to estimate chlorophyll a in Case 2 waters is examined using in situ and airborne radiometer data unaffected by atmospheric effects.
Using OC4 version 4 (OC4v4), predicted values were compared with fluorometrically determined values of chlorophyll a. Results indicate that chlorophyll concentrations determined by the OC4v4 model (n= 149; mean = 7.33 ug per liter) are comparable to field chlorophyll a concentrations (n= 149, mean = 7.73 ug per liter).

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A PILOT STUDY OF DEEP WATER CORAL MICROBIAL ECOLOGY

Deep water reefs consisting of both stony and soft coral species have been identified off the coasts of North America, Europe, Australia and New Zealand, at depths of hundreds to thousands of meters. Recent microbial ecology studies of shallow water coral species have found that most of the associated bacteria and archaea were novel species, not present in the overlying seawater. These microbes may be cycling carbon, producing protective antibiotics, fixing nitrogen, chelating iron, or any number of other beneficial activities yet to be described. In the case of deep water corals, the ecology is fundamentally different due to the lack of algal symbionts, so the microbiology is likely to be unusual. Samples taken from deep water octocorals (sea pens) were used for method development, and preliminary microbial data will be discussed. This is a very new field, but vitally necessary, as we must know the commensal flora of the corals in order to better understand the overall biology of the organisms and the ecology of deep reefs.

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PHYTOPLANKTON COMMUNITY STRUCTURE AT CONTRASTING SITES IN THE IRISH SEA: A MODELLING INVESTIGATION

It is critical to understand the controls on phytoplankton community structure before predictions can be made on the impact of perturbations brought about by changes in climate or eutrophication status. For example, there is still a need to resolve the ongoing debate as to the relative importance of “bottom-up” and"top-down” factors in controlling the seasonal succession of phytoplankton species. Bottom-up factors (e.g light and nutrient availability) mediate competition between phytoplankton groups by impacting on growth rates whereas top-down control (e.g. grazing) means that the seasonal dynamics of phytoplankton groups is controlled by zooplankton predation. We present an ecosystem model, which is embedded within a one-dimensional physics model, to study the interplay between bottom-up and top-down factors in controlling phytoplankton seasonal succession at contrasting sites in the Irish Sea. It is concluded that under conditions of sedimentary nutrient re-supply, top-down grazing helps to control the balance between diatoms and non-diatoms. In deeper, stratified waters, there is only bottom-up control (nutrient limitation) of phytoplankton community structure.

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FATE OF NITROGEN DURING BUILDUP AND DEGRADATION OF MICROPARTICLES DERIVED FROM DISSOLVED ORGANIC MATTER

As shown recently (Kerner et al. 2003: Nature 422: 150-154), freshwater DOM has a marked capacity to aggregate finally forming microparticles between 0.4-2.5 µm in size and enriched in nitrogen (C:N » 5). Here we present further results relating to the kinetics of the binding of different classes of substances to the microparticles (DNA, sugars, lipids and proteines) obtained from flow cytometric measurements. We compare results on aggregation of DOM present in the Elbe with the same DOM to which phytoplankton exudates were added from laboratory cultures. Astonishingly, DOM enriched with exudates did not show significantly higher capacities for aggregation. Further results are shown from studies on the degradation of aggregated matter of different size by heterotrophic plankton organisms from the Elbe of up to 5 µm in size. A preferential consumption of high molecular organic matter enriched in nitrogen was found resulting in an marked decrease of the C:N ratios in the undegraded remains. Application of 15N-NH4 as a tracer further showed that most of the organic nitrogen consumed was released as ammonium (reammonification). The almost complete reammonification of the degraded organic nitrogen indicates that higher organisms rather than bacteria were responsible for the degradation process. Thus, our results further support our assumption that aggregation of DOM to microparticles provides a by-pass to the microbial loop mentioned in the paper cited above.

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MATHEMATICAL MODELLING OF SEDIMENT SILICA EARLY DIAGENETIC PROCESSES

The processes controlling preservation and recycling of particulate biogenic silica in superficial sediments must be understood in order to calculate oceanic mass balances for this element. Two models representing early diagenesis of silica were used to calculate the vertical distributions of pore water and solid phase silica in the sediment. The first model contains one type of biogenic silica, the second contains two types of biogenic silica which differ by their reactivity (fast dissolving and slow dissolving). An explicit term of reprecipitation was incorporated into these models. The distributions of pore water and solid silica predicted by the models were compared to experimental data reported from the Southern Ocean, the Equatorial Pacific and the North Atlantic (Porcupine Abyssal Plain). Good agreements were found between predicted and measured dissolved and solid silica, over a wide range of oceanic areas and sediment composition, from opal rich to opal poor sediments. The apparent silica dissolution rate constant, the saturation concentration of biogenic silica dissolution , the biogenic silica flux deposited at the sediment-water interface, the dissolved silica reprecipitation rate constant, and the saturation concentration for silica reprecipitation were the critical parameters. The adjustments necessary to explain the observed profiles are discussed in terms of biogeochemical patterns for silicon cycle in the global ocean.

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PHOTOCHEMICAL FORMATION OF CARBON MONOXIDE AND DISSOLVED INORGANIC CARBON IN THE DELAWARE ESTUARY AND NORTHWEST ATLANTIC OCEAN

While it has been known for some time that the photolysis of dissolved organic matter yields low molecular weight organic products, it has only recently been shown that the major photoproducts are inorganic species, in particular CO and dissolved inorganic carbon (DIC). Photochemical DIC formation may occur both directly through the photochemical formation of carbon dioxide and indirectly through coupled photochemical and biological pathways. We employed highly sensitive analytical systems to study CO and DIC photoproduction in seawater collected from three cruises in the Northwest Atlantic Ocean and Delaware Estuary. Details of this study will be presented including a discussion of the importance of photochemical remineralization in the estuarine and oceanic carbon cycles. Observed rates, quantum yields, and in situ irradiance measurements, provide evidence that direct and indirect photochemical remineralization of dissolved organic matter is a significant source of DIC in estuarine and oceanic environments.

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INCREASING AMMONIUM CONCENTRATIONS IN THE CAPE FEAR RIVER ESTUARY: WHERE IS IT COMING FROM?

Concentrations of ammonium in the Cape Fear River estuary (CFRE) in southeastern North Carolina have almost doubled between 1996 and 2001. We have applied a system-wide approach to determine inputs of ammonium in the estuary. The sources evaluated include atmospheric deposition, riverine fluxes (including industrial and municipal point and non-point sources), release from particles, and benthic fluxes. Initial benthic flux experiments indicate fine-grained upper estuarine sediments may be a seasonally significant source of ammonium whereas mobile, sandier lower estuarine sediments are net sinks. Atmospheric deposition may provide significant episodic additions of ammonium to the estuary but is relatively unimportant on an annual basis. Results from exchangeable ammonium and mixing experiments suggest ammonium transport on particles and its subsequent release during estuarine mixing are important mechanisms for ammonium addition to the CFRE. This mechanism may be especially important in the CFRE because salinity in the upper estuary has increased over the past 7 years concomitantly with the ammonium increase.

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HYBRIDIZATION BASED DETECTION OF FECAL BACTERIAL CONTAMINANTS USING THE LUMINEX 100 SYSTEM

Traditional water quality assays have drawbacks in terms of accuracy and rapidity of detection of organisms. To better protect human health and economic interests, improved assays must be developed. We are testing the feasibility of the Luminex 100, a novel flow cytometer based DNA hybridization system, to detect fecal bacterial contaminants in recreational waters. This method consists of combinations of fluorescent beads covalently bound to capture probes. Target DNA is amplified and labeled with biotin. Upon hybridization, beads bearing target amplicons are classified by their spectral addresses. Detection of the amplicon is based on streptavidin coupled phycoerythrin fluorescence. We designed probes targeting the bacterial species and groups: E.coli, Bacteroides distasonis, Enterococci faecalis, Enterococci faecium, the Bacteroides fragilis group and the total coliform group. The assay is specific for the targeted organisms and can be completed in less than an hour following target DNA amplification. The Luminex technology provides a simple, accurate and rapid means of detection of targeted organisms. This high-throughput system allows detection of multiple organisms from a single sample through multiplexing of bead sets with different spectral addresses.

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PHYTOPLANKTON OF THE LOWER HUDSON AND EAST RIVERS, NY: THE INFORMATION CONTENT OF CATEGORICAL DATA

Canonical correspondence analysis (CCA) was used to analyze 8 years of weekly phytoplankton samples from surface water at 2 sites in Lower Manhattan during 1995-2003. Presence-absence data of 29 taxa readily identifiable from living material with the light microscope were used, as well as temperature, salinity, pH, Secchi depth, and dissolved oxygen. The 2 sites were: The River Project (Pier 26 on the Hudson) and the South Street Seaport (Piers 15-16 on the East River). The Hudson sample points formed distinct clusters with respect to salinity, temperature and season, while the East River samples did not. This suggests significant differences in organization of phytoplankton at the 2 sites: in some sense Lower Hudson River phytoplankton is more structured than that of the East River. Data of the kind analyzed here can be readily obtained from inexpensive sampling programs, perhaps involving students or volunteers, using relatively simple gear and minimal lab facilities. The analysis indicates that meaningful statistical information can be obtained from such data.

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PUBLIC MIS-NOTIFICATION OF COASTAL WATER QUALITY: A PROBABILISTIC EVALUATION OF POSTING ERRORS AT HUNTINGTON BEACH, CALIFORNIA

Whenever measurements of fecal pollution in coastal bathing waters reach levels that might pose a significant health risk, warning signs are posted on public beaches in California. Analysis of historical shoreline monitoring data from Huntington Beach, southern California, reveals that protocols used to decide whether or not to post a sign are prone to error. Errors in public notification originate from the variable character of pollutant concentrations in the ocean, the relatively infrequent sampling schedule adopted by most monitoring programs, and the intrinsic error associated with binary advisories in which the public is either warned or not. In this paper we demonstrate that public mis-notification of coastal water quality can be reduced by utilizing probabilistic approaches for now-casting coastal water quality, and adopting analog, instead of binary, warning systems.

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SPATIAL AND TEMPORAL VARIABILITY OF MESOZOOPLANKTON BIOMASS SIZE SPECTRA IN CHESAPEAKE BAY AS MEASURED BY AN OPTICAL PLANKTON COUNTER

Hydrographic variables and mesozooplankton biomass were measured simultaneously throughout the water column and continuously using a towed vehicle (Scanfish). The Scanfish included hydrographic sensors and an Optical Plankton Counter (OPC). Axial surveys along the main channel of Chesapeake Bay were conducted three times per year in April, July and October. Biomass size spectra were calculated for mesozooplankton in the size range of 267-2002 um using linear regression. The slope of the combined biomass size spectra from the years 1996, 1997, 1999 and 2000 was -1.16. This slope is similar to other studies conducted on marine plankton. Slopes of the biomass size spectra varied inter-annually, seasonally, spatially and with hydrographic variables. The slope ranged from -1.35 to -1.09 inter-annually and a significant amount of residual variation was found about the regression line indicating a disturbed ecosystem. The variation of the slope appears to be related to freshwater discharge that largely controls nutrient and organic matter input into the estuary. It is possible that mesozooplankton size spectra may be used as biological indicators to gauge the success of Chesapeake Bay nutrient reduction efforts.

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HIGH RESOLUTION MODELING OF THE NORTH PACIFIC AND ALONG THE US WEST COAST USING A NESTED HYCOM MODEL

A high resolution regional model of the US west coast has been nested within a model of the North Pacific using the Hybrid Coordinate Ocean Model(HYCOM). The Pacific model extends from 20S to 65.8N, has horizontal grid resolution of 1/12th degrees, includes input from 254 rivers and is forced by ECMWF surface fluxes from 1979 to 2003. The regional model, which uses daily boundary information from the Pacific simulation, extends from 30N to 50N and from 115W to 135W. The regional model simulations focus on the period from 1999 to 2002 and include a variety of experiments in which horizontal resolution varies from 1/12th degrees to 1/25th degrees, and surface forcing varies from the ECMWF global fluxes to those from the Navy's COAMPS mesoscale atmospheric model. As part of PARADIGM, project ecosystem models will be incorporated into both the Pacific and regional HYCOM models, as discussed in a related presentation in this session.

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OBSERVATIONS OF IRON LIMITATION IN A NON-HNLC REGIME: RAPID GROWTH RESPONSE TO IRON ADDITION

Iron limitation of phytoplankton has thus far been characterized under high nutrient, low chlorophyll (HNLC) conditions, which persist in some open ocean and coastal upwelling regions due to the low supply of iron relative to macronutrients. In contrast to these areas, macronutrient concentrations in surface waters of the Southern California Bight (SCB) are relatively low (32 year mean = 1.2 uM nitrate), major sources including weak coastal and offshore upwelling and horizontal transport. We investigated the potential for iron limitation of SCB phytoplankton by conducting shipboard iron addition grow-out incubation experiments with surface seawater collected at 33 stations. In ten iron addition experiments during spring and summer 2003, we observed rapid and significant increases in phytoplankton growth and nitrate uptake (within 1 day), when compared to unamended controls. In the SCB, the kinetics of iron response was unusually fast relative to previously studied HNLC regimes, where a lag of 2-5 days is typical. This finding is important for examining the effects of small perturbations in iron flux on primary productivity and biogeochemical cycles in regions not typically regarded as HNLC.

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INSTRUMENT INTERCOMPARISON OF CHROMOPHORIC DISSOLVED ORGANIC MATTER (CDOM) MEASUREMENTS IN OLIGOTROPHIC AND COASTAL WATERS

Chromophoric Dissolved Organic Matter (CDOM) has been shown to be an important component of the optical properties of both coastal waters and the open ocean. Quantifying the effects of CDOM absorption is especially important for accurate estimates of Chl a concentrations from satellite ocean color sensors in coastal regions. Recently, a variable pathlength (2-200 cm) sample cell spectrophotometer has become commercially available (Ultrapath; World Precision Instruments), however few CDOM absorption field data have been reported from this instrument. Here we evaluate the effects of salinity-induced changes in the refractive index of reference water for this instrument, as well as assess CDOM measurements collected concurrently from 3 different instruments (the Ultrapath, a Hewlett-Packard 8452 photodiode array spectrophotometer, and a Perkin-Elmer Lambda 45 spectrophotometer) in both oligotrophic and coastal waters. In addition to these estimates of CDOM contributions near Hawaii ([Chl a] ? 0.08-0.10 mg m-3) and the Chesapeake Bay ([Chl a] ? 3-100 mg m-3), comparisons with filtered and unfiltered WETLabs ac-9 absorptions and CDOM fluorescence from a WETLabs WETStar fluorometer are presented.

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SEASONAL VARIATIONS IN PHYTOPLANKTON ASSEMBLAGE AND TRACE GASES AFFECTING THE CLIMATE IN COASTAL AREA OF JAPAN

Phytoplankton produce volatile organic compounds (VOCs), which play important roles in atmospheric chemistry. Nevertheless, seasonal variations in phytoplankton and VOCs have been rarely observed simultaneously. We studied on seasonal variations of phytoplankton and VOCs in seawater collected monthly in April - December 2001 in Sagami Bay, Japan. Results show that species composition of phytoplankton varied monthly. The phytoplankton increase dominated by small-sized diatoms (Leptocylindrus, Nitzschia) and dinoflagellates (Ceratium) were observed in June and September. In July and October, the number of large-sized diatoms (Rhizosolenia, Guinardia) increased. The concentrations of bromoform, methyl chloride, dibromochloromethane, and bromodichloromethane also changed monthly. This indicates that phytoplankton assemblage has significant effect on concentrations of these compounds. On the other hand, the concentrations of isoprene and dibromomethane changed seasonally: high in summer and low in winter. This suggests that the concentrations of these compounds are independent of species composition. High concentration of dimethylsulfide (DMS) was observed when large-celled diatoms increased. This indicates that diatoms may be one of the important factors of DMS cycles, though diatoms are regarded as minor producer of dimethylsulfoniopropinate.

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MICROBE-PARTICLE INTERACTIONS IN THE PLANKTON: FLAGELLATE COLONIZATION AND GRAZING ON ATTACHED BACTERIA

Most pelagic bacteria and protists are motile, yet many attach to particles, where they may experience enhanced living conditions. The microbes encounter or 'find' particles because the microbes are motile. Swimming patterns of two flagellates, Bodo and Spumella, were very different, the former swimming slowly in an erratic, random pattern, and the latter faster and along smooth helixes of variable amplitude and frequency. At spatial scales exceeding ca. 50 um, the motility of Bodo can be described as random walk and modelled as diffusion.

Spumella showed directional persistence of the helical axes up to a scale of at least about 0.5 mm, and its motility can, thus, not be characterised as random walk at such small scales. Motility analyses predicted rather well overall rates at which the two flagellates colonized agar spheres. Bodo ingested attached bacteria at a rate of between 55-120 bacteria/ind/h, increasing with density of bacteria on the sphere. Bodo grazing appeared to have a strong impact on the distribution of bacteria on sphere surfaces, with bacteria being much more aggregated in the presence of the grazer.

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BIOMASS, PRODUCTION AND COMMUNITY STRUCTURE OF HETEROTROPHIC BACTERIA IN THE WESTERN ARCTIC

Heterotrophic prokaryotes are often large components of biomass and carbon fluxes in many oceans, but they may be less important in the Arctic Ocean because of perennially low water temperatures. We examined the biomass (abundance and cell size), production, and community structure of prokaryotic communities in spring and summer 2002 as part of the Western Arctic Shelf-Basin Interactions (SBI) project. Bacteria appear to dominate these communities, according to results from fluorescence in situ hybridization (FISH) with oligonucleotide probes; the general bacterial probe usually recognized >75% of total cells. The bacterial communities were mainly composed of Cytophaga-like bacteria and alpha-proteobacteria. The alpha-proteobacterial subgroup, SAR11, which was originally discovered in the Sargasso Sea, made up as much as 50% of total prokaryotic abundance. Total prokaryotic biomass was nearly half of phytoplankton biomass (estimated from chlorophyll concentrations). Bacterial production relative to primary production was very low (about 4%) in spring (May-June), but increased to levels observed in other oceans (about 10%) in summer (July-August). Except for spring, the activity and even the structure of bacterial communities in the SBI region are remarkably similar to other oceanic systems.

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AN EVALUATION PROCESS TO ASSESS STUDENTS' INTERPERSONAL SKILLS AND CAREERS OUTLOOKS IN AN REU PROGRAM

NSF's Research Experience for Undergraduates (REU) Program's requires students to conduct their own research project under the guidance of researchers. Mote Marine Laboratory (MML) is an REU Site for students who are Native Pacific Islanders. Along with completing independent research, the PIs believed it was important to assess interpersonal skills and career outlook. Students completed formative surveys on arrival and summative surveys at the end of their internship. In addition, mentors completed a summative survey with matched items from the intern survey. Students also responded to an open ended essay question at the beginning of their internship and upon exit. The goal of this activity was to assess student understanding of the scientific process. Since the REU program goals are to retain minorities in the sciences, students' perceptions of their experience and performance may be a critical factor in continuing a science career. Comparisons of student and mentor evaluations will be discussed. Since this is MML's first year hosting an REU program, survey results will be added to future groups to assess trends in student/ mentor performance perceptions.

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UTILIZING AUTOMATED, ABSORBANCE-BASED OPTICAL DISCRIMINATION TO MAP PHYTOPLANKTON DISTRIBUTION

Satellite and airborne remote sensing are showing promise for detecting and tracking surface expressions of some harmful algal blooms, but subsurface events remain problematic. An approach has been developed to detect blooms of the toxic dinoflagellate, Karenia brevis through analysis of absorbance spectra, measured by in situ instrumentation. The classification technique relies on fourth-derivative analysis of particle absorbance spectra. When applied to natural, mixed populations of phytoplankton in the eastern Gulf of Mexico the fourth-derivative discrimination technique yielded a significant, linear relationship between the derivative spectrum-based similarity index and the fraction of chlorophyll biomass contributed by K. brevis. Maps have been compiled from four ECOHAB-Florida cruises and five local surveys utilizing this approach. These results demonstrate the utility of the technique to mapping the distribution of Karenia brevis blooms over the central west coast of Florida. New modes of deployment include fixed moorings and autonomous underwater vehicles. This technique, applied in these deployment modes, in conjunction with new molecular-based species-detection technology form the core of an automated detection and tracking network being developed along the west coast of Florida.

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DETECTION OF POSSIBLE JAPANESE COMMON SQUID MIGRATION ROUTES IN THE SEA OF JAPAN FROM NIGHTTIME VISIBLE IAMGES

This study used Defense Meteorological Satellite Program (DMSP)/ Operational Linescan System (OLS) satellite images to classify and analyze the spatial and temporal variability of nighttime fishing vessel lights in the Sea of Japan from 1994 to 1999. OLS images can detect the powerful lights used to catch squid. Japanese common squid (Todarodes pacificus) fishing areas were defined as the bright areas created by two-level slicing methods. Using image classification and separability analysis, we divided the Sea of Japan into seven provinces based on different temporal variability in squid fishing area characteristics. The classification takes the main northern and southern squid migration patterns into account. One of the northern migration patterns formed along Honshu Island to north. Another appeared along the east coast of Korea, northward through Yamato Rise. Southern migration patterns were nearly the reverse of northern migration patterns. These seven classified areas also correspond with the oceanographic characteristics in the Sea of Japan. This study's use of remotely sensed data offers a powerful and innovative way by which to determine the migration and ecology of the Japanese common squid.

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SEASONAL MODELING OF COLORED DISSOLVED ORGANIC MATERIAL DYNAMICSAT THE BATS SITE

Chromophoric dissolved organic matter (CDOM) is the fraction of the ocean dissolved organic matter pool that is optically active. Field and satellite observations have shown that the open ocean CDOM distribution exhibits large seasonal and interannual variations throughout the upper water column due to local scale processes. We hypothesize that a combination of photobleaching, biological production, and entrainment processes are the proximate factors regulating open ocean surface CDOM distributions. To support this theory we couple a 1-D mixed-layer model with simple model of the open ocean CDOM cycle to recreate the strong seasonal cycle in the CDOM signal observed at BATS. The BATS data consistently shows low CDOM values during the summer, when there is a shallow mixed layer and high solar radiation fluxes. Higher surface CDOM values occur in the fall and winter, when mixing entrains elevated subsurface concentrations to the sea surface. The coupled model successfully replicates many aspects of the seasonal CDOM cycle at BATS. With improved models of the CDOM cycle, we plan to model the interannual variability of CDOM at BATS and other open ocean sites.

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THE EVOLUTION OF THE INTERMEDIATE AND DEEP WATER MASSES OF THE EASTERN MEDITERRANEAN AS SEEN IN TRANSIENT TRACER DATA

The Eastern Mediterranean Transient (EMT) which started in the 90s was originally an event of drastic changes in the deep and bottom layers of the Eastern Mediterranean, when a second source of deep water became active in the Aegean Sea. Transient tracers, as CFCs, showed dramatically increased ventilation rates of the bottom waters and highlighted the spreading of the water masses away from the new source in the Aegean. But subsequent changes in intermediate layers (LIW, CIW) provided the system with interesting feedbacks between the two competing deep water sources and linked the deep and shallow circulation through the role the intermediate water masses play in the deep water formation process. An increased salt transport from the Aegean towards the Adriatic has provided the Adriatic the necessary means to restart convection. The shutdown of deep convection in the Adriatic has recently been ended and tracer data from 1999 onwards indicate increased levels of activity in this source area again. Most recent CFC data show that the intermediate layer is still undergoing important changes as it is more strongly ventilated now from the Aegean source.

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RELEASE OF SEDIMENT POREWATER AND SOLUTES DURING EBULLITION

The ebullitive release of porewater solutes to overlying water was measured in the laboratory using a fluoride tracer. Methanogenic lake sediment was spiked with fluoride to 60 mg/L in test and control chambers. In 3 weeks a boundary developed at 4 cm between sulfate reduction and methanogenesis. After purging the overlying water with fluoride-free water for 4 hours to reduce the porewater concentration gradient, bubbles with an average volume of 0.24 cm3 were injected 4.6 cm below the interface at a rate of 177 bubbles/m2/minute for 3 hours in the test chambers. No bubbles were injected in the controls. Fluoride concentrations increased linearly with time, with the test chambers having a greater slope, attributable to ebullitive solute release. Assuming the fluoride originated from porewater at 60 mg/L, the volumes corresponding to the increased fluxes were 12, 16, and 17 microliter/bubble. When ebullition was stopped, flux in the test chamber decreased to a rate similar to the control chamber. Desorption of fluoride from solids transported to the surface by bubbles could contribute to the measured ebullitive release.

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HIGH OVERALL DIVERSITY AND DOMINANCE OF MICRODIVERSITY AMONG CO-EXISTING SALT-MARSH SULFATE REDUCERS

The biogeochemistry of Atlantic salt marshes is characterized by the interplay between the marsh grass Spartina and sulfate-reducing bacteria (SRB), which mineralize the diverse carbon substrates provided by the plants. It was hypothesized that SRB populations display large diversity due to the rich chemical and spatial structuring provided by the plant. A 2,000-member delta-proteobacterial 16S rRNA clone library was analyzed for sequence diversity and phylogenetic relationships. The dataset was corrected for chimeric sequences and amplification errors to allow interpretation of all levels of divergence. This revealed the presence of 348 unique sequences (ribotypes) with an estimated total of 623. Most surprisingly, 46% of these sequences fell into groups with <1% divergence revealing the dominance of microdiverse populations. Over 80% of the sequences, phylogenetically clustered with relatively closely related and metabolically versatile genera of Desulfobacteraceae family. These findings raise important questions as to what extent diversification among these SRB is driven by niche differentiation but overall suggest ongoing and long-term co-evolution of the plant and bacterial community.

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IMPLICATIONS OF TEMPORAL, SPATIAL AND NUTRITIONAL VARIABILITY TO PLANKTON COMMUNITY FUNCTION IN PAMLICO SOUND, NORTH CAROLINA

We tested the hypothesis that the transfer of biomass from microplankton to net-caught mesozooplankton in Pamlico Sound, NC varies as a function of proximity to the eutrophic Neuse River Estuary and its implicit effect on food quality (as gauged by phytoplankton composition and seston nutritional composition). Biomass-transfer efficiency was estimated as the ratios of zooplankton C-biomass (ZC), to particulate organic-C (ZC:POC) and to phytoplankton-C (ZC:PC). ZC:POC and ZC:PC averaged 0.03 and 0.15 respectively; variability (standard deviations) exceeded the means in both cases. Variability in transfer efficiency appeared independent of proximity to the Neuse River but, at two locations, increased from June to October. Both zooplankton biomass and transfer efficiency varied with phytoplankton chlorophyll a and diatom biomass, but were independent of seston protein, lipid and carbohydrate levels. Transfer efficiency was also independent of functional diversity in the phytoplankton but varied inversely with zooplankton diversity. The ecosystem functioned with higher trophic efficiency when relatively few taxa (dominated by the copepod Acartia tonsa) were present, than when the zooplankton community was more diverse.

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FROM INDIVIDUALS TO POPULATIONS OF NEOCALANUS CRISTATUS: PROCESSES INFERRED FROM STABLE ISOTOPES

Temporal and spatial patterns in the carbon and nitrogen stable isotope composition of whole late copepodid stage Neocalanus cristatus individuals from the northern Gulf of Alaska (GOA) and Prince William Sound, Alaska (PWS) region, when systematically sampled, suggested that pelagic production can be dichotomized into “coastal” and “offshore” sources. Whereas coastal sources were rather consistent among years, offshore sources, while always dichotomous from coastal sources, varied substantially among years. Extreme values occurred within a given year; the highest values occurred at all GOA stations during 1996 and the most negative values occurred at all GOA stations during 2001. Nevertheless, lipid-normalized delta C-13 values less than -21.5 were only found offshore. C-13 values similar to those found in PWS were found consistently at station GAK1, located in the GOA but downstream in the Alaska Coastal Current from PWS, and occasionally at other stations. The pattern of these occasional occurrences is consistent with eddy patterns observed in satellite images. Based on isotopic analysis, 50 to 90%, varying from year to year, of Neocalanus diapausing in deep waters in PWS originated offshore.

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THE IMPACTS OF TRAWLING ON BENTHIC HABITATS: AN ANALYSIS OF RECOVERY IN THE WESTERN GULF OF MAINE CLOSURE

Overall declines in commercially valuable groundfish stocks in the Gulf of Maine may be closely correlated to the degradation of benthic biodiversity as a result of consistent long-term fishing pressure. We are investigating the biodiversity of benthic habitats of the Western Gulf of Maine Closure (WGOMC), a marine protected area that has been closed to trawling for five years. Biodiversity in the WGOMC and actively trawled habitats was investigated in the summers of 2002/2003 with video footage via a remotely operated vehicle (ROV), and sediment grab sampling. Thus far, biodiversity of epifaunal species in sites in and out of the WGOMC have been quantified through video analysis. Our analysis has shown significant differences in spatial gradients and abundances of epifaunal species between closed and actively trawled sites, indicating possible shifts in the spatial and temporal trajectories of recovery among engineering species.

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BOTTLENOSE DOLPHIN (TURSIOPS TRUNCATUS) POPULATION STRUCTURE ALONG THE MID-ATLANTIC COAST OF THE U.S.: A STABLE ISOTOPE APPROACH

Bottlenose dolphins along the Atlantic coast of the U.S. are designated as “depleted” under the U.S. Marine Mammal Protection Act due to an epizootic event in 1987-88. These animals are further impacted by significant levels of fishery interactions along part of their range. Effective management requires a determination of the number of stocks along the coast. The present study investigated using stable isotope analysis of delta-13C, delta-15N, and delta-34S in skin as a potential tool to differentiate stocks. Skin samples were obtained from live-animal biopsies. There were significant differences in delta-13C, delta-15N, and delta-34S between dolphins sampled in estuaries (n=27) and on the coast (n=72) in North Carolina (P<0.001). These results are consistent with isotopic differences between phytoplankton-based marine environments and estuaries influenced by inputs of mainland C3 plant materials. This result indicates that stable isotopes can provide valuable insight into the environment (coastal marine or estuary) in which bottlenose dolphins are living and feeding. Stable isotope analysis provides another tool contributing to the delineation and understanding of bottlenose dolphin population structure to assist in development of optimal management practices.

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PREDICTING BIGEYE TUNA (THUNNUS OBESUS) LONGLINE CATCH AT PALMYRA ATOLL USING A GENERALIZED ADDITIVE MODEL

Generalized additive models (GAMs) were used within a k-fold cross-validation framework to construct a predictive model of bigeye tuna (Thunnus obesus) catch rate on longline fishing gear around Palmyra Atoll. This approach was contrasted with commonly used stepwise model construction techniques to examine the effects of overfitting. Both the total number of predictor variables in the GAM and their degree of smoothing were shown to contribute to model overfitting, which manifested itself in poor predictive ability under cross-validation. A parsimonious model using several predictor variables was found to be satisfactory for predicting longline fishing success.

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HOW ANIMALS OF DIFFERENT SIZES ENCOUNTER CHEMICAL CUES IN TUBULENT AMBIENT WATER FLOW

Many animals use odors in the water around them to detect mates, competitors, food, or predators, and larvae of many benthic marine animals settle in response to dissolved chemical cues released by organisms on the substratum. Such chemical cues are dispersed in the water by turbulent ambient currents and waves. Although turbulent odor plumes have traditionally been modeled as diffuse clouds, they are composed of fine filaments of scent swirling in odor-free water. We have used a combination of field flow measurements, laboratory studies of animal behavior and kinematics, planar laser-induced flourescence measurements of odor dispersal in wave-flumes, and mathematical modeling to work out the patterns of odor encounter by the olfactory antennules of large benthic crustaceans, and by microscopic larvae swimming in the water above rough substrata. These studies reveal that the size and speed of an organism and its olfactory organs determine the on-off temporal patterns of odor concentrations it encounters as it moves through the environment.

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RECENT RESULTS FROM THE HF RADAR NETWORK OF THE NEW JERSEY SHELF OBSERVING SYSTEM (NJSOS) AND THE REGIONAL NORTHEAST OBSERVING SYSTEM (NEOS)

A nested HF radar network has been deployed along the New Jersey coast as part of the New Jersey Shelf Observing System (NJSOS) and the larger regional NorthEast Observing System (NEOS). A 25 MHz standard system (range about 50 km) setup for continuous operation since 1999 includes two sites in Brant Beach and Brigantine, New Jersey. A second 5 MHz long-rang system (range about 170 km) includes four New Jersey sites set up in Wildwood, Tuckerton, Loveladies, and Sandy Hook, one Massachusetts site in Nantucket, and one Rhode Island site on Block Island. Both the long-range and standard-range systems provide real-time maps of surface currents, with resolutions of 1.5 km (standard) and 6 km (long-range). Recent additions to the network included GPS synchronization, which allows all long-range sites to operate on a single frequency without interfering with each other. In addition to single frequency operation, the GPS synchronization allows the existing coastal stations to be bistatically linked to each other. Without adding additional hardware, four coastal sites provide four monostatic radial current maps and 12 bistatic hyperbolic current maps simultaneously. This both increases data coverage and reduces measurement error. Two bistatic transmitting buoys (one 25 MHz and one 5 MHz) compliment the coastal sites. This operational, nested, and multistatic network provides real-time current maps for scientific and operational users.

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EFFICIENCY OF PHOTOSYNTHETIC LIGHT UTILIZATION IN AEROBIC ANOXYGENIC PHOTOHETEROTROPHS (AAPS)

AAPs of the two marine genera Erythrobacter and Roseobacter were recently found to be widely distributed in the surface waters of the open ocean. They contain bacteriochlorophyll a and carotenoids as the light absorbing pigments. The UV (370 nm) and infrared (800-850 nm) absorption bands of bacteriochlorophyll are highly ineffective in light harvesting due to strong attenuation of the solar light within the first few meters of the water column. Instead, the carotenoids, which are covalently bound to the light harvesting complex 1 (LH1), effectively absorb the light in the 430-550 nm region, constituting the primary light harvesting apparatus. Interestingly, AAPs also contain large amount of carotenoids (up to 80%) that are not covalently bound to LH1. These carotenoids dissipate the absorbed light, reducing the overall efficiency of light utilization. The ratio of photosynthetic to nonphotosynthetic carotenoids varies in response to light exposure, and to the presence of dissolved organic dissolved. We will present our observations on the relationship between environmental factors and photosynthetic yields in AAPs, and discuss how this relationship may explain the ecological and geographical distribution of AAPs.

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IRON LIMITATION STATUS OF PHYTOPLANKTON COMMUNITY IN THE OYASHIO REGION DURING SPRING

The Oyashio, a cold western boundary current of the North Pacific, has a spring phytoplankton bloom in April and/or May, while high-nutrient, low-chlorophyll water occurs in the Oyashio region during late spring and summer, suggesting that factors other than macronutrient are responsible for termination of the spring bloom. Shipboard incubation experiments were performed in the Oyashio region during March-May 2003 to elucidate the iron limitation status of phytoplankton community during a spring bloom. In the coastal station, ambient dissolved iron decreased from 0.64 nM in April to 0.26 nM in May. However, there was little difference in phytoplankton growth between iron-enriched samples and controls. When iron availability to phytoplankton was reduced by the addition of the fungal siderophore desferrioxamine B, accumulation of Chl-a was lower relative to controls. In the offshore stations, low dissolved iron concentrations (<0.1 nM) were observed in May. Chl-a increased 6-fold in the iron-enriched samples, while the increase was not evident in the controls. These results suggest that phytoplankton growth in the Oyashio region can be limited by iron at the end of spring bloom.

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MESOZOOPLANKTON COMMUNITY RESPIRATION AND ITS RELATION TO PARTICLE FLUX IN THE OLIGOTROPHIC EASTERN MEDITERRANEAN

Organic carbon flux, zooplankton carbon consumption rates and stable nitrogen isotopes were measured in the deep water of the eastern Mediterranean. Standardized carbon consumption rates of zooplankton were higher than rates measured in the deep open ocean, probably due to the elevated temperature of ca 14 C in the bathypelagic zone of the Eastern Mediterranean. The absolute rates, however, were very low, reflecting the oligotrophic character of the basin. Zooplankton were estimated to consume 23 % of the sinking flux between 1050 m and 4250 m. Due to the high temperature in the Levantine deep-sea, however, the carbon losses from the sinking flux by remineralisation are probably underestimated by the Martin equation and higher total losses may occur. Lucicutia longiserrata, an intrinsic faunal element in the deep Levantine Sea, played a significant role in carbon recycling. The increased recycling efficiency of pelagic organisms in the bathypelagic zone possibly facilitates starvation of the benthos in the nutrient-poor Levantine Basin.

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MODELING AND FIELD OBSERVATIONS OF ALGAL BLOOMS IN SOUTH SAN FRANCISCO BAY, 1: PHILOSOPHY AND INITIAL APPROACHES

This talk will explore the philosophy employed by our group in developing a conceptual framework for understanding algal bloom occurrence in shallow turbid estuaries, and in particular South San Francisco Bay. Our approach has been “process-oriented”, by which we identify the key physical and biological processes controlling bloom development, rather than “result-oriented” where the attempt is to duplicate and predict real bloom magnitudes. We employ a “building-block” approach in which we successively add biological, physical, and dimensional complexity. Our first studies utilized one-dimensional (vertical) models of the water column and showed the importance of stratification, benthic grazing, and vertical mixing to bloom occurrence. Because this approach could not explain why blooms did not occur in the summer, or the occasional occurrence of spring blooms without stratification we added dimensional complexity by using a “pseudo-2D” approach in which both the channel and shoal compartments are modeled. This approach shows the critical importance of lateral transport, benthic grazing in the shoal, and light climate in the shoal, but does not explain the impact of episodic wind events or intratidal horizontal transport.

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FEEDING AND AGGREGATE COLONISATION OF HARPACTICID COPEPODS MICROSETELLA NORWEGICA AND AMONARDIA NORMANI

We measured the functional response of suspension vs. surface feeding on the diatom Thalassiosira weissflogii, as well as colonization and feeding on aggregates of two harpacticid copepods, M. norwegica and A. normani. Pelagic M. norwegica had similar maximum ingestion rates on surface and in suspension (respectively 1.5 and 2 ug C ind.-1 day-1), but high ingestion rates in suspension were only obtained at ecologically irrelevant concentrations (>800 ug C l-1). Semi-benthic A. normani had >10 times higher maximum ingestion rate on the surface than in suspension (4 vs. 0.3 ug C ind.-1 day-1), irrespective of food concentration. Both species were able to find artificial aggregates (agar spheres pre-colonized by micro-organisms) suspended in the water, but A. normani had higher colonization and pellet production rates (up to 50 pellets ind.-1 day-1), corresponding to the maximum surface ingestion rates observed with T. weissflogii. We conclude that harpacticids in the pelagic obtain high feeding rates only if feeding on surface and are therefore likely to actively search for aggregates. Feeding and therefore aggregate degradation rates by pelagic harpacticids are potentially high.

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ASSESSMENT OF OPTICAL CLOSURE USING THE PLUMES AND BLOOMS IN-SITU OPTICAL DATASET, SANTA BARBARA CHANNEL, CALIFORNIA.

The Plumes and Blooms (PnB) Project has collected an extensive data set of in-situ optical and oceanographic observations for 7 stations along a transect across the Santa Barbara Channel, California. Inherent optical properties (IOPs), such as spectral absorption, beam attenuation, and backscattering coefficients, and apparent optical properties (AOPs), such as the vertical attenuation coefficient for downward irradiance (Kd) and remote-sensing reflectance (Rrs), are collected to build and validate ocean color algorithms for Case II waters. Existing models relating IOPs and AOPs to chlorophyll concentrations are evaluated as a first test of dataset quality. Available optical closure relationships are also evaluated including the single scatter approximation and Kirk's (1984) relationship for Kd. For Rrs, the Gordon et al. (1988) approximation is used. Preliminary results indicate that the closure formulae for Kd perform well suggesting that the in-situ absorption determinations are of adequate quality. However, comparisons for Rrs are poor suggesting difficulties in the PnB in-situ backscattering determinations.

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FIELD MEASUREMENTS ON THE VARIABILITY IN BIODEPOSITION AND GRAZING PRESSURE OF SUSPENSION FEEDING BIVALVES IN THE NORTHERN BALTIC SEA

Mytilus edulis and Dreissena polymorpha are the most prevalent filter-feeding bivalves in the northern Baltic Sea. They are potentially able to control the standing stock and production of primary producers. Consequently, the filter-feeders are considered to play a key role in the stability of coastal ecosystems. Field experiments were performed to estimate the functional relationships between environmental conditions and the biodeposition rates of the bivalves. Temperature, salinity and phytoplankton biomass were the major cause for temporal and spatial variation in the biodeposition rate of the mussels. There were significant interactions between temperature, phytoplankton biomass and current velocities when affecting the biodeposition rate of the bivalves. Significant effect of salinity was observed at limited food levels. The biodeposition rates increased with ambient temperature. In more eutrophicated regions the values levelled off at high food concentration. In less eutrophicated conditions a linear model gave the best fit suggesting that saturation level was not obtained. The population of filter-feeders filtered daily on average from 3 to 2426% of overlaying water in the littoral area constituting an important sink for primary production.

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VOLTAMMETRIC STUDIES OF DISSOLVED OXYGEN AND SULFUR ON GOLD, GOLD AMALGAM AND BISMUTH-ON-GOLD ELECTRODES

Gold, gold amalgam and bismuth-on-gold microelectrodes have been used for the measurement of dissolved oxygen and sulfide in seawater. We compared these three 100-micrometer-diameter electrodes for possible use in in-situ mooring applications. For both oxygen and sulfide, the gold amalgam electrode has the best detection limits. Bismuth-on-gold electrode is not very useful for oxygen determination. The mechanisms of the electrode reactions will be discussed to demonstrate the usefulness of these electrodes for environmental monitoring. All electrodes have no membrane covering the surface as electrochemical conditioning (cleaning) of each electrode after each voltage scan allows for precision of better than 2 % on replicate scans. The dynamic range of concentration detected is over five orders of magnitude depending on electrochemical mode selected for analysis.

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THE INTERACTION BETWEEN TURBULENT FLOW AND THE CANOPY OF THE RED ALGA ADAMSIELLA CHAUVINN

Macroalgal communities are influenced by hydrodynamics in a number of ways. One important aspect is the effect of water velocity on the thickness of the diffusion boundary-layer (DBL), which may in turn influence seaweed growth and production by controlling mass fluxes. The interaction between water flow and a single blade is well established; however, what is not clear is how a macroalgal canopy affects turbulent structure. The subtidal red seaweed, Adamsiella chauvinii forms a canopy 10-15 cm in height in a tidally-driven wave-sheltered environment. The potential exists for the canopy structure to both dampen and generate turbulence at different scales. In a flume study we examined the effect of algal density on flow dynamics (turbulent energy, mean flow). Results indicate that the spatial arrangement of plants had an impact on flow dynamics and at high densities flow within the canopy was markedly reduced. Reduced flow may have direct implications on factors such as nutrient uptake, photosynthesis and growth in macroalgae.

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DIEL AND TIDAL VARIATION IN THE VERTICAL STRUCTURE OF OXYGEN, TEMPERATURE, AND SALINITY REVEALED BY AN AUTOMATIC SHALLOW WATER PROFILER.

Diel oscillations in oxygen can yield measurements of total system metabolism, which may be a useful indicator of eutrophication status. However, spatial structure including vertical patterns complicate the design of an appropriate sampling strategy. An automated profiler using the YSI 6600 water quality sonde has been developed that records profile of a suite of variables at closely spaced intervals in shallow coastal waterbodies. Even in quite shallow (1-2m) tidal systems, pronounced vertical structure is often seen. Recent time series of profiles demonstrate large diel and tidal variations in the O2 profiles that have implications for calculations of total system metabolism. Differences in closely spaced profiles (~ 5 mins) suggest large, fast internal displacements perhaps associated with internal waves.

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ESTIMATING GROWTH RATES AND GENERATION TIMES FROM MEASUREMENTS OF FEEDING, DEFECATION AND METABOLISM: DOES THE WHOLE EQUAL THE SUM OF THE PARTS?

Growth rates and generation times are not easy to measure directly, but are important parameters to estimate to be able to quantify the population dynamics of important bloom-forming salps such as Salpa aspera. The delicate nature of these salps has precluded our holding this species in the lab for more than a few days, and growth has been measured only for the smaller salps from each of the aggregate and solitary generation. Therefore we have used experimental determinations of ingestion, defecation, and metabolic rates to estimate specific growth rates by difference for a range of sizes in both generations. Growth rates based on a composite of energetics data, compare favorably with our actual growth measurements. Coupled together with measurements of the size at reproduction for each life stage (solitary and aggregate), these rates have allowed us to make preliminary estimates for field generation time of about three weeks. Given the measured number of aggregates produced per solitary (~90) and the measured fertilization success (~75%), the salp population would be expected to increase by about two orders of magnitude each month when food conditions were favorable and predation rates were low.

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CONTINUING CHANGES IN THE DISTRIBUTION OF DISSOLVED OXYGEN AND NUTRIENTS IN THE EASTERN MEDITERRANEAN AS A RESULT OF THE TRANSIENT EVOLUTION

Changes in the vertical distribution of the physical and chemical parameters in the Eastern Mediterranean (EM) following the transient evolution were documented during basin-wide oceanographic surveys between 1987 and 1999. These changes influenced primarily, but not only, the deep layers and confined the old EM deep water (DW) of Adriatic origin to the 1000-2000 m in the Levantine, uplifting the minimum-oxygen/maximum-nutrient water mass from 2500 m in 1995 to 1500 m in 1999. In 1999, the denser and younger EMDW of Aegean origin appeared at the bottom layer, more evident at the central EM and moving prevalently into the Levantine basin. The realization of an additional EM basin-wide survey in 2001 showed these changes to level off between the eastern Ionian and the western Levantine, with oxygen and nutrients vertical distributions below 500 m similar to those found in 1999. Only in the Sicily channel, western Ionian and the eastern Levantine oxygen increased and nutrients decreased below 500 m in 2001, indicating further spread of the transient towards the eastern and westernmost parts of the EM and its finishing influence.

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PRIMARY PRODUCTION IN THE MARGINAL ICE ZONE IN THE BARENTS SEA

The First of tree cruises within the CABANERA (Carbon flux and ecosystem feedback in the northern Barents Sea in an era of climate change) project went to the northern Barents Sea in July 2003. Four full stations were done, both spring and summer situations were encountered. The chlorophyll a concentration and the primary production were analyzed from two size fractions: GF/F and 10 µm. The primary production was analyzed with the 14C method. The water samples were incubation in situ in 9 depths from the surface and down to 60 meters for 24 hours. Primary production based on winter nutrients (new production) was done at 1 meter and at the depth of chlorophyll a maximum. Results from this work will be presented.

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TRANSPORT AND TRANSFORMATIONS OF NITROGEN AND CARBON IN A SUBTERRANEAN ESTUARY

Prior to discharge to sea, fresh groundwater mixes with underlying saline groundwater, forming a subterranean estuary, and driving circulation of fresh and saline groundwater through nearshore sediments. Mixing of fresh and saline water masses may alter terrestrial nitrogen and carbon loads discharged to sea, and advection through nearshore sediments associated may augment return of regenerated nutrients from sediments to surface water. To estimate nitrogen and carbon fluxes due to submarine groundwater discharge, we are coupling radiochemical estimates of fresh and saline groundwater discharge with detailed measurements of nutrient content within fresh and saline groundwater. In addition, we are analyzing natural abundance stable isotope ratios to investigate sources and transformations of nitrogen and carbon in nearshore aquifers. Results suggest that rate of transport to surface waters of fixed nitrogen due to advection of saline groundwater through sediments is approximately 25% of rate of terrestrial nitrogen loading. Advection of groundwater through sediments results in substantial remineralization of both terrestrial and estuarine DOC. Large nitrogen losses occur in both the freshwater aquifer and the subterranean estuary. We are currently investigating nitrogen loss mechanisms.

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DEFINING THE PARAMETERS REGULATING ANTARCTIC PHYTOPLANKTON SPECIES DISTRIBUTION: NUTRIENT UTILIZATION

Recent field studies in the Ross Sea indicate that although regions dominated by both Phaeocystis antarctica and diatoms remove nutrients from the environment in molar ratios near the Redfield ratio (106:16:1), regions dominated by one type or the other exhibit very different ratios. The TDIC:NO3:PO4 disappearance ratio in areas dominated by P. antactica is more than twice as high as the ratio in waters dominated by diatoms, 133:19:1 and 63:9.5:1, respectively. It is unknown whether these different ratios are due to fundamental differences in metabolism between taxa or are responses to environmental factors. Chemical analyses of phytoplankton species grown under laboratory conditions were completed to verify these compositional differences. Cultures of three diatom species (Fragilariopsis cylindrus, Nitzschia subcurvata, F. curta) and P. antarctica were grown and periodically sampled to measure disappearance of dissolved inorganic nutrients and accumulation of particulate material. We determined the nutrient disappearance and elemental ratios for each taxa and the degree to which these ratios reflect incorporation of nutrients into cells, intracellular and extracellular nutrient pools, and the loss of organic material from cells to the medium.

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MICROGRAZER-DILUTION EXPERIMENTS IN THE HNLC WATERS OF THE BERING SEA: A NOVEL APPROACH TO ESTIMATING IRON STIMULATION

During August-September 2003, we conducted a series of micrograzer-dilution experiments in the Bering Sea. This region is characterized by an abrupt transition from shallow, nutrient-rich coastal waters to Fe-limited open ocean waters, separated by a “green belt” of high productivity. As part of this experiment, we evaluated the potential role of ammonium preference, copper inhibition, and the effects of using Go-Flo versus pumped trace-metal clean collection methods on the growth and grazing rates in these Fe-limited waters. In all cases, estimated growth rates were ca. twice that of the estimated grazing rates. By comparing our grazer-dilution experiments to long-term grow outs amended with macro- and micronutrients or the iron-specific chelator desferoximine-B, we suggest that grazer-dilution experiments can be used to assess the short-term (24-48 h) enhancement of phytoplankton growth from iron additions. An overview of these experiments will be presented, with emphasis on the novel application of grazer-dilution methods to estimates of Fe-stimulated growth rates.

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PHYTOPLANKTON COMMUNITY RESPONSE TO FE AND TEMPERATURE GRADIENT IN THE NW AND NE SUBARCTIC PACIFIC OCEAN

On board bottle incubation experiments were carried out adding different amounts of Fe at occasion of SEEDS (the Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study) experiment in 2001 and SERIES (Subarctic Ecosystem Response to Iron Enrichment Study) in 2002 to elucidate phytoplankton community response to Fe concentration. Temperature gradient from 5 to 18 C was also applied to the incubation experiment because temperature also affects growth rate and metabolic functions in phytoplankton cells such as enzyme reactions. Specific chlorophyll a increase rate (growth rate) for micro-size (>10 µm) was the highest between 9 and 13 C at the same Fe concentration, doubled from 5 C to 9 C. The surface mixed layer temperature was 9 C at the beginning of Fe fertilization, but it was 5 C just two weeks before. This drastic increase in growth rate with temperature was a reason for the highest chlorophyll a increase in SEEDS 2001 among the meso-scale Fe enrichment experiment in the HNLC regions.

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RECENT SCIENCE APPLICATIONS AND ADVANCEMENTS FOR THE REMUS AUV

Advancements in science are often triggered by advancements in technology. In the past several years, AUV technology has progressed to the point where they are routinely used to collect science quality data. The REMUS (Remote Environmental Monitoring UnitS) AUV, now commercially available with a variety of instrumentation, is allowing scientists to make measurements on a three-dimensional spatial scale that here-to-fore had been unattainable. In this paper we discuss some of the instrumentation that has recently been deployed on REMUS. We also discuss ground breaking sampling strategies that allow the vehicle to perform broad area surveys and yet allow the AUV to automatically adapt that strategy based on sensor data. This capability further expands the methods for data collection. For example, when significant concentrations of Chlorophyll A are detected, this technology could be utilized to allow the vehicle to redirect itself to map the spatial extent of the algal bloom. Also described is the development of an AUV dock that will allow REMUS to remain on station until a significant oceanographic event occurs or to perform repeated surveys of an area of interest.

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WATER COLUMN TURBULENCE AND ITS EFFECTS ON MARINE PLANKTON

The vertical extent of the mixed surface layer may have important effects on aquatic primary production and increasing mixing depth has been shown experimentally to negatively affect phytoplankton biomass in the marine environment. Recent reaction-diffusion models of light-limited phytoplankton population growth suggest that the degree of water column turbulence substantially affects the vertical distribution of phytoplankton. Enclosure experiments in the coastal North Atlantic where turbulence was varied across a broad range of intensities and on the scale of metres to tens of metres support these expectations. Low intensity of mixing produced steep vertical gradients of phytoplankton and algal size distribution. Increasing mixing intensity resulted in increasingly homogeneous profiles. The vertical distribution of the limiting nutrient, nitrogen, was homogeneous at higher mixing intensity but inverse to the concentration of biomass in low-turbulence situations. Our results also indicate that intermediate levels of larger scale turbulence may result in smaller algal blooms than both high and very low intensities of mixing. We will discuss how this relates to different scales of turbulence, community composition and the average light intensity experienced by the algae.

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INVESTIGATING THE REDUCTIVE MECHANISM OF FE ACQUISITION BY MARINE DIATOMS

Diatoms are able to extracellularly reduce Fe(III) and release Fe(II) from a variety of compounds (Maldonado and Price) and the “ferric chelate reductase” (FCR) system is also capable of reducing Cu(II) compounds (Jones et al. 1987). This apparent lack of substrate specificity can be explained by the presence of several compound/class-specific reductase enzymes. However, given the diverse milieu and low concentrations of Fe species in seawater, a more favorable strategy of Fe acquisition would include a FCR that operates via the liberation of an intermediate electron acceptor capable of reducing a variety of Fe species. One plausible intermediate would be O2, as the univalently reduced form O2- can reduce some Fe species. We generated O2- (xanthine/xanthine oxidase) in the presence of 59Fe(III)EDTA and measured 59Fe(II) trapped with ferrozine. We also measured Fe(II) trapping and Fe uptake in T. weissflogii cultures +/- Cu,ZnSOD; trapping was decreased by ~50-80% but the effect on uptake was more variable and much less pronounced. These results will be discussed in the contexts of genomic data and theoretical considerations for an O2- mediated reductase.

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CHARACTERIZATION OF THE PROTEINACEOUS MATTER IN MARINE AEROSOLS

Marine aerosols, produced when air bubbles burst at the sea surface, transfer oceanic material to the atmosphere. Concentrations of compounds in surface layers often differ from that in bulk seawater. We examined enrichment of natural and simulated aerosols with dissolved free (DFAA), dissolved combined (DCAA), and particulate (PAA) amino acids, bacteria and viruses (as carriers of protein), and semi-transparent particles. We also evaluated D/L ratios in all amino acid fractions. DFAA and DCAA were enriched in aerosols by up to 20 fold compared to bulk seawater, and appear to be mainly of phytoplankton origin. PAA enrichment usually was even higher (up to 60 fold). Examination with Alcian Blue (a dye targeting acidic carbohydrates) and Coomassie Blue (a dye targeting proteins), showed that both transparent particles were greatly enriched in aerosols and had similar size distributions. Both D/L ratios and the abundance of microorganisms suggested that, even though bacteria and viruses were enriched in aerosols by up to two orders of magnitude, they made only a small contribution to total protein.

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MICROBIAL PROCESSES CONTRIBUTION TO CARBON BIOGEOCHEMISTRY IN THE MEDITERRANEAN SEA: SPATIAL AND TEMPORAL SCALE VARIABILITY OF ACTIVITIES AND BIOMASS

CO2 uptake and sequestration estimates are essential for reliable prediction of the future Earth climatic changes. Up until now, the influence of climatic changes on the functionality and structure of the microbial aquatic biocenoses has not been systematically studied and the interdependence of climate, carbon cycle and microbes is not well understood. Mediterranean is expected to be a very climate-sensitive ecosystem and long-term predictions could help to understand the oceanic global changes.This work aims at discussing the importance of some of the microbiological processes that could be involved in the climatic variability. The study was conducted from 1996 to 2002 with the aim of examining the microbial processes controlling the C transfer from biotic to abiotic compartments, and viceversa. Within this general framework, special attention was paid to different levels of temporal and spatial scales.The results have highlighted an unstable system reacting rapidly to changing environmental conditions.

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REMOTELY FORCED PHYSICAL PROCESSES AND THEIR LOCAL BIOLOGICAL CONSEQUENCES: INTERNAL WAVES AND KELP FORESTS ALONG THE BAJA CALIFORNIA COASTLINE

Many benthic organisms find either their northern or southern limits of distribution in the complex biogeographic transition zone along the coast of the Baja California peninsula (Mexico). At times, giant kelp forests can be completely extirpated from the coastline of Baja California. At other times, in central Baja California, which is the southern limit of distribution in the Northern hemisphere of giant kelp, these forests can reach their highest density along their entire range of distribution. In order to explore water column dynamics along the Baja California coastal zone and to relate the along shore and across shore processes with kelp forest dynamics, subtidal moorings were deployed in a vertical distribution every 3m in 30m depth, at eight sites, just offshore of prominent kelp communities. Data focusing on stratification, upwelling, internal waves, nutrient pumping, and subtidal and intertidal kelp density and abundance will be presented. The correlation among sites, the lag time for signals to propagate along the shore, the local effect of remotely generated signals, and the biological implications of such signals will be discussed.

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MARINE ENVIRONMENT OF THE CENTRAL AND EASTERN ALEUTIAN ISLANDS

Salinity, temperature, and nutrient data were collected in and around the eastern and central Aleutian passes during the summers of 2001 and 2002. The data suggest that Samalga Pass (~169.5W) acts as a division between the shallow, shelf passes to the east and the deeper, oceanic passes to the west. In the North Pacific, a strong front in surface water properties was observed near Samalga Pass in both 2001 and 2002. Surface waters were significantly warmer and fresher east of Samalga Pass than west of the pass in both years. Surface nutrient concentrations also exhibited substantial differences with low nutrient concentrations east of Samalga Pass and higher concentrations west of Samalga Pass. A combination of physical mechanisms (vertical vs. lateral mixing, coastal vs. shelf circulation, and outflow from the Bering Sea) explains the observed spatial patterns. Combined with evidence of similar patterns in many ecosystem parameters, these data suggest that Samalga Pass forms a significant boundary between the eastern and central Aleutian ecosystems.

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NUTRIENT UPTAKE BY PHYTOPLANKTON IN TURBULENT ENVIRONMENT : DO SURGE UPTAKE COULD CHANGE GROWTH AND COMPETITION ?

Classically, the relation of phytoplanktonic growth and nutrient availability is modelled by the well known function of Michaelis-menten. However, this function do not take into account the time process of surge uptake which allow to a cell to use quickly newly available nutrient. At the cell size, a such variability in nutrient concentration could be due to turbulence under i) the development of a patchy distribution or ii) variations of nutrient supply under intermittency. To explore the potential effect of the interaction of surge uptake and nutrient supply variability we have develop a model with two time scales : the fast one is associated to the nutrient (surge) uptake and the slow one corresponds to population growth. In the case of population growth, an analytical solution is obtained and the effect of variable inputs is studied. In the case of competition between two species, it appears that the capacity of the cell to use quickly newly available nutrient control the competition. The values of Ks and V max of the Michaelis-menten equation do not completely control the competition.

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VERTICAL EXPORT OF PARTICULATE ORGANIC CARBON AND CALIBRATION OF SEDIMENT TRAPS USING 234TH IN THE BARENTS SEA

Thorium-234 (t1/2=24.1 days) is a key tracer for determining the vertical export of POC, which can be calculated from the 234Th deficit and the POC/234Th ratio of sinking particulate matter. Samples for 234Th and POC measurements were collected at four stations during the CABANERA cruise from July 8th – 22nd 2003 along a north-south transect in the Barents Sea. Total 234Th was measured at five depths at each station (10, 20, 60, 90, 120m), and large particles (>53mm) 234Th and POC were measured at three depths (20, 60, 120m). Particulate 234Th and POC were measured at the same three depths in the drifting sediment traps for the calibration of the traps. The 234Th/238U disequilibrium indicates particle export at all stations. At 60m, the 234Th fluxes varied from 410.4 to 495.4 dpm/m-2/day-1, and are slightly lower in Arctic water than in Atlantic water. On-going work (POC determinations) will lead to determination of the export fluxes of POC in both seawater and sediment traps.

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MOLECULAR ANALYSES OF AUTOTROPHIC AMMONIA-OXIDIZING BACTERIA IN DEEP-SEA HYDROTHERMAL VENTS ENVIRONMENTS

The injection of ammonium from the deep-sea hydrothermal systems at Endeavour Segment and Guaymas Basin, stimulated the growth of autotrophic ammonia-oxidizing bacteria (AOB). Using polymerase chain reaction targeting 16S rRNA and ammonia monooxygenase genes, AOB have been detected in the neutrally buoyant hydrothermal plumes, hydrothermal fluids and hydrothermal sediments. High abundances of AOB, quantified by fluorescence in situ hybridization, corresponded closely with high ammonium concentrations and ammonia oxidation rates. AOB belonging to beta-Proteobacteria were readily detected in all samples, while gamma-proteobacterial AOB were only found in the hydrothermal sediments at Guaymas Basin. Phylogenetic differences have been observed in the Endeavour versus Guaymas AOB communities. In general, AOB formed a substantial component in the particle-associated communities (up to 51%) against free-living communities (up to only 5 %), and the former usually consisted of a larger proportion if Nitrosomonas-like sequences. Autotrophic ammonia-oxidizing bacteria are the key players in nitrification, an important process in marine nitrogen cycling. Information from these molecular analyses will be related to the measured geochemical parameters. Such interdisciplinary approaches may provide insight into these complex microbially mediated systems.

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IRON HOTSPOTS IN MARINE AGGREGATES OF THE SUBARCTIC PACIFIC

Using synchrotron x-ray fluorescence (XRF), we show that marine aggregates collected from Ocean Station Papa (OSP) in the Subarctic Pacific in February 1996 display micron sized discrete hotspots of iron. The hotspots are observed in samples collected from surface to deep. X-ray absorption spectroscopy (XAS) of several hotspots indicates that this iron is not organically bound and is likely of mineral origin. Aerosol monitoring stations do not show evidence of any dust delivery to the subarctic Pacific at this time. We propose that these iron-rich particles have a continental origin, and are delivered offshore in the winter when winds force coastal water to downwell and travel laterally along the pycnocline. Bulk chemical analyses of particulates collected the subsequent year show indications of an enriched iron layer originating at the depth of the continental shelf and propagating offshore. We believe the presence of iron-rich particles at OSP may be a marker for the continental delivery of iron. This conclusion could not have been obtained with bulk chemistry alone, and highlights the usefulness of synchrotron XRF and XAS in chemical oceanography.

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MECHANISMS OF ON-SHELF RETENTION OF COPEPODS IN AN UPWELLING SYSTEM

One of the great challenges facing plankton organisms inhabiting coastal upwelling zones is life cycle closure. That is, how do the life cycles stages (eggs, nauplii, juveniles and adults) avoid being swept out of the system in the face of persistent offshore and alongshore transport? To determine the mechanisms that might explain retention and/or loss during the coastal upwelling season, one needs (1) detailed descriptions of cross-shelf and alongshore Lagrangian circulation patterns, (2) data on animal densities along cross-shelf transects at several latitudes, (3) data showing where in the where in the water column life cycle stages life during both the day and night, from samples collected at discrete depths, and (4) knowledge of ontogenetic changes in depth distributions. In this paper we show the day-night variations in vertical distributions and weighted mean depths of two copepod species, Calanus marshallae and Pseudocalanus mimus in shelf waters off central Oregon, and discuss retention on the Heceta Bank. Results show us a pattern of increasing depth with increasing stage in life history, where adults spend more time at greater depth.

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ORGANIC CONTROLS ON THE BIOGEOCHEMISTRY OF MERCURY IN LONG ISLAND SOUND

Mercury (Hg), the soft metal endmember of the Irving-Williams Series, has a particularly strong complexation affinity for organic matter. This coordination chemistry results in first order control of the fate of Hg in coastal marine systems, both in the water column and sediments. For example, complexation by chromophoric organic matter results in reduction of ionic Hg(II) to volatile elemental Hg and subsequent detoxification of water bodies through gas exchange. Adsorption of organic matter to particles also increases particulate affinity of Hg, lowering Hg solubility even in the presence of chloride. Under low oxygen, sulfate-reducing conditions, organic control of Hg solubility is an important factor in determining the rate of methylation, and therefore bioaccumulation, of Hg. Using data from Long Island Sound, an impacted and partially urbanized watershed, these trends will be illustrated. Observations and experiments include first order mass balances of Hg, monomethylHg and dissolved organic matter, as well as intact sediment core methylation incubations and measurements of the gross rate of Hg(II) reduction in the presence of dissolved organic matter.

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PARTICULATE EXPORT IN THE NORTHEAST ATLANTIC: AN INTEGRATED ATTACK USING PRODUCTION RATES, TRACERS AND A NOVEL DRIFTING SEDIMENT TRAP.

The temporal and spatial variability in export flux of material from the surface ocean and its decreases with depth has a major influence on the earth system. However there are major uncertainties associated with existing estimates due to unconstrained assumptions. Using a novel lagrangian sediment trap (PELAGRA) we have measured export directly and compared this to simultaneous estimates using primary production and 234Thorium inventories. The study was carried out over the Porcupine Abyssal Plain in the Northeast Atlantic (near the JGOFS NABE site) in July 2003 in combination with measurements to define the chemical, physical and biological context (nutrients, CTD, phytoplankton, micro- and mesozooplankton, primary production and satellite remote sensing). The study site was characterised by a stable anticyclonic eddy with low nutrient levels and a subsurface chlorophyll maximum. The previous debilitating problems of upper ocean sediment trap studies appear to have been overcome and the fluxes measured by PELAGRA agree closely with other estimates. About 9% of the total primary production was exported from the upper ocean at this time.

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PRIMARY PRODUCTIVITY AND CHLOROPHYLL RESPONSE SIGNATURES FOR AN IN SITU MESOSCALE PACIFIC SECTOR SOUTHERN OCEAN FE ENRICHMENT EXPERIMENT (SOFEX) AT 55S AND 66S

Iron enrichments were accomplished at two sites in the Southern Ocean during summer 2002. The North patch (Subantarctic Zone) was characterized by high nitrate, low silicate water while the South patch (Subpolar Regime) was rich in both macronutrients. Iron addition stimulated increases in total chlorophyll (7x in North, 12x in South) and primary productivity (20x North, 6x South). The percentage of large phytoplankton (greater than 20um) increased dramatically in the North while they remained around 50 percent throughout the experiment in the South. Characteristic differences in the ratio of fluorescent chloropigments to photosynthetically active chlorophyll-a were associated with patch location, depth, time from enrichment, and total biomass (largest in surface, late enriched South patch - about 3x). Particulate organic carbon flux increased over time in the South patch and trends with respect to primary productivity will be presented. We conclude that iron addition stimulated productivity in both high and low silicate regimes however, the nature of these increases differed. This evidence supports the hypothesis that silicate availability is a factor in determining community development in response to iron deposition.

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A NORTH ATLANTIC OCEAN SECTION FOR DISSOLVED FE AND AL

As participants in the Repeat Hydrography/CLIVAR program, we collected dissolved Fe and Al samples from the upper 1000 meters at 62 stations in the North Atlantic from 60N to 5S on the 2003 A16N expedition. Dissolved Al and Fe were determined by shipboard FIA, and verified by isotope dilution ICPMS (Fe). Colloidal Fe and Al samples were collected at 15-25 meters at each station using cross-flow ultrafiltration. Dissolved Fe concentrations ranged from <0.3 nM to 2.3 nM and the profiles all showed oceanographically consistent features. Because of the close profile spacing (1-degree), contour plots of the distributions revealed a large number of well-resolved features. Significant inputs of both elements from the deposition of Saharan dust into the waters of the equatorial Atlantic resulted in a 3-4 fold enrichment in dissolved Fe and a nearly 10-fold enrichment in dissolved Al in the surface waters. A large region of elevated Al concentrations due to the Mediterranean Outflow was observed from 700-1000 meters between 35N and 45N. Dissolved Al was also enriched from 75-450 meters between 20-35N. Elevated Fe concentrations were observed from 75-1000 meters from 5-18N underlying the Saharan surface water inputs and within the oxygen minimum zone beneath the high productivity upwelling zone off NW Africa. These data will be used to calibrate a dust-deposition model, and will be used in GCM models of oceanic Fe biogeochemistry.

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TON AND TOP STOICHIOMETRY AND DISTRIBUTION ACROSS THE INDIAN OCEAN SUBTROPICAL GYRE

Dissolved organic nitrogen and phosphorus are the largest pools of fixed N and P in oligotrophic oceans. The labile fraction of these pools has been suggested to cycle in a quasi Redfield type manner in diverse oceanic regimes. We present here the first simultaneous determination of total organic nitrogen (TON) and total organic phosphorus (TOP) distribution and stoichiometry across the Indian Ocean Subtropical gyre with measurements of biological and environmental factors that might control their abundance. Inorganic nutrients were strongly depleted in the upper water column with an excess of phosphate relative to nitrate meaning that surface inorganic N/P ratios were lower than the elemental phytoplankton requirements. TON and TOP were the dominant pools of fixed N and P in the upper water column. This factor has likely favoured the algal assemblages that were present (mostly cyanobacteria). TON and TOP spatial gradients were observed reflecting differential DOM consumption across the transect. Scatter plots of TON to TOP show that most datapoints lie below the classic Redfieldian line. We therefore infer a preferential consumption of TON relative to TOP.

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MICROZOOPLANKTON ROLES AND RATES IN MARINE FOOD WEBS

The grazing impacts of microplanktonic consumers (<200-µm, protist-dominated heterotrophs) on phytoplankton and their implications for production and remineralization processes in the marine food web are assessed from the global database of dilution experiments. Microzooplankton consumption is the main source of phytoplankton mortality in the oceans varying from 60% for coastal and estuarine environments to 70% for the open oceans, and from ~59% for temperate-subpolar and polar systems to 75% for tropical-subtropical regions. The contribution of microbial grazers to total community respiration is roughly comparable to bacteria. In contrast, microzooplankton secondary production can be 2-5 times the typical values for bacterial production. High grazing impacts and high GGEs are consistent with comparable population growth rates for microzooplankton and phytoplankton under ambient conditions. Transfer efficiencies of microzooplankton production to mesozooplankton depend critically on the number of predatory interactions among micro-consumers. Presently, potential ecosystem differences in micrograzer activity and/or trophic structure are major uncertainties for biogeochemical models that seek to predict the microbial community role in carbon cycling from bacterial parameters alone.

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EXAMINING MARINE PHOTOSYNTHETIC RESPONSES USING NATURAL FLUORESCENCE

Many important photosynthetic properties have no direct optical manifestation. Consequently, examining their variability with optical methods requires the derivation and verification of suitable proxy parameters. Oceanic natural fluorescence data are currently being collected using satellite sensors, yet it is unclear how best to interpret these data meaningfully in ecological or photosynthetic terms. The underlying relationships between natural fluorescence and different photosynthetic properties and/or rates have not been well examined over the spatial, temporal, and taxonomic scales characteristic of remotely sensed fields. Laboratory experiments with phytoplankton cultures have provided insights into how proxies for discriminating broad classes of photosynthetic responses can be best derived from the minimal number of independent variables available from MODIS fields of natural fluorescence and other wavelengths. We describe the theoretical bases of certain proxies, and we examine their power for quantifying biomass-independent photosynthetic variability using MODIS data, in the context of radiometric, IOP, and photosynthetic measurements taken during recent field studies off Oregon and Alaska.

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THE INFLUENCE OF OCEAONGRAPHIC CONDITIONS ON THE LONGLINE CATCH RATE OF ALBACORE TUNA IN THE SUBEQUATORIAL REGION OF THE SOUTH PACIFIC.

Over the last 10 years, there has been considerable development of the domestic longline fisheries in the subequatorial region of the southwestern Pacific Ocean. Regionally important fisheries, principally catching albacore tuna (Thunnus alalunga), operate in the Exclusive Economic Zones of New Caledonia, Fiji, Tonga, and French Polynesia. For each of these fisheries, the average monthly catch rate of albacore was determined for the main area of the longline fishery. Satellite derived sea surface temperature (SST) data and chlorophyll-a concentration were used to define the monthly oceanographic conditions in each of the main fishing areas. For each area, the monthly average, minimum, maximum, and range of SST and chlorophyll-a observations were determined. A generalised linear modelling approach was used to determine the relationship between monthly catch rate and the variables defining the prevailing oceanographic conditions. The respective models accounted for 30-50% of the variance in monthly catch rates from the four fisheries. For each fishery, the respective model generally described the observed seasonal trends and inter-annual variation in the catch rate of albacore tuna.

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LARVAL SETTLEMENT AS A FUNCTION OF THE DISTRIBUTION OF INSTANTANEOUS FORCES IN A TURBULENT BOUNDARY-LAYER

In a field experiment larvae of the barnacle Balanus improvisus showed reduced initial adhesion, settlement and recruitment with increasing local flow speed. Larval supply was uncorrelated to flow speed. The negative correlation between local flow speed and recruitment is mainly explained by the pattern of initial adhesion suggesting a mechanism operating immediately after contact and before behavioural responses. We propose that turbulent flow structures near the substrate surface determine available time for initial adhesion based on critical levels of hydrodynamic forces leading to detachment. In a study of turbulent flow structures in the near-bed layer using ADV, hot film anemometer and PIV we measured periods of stress lulls and estimated peak drag and lift forces. From the flume data on the temporal distribution of instantaneous forces we tested hypotheses of critical periods of low forces and frequency of peak forces as mechanisms explaining field correlations between larval settlement and local hydrodynamics.

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WHEN THE AVERAGE IS NOT ENOUGH: EFFECT OF UNSTEADY FLOW ON DINOFLAGELLATE POPULATION GROWTH

Dinoflagellate population growth is inhibited by fluid shear at levels present in ocean turbulence in surface waters. Previous laboratory studies using Couette flow, a simple shear flow in the gap between concentric cylinders, have involved steady conditions that do not capture the dynamic features of unsteady in situ shear. In this study, cultures of the dinoflagellate Lingulodinium polyedrum were exposed to oscillating Couette flow involving sinusoidal rotation of the outer cylinder. The flow field was estimated using the analytical solution for steady oscillatory flow between infinite plates. Shear treatments involved only temporal changes in shear with minimal spatial gradients across the gap. For an average (absolute value) shear of 4/s, equivalent to that present in surface turbulence during windy conditions, decreases in net growth due to oscillating shear were greater than for steady shear. Differences in the amount of growth inhibition were due to the integrated shear exposure, not average or maximum shear levels. These results demonstrate the importance of quantifying the entire shear distribution when examining the effect of unsteady flows on dinoflagellate population growth.

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ARCHAEAL DIVERSITY IN A DEEP SEA SEDIMENT OF THE AEQUATORIAL PACIFIC OCEAN BASED ON 16S RDNA ANALYSES

The diversity of both archaeal and bacterial microbial communities of an organic poor deep sea near surface sediment (9 mbs) of the aequatorial pacific was investigated using molecular methods. Sediment samples were taken in February 2002 during an ODP- cruise (Leg 201) with the JOIDES Resolution on site 1225 which represents a relatively cool (2-25 degree C) deep sea sediment typical of a large portion of the eastern aequatorial pacific. The clay rich sediment containing carbonate and siliceous oozes is further characterized as extremely organic poor (less than 5 mM DIC) with sulfate-rich porewaters (30 mM). Cell numbers calculated by DAPI staining were low (approximately 1,000,000 cells/cm3). Little is known about the composition of microorganisms buried in these deep sea pleistocene sediment and how they are controlled by chemical and physical parameters. After DNA-extraction of the sediment archaeal and bacterial 16S rDNA primers were used to amplify 900 bp fragments for cloning, sequencing and phylogenetic analyses.
The microbial community composition will be analyzed in relation to in-situ geochemical gradients (oxygen, nitrate, metals, sulfate) in the sediment columns (see www.odp.taemu.edu).

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THE IDENTIFICATION AND CLASSIFICATION OF BIO-GEOPHYSICAL PARAMETERS IN PLYMOUTH COASTAL WATERS, UK.

Any optical input to water quality decision making systems and coastal bio-geo-chemical models requires a detailed knowledge of the optical properties of substances suspended or dissolved in the water. The complex nature of case-II waters makes the interpretation of these optical signatures problematic. These complexities can be addressed by gaining insights into the optical behaviour of individual particles and their relationships with co-existing constituents. The research has initially focused on investigating the influence of estuarine and coastal particulate material on the marine optical environment. By developing a database of particulate bio-geo-chemical status and optical properties, the project aims to understand the hyperspectral behaviour of optically complex coastal waters. Hyperspectral optics have been combined with a classification of the suspended particulate matter (using techniques that include total concentration, organic/inorganic ratios, particle size, particulate absorption, atomic absorption spectroscopy and x-ray diffraction) and measurements of the dissolved fraction. Results from the previous field campaigns and experiments will be presented together with plans for the ongoing development of the research.

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NITROGEN CYCLING IN INTERTIDAL SEDIMENTS: DETERMINATION OF IN SITU DENTRIFICATION RATES

Nitrogen removal through denitrification is significant for the trophic state of coastal waters. The magnitude and vertical variation of denitrification rates were determined in the Scheldt estuary (Belgium, The Netherlands) by combining three different approaches. Microsensors were used to measure N2O, NO3- and O2 profiles in the presence of the N2O reductase inhibitor acetylene. To obtain rate information time series of N2O profiles were recorded. In separate sediment plug reactor experiments, affinity constants (Ks) and maximum nitrate reduction rate (Rmax) were obtained. Bio-irrigation rates were estimated from Br fluxes obtained in core incubations. The experimental data was integrated with reactive transport model simulations to obtain high-resolution profiles of denitrification rates. The results imply a high degree of consistency between reaction kinetics measured in sediment plug reactor experiments and rates derived from microprofiling. In the sediments studied, the zone of denitrification is restricted to a 2-3 mm thin sediment horizon, 2 mm below the sediment surface. In situ rates were as high as 300 nmol cm-3 h-1.

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MODELLING THE BIOLOGICAL CO2 PUMP IN SEASONALLY ICE-COVERED REGIONS OF THE ARCTIC OCEAN

Sea ice limits pelagic primary production in the Arctic Ocean, but provides a substrate for ice algae, which are estimated to represent up to 25% of the total primary production in the Arctic Ocean. They may also be exported at depth more efficiently than pelagic phytoplankton. The pelagic phytoplankton bloom generally occurs after ice break-up, but some under-ice blooms have also been observed following early ice algae release from the bottom of the ice. Snow thickness appears to control the onset and decline of the ice algae bloom through its control on the amount of solar radiation that reaches the algae. The accretion/ablation rate at the ice bottom will also be important through its effect on the ice structure, nutrient fluxes and ice algae layer stability. We here explore the effects of these physical forcings on the onset, variability, and decline of an ice algae bloom, and on the timing and magnitude of the pelagic phytoplankton bloom, using a coupled ice-ocean-ecosystem model.

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FLOW-CYTOMETRIC ANALYSIS OF HETEROSIGMA AKASHIWO PERMITS RAPID DETECTION OF VIRAL INFECTIONS

Improved marine ecosystem management is dependent on developing rapid methods for monitoring the state of harmful algal blooms to help predict their severity and duration. Using flow cytometry (FCM) we followed changes in cellular parameters directly caused by viral infection of the bloom-former Heterosigma akashiwo in near real-time. Using live/dead assays we were able to discriminate between infections with a dsDNA virus (OIs20) and a ssRNA virus (HaRNAV). Both the 'dead' assay with SYTOX Green, which stains cells with compromised membranes, and the 'live' assay with FDA, which stains cells with intracellular esterase activity, showed that infection with OIs20 proceeded rapidly and resulted in the accumulation of a dying subset of the population before lysis of the cells (up to 80%). In contrast, infection with HaRNAV was not detectable prior to the decline in abundance of H. akashiwo using the live/dead assays. The low percentage dead cells indicated that the host cells disintegrated rapidly. This experiment demonstrates the potential of using FCM for examining the state of infected HABs and their mode of lysis.

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THE EQUATORIAL PACIFIC UPWELLING PLANKTONIC FOOD-WEB: STRUCTURE AND FUNCTIONING

Description of the photic layer (0-100m) planktonic food-web is based on a 8 N-8 S transect along 180 , made in the equatorial upwelling region (EBENE cruise). It uses different methods dealing with biomass and flux measurements of organisms ranging from the pico- to the mesoplanktonic size. At 0 , phytoplankton biomass (2340 mgC/m²) is dominated by picoeukaryotes (53%) and equals the total heterotrophic biomass, including bacteriae. On a 24-hour timescale, the autotrophic production (equal to 51-58% of the carbon biomass) is entirely grazed, with Protists contributing 73% of the total (microzooplankton and mesozooplankton). Latitudinal variations are also considered and lead to the balance between production and grazing losses, with a variable contribution of Protists, related to different phytoplanktonic community compositions. The coherence of the results obtained by independent methods suggests that the essential features of the system have been adequately represented by rate and standing stock measurements from the EBENE study.

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SIMULATION OF THE OCEAN DMS(P) POOLS DURING SERIES IN THE NORTH-EAST PACIFIC

A 1-D coupled biogeochemical-ocean model was used to simulate the evolution of the dimethylsulfoniopropionate (DMSP) and dimethylsulfide (DMS) pools during the SERIES large scale iron enrichment experiment conduced in July 2003 in the North-East Pacific. Forced by the wind data measured on-ship and controlled by the observed ocean temperature and salinity, the upper ocean turbulent model GOTM (General Ocean Turbulent Model) reproduces adequately the evolution of the surface mixed layer observed during the 4-week experiment. Data collected during SERIES (pools sizes and rates measurements) were used to adapt and validate a new sulfur module originated from NODEM (Northern Ocean DMS Emission Model). Preliminary results show that both temporal changes in the biological cycling of DMS and of the effect of wind-induced turbulence on the vertical distribution of DMS are needed to properly reproduce the observations. The sensitivity of the model to iron-induced changes in the biological cycling of DMS will be discussed.

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DYNAMICALLY CONSTRAINED SYNTHESIS OF THE ACOUSTIC TOMOGRAPHY, SATELLITE ALTIMETER AND IN SITU DATA IN THE KUROSHIO EXTENSION REGION

A quasigeostrophic model of an open ocean region is employed to produce a dynamically constrained synthesis of acoustic tomography and satellite altimetry data with in situ observations. The data assimilation algorithm is based upon the 4D variational data interpolation scheme controlled by the model's initial and boundary conditions. The data sets analyzed include direct and differential travel times measured at the array of five acoustic transceivers, Topex/Poseidon altimetry, CTD soundings, and ADCP velocity profiles. The results of assimilation are compared with
the statistical inversion of the same travel time data. It is shown that mesoscale variability can be effectively monitored by five transceivers supported by relatively sparse in situ measurements. Analysis of the energy and enstrophy balances of the optimized model solution shows that the mean currents in the region are aroclinically and barotropically unstable. Energy exchange between the depth-averaged and shear components reveals a weak decay of the barotropic mode due to topographic interaction. Potential enstrophy is transferred from the mean to mesoscale currents.

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FE AND ZN IMPACT ON PHYTOPLANKTON GROWTH IN TWO HNLC SYSTEMS IN THE PACIFIC SUB-ANTARCTIC AND SUB-ARCTIC REGIONS.

Zinc and iron limitation was investigated in two HNLC areas, in the Sub-Antarctic zone south of New Zealand and in the Bering Sea. Even though culture experiments have shown an impact of free zinc depletion on diatom growth, our field work did not reveal such a trend, despite very low concentrations in the surface layer (6 pM to 200 pM). Iron was clearly limiting phytoplankton growth in both HNLC areas, inducing a 2.5 to 6-fold Chl a increase. All iron amendments resulted in enhanced diatom growth, as evidenced by a 1.5 to 2.4-fold increase of biogenic silica compared to control and zinc treatments. The Sub-Antarctic HNLC was furthermore characterized by probable Fe/Si co-limitation processes as Si(OH)4 concentrations remained <0.5 microM while Fe seemed to be the sole primary limiting nutrient in the Bering Sea HNLC system, where all nutrients were abundant including Si(OH)4. Silicification assays were conducted as well, using PDMPO, a molecular probe that can be used to trace silica deposition in diatoms. Differences in the degree of silicification of diatoms between different amendments are expected to be seen.

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DIFFUSIVITIES OF HEAT, SALT, AND SF6 IN THE THERMOHALINE STAIRCASES EAST OF BARBADOS

Sulfur hexafluoride was released near the center of the region of thermohaline staircases east of Barbados in 2001. A survey 10 months later found 50 to 60% of the tracer between 48 and 70oW, the remainder lying beyond these limits. The vertical spread of the tracer gave a diapycnal diffusivity, K(SF6), in the staircase region of 0.8 to 0.9 cm2/s. The diffusivity for salt, K(S), should be similar since the molecular diffusivities are similar. Measurements of thermal dissipation rates gave a heat diffusivity of about 0.4 cm2/s, corresponding to K(S) of 0.7 to 1.3 cm2/s if the transport is by salt fingering. Dissipation of kinetic energy gave a K(S) of 1 to 1.5 cm2/s under the same hypothesis. The three estimates of K(S) are consistent with one another, supporting the hypothesis that salt fingering is largely responsible for diapycnal mixing in this region and providing an accurate estimate of the diffusivities. K(SF6) in the Caribbean Sea was about 0.2 cm2/s, suggesting that staircases must be present for salt fingering to raise diffusivities much above typical pycnocline values of 0.1 cm2/s.

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RELATIONSHIP BETWEEN CLEARANCE AND UPTAKE RATES OF CD, SE AND ZN IN THE BIVALVES, M. CALIFORNIANUS, P. AMURENSIS, M. BALTHICA AND C. FLUMINEA

Clearance rates of four benthic bivalves Mytilus californianus, Potamocorbula amurensis, Macoma balthica and Corbicula fluminea were compared to uptake rates of waterborne Cd, Se and Zn to evaluate the functional relationship between the dissolved metal uptake rate and pumping activity of the clams. This relationship was established at a range of water temperatures and clam size classes. Uptake rates of 3 metals were positively related to filtration rates of the clams except for the M. balthica. Generally, weight-specific clearance and metal uptake rates of the clams increased with water temperature, but decreased with body size, probably due to covariance of the metabolic rates with temperature and body size. Interestingly, both the filtration and metal uptake rates of the fresh water clam C. fluminea were not proportional to the external temperature (5, 13 and 21oC). Both clearance and metal uptake rates of the C. fluminea were lowest at 5oC, highest at 13oC, and then decreased with the increase of temperature from 13 to 21oC. Inter-clam species specific relationship between clearance rates and metal uptake rates were positive for all three metals over a range of temperature and body size.

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CHRONIC PHYSIOLOGICAL AND REPRODUCTIVE EFFECTS OF WATERBORNE AG TO THE CLAM RUDITAPES PHILIPPINARUM

A laboratory microcosm experiment was conducted to evaluate chronic physiological and reproductive responses of the clam Ruditapes philippinarum exposed to waterborne Ag. During 6-week exposure of the clams to a range of dissolved Ag (0.1 ~ 20 ppb), filtration rate, respiration rate, carbon assimilation rate, glycogen content, and reproductive activity of the clams were determined periodically. Tissue Ag concentrations linearly increased with exposure time and waterborne Ag concentrations. Mean clearance rate and carbon assimilation efficiency of the clams had significant negative relationships with tissue Ag concentrations. Accordingly, scope for growth decreased with tissue Ag concentrations. Further, gonadal development of the clams at the highest Ag exposure significantly reduced, while those exposed at the lower Ag concentrations increased during the same period.

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MEDFLUX: ASSOCIATION OF ORGANIC MATTER WITH BALLAST MINERALS IN SINKING PARTICLES

Recent evidence points to a relatively constant ratio of organic matter to mineral ballast in particles sinking in the deep ocean. We hypothesized that ballast minerals physically protect a fraction of their associated organic matter, and that this protected OM dominates over the unprotected fraction deeper in the water column. We also suggested that the ratio of organic carbon to ballast may be key to predicting variability in export fluxes and sinking velocities of organic carbon as estimated using radiotracers. We participated in four cruises at the French JGOFS DYFAMED site in the western Mediterranean to test these ideas. Besides our standard in-situ pump, Niskin bottle and IRS sediment trap techniques for collecting particles, we used for the first time a new conical, free-floating NetTrap, an elutriator, and an IRS trap in the sinking velocity mode. The sinking velocity mode allowed collection of particles with sinking rates from 1-1000 m/d. We measured a large suite of organic and inorganic parameters. Here we present results that bear on these hypotheses.

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CONTAMINATED SEDIMENT TRANSPORT AND DEPOSITION IN THE LOS ANGELES URBAN OCEAN

The central Southern California Bight (Los Angeles margin) is an urbanized section of coastal ocean that has complex topography, sediment-distribution patterns, and oceanographic processes. Ocean outfalls, rivers, streams and coastal industries discharge contaminants into this system. Oceanographic, geologic and biologic processes transport, and ultimately deposit these contaminants along with or bound to native geologic materials. From 1992 to the present, the US Geological Survey, together with allied agencies, conducted a series of investigations to 1) map the distribution of contaminants in seafloor sediment of the Southern California Bight and 2) determine the dominant processes that influence the distribution of sediment and associated contaminants. To achieve these goals, we collected over 200 box core samples and analyzed the recovered sediment for contaminants, accumulation rates, and toxicity. The resulting data document changes in contamination as a function of place and time and reflect the processes that caused change. By developing a solid understanding of the relation between processes and distributions, we are improving sediment transport models and increasing our ability to forecast the future state of contamination in this urban ocean environment.

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ROLE OF STORAGE LIPID DURING MARINE ZOOPLANKTON REPRODUCTION

Storage lipid, e.g. wax esters, triacylglycerols, provides energy for such reproductive processes as formation of ovary and oocytes. Lipovitellins, the principal components of zooplankton yolk spheres, are water soluble particles composed of approximately equal amounts of lipid and protein. Lipid droplets and lipovitellin provide both energy and materials during early embryo development. Many high latitude zooplankton accumulate extensive stores of lipid during the spring and summer when food is plentiful. These lipid stores provide energy during the winter and energy and materials for reproduction in the winter or spring. Sections of female ovaries and early embryo stages viewed under the light or electron microscope reveal numerous lipid inclusions in the ovaries and oocytes from zooplankton collected at both low and high latitudes. Thus, it appears that storage lipid play an important role during reproduction in many, if not most, zooplankton.

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EFFECTS OF VARIABILITY IN HYDROGRAPHIC STRUCTURES ON BIOLOGICAL ACTIVITY IN BERING STRAIT OVER FOUR YEARS, 2000-2003

Long-term monitoring of the inflow into the Arctic Ocean through the US side of Bering Strait has been conducted over the last four years. The interannual variation of nitrate concentration and phytoplankton biomass in the strait were large as a result of different physical structures among the different seasons and years. The physical structure observed in 2002 was unusual due to southward wind and current flows. As a result, low salinity Alaska Coastal Water (salinity <31.8 psu) spread westward on top of higher nutrient and more saline Bering Shelf Water (31.8<salinity<32.5 psu) extended eastward on the bottom. Eventually, more nitrate was available on the eastern side of Bering Strait and thus more phytoplankton activity was observed in 2002 than in any of the other years. In contrast to that, nitrate concentrations in 2000 were almost depleted when ACW occupied most of the strait and, as a result, the phytoplankton biomass was lowest for the four observation periods. The BSW maintained enhanced biological conditions on the western side of Bering Strait, except in 2000 through early September each year.

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OCEAN COLOR VARIATIONS OF BLUE WATERS AND IMPLICATIONS TO REMOTE SENSING

Remote-sensing reflectance data over different blue waters collected by SeaWiFS were analyzed and a wide range of variations were found. These blue waters are located in the Sargasso Sea, the Gulf of Mexico open ocean, and the North Pacific Ocean, where influence from land runoff is negligible. These waters are often assumed belong to Case-1 category, where changes of ocean color indicate changes of chlorophyll concentration, while other non-chlorophyll components (such as colored dissolved organic matter) co-vary with chlorophyll in a “known” pattern. The study here, however, suggests that even for oceanic blue waters the changes in ocean color may not necessarily be caused by changes in chlorophyll concentration. More importantly, the results indicate that the quantitative relationship between non-chlorophyll and chlorophyll of blue waters is not a constant. Therefore one needs be cautious to use quantitative Case-1 relationships of one area to another area. Furthermore, in ocean-color remote sensing, it might be better to use analytically based algorithms instead of empirical statistical algorithms for the retrieval of the optical properties of these waters.

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INTERACTIONS BETWEEN ANTHROPOGENIC FORCING, CARBON FLUXES AND PELAGIC ECOSYSTEMS IN THE UPPER OCEAN

Understanding the factors that control the interactions between the ocean biota and the Earth System are critical components of conceptual and numerical models of ocean-climate interactions. Because the effects of food webs on climate are determined by carbon sequestration in the ocean’s interior and not export from the euphotic zone, the whole water column down to 1000-2000 m must be considered. Our approach is based on the interactions of five functional groups of plankton organisms (phytoplankton, heterotrophic bacteria, micro- and mesozooplankton, microphagous macrozooplankton), four biogeochemical carbon fluxes (photosynthesis, calcification, respiration, deep transfer) and three classes of food-web processes that affect organic matter (synthesis, transformation, remineralisation). We show that the food-web processes provide a framework for describing the roles of plankton organisms in determining the biogeochemical fluxes of carbon, and for analysing potential interactions between climate change and the ocean’s biology.

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DYNAMICS OF A SIZE-STRUCTURED MODEL OF PLANKTON ECOSYSTEMS WITH FLUCTUATING ENVIRONMENTAL FORCING

The complexity of plankton ecosystem models is commonly increased by adding state variables to the basic nutrient, phytoplankton, zooplankton (NPZ) components, and by choosing more complicated functional relationships. The intended consequence of this is that the results may resemble the real ocean better than the simpler model. A potentially problematic consequence is that the intrinsic dynamical behavior of the system also becomes more complex – often to the extent that the behavior cannot be straightforwardly characterized for the given system. In order to study the response of different size classes of phytoplankton to variability in nutrient input we have extended an NPZ model by inclusion of a second size class of both P and Z. We present details of the sensitivity of the equilibrium solutions to parameter values, including those characterizing the local environment: temperature, light and nutrient input. These results are contrasted to the mean ecosystem response from Monte Carlo simulations where the nutrient input rate varied stochastically, preserving the statistics of several scenarios of environmental forcing.

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REGIONAL SCALE MODULATION OF INTERNAL TIDAL UPWELLING ALONG THE FLORIDA KEYS REEF TRACT

Internal tidal upwelling in summer along the Florida Keys reef tract produces significant hydrographic variability, sudden cooling, and input of dissolved nutrients to shallow reef slope waters. Benthic macroalgae form dense communities of large individuals in a zone regularly exposed to upwelled cool water at 35 to 70 m depth seaward of the reef tract. The signal of internal tidal upwelling is strongly modulated by larger scale oceanographic processes, specifically variability in proximity to shore and strength of alongshore Florida Current flow. Bouts of enhanced internal tidal activity typically lasting 4 – 7 days and reoccurring intermittently at weekly to monthly periods can be detected nearly synchronously at sites separated by as much as 50 – 70 km along shore. Strong flow to the NE is associated with shoreward up tilt of isotherms and uplift of the offshore thermocline. Uplifted subthermocline water is then transported across shore to the reef tract in near-bottom internal tidal bores. This interaction of physical processes across a range of forcing frequencies has significant biological consequences at organismal to ecosystem spatial scales.

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EDUCATION, OUTREACH AND CRITERION 2: OPPORTUNITIES FOR INTEGRATING RESEARCH AND EDUCATION IN THE GEOSCIENCES

Within NSF's merit review system, all Principal Investigators and reviewers are required to address two criteria for excellence: intellectual merit and broader impacts. Ocean scientists may satisfy the broader impacts (also known as "criterion 2") requirement in a variety of ways. Activities related to education and outreach may focus on teaching, training and learning, broadening participation of underrepresented groups, enhancing infrastructure, disseminating public information and increasing the knowledge base needed to better understand important societal issues.

To help PIs better understand and satisfy the criterion 2 requirement, the Geosciences Directorate provides guidance to the community via publications and presentations and funding for focused activities that effectively integrate research and education. Assistance is also available through the Centers for Ocean Science Education Excellence initiative. This presentation will describe the range of approaches appropriate for meeting requirements of criterion 2 and focus attention on using education and outreach partnerships as an effective strategy.

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EFFECTS OF INTERANNUAL VARIABILITY ON THE POPULATION DYNAMICS OF A DOMINANT CALIFORNIA CURRENT COPEPOD: APPLICATION OF AN INDIVIDUAL-BASED MODEL

The cues that lead to the initiation and termination of the dormant (overwintering) phase of copepods are poorly understood. This is a problem when examining population dynamics as related to interannual climate variability. During this dormant phase, copepods leave the unproductive surface waters and remain at depth, exhibit lowered metabolism, and experience lower predation pressure. The entrance timing and length of this phase are partly set by the environmental conditions the copepod has experienced during its life history. The physiological condition (~reproductive potential) when they return to the surface is a function of their state when entering dormancy and the conditions during, and duration of, their dormant period. Thus the success of copepod populations in any particular year, are a complicated function of the current environmental conditions and the condition of the overwintering "seedstock" which was set the previous year. Here, I use an individual-based model of Calanus pacificus to examine how variability in the yearly cycle of the spring bloom - in timing, magnitude and duration - and seasonal temperature affect copepod production. The variations in the cycles are meant to be representative of changes, which might occur due to processes similar to El nino or "regime" shift scale events. Results of a sensitivity analysis for an upwelling dominated system, along with model runs forced by 9 years of mooring temperature data (92-01) will be presented.

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WHEN SHOULD POLLUTION BE RELEASED? DYNAMICAL SYSTEMS ANALYSIS AND CONTAMINANT CONTROL ON THE COAST OF FLORIDA

We describe a dynamical systems framework for Lagrangian transport in time-chaotic flows. In particuliar, we will show how dynamical systems theory can be utilized in the context of "real" problems, such as those derived from the remote sensing observations or the output of a large scale numerical model. We will illustrate these methods with the study of fluid transport near the Atlantic coast of Florida using a velocity field observed experimentally from high frequency radar measurements. Numerical simulations shows that dynamical barriers present in the flow can be exploited to control the effect of contaminants released from the coast. We present an algorithm that modifies the release windows of coastal contaminants in order to minimize the average conentration of pollutants in the coastal area.

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COASTAL OBSERVING WITH THE BOTTOM STATIONED OCEAN PROFILER

The benefits of untethered or drifting buoys and platforms have been well documented over the past decade. Study of physical, chemical and biological processes in the ocean can often be enhanced using observation systems that profile and/or drift. An autonomous platform developed at the University of South Florida provides the benefits of an untethered drifter and a stationary buoy for coastal ocean applications. The Bottom Stationed Ocean Profiler (BSOP) is a platform that stations itself on the sea floor and autonomously profiles to gather water column profile data. Currently, multiple units of two designs are performing data collecting missions on the West Florida Shelf. In untethered offshore tests the BSOP units have proven themselves reliable and retrievable, collecting and transmitting data for extended deployment periods. Deployments have involved one or more units profiling independently for durations of up to 100 cycles over periods of over two weeks. All profilers are equipped with a CTD, and harbor testing has involved incorporation of additional sensors. Testing has shown that the BSOP is robust and capable of accommodating a variety of sensors.

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COSEE-WEST AND MARINE SCIENCE OUTREACH AT THE UNIVERSITY OF SOUTHERN CALIFORNIA

The University of Southern California has a long history of outreach in marine science education. Through the Wrigley Institute of Environmental Studies and Sea Grant, ocean scientists are directly involved in community education via programs such as the Island Explorers marine science curriculum, summer science programs, parent-child education, and teacher workshops. In 2002, a Center of Ocean Science Education Excellence was established in greater-Los Angeles (COSEE-West) through a grant to USC and the University of California Los Angeles from the National Science Foundation. COSEE-West builds on previous work at both of these universities to link ocean scientists to classroom education. By offering teachers and scientists opportunities to interact directly through lectures, workshops and retreats, COSEE-West is fostering in-depth, long-term collaborations between the ocean research and education communities. Likewise, COSEE-West is building relationships between researchers and free-choice learning institutions such as museums and aquaria through professional development opportunities for docents and staff, and helping researchers become involved in the development of science-based exhibits. An overview of the USC programs linking marine scientists/ oceanographers with formal and informal science education will be presented.

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INTERACTIONS OF LIGHT, NUTRIENTS AND CARBON LIMITATION ON C:N:P STOICHIOMETRY IN EMILIANIA HUXLEYI

Phytoplankton provide a link between the C, N and P cycles in the sea. Here we document deviations of particulate C:N:P from the Redfield ratio (106 C:16 N: P) in a non-calcifying strain of the coccolithophorid Emiliania huxleyi. E. huxleyi was grown at a dilution rate of 0.3 d-1 in cyclostat cultures at photon flux densities (PFD) of 600 and 100 umol photons m-2 s-1, pCO2 levels of 350 and 2000 uatm and nitrate:phosphate ratios of 5, 15 and 30. Chemostats were N-limited when nitrate:phosphate equaled 5 or 15 and P-limited when nitrate:phosphate equaled 30, independently of PFD and pCO2 levels. Particulate C:N varied from 8 to 15 and particulate C:P varied from 90 to 400, with significant treatment effects attributable to nitrate:phosphate, pCO2 and PFD. Elevated pCO2 led to increases in the particulate C:N and C:P ratios, but the extent of the increase depended on PFD and supply of phosphate and nitrate. It is likely that changing C:N:P stoichiometry of phytoplankton in response to rising pCO2 will have significant effects on ocean biogeochemistry and food web dynamics.

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A POSSIBLE PREDICTING APPROACH FOR THE TOXIC DINOFLAGELLATE ALEXANDRIUM TAMARENSE USING OPTICAL PROPERTIES

The increase in frequencies and the noxious effects of harmful algal blooms such as Alexandrium tamarense in coastal waters have led to the enhanced interest in monitoring and detecting of such blooms. Detecting and monitoring of blooms are essential to describe the trends of blooms, and thus providing a means for the protection of commercial aquaculture and public health. Optical signatures collected from remote sensing and in-situ moored equipment are ideal for monitoring and may offer reliable ways to mitigate the occurrence of blooms. In the present study, A. tamarense were exposed to three nitrogen (N) sources and the effects of N on the variability in optical properties of A. tamarense were examined. An approach to detect A. tamarense using the absorption ratio at three wavelengths was evaluated. Comparison between phytoplankton species such as diatom and dinoflagellates of coastal waters was done to identify the difference in absorption ratios, which may be used to characterize A. tamarense. In addition, the reliability of the absorption ratio was tested on hypothetical mixed assemblages of diatom and A. tamarense, and natural phytoplankton and A. tamarense.

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ECOSYSTEM DYNAMICS IN MASSACHUSETTS BAY AND MONTEREY BAY: BIOGEOCHEMICAL AND BIOGEOCHEMICAL-PHYSICAL BALANCES

Biogeochemical and biogeochemical-physical balances are investigated for coastal ecosystems. Using dominant balances, i.e. approximate mathematical relationships among different terms/processes, is common in physics but less common in biology. Presently, such balances are investigated using data assimilation, i.e. combining data and models. The assimilation scheme is four-dimensional and multivariate, biological/physical data influence biological/physical fields. Massachusetts Bay during August-September 1998 and Monterey Bay in August 2003 are discussed as examples. Zeroth-order biogeochemical balances are introduced and utilized to initialize biogeochemical fields and uncertainties, and to calibrate model parameters. The predictive capability and predictability limits of the ecosystems are evaluated using uncertainty predictions. For Massachusetts Bay, evidence of Chl-a patchiness is provided, sub-mesoscale dynamics is found to be important, and effects of ecreasing light levels and of increasing storms and sub-mesoscale to mesoscale variability are highlighted. Different sub-regions of trophic enrichment and accumulation are synthesized. Preliminary results are presented for Monterey Bay, focusing on differences between the upwelling and relaxation states. Finally, suggestions for model improvements and adaptive sampling, i.e. predicting the most useful data, are provided.

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TROPHIC ECOLOGY OF ESTUARINE MEIOFAUNA: RELATIONSHIP BETWEEN BENTHIC FORAMINIFERA AND FOOD RESOURCES IN SOUTH SAN FRANCISCO BAY, CA, U.S.A

Water column parameters (chlorophyll concentration) and sediment parameters (chlorophyll, total organic carbon, nitrogen, amino acids, bacterial abundance) were measured, and benthic foraminiferal population size and biovolume was counted and calculated monthly from November 1999, through November 2001 from one site in South San Francisco Bay. Water column chlorophyll peaked in the spring of 2000 and 2001 and the fall of 2000, with sediment parameters peaking one to three months later. The benthic foraminiferal population peaked during the spring of both study years, and showed a large peak in the fall of 2001 dominated by the small sized foraminifer, Fursenkoina pontoni. The data strongly suggest that benthic foraminifera increase in numbers following phytoplankton blooms when many kinds of sediment organic matter also increase. Foraminiferal biovolume and standing crop generally increase when sediment C:N ratio increases, suggesting that benthic foraminiferal populations in South San Francisco Bay are exploiting a detrital food source. Thus, foraminifera are probably quick to exploit sediment organic matter, and may be important reminieralizers of nutrients in this system.

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REAL-TIME ERROR FORECASTING, DATA ASSIMILATION AND ADAPTIVE SAMPLING IN MONTEREY BAY DURING AOSN-II USING THE ERROR SUBSPACE STATISTICAL ESTIMATION SYSTEM

During the August 2003 AOSN-II experiment, the Error Subspace Statistical Estimation (ESSE) system was utilized in real-time to forecast physical fields and uncertainties, assimilate various data (ships, AUVs, gliders, aircraft, satellites) provide suggestions for adaptive sampling and guide dynamical investigations. ESSE aims to capture, forecast and reduce the largest uncertainties i.e error subspace. It is currently based on a singular value decomposition of the minimum error variance update and on an adaptive ensemble scheme to forecast the largest errors. Each ensemble member was a sample path of the HOPS primitive equation model forced stochastically to represent model errors. Using a total of 4323 ensemble members, 10 sets of ESSE error forecasts assimilation outputs, adaptive sampling recommendations and dynamical interpretations were issued and posted on the web. Scientific and operational results will be presented, including: dynamical findings in Monterey Bay and California Current region focusing on different stages of the upwelling and relaxation states; ensemble properties (convergence, mean, most probable forecast (co)-variances and singular vectors); forecast skills; and subjective/quantitative adaptive sampling based on field, error and data forecasts.

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INTERACTIONS BETWEEN ZOOPLANKTON AND KARENIA BREVIS IN THE GULF OF MEXICO

Blooms of the toxic dinoflagellate K. brevis are common in the Gulf of Mexico, yet no in situ studies of the interactions between zooplankton and K. brevis in the Gulf of Mexico have been conducted. Zooplankton numerical abundance, biomass and taxonomic composition of non-bloom and K. brevis bloom stations within the ECOHAB study area were compared. At non-bloom stations, the most important determinant species were Parvolcalanus crassirostris, Oithona colcarva and Paracalanus quasimodo at the 5-m isobath and P. quasimodo, O. colcarva and Oikopleura dioka at the 25-m isobath. There was considerable overlap between the 5 and 25-m isobaths, with 9 species contributing to the top 90% of numerical abundance at both isobaths. Within K. brevis blooms Acartia tonsa, Centropages velificatus, Temora turbinata, Evadne tergestina, O. colcarva, O. dioika, and P. crassirostris were consistently dominant. Variations between non-bloom and bloom assemblages were evident, including variations in numerical abundance and biomass and the reduction in numerical abundance of 3 key species. Calculated grazing pressure proved insufficient to terminate K. brevis blooms, despite occasional grazing hot spots.

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ASSESSING PHYTOPLANKTON BIOMASS AND PHYSIOLOGICAL VARIABILITY AT STATION ALOHA (22 45’N; 158 00’W) USING RADIANCE REFLECTANCE PROFILES

Nearly monthly deployments of a Profiling Reflectance Radiometer (PRR) have been made at Station ALOHA (22 45’N, 158 W) as part of the Hawaii Ocean Time-series program since February 1998. Profiles of chlorophyll a (chl a) concentration and yellow substance absorption at 440 nm have been derived from downwelling irradiance measurements at three wavebands. In addition, upwelling radiance at 683 nm measured by the PRR allows the quantification of chl a passive fluorescence. Based on these measurements we derive vertical profiles of fluorescence quantum yield for the phytoplankton assemblage and analyze their seasonal and interannual variability in the context of other HOT core measurements. Furthermore, we compare this variability with that derived from primary production estimated by 14C in situ uptake and Fast Repetition Rate fluorometry (FRRf). Preliminary results suggest that fluorescence quantum yield in the study area does not vary significantly over time, with the exception of periods when summer phytoplankton blooms are observed. We will discuss possible causes of the apparent uncoupling between the observed variability in the fluorescence quantum yield, 14C derived Primary Production, and FRRf derived photosynthetic parameters.

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SERIES: INFLUENCE OF IRON FERTILISATION ON DIMETHYLSULFIDE (DMS) AND DIMETHYLSULFONIOPROPIONATE (DMSP) DISTRIBUTION IN THE EASTERN SUBARCTIC PACIFIC

The response of dimethylsulfide (DMS) and dimethylsulfoniopropionate (DMSP) to the iron fertilisation of a 64 km2 area in the North-East Pacific conducted in July 2002 is presented. Previous iron enrichment have shown none to 3-fold increase in DMS concentrations. When observed, the increase in DMS coincided with the peaks in biomass and diatoms but was attributed to the grazing of the early iron-induced haptophyte bloom. This experiment generated a haptophyte bloom followed by a massive diatom bloom. The haptophyte bloom coincided with a marked increase in DMSPp concentrations, but DMS levels remained similar outside and inside the iron patch. An increase in microzooplankton grazing caused a rapid decline of the abundance of haptophytes. The crash of the haptophyte bloom (and DMSP) was accompanied by a drastic decrease in DMS which persisted during the following diatom bloom. This unexpected DMS deficit in the upper mixed layer DMS burden indicates a rapid microbial re-cycling of the DMSP with little conversion into DMS. The influence of iron fertilisation on oceanic DMS production is thus more variable than previously reported.

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VERTICAL DISTRIBUTION OF METHANOGEN COMMUNITIES IN ORGANIC-RICH SUBSURFACE SEDIMENTS OF THE PERU TRENCH

Sediment cores were collected from three deep boreholes (0-267 mbsf) during Ocean Drilling Program Leg 201 in February 2002. We examined the distribution of methanogens (methane-producing Archaea) and methanogen communities along geochemical profiles (incl. sulfate, methane, acetate, ethane) to determine shifts in community composition related to porewater chemistry. Specific focus was on hydrate-containing samples as well as the sulfate-methane transition zone. We phylogenetically analyzed communities by PCR-amplification of the methyl-coenzyme M reductase gene (mcrA), a key enzyme in methanogenesis and present in all known methanogens. Preliminary results indicate that methanogens were present throughout most of the sulfate reduction zone and that diverse communities of methanogens extended to depths of >200 mbsf.

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BIODIVERSITY AND FUNCTION IN MARINE SEDIMENTS: A MUDDLE OR A SOLVABLE MYSTERY?

Among scientists working in both shallow and deep-sea sediments, there has been a traditional separation of the 'bug counters' who generate diversity data and the ecosystem scientists who generate bulk measurements of processes and functions such as respiration, production and carbon burial. The few studies that have attempted to link diversity and function in marine sediments have yielded inconclusive results, and we are left to infer relationships largely from studies designed for other purposes. We will explore the forms of macrofaunal diversity that are most likely to influence sediment ecosystem function, highlight

the types of functions that might be most altered by changes in diversity, and suggest research approaches that are likely to be productive. We will identify instances where novel measurements are needed and explore natural variation in function in the marine environment as a potential research tool. For example, comparisons of deep-sea sediments where macrofaunal diversity is relatively high, with oxygen-stressed slope and shallow estuaries where diversity is low, could offer insight into the role of sediment biogeochemistry in linking diversity and function, and offer a springboard for experimental studies.

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A REGIONAL OBSERVING AND PREDICTION SYSTEM FOR HAWAII

The status of the Hawaiian Ocean Prediction System is discussed. Regional, high-resolution circulation and surface wave models have been implemented for the waters surrounding Oahu and Kauai, Hawaii. These models, plus planned models for Maui and Hawaii counties, provide the framework for assimilating a wide variety of observations of an observing system for the Hawaiian Islands and the surrounding regions. A unique aspect of the ocean prediction system is the development of technology for assimilating acoustic tomography data from the Navy's Pacific Missile Range Facility (PMRF) off Kauai. This technology is shown to be rather unique in that all the PMRF sources and receivers are bottom-mounted. An assimilation technique based on the Physical-space Statistical Analysis System (PSAS) is presented and discussed. The methodology provides a means of tomographically estimating salinities, temperatures, and currents over a large section of the PMRF underwater range and assimilating these estimates into the ocean circulation models.

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TOPOGRAPHICALLY INDUCED MIXING AND OCEAN PRODUCTIVITY.

Interactions between topographic features and the mean flow enhances mixing and results in hotspots of biological productivity in the equatorial Pacific. These features may dominate both the mean and variance in fluxes of nutrients to the surface, primary productivity, and fisheries yield in this region. Examples are presented based on shipboard, satellite and model analyses from this region.

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AN APPROXIMATE TREATMENT OF PH-DEPENDENT ADSORPTION IN REACTION-TRANSPORT MODELS

Sorption of a number of aqueous ionic species (such as Fe2+, Mn2+, PO43-, etc.) on sediment solid substrates has become a well-recognized component of reaction-transport models (RTM) for early diagenesis. However, up until now, the pH dependence of the corresponding adsorption coefficients has been rarely considered. Such omission becomes a significant disadvantage in systems with large pH variations, either spatial or temporal (e.g.lakes with seasonal variations in the bottom water pH). We introduce a non-linear adsorption coefficient that takes the adsorption pH-dependence into account. However, a RTM numerical code becomes consequently more complex since the adsorption equations are coupled to the pH balance equations. Based on the separation of time scales between adsorption and acid-base speciation reactions (typically, minutes vs. milliseconds), we suggest a novel approximation that deals with these computational difficulties. We compare the results from this numerical approach with benchmark results obtained from the method-of-lines in a simple model of iron diagenesis.

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FACTORS AFFECTING THE PERFORMANCE OF THE OPTICAL PLANKTON COUNTER IN LARGE LAKES: INSIGHTS FROM LABORATORY STUDIES

There has been a question as to whether accurate measurements of zooplankton concentration and biomass in large lakes and oceans have been obtained using the optical plankton counter (OPC). How the OPC measures and counts zooplankton can be affected by many factors including zooplankton species composition and density, OPC tow speed and angle, sea conditions, and phytoplankton blooms. Size, shape, orientation, and transparency are important variables of zooplankton species composition and sea conditions determine the size and amount of suspended solids that may distort zooplankton measurements. We performed laboratory experiments using polystyrene spheres, nylon rods, or live zooplankton in an OPC circulation system to gain an insight into some of the factors affecting OPC performance. Our overall conclusion is that the OPC accurately counts and sizes zooplankton at low zooplankton concentrations when other suspended particles are also low.

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RETRIEVING THE ABSORPTION COEFFICIENT AND SUSPENDED SEDIMENT CONCENTRATION OF COASTAL WATERS FROM HYPERSPECTRAL AND MULTISPECTRAL SATELLITE DATA

The processing of ocean color satellite data is usually carried out in two separate stages: atmospheric correction followed by retrieval of water constituents concentrations. The ocean is often considered dark in the near infrared (NIR) bands. In coastal waters where scattering from suspended sediments is significant, this assumption breaks down. This problem can be overcome by retrieving both the atmospheric and water characteristics simultaneously. We have employed a spectral fitting method to retrieve the optical properties of turbid coastal waters from hyperspectral data such as those acquired by the EO-1 Hyperion instrument. Scattering by suspended sediments and absorption due to CDOM and chlorophyll can be decoupled by this method. For multispectral data with a limited number of bands, the inclusion of the short-wave infrared (SWIR) bands in the spectral fitting model proves to be beneficial. In this paper, the method and results of retrieving the optical properties of coastal waters from Hyperion data are presented. The extension to high resolution multispectral data (such as Landsat, SPOT 5 and Ikonos) is discussed.

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SEDIMENT FOCUSING AND SOURCES OF SEVERE HEAVY METAL POLLUTION IN THE COASTAL AREA, TAIWAN

Severe heavy pollution has occurred in the coastal area adjacent to Taiwan most important industrial parks. In order to trace the sources of heavy metal pollution and to understand the mechanisms governing heavy metal deposition, a set of sediments covering the HsienChu rivers and coast areas were examined for its bulk sediment heavy metal concentrations. Extremely high concentrations of heavy metals (up to 2900 ppm Cu, 2680 ppm Zn, 1700 ppm Pb) were found in river sediments outside the industrial parks and its surrounding factories. In addition to the anthropogenic pollution, grain size and the sediment focusing effect are the most important factors governing heavy metal distribution. Heavy metal concentrations in unpolluted sediments displayed good linear relationships with respect to the percentage of fine-grained sediments. Focusing effect was observed from the higher sedimentation rate as well as the preferential deposition of fine-grained sediment in the central lagoon. Heavy metal concentrations in the Pb-210 dated core showed a marked increases since 1985, and corresponded well with the rapid expansion of the industrial parks. The high concentrations of heavy metal in river sediments and the increasing level of heavy metals in core demonstrated that the development of the computer industry is taking its toll on the surrounding environment. Proper pollution prevention measures are urgently needed to prevent further destruction of the coastal environment.

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MOLECULAR AND ECOLOGICAL CHARACTERIZATION OF THE PFIESTERIA-LIKE DINOFLAGELLATE CRYPTOPERIDINIOPSIS SP

We analyzed mitochondrial cytochrome b gene (cob) sequence and prey-predator dynamics for Cryptoperidiniopsis sp. (CCMP1828) and compared them with the morphologically similar dinoflagellate Pfiesteria piscicida. Phylogenetic analysis with cob as well as rRNA SSU and LSU showed that Cryptoperidiniopsis sp. was closely related to P. piscicida. In batch cultures with Rhodomonas sp. as food, a classical predator-prey oscillation was constantly observed. This sharply contrasted with P. piscicida, which typically depleted Rhodomonas sp. rapidly, leading to extinction of both the prey and the predator populations. Cryptoperiniopsis sp. increased, peaked, and decreased, following the dynamic of Rhodomonas sp.; the time lag between the prey and predator peaks was not significantly affected by food concentration or prey/predator ratio, with an average of 9.8 +/- 1.6 days. Regression analysis indicated that Cryptoperidiniopsis growth was strongly correlated with prey/predator ratio, with a threshold of 3.5 to support positive growth. We conclude that albeit genetically similar to P. piscicida, which is an imprudent and voracious predator, Cryptoperidiniopsis sp. had a contrasting prey-dependence apparently as a "prudent" predator.

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PHOTOSYNTHESIS GENES IN PROCHLOROCOCCUS CYANOPHAGE

Here we report the presence of genes central to oxygenic photosynthesis in representatives of two families of double-stranded DNA viruses (Myoviridae, Podoviridae) known to infect the marine cyanobacterium, Prochlorococcus. The genes for psbA and high light inducible proteins (hlis) were found in the three cyanophage investigated, while psbD, petE and petF were present in different myoviruses. These uninterrupted, full-length genes are clustered together in the phage genomes. Highly conserved amino acid sequences imply that these genes have been subjected to strong selective pressure, suggesting a functional role that affords an adaptive advantage for the cyanophage. Molecular phylogenies indicate that phage-encoded psbA, psbD and hli gene sequences cluster with Prochlorococcus strains consistent with their host range. This suggests that these genes are of common ancestry to those from Prochlorococcus and were horizontally transferred between host and phage. However, phylogenetic analyses of petE and petF were inconclusive as to the origin of the phage-encoded genes. We hypothesize that Prochlorococcus cyanophage encode functional genes that are involved in host photosynthesis during infection and may even be involved in functional diversification of some host photosynthetic genes.

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PATTERNS OF SEWAGE CONTAMINATION IN CORAL REEFS OF THE FLORIDA KEYS: HUMAN AND OCEAN HEALTH LINKAGES

Research over the last decade has shown deterioration in the reefs of the Florida Keys National Marine Sanctuary (FKNMS), while nearshore sewage contamination and human disease has been documented along the island chain. Here we demonstrate the potential distribution of sewage in the FKNMS, including the reef tract, by the molecular detection of human enteric viruses in the mucopolysaccharide produced by corals. Surface water, ground water and various coral species were sampled along nearshore to offshore transects in the Upper and Middle Keys. Samples were analyzed for bacterial indicators of sewage (fecal coliform bacteria, enterococci and Clostridium perfringens), using standard methods, and human enteroviruses, using direct RT-PCR. Both indicator bacteria and human viruses were infrequently detected in the water samples; however, indicator bacteria were found at levels up to two orders of magnitude greater in mucus samples, particularly at nearshore stations, and human viruses could be detected in mucus at all stations, including a protected reef 7 km offshore. Corals positive for viruses ranged from 93% nearshore to 70% offshore. The significance of these results relates both to the potential spread of sewage contaminants offshore, and in coral reefs, and to the potential human risk of disease from recreational exposure in these environments.

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SATELLITE DETECTION OF 2002 CORAL BLEACHING IN THE HAWAIIAN ARCHIPELAGO

During the 2002 summer, a major coral bleaching event occurred throughout the Northwestern Hawaiian Islands. The NOAA Coral Reef Watch's satellite near-real-time coral bleaching HotSpot/Degree Heating Week (DHW) monitoring system successfully detected the development of anomalously high Sea Surface Temperatures (SSTs) in the region during the summer and issued a warning of potential bleaching well before bleaching was reported. A field survey was conducted in conjunction with the satellite monitoring as well as in situ temperature observations from the Coral Reef Early Warning System buoys operated in the area by the NOAA Pacific Islands Fisheries Science Center, Coral Reef Ecosystem Division. In this study, the accuracy and efficiency of the satellite monitoring are examined using in situ observations. Retrospective HotSpot and DHW charts are derived from the NOAA/NASA Pathfinder Ocean AVHRR SST datasets for the region to investigate the relationship between the occurrence and magnitude of bleaching inducing thermal stress and major climate events, such as El Nino/La Nina, during 1985-2002. Highlighted events of anomalously high SSTs during the time period shown by HotSpot/DHWs demonstrate good agreement with bleaching observations.

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EFFECTS OF ZOOPLANKTON (COPEPODS) GRAZING ON MICROBIAL FOODWEB STRUCTURE: STUDIES CONDUCTED IN THE MISSISSIPPI RIVER PLUME AND IN THE COASTAL GULF OF ALASKA

The affects of micro- and mesozooplankton grazing on the size structure and species composition of phytoplankton communities varies because each grazer category consumes a different portion of the phytoplankton community. Furthermore, the biomass and composition of microzooplankton communities can be directly affected by mesozooplankton grazing. Here we demonstrate the direct and indirect affects of mesozooplankton grazing on the food web structure in two different study sites, the Mississippi River plume and the coastal Gulf of Alaska. In the Mississippi River plume, we measured the relative importance of micro- and mesozooplankton grazing on 3 size fractions of phytoplankton. We show how copepod grazing enhances the transformation of a diatom dominated phytoplankton community in the plume to a picoplankton dominated phytoplankton community in the open Gulf of Mexico. In the coastal Gulf of Alaska, we demonstrate the direct and indirect (cascading) effects of grazing by large copepods, Neocalanus spp., on the structure and composition of the pelagic food web. Neocalanus spp. fed directly on large phytoplankton and protozoa but cascade effects on the nano- and picoplankton were small.

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MEDFLUX: COMPARISON OF POC MEASUREMENTS IN BOTTLES AND IN-SITU PUMPS—TEST OF PRESSURE AND ADSORPTION EFFECTS

A discrepancy between POC estimates from samples collected in Niskin bottles and in-situ pumps is often reported. Two hypotheses have been proposed to explain the higher POC concentrations found in bottle samples: DOC adsorption to the filter is relatively more important in small volume filtrations, or the higher pressure differential across the filter in the pumps causes some material to be lost. We tested both of these theories in laboratory experiments as well as simultaneous sampling in the field (DYFAMED site). Using bottle samples, we found no evidence to support a difference in POC estimates due to changing filtration pressures between 0.2 and 1 atmosphere, which encompasses the range of both lab and pump filtration. We did find a DOC adsorption background on filters. However, even after adsorption correction using stacked filters, higher POC values were still observed in bottles relative to pumps at the particle maximum depth, while chlorophyll concentrations agreed well. Our results suggest that material other than phytoplankton cells may be responsible for observed POC discrepancies.

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DMS(P) DYNAMICS DURING A SPRING DIATOM BLOOM IN THE NORTHWEST ATLANTIC

Central to the understanding of the links between climate and oceanic biogeochemical cycling is the investigation of the seasonal variability of the marine source of DMS and the impact of food web structure on its production and fate. Diatom dominated food webs are generally considered to biosynthesize only a small quantity of dimethylsulfoniopropionate (DMSP), the precursor of DMS, but there are indications that large efflorescences of this taxonomic group may significantly contribute to sea-air fluxes of DMS during springtime. To test this hypothesis, DMSP and DMS distribution and production were studied during the spring diatom bloom in the northwest Atlantic in the course of an 8-day Lagrangian study. DMSP and DMS production and consumption rates were determined during short-term (6 h) incubations using bacterial inhibitors of DMS consumption in parallel to a method using the isotope 35S. The late growth phase and early senescent phase of the diatom bloom were captured. Preliminary results show massive loss of particulate DMSP to deeper waters via sedimentation of senescent diatom cells with little DMS net and gross production occurring in the surface mixed layer.

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WESTERN ARCTIC SURFACE SEAWATER CHARACTERIZATION DURING 2002 AND 2003 SHELF-BASIN INTERACTIONS CRUISES

The linkages between the arctic shelves and the adjacent ocean basin exhibit variability related to seasonal, annual and climate-scale changes. The purpose of this study was to understand how surface seawater expresses the physical, chemical and biological processes occurring during summer in the Chukchi and Beaufort seas. As part of the Shelf-Basin Interactions program, this study analyzed the underway surface measurements of temperature, salinity and fluorescence collected during the 2002 USCGC Healy and the 2003 RVIB Nathaniel B. Palmer cruises. The 2002 East Barrow transect exhibited heavier ice cover than in 2003, and these 2002 ice conditions were associated with lower surface temperature and salinity than 2003. The 2002 surface measurements indicated the section east of Barrow Canyon was the only shelf-basin transect with surface salinities above 28, whereas in 2003, surface salinities varied from 27 to 30, reaching 31 in the section east Barrow Canyon. These observations suggest that ice cover and water mass exchange control surface seawater characteristics. We expect these regional underway ecosystem measurements to respond to interannual and longer variations in ice cover.

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BIOFOULING CONTROL METHODS FOR OCEANOGRAPHIC INSTRUMENTATION AS COMPLILED FROM THE NOVEMBER 2003 ACT BIOFOULING WORKSHOP

Biofouling is the common factor affecting the proper performance of in water monitoring sensors, especially when deployed in the coastal zones. Although a variety of mechanical cleaning methods, coating applications of various material types and chemical control methods are practiced, there are very few clear guidelines for the application of specific biofouling control techniques to specific sensor types, platform types and environmental/operating conditions. The Alliance for Coastal Technology (ACT), as part of its Sensor Technologies Workshop Series, hosted an invitation-only workshop of over 25 environmental managers, research scientists, and private sector technology developers who are engaged in

development and use of in water monitoring sensors. The primary goals of the workshop were twofold. The first goal was to define the various existing and experimental biofouling control techniques practiced. The second goal was to match the identified techniques with specific sensor types, platform types and operational/environmental conditions. This paper will summarize will describe: the methodologies used to define biofouling problems, recommended biofouling control methods and recommended areas of continued research as it applies to biofouling control for submerged oceanographic instrumentation.

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GEOGRAPHIC PATTERNS IN THE DEMERSAL ICHTHYOFAUNA OF THE ALEUTIAN ISLANDS SHELF

We examined geographic patterns in the Aleutian Islands ichthyofauna from the individual to the community level of organization. At the highest level of organization, we found depth- and longitudinally-related trends in fish community composition. We also found geographic patterns in the diet composition of demersal fish predators. At a somewhat lower level of organization, cluster analysis indicated spatially-defined groups of rockfish and other similar species (such as Atka mackerel). Many of these species clusters showed unique geographic distributions within the Aleutian Islands region. At the individual level, we document longitudinal changes in Northern rockfish and Atka mackerel growth. We also examined geographic patterns in caloric density of several different demersal fish species. Many of the geographic patterns that we describe are coherent with the spatial changes observed by other authors in this session.

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PHYTOPLANKTON RESPONSE TO LOW ZINC CONCENTRATIONS UPON THE ADDITION OF IRON IN THE HNLC NE PACIFIC OCEAN

It is now clear that iron can act to limit phytoplankton growth in HNLC regions. However, the addition of iron and the resultant increase in phytoplankton growth causes a significant decrease in other bio-essential trace metals such as Zn. Iron and zinc enrichment experiments were carried out at Ocean Station Papa in the subarctic North Pacific and demonstrate that addition of iron reduces the bioavailable zinc concentration to 0.2 pM, which is lower than that established in culture experiments to limit phytoplankton growth. Zinc speciation results indicate that phytoplankton respond rapidly to low concentrations of dissolved zinc by producing zinc-binding ligands so as to optimize the availability of this essential element. Zinc-binding ligands increased by an order of magnitude (0.3 to 1.3nM) as the total dissolved zinc concentration decreased (0.08 to 0.03nM) over 8 days. The production of these ligands demonstrates a linear relationship with 9-fold increase in chlorophyll. This provides the first field evidence of how phytoplankton can respond to the low concentrations of zinc upon iron addition and perhaps a similar response occurs for other bio-essential trace metals.

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HYPERSPECTRAL ASSESSMENT OF BLOOM EVENTS OF THE HARMFUL ALGA, KARENIA BREVIS

Efforts to detect and monitor harmful algal blooms have the potential to be greatly enhanced by remote and in situ optical methodologies. However, there are outstanding questions regarding the amount of information available in spectral signatures of natural populations and the ability to deconvolve contributions by target species to bulk optical properties. We have examined this problem for the red tide species, Karenia brevis, using a variety of hyperspectral (high resolution spectral) methods. Measurements were conducted during bloom events of K. brevis off the west Florida shelf and included in situ hyperspectral measurements of remote sensing reflectance and inherent optical properties. Similarity indices between reference and sample fourth derivative spectra of absorption were significantly correlated with cell concentrations of K. brevis. Reflectance spectra pose a greater challenge for detection, as they must be partitioned into both backscattering and absorption terms due to water and other constituents using inversion algorithms. Preliminary results using a quasi-analytical algorithm to retrieve phytoplankton spectral absorption from hyperspectral remote sensing reflectance showed promise for detection and assessment of K. brevis bloom events.

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IMPROVEMENTS IN OCEAN COLOR OF CASE I WATERS FROM POLDER-2 IMAGERY

The optically most significant substances in case I waters are phytoplankton, detritus, dissolved material and inorganic particulates. Since the success of CZCS, the interpretation of ocean color in terms of chlorophyll concentration (Chl) is now well recognized. Besides Chl, recent studies have shown that marine absorption (a) and backscattering (bb) coefficients can be retrieved from ocean color observations. These parameters are essential for researches related to carbon cycle since they contain information on phytoplankton species, as well as on dissolved and particulate organic matters (CDOM and POC).
POLDER-2, launched in December 2002 onboard ADEOS-2, is the first ocean color sensor for which a and bb are routinely produced in addition to Chl. We will briefly describe the operational ocean color algorithm and present the first POLDER-2 ocean color results with particular emphasis on the validation of a and bb. We will then show applications based on these parameters such as the CDOM and POC estimate from a and bb or the characterization of phytoplankton groups from the bb/a ratio. Preliminary POLDER-2 products can be downloaded at http://smsc.cnes.fr/POLDER/A_produits_scie.htm.

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POTENTIAL CONTROLS ON INTERANNUAL PARTITIONING OF ORGANIC CARBON DURING THE WINTER/SPRING PHYTOPLANKTON BLOOM AT THE BERMUDA ATLANTIC TIME-SERIES STUDY SITE

Carbon export from the euphotic zone at the Bermuda Atlantic Time-series Study (BATS) is dominated by particulate organic carbon (POC) export and seasonal dissolved organic carbon (DOC) accumulation and subsequent convective export. We have compiled seasonal DOC accumulation and POC flux data during the course of the winter/spring bloom and examined potential controls on interannual variability of organic carbon partitioning. When expressed as fractions of cumulative primary production, a negative relationship between seasonal DOC export and POC flux was observed, that was in part, further related to relative abundances of Haptophytes and Prochlorophytes that account for ~60% of integrated chlorophyll biomass at BATS. Increased Haptophyte abundance resulted in higher seasonal DOC export and lower POC fluxes, with interannual variability in winter/spring Haptophyte abundance negatively correlated with the winter NAO index. This relationship suggests that Haptophytes are a more important component of the phytoplankton community when a negative NAO phase enhances winter/spring mixing and nutrient inputs. These findings support a recent hypothesis that increased stratification in the North Atlantic due to global warming could favor the blooming of diatoms over Haptophytes.

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CHEMICAL CUES FROM GRAZING COPEPODS SUPPRESS COLONY FORMATION IN PHAEOCYSTIS: WHEN BIGGER ISN'T BETTER

Numerous aquatic organisms induce morphological defenses in response to chemical cues from consumers. For example, some phytoplankton escape in size by forming large colonies after detecting chemical cues associated with grazers. We found the opposite pattern for the cosmopolitan marine alga Phaeocystis when it was being grazed by copepods. When exposed to mixed species of mesozooplankton, a single copepod species, or only chemical signals from these grazers, the alga grew primarily as solitary cells, with colony formation and the proportion of total cells within colonies both being suppressed significantly. When copepods were offered solitary cells versus colonies, they fed more on colonies, so Phaeocystis suppression of colony formation in the presence of copepods appears adaptive. Neither nutrients nor pH correlated with colony suppression. Up to 84% of the colony suppression occurring when Phaeocystis was directly grazed by copepods happened when only chemical cues were present and there was no direct contact with copepods. Therefore, assessments of Phaeocystis grazing based on colony counts may overestimate grazing and confuse understanding of trophic interactions and nutrient cycling in Phaeocystis-dominated ecosystems.

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USING MICROFISH TO IDENTIFY BIOSYNTHETICALLY METABOLICALLY ACTIVE BACTERIOPLANKTON IN THE OREGON UPWELLING SYSTEM

The goal of this project is to identify the phylogenetic groups of heterotrophic bacteria which are active in terms of substrate incorporation. We examined samples collected during a 2002 cruise in the Oregon upwelling system from three regions: eutrophic shelf, oligotrophic offshore and intermediate slope. Samples were incubated with tritiated leucine and processed following the cruise for microautoradiography and fluorescent in situ hybridization: MICROFISH. Our results indicated that beta-Proteobacteria were the most abundant substrate-active cells in slope waters. Over the shelf, cells incorporating leucine were numerically dominated by Cytophaga-Flavobacteria in the deepest samples, and gamma-Proteobacteria at the mid-depth and surface samples. The overall proportion of cells incorporating leucine was lower in offshore waters than in shelf or slope regions. As observed in other marine systems, there was not always a 1:1 relation between abundance of bacterial cells and the proportion of cells incorporating leucine.

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MOLECULAR BIODIVERSITY OF PICO-EUKARYOTES IN THE ARCTIC OCEAN

Three recent research programs in contrasting physical regimes in the Arctic Ocean underscore the heterogeneous nature of north polar seas and the widespread predominance of small-cell protists. Work in the freshwater-influenced Beaufort Shelf region (CASES-2002) showed that the less than 3 micometer fraction accounted for 35-75% of the total Chl a. Picocyanobacteria were present in all samples but pico-eukayotes accounted for most of the picophytoplankton biovolume. DNA extractions of samples from the Canada Basin (JWACS) showed that almost all microbial biomass was in the < 3 micrometer fraction. Similarly, our research in the Norwegian Sea (PICODIV-Arctic) indicated the predominance of less than 3 micrometer protists. Analysis of the latter samples by DGGE and clone libraries showed that this fraction contained diverse phototrophs and heterotrophs including; bolidophytes, stramenopiles, alveolates and cercozoans. These pico-eukaryotic assemblages were depth stratified and the communities could be followed horizontally along two separate transects.

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ORGANIC MATTER PATHWAYS TO ZOOPLANKTON AND BENTHOS UNDER PACK ICE IN WINTER AND OPEN WATER IN LATE SUMMER IN THE NORTHERN BERING SEA

We used stable isotopes to investigate organic matter (OM) pathways to macroinvertebrates under ice cover in winter and open water in late summer in the northern Bering Sea. Compared to suspended particulate organic matter (SPOM), euphausiids, copepods, and pelagic amphipods were enriched by 2.4-3.7‰ del13C, but only 0.8-2.9‰ del15N, suggesting substantial microbial activity on particles consumed. In sediments, del13C of OM was enriched by 3.4‰ over SPOM, with further enrichment of 1.4‰ in a benthic amphipod and ~2.6‰ in four clam species (4.8 to 6‰ above SPOM). However, del15N of these animals was only 0.9 to 2.9‰ higher than in SPOM. Active chlorophyll in subsurface sediments indicated rapid vertical mixing. We conclude that most OM consumed by clams and amphipods was not freshly deposited SPOM, but mostly reworked material containing much organic N synthesized in a microbial loop. Despite a large pool of sediment OM, annual and long-term patterns of reproductive success of the macrobenthos may still depend on the ice-edge spring bloom, whose magnitude and intensity may vary with changes in the extent and timing of winter ice cover.

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LARGE SCALE PATTERNS IN BIO OPTICAL PROPERTIES IN THE ATLANTIC OCEAN

The Atlantic Meridional Transect (AMT) utilises the biannual passage of the RRS James Clarke Ross, between the UK and the Falkland Islands, to undertake scientific measurements. Since 1995, 13 cruises have been made along this track. This has given a unique time series of measurements on an ocean basin spatial scale encompassing the major regions of the North and South Atlantic Oceans. In September the AMT track involves sampling in the boreal autumn and austral spring, returning for the UK the following April thus sampling in the austral autumn and boreal spring. We present a suite of optical measurements taken on AMTs 12 and 13 demonstrating patterns in spatial variation between biogeochemical provinces. Radiance and irradiance measurements are included, along with primary production based on Fast Repetition Rate Fluorometer (FRRF) measurements, and absorption and scattering spectra. We also present profile data of spectral absorption of the phytoplankton and CDOM from within the North and South Atlantic Gyres. Future plans for this methodology are discussed.

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MODELING AND FIELD OBSERVATIONS OF ALGAL BLOOMS IN SOUTH SAN FRANCISCO BAY, 3: INTRATIDAL PHYSICAL PROCESSES

Modeling of idealized lateral transport has shown that exchange of phytoplankton biomass between South San Francisco Bay's channel and adjacent shoals can control system-wide bloom development. Because of this apparent criticality of lateral transport, a fully two-dimensional hydrodynamic model was adapted to resolve many of the actual physical processes governing lateral mass exchange. This model captured many intratidal physical processes and aided the development of new hypotheses regarding the apparent disconnect between local phytoplankton growth rates and observed local biomass trends. For example, tidal-timescale oscillatory transport of biomass between positive growth and negative growth regions means that biomass may not accumulate locally despite positive local growth rates. Furthermore, long-term (tidally averaged) export of biomass can prevent a bloom from occurring in a region associated with positive local growth rates. Finally, tidal shallowing and deepening of the water column can control, on a local level, whether biomass increases or decreases over timescales of weeks or months; this is due to the nonlinear dependence of local depth-averaged photosynthesis and benthic consumption on time-varying water column depth.

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ENGAGING HIGH SCHOOL STUDENTS IN AN OCEAN SCIENCES CONFERENCE

California COSEE encourages high school and community college educators to take advantage of the vast amount of information and expertise available at the many scientific conferences held across the country each year. Conference poster sessions are particularly suitable for students, as they are similar to student science fairs. Students can gain knowledge on a wide variety of scientific topics as well as an appreciation for how science is done directly from those doing current research. An example of this successful approach occurred in 2001 when one hundred high school students attended the ASLO/AGU Ocean Sciences Meeting in Hawaii. Students viewed and discussed posters with researchers and participated in an informal panel discussion with several scientists. Student reports and comments were summarized in post-conference communication with the researchers, with many responding that the student interactions were the highlight of the meeting. For many of the students and their teacher the meeting was the best event of the school year. This incredible learning experience is being repeated at the 2004 Ocean Research Conference to provide this same opportunity to more local students.

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IN SITU VOLTAMMETRY: A SOLID-STATE SENSOR FOR MONITORING ESTUARINE REDOX DYNAMICS

An in situ submersible electrochemical analyzer (DLK-Sub-III) designed by Analytical Instrument Systems, Inc. was coupled to a microcat CTD for estuarine profiling. The electrochemical analyzer can multiplex up to four gold/amalgam electrodes (encased in durable plastic) to study key redox species (oxygen, sulfide and sulfur speciation). The system was deployed on the R/V Cape Henlopen's rosette/CTD system so that water samples could also be obtained. A comparison of CTD, Winkler, and in situ voltammetric measurements for oxygen will be given for a cruise in the Chesapeake Bay during summer 2002. The rate of descent of the package was about 1m per every 10-15 sec. Voltammetric scans were taken using cyclic voltammetry from -0.05 to -1.85 V at 1000 mV/sec scan rate. We describe the analyzer and electrodes by showing variability in the overlap of the oxic/anoxic interface (the width of the suboxic zone varies from 0 –3 m in a 30 m water depth). The analyzer is capable of continuous in situ monitoring of chemical parameters and is capable of being placed on moorings.

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WIRELESS DATA COMMUNICATIONS FOR THE US COASTAL OCEAN

Plans are emerging for an Integrated Ocean Observing System (IOOS) for the entire Coastal Ocean of the US. Apart from scientists, law enforcement coastal zone planners, public health organizations, recreational boating interests, maritime shipping, and a panoply of other constituencies need data and information products of many types from the Coastal Ocean that will be provided by the IOOS. To be useful, these data and information products must be collected and distributed in real time. Present wireless data communications solutions, which include commercial cellular or satellite technologies or custom line-of-sight radio networks, are not satisfactory for an operational system like IOOS. At a workshop sponsored by the Alliance for Coastal Technologies (see http://actonline.ws/Download/Telemetry_Report.pdf) the concept of a "U.S. Coastal Area Network" (U-SCAN) was developed that would consist of a permanent wireless infrastructure that covers the entire US coastal ocean that would be

accessible to any qualified individual or organization. This presentation will summarize the existing technologies for wireless data telemetry and communications in the US Coastal Ocean and outline the need, technical feasibility, and non-technical obstacles of a U-SCAN.

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CHROMOPHORIC DISSOLVED ORGANIC MATTER VARIABILITY INTHE WAKE S OF HURRICANES AND TYPHOONS: RECENT FINDINGS

Chromophoric dissolved organic matter (CDOM) absorption coefficient variability in the wake of Hurricane Gert was recently reported. Specifically, it was found that CDOM vertically mixed from deeper depths possesses a higher absorption coefficient than the photochemically degraded CDOM within the undisturbed pre-storm upper mixed layer. Herein, new findings are presented for all the global oceans during October 1997-to-August 2003: (1) hurricane or typhoon vertical mixing is a rather common phenomenon, (2) 198 named hurricane/typhoon CDOM wakes have now been identified , (3) hurricanes and typhoons can potentially play a significant role in ecosystem carbon flow especially in the vertical dimension, (4) the photodegradation depth gradient of CDOM, as corroborated by the wakes, suggests that a similarly diverse DOM cycling depth gradient may also exist, (5) to the extent that CDOM and nutrients are correlated, the CDOM signature may assist in establishing nutrient availability and DOM cycling in the surface layer/photic zone. The CDOM absorption coefficient inherent optical property is retrieved by radiative transfer model inversion of SeaWiFS water-leaving reflectances. The storm-induced variability of the retrieved phytoplankton absorption coefficient is small/undetectable.

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PATHOGENIC MARINE SNOW: THE POTENTIAL ROLE OF MARINE AGGREGATES IN THE TRANSMISSION OF A SHELLFISH DISEASE

We hypothesis that marine aggregates (e.g., marine snow, organic detritus, flocs) may facilitate the transmission of bivalve diseases by two mechanisms: (1) as reservoirs, if aggregates are enriched with pathogens; and (2) as vectors, if aggregates are more readily captured by the gills of suspension-feeding bivalves. Northern quahogs (Mercenaria mercenaria) have suffered severe mortalities from a protistan pathogen called Quahog Parasite Unknown (QPX). Detection strategies for QPX in aggregates have been verified using artificially-enriched aggregates generated on a roller table. In preliminary studies, we have detected QPX in quahog mucus, artificial aggregates made from seawater filtered by QPX-infected quahogs, and natural aggregates. Video from an endoscope positioned directly above the incurrent siphon shows all aggregates, smaller than the diameter of the siphon, enter the bivalve's pallial cavity. Any aggregates that are not ingested are collected at the base of the incurrent siphon until periodically rejected as pseudofeces. This is also the most common location for tissue infection in quahogs from Massachusetts, strongly suggesting that sequestration of pathogen-rich, aggregates in this area may provide an important pathogenic mechanism in disease development.

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CROSS-SHELF CIRCULATION AND TEMPORAL AND SPATIAL PATCHINESS IN LARVAL BIVALVE SUPPLY AND SETTLEMENT ON THE INNER CONTINENTAL SHELF OF THE MID-ATLANTIC BIGHT

The relationship between wind-driven cross-shelf circulation and larval transport and settlement was examined during the summer upwelling season in July at LEO-15. Near-bottom larval concentrations (in July, in 1996-1998) measured every 4 hours at two inshore stations at 12-m depth and one offshore station at 20-m depth showed that pulses of highest larval surfclam concentrations coincided with the arrival of warm water at the bottom sampling stations due to downwelling. Spatial distributions of bivalve larvae were further explored by adaptive sampling using a shipboard plankton pump (1998) and a plankton pump on a REMUS autonomous vehicle (2002 and 2003). Surfclam settlement experiments in July 1997 at three LEO-15 stations (two inshore and one offshore) indicated higher settlement during downwelling than during upwelling at one inshore station and one offshore station. Overall, surfclam settlement was higher inshore. The evidence suggests that surfclam larvae are moved offshore during upwelling, become concentrated at a convergence front, and are transported to the bottom inshore during downwelling.

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DELINEATING DWARF AND TALL RHIZOPHORA MANGLE STAND STRUCTURES USING STABLE CARBON COMPOUND SPECIFIC ISOTOPIC ANALYSES

Mangrove ecosystems are an essential component of (sub)tropical coastal environments. These highly productive regions reduce erosion and provide a habitat for marine life. Changes in the physical environment (sea-level) result in physiological stress to the mangroves, which can be reflected in R.mangle stand structure (dwarf and tall trees). Stable carbon and nitrogen isotopes can be used to discern dwarf and tall R.mangle leaves at the bulk (McKee et al., 1995) and molecular level (Smallwood et al., submitted). A taphonomic study has shown that bulk d13C values from R. mangle leaves (fresh - fossil) can be used to tentatively reflect stand structures from which the leaves originated (Wooller et al, 2003). Fossil leaves are preserved in peat cores to a depth of 10m (~8000 years) and a highly variable isotopic signature has been discerned down-core. We examine how compound specific isotope analysis can be used to compare the isotopic composition of recalcitrant n-alkanes (C21 to C36) and triterpenoids of fossilized R. mangle leaves in order to strengthen the interpretation of bulk d13C data and hence reconstruct past mangrove ecosystems.

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THE AUTONOMOUS VERTICALLY PROFILING PLANKTON OBSERVATORY PROVIDES REAL-TIME OCEANOGRAPHIC DATA TO EDUCATORS

The Autonomous Vertically Profiling Plankton Observatory (AVPPO), a bottom-mounted, winch-driven profiling system at the Martha's Vineyard Coastal Observatory near Woods Hole, Massachusetts, telemeters to shore biological, chemical, and physical data collected throughout the water column. Data, including digital images of plankton identified by artificial intelligence, are available on an interactive web site allowing users to select variables for real-time plotting and interpretation. A workshop held for educators introduced the AVPPO web site and available real-time data within the contexts of the coastal ocean, plankton populations, water transport simulations, and sea surface temperature and ocean color via satellite. Techniques in real-time data processing and interpretation, food web dynamics, tides, optical properties of water, and remote sensing by satellites were presented, as were activities for classroom use. Educators interacted with researchers to discuss how best to use the web site data in a classroom to observe ocean phenomena and develop questions and explanations of coastal ocean processes. Efforts are underway to integrate this newly accessible source of information into existing science curricula, and coordinate it with current practices, frameworks, and standards.

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VITREOSALPA GEMINI, A NEW SPECIES OF MESOPELAGIC SALP.

Salps are gelatinous planktonic animals that are abundant and important grazers of phytoplankton in the world's oceans. All species known to date live in the upper 200 m of the ocean, although some migrate daily to greater depths, sometimes as much as 800 m down. We have recently found a new, undescribed genus and species of salp in Monterey Canyon that lives entirely within the mesopelagic and bathypelagic zones, at depths between about 200 and 2200 m. We have observed, photographed and collected specimens using the MBARI ROVs Ventana and Tiburon during dives in 2001-2003. This species, Vitreosalpa gemini, is exceptionally transparent and fragile, and nearly invisible in the water. The sexually reproducing aggregates give birth to twin embryos, unique among all salp species. Being limited to the mesopelagic and bathypelagic zones, Vitreosalpa must rely entirely on detrital particles or small organisms as a food source. Their slow swimming speed and extremely low metabolic rate suggest that they require little food to survive, and are well adapted to the poverty of deep water.

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DISSIMILATORY SULFATE REDUCTION POTENTIAL OF PROKARYOTIC COMMUNITIES FROM MOBILE DELTAIC SEDIMENTS

Dissimilatory sulfate reduction plays a central role in the global sulfur cycle in suboxic-anoxic environments including tropical mobile deltaic mud belts. We explore the phylogenetic and functional diversity of the sulfate-reducing bacteria by characterizing PCR-amplified dissimilatory sulfite reductase (dsrAB) genes from 10-20 and >50cm depth intervals of deltaic muds along French Guiana and in the Gulf of Papua. The majority of dsrAB sequences retrieved had among their closest relatives sequences of uncultured sulfate reducing bacteria from deep-sea cold methane seep environments, napthalene mineralizing consortium and symbionts of Alvinella Pompejana and Olavius algarvensis inhabiting deep sea hydrothermal vents. Other close relatives were sequences from free-living low G+C Gram-positive, and delta-proteobacteria. The presence of dsrAB genes is consistent with permanent suboxic-anoxic conditions in these mobile muds. 35S radiotracer incubations showed significant gross but little net sulfate reduction. DSR gene analysis is thus a promising and specific approach for investigating sulfate reducing bacteria diversity in complex non-sufidigenic habitats.

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DIVERGENCE BETWEEN BIOLOGICAL AND GEOCHEMICAL SIGNALS OF N2 FIXATION IN THE TROPICAL WESTERN ATLANTIC

Previous attempts to quantify N2 fixation using biological and geochemical techniques have done so separately, yet there are differences between these independent estimates over the global ocean. To understand the mechanisms behind this discrepancy, we need to reassess any temporally and spatially collocated geochemical and biological data. As part of an NSF Biocomplexity project – The Potential Influences of Riverine and Aeolian inputs on N2 fixation in the Atlantic (PIRANA), we compared rates of N2 fixation by Trichodesmium and the endosymbiotic cyanobacteria Richelia intercellularis to the excess nitrate (DIN xs = N-16P) measured along isopycnals (26, 26.5 and 27) at stations sampled during three field surveys: January-Februray 2001, July-August 2001 and April-May 2003. While there were many stations where relatively high N2 fixation rates (100 to 900 micromoles N/m2/day) coincided with excess nitrate (>0), there were specific, repetitively sampled regions in which high N2 fixation rates coincided with depleted nitrate (DIN xs < 0). We examine the reasons, and implications for such a divergence and discuss the idea that the Western tropical Atlantic may be a significant source of excess nitrate.

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COMPARISON OF ESTIMATES OF MINERAL DISSOLUTION RATES IN OCEAN SEDIMENTS BASED ON U-SERIES DISEQUILIBRIUM AND MULTICOMPONENT REACTIVE TRANSPORT MODELING.

U-series disequilibrium between interstitial waters and primary and authigenic solid phases provide a method of estimating mineral dissolution rates for fine-grained ocean sediments. A model for mineral reaction rates based on U-series disequilibrium was developed and applied to a 50 m section of core from ODP Site 984 in the North Atlantic. Mineral dissolution rates inferred in this way are compared to rates determined from a multicomponent reactive transport model considering major element pore water geochemical profiles and physical parameters such as the sediment porosity, burial rate, and effective diffusivity of ions in the sediment. Both models make use of a parameter estimation method which optimizes model reaction rates to achieve an optimal fit of measured data. The effects of the temperature gradient, burial, and steady-state compaction are also considered in conjunction with geochemical and isotopic data. Reactive transport models often do not consider sediment compaction and the resulting differential burial rate of fluid and sediment on the overall system behavior—the incorporation of these physical processes provides a model that can evaluate long-term (circa 5 Mya) reactive transport processes in ocean sediments.

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VALIDATION OF REMOTELY SENSED OCEAN COLOUR PRODUCTS IN WESTERN AUSTRALIAN COASTAL WATERS

The state government of Western Australian has provided funding for research into the state's marine environment (SRFME - Strategic Research Fund for the Marine Environment). Coastal waters near Two Rocks (31 30'S 115 35'E) have been sampled monthly since February 2002. Temperature, salinity and fluorescence have been sampled underway from surface waters along a transect as well as through the water column at selected sites. Optical measurements have been collected with a Biospherical PRR-600, HOBILabs HydroRad-2 and a Curtin University developed hyperspectral radiometer. These data sets have been used to estimate concentrations of in-water constituents such as Chl-a (chlorophyll-a) and CDOM (chromophoric dissolved organic matter). In situ water samples have been collected and analysed for pigment composition and concentration, absorption coefficients for dissolved and particulate material and total suspended material. The instrument and in-water measurements have been used to validate MODIS (Moderate Resolution Imaging Spectroradiometer) and SeaWiFS (Sea-viewing Wide Field-of-view Sensor) ocean colour products for this area of the Western Australian coastline.

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INTERANNUAL VARIATIONS IN THE ABUNDANCE AND TROPHIC STRUCTURE OF EPIPELAGIC MESOZOOPLANKTON IN THE IONIAN SEA

The abundance and composition of zooplankton communities reflect the abundance and composition of their food resources, thus providing an integrated picture of the pathways at the base of the pelagic food webs. The abundance, specie composition and trophic structure of mesozooplankton have been analyzed to depict the epipelagic scenario of the consumer communities and evince the basic traits of the trophic food webs in the euphotic zone of the Ionian Sea. A temporal comparison has been performed on data obtained in the springs of 1988, 1992, 1999 and 2002 with the aim of discerning patterns related to the evolution of the physical dynamics in the basin. Overall, the epipelagic zooplankton showed very similar characters in terms of total abundance on the interannual scale. However, the distribution of species and trophic guilds indicated regional differences in the structure of trophic web and in the carbon flow. These horizontal features were remarkable in the spring of 1999 and seemed to be indirectly related to the influence of the Eastern Mediterranean Transient.

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THE ROLE OF COPPER IN THE HIGH-AFFINITY IRON TRANSPORT SYSTEM OF MARINE DIATOMS

In the oceans, the chemical speciation of Fe is dominated by complexation with strong organic ligands, yet little is known about how phytoplankton acquire Fe from these complexes. Our previous work has shown that Fe-limited marine diatoms possess membrane-bound enzymes that reduce organically complexed Fe(III) extracellularly, and promote the release of Fe(II) into solution. It is believed that this liberated Fe(II) must be reoxidized prior to uptake since only Fe(III) species are thought to be transported across the cell membrane. In yeast, such a reoxidative mechanism has been documented and shown to involve a multi-Cu containing oxidase. To investigate the presence of these oxidases in the high-affinity Fe transport system of diatoms, we examined the effects of Cu supply on the rates of Fe(III) reduction, Fe(II) oxidation, and cellular Fe uptake by Fe-limited diatoms. Our results indicate that Fe-limited diatoms promote both the reduction of organically-bound Fe(III) and the subsequent reoxidation of Fe(II) prior to uptake. Low Cu availability inhibits Fe(II) oxidation and cellular Fe uptake, suggesting that Cu plays an essential role in Fe acquisition by Fe-limited diatoms.

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VARIATION OF PIGMENT COMPOSITION IN RESPONSE TO LIGHT QUALITY

We present a method using calculations of the underwater light field to predict/describe phytoplankton pigment composition at depth. Our results allow us to examine how changes in water column constituents that alter the underwater light field, may affect the composition and function of phytoplankton pigments at depth. We identified stations from various cruises off the West Florida Shelf that exhibited extremes in chlorophyll and/or CDOM concentration. Optical and water column constituent measurements from these stations were used to develop input parameters to Hydrolight 4.1, a radiative transfer theory model, to simulate the underwater light field. Specific phytoplankton absorption spectra were deconvolved into pigment groups at depth, allowing us to examine how changes in water column contiuents affect pigment composition, and what this indicates about pigment adaptation to the existing light field.

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BIOGEOCHEMICAL FLUXES IN THE IONIAN SEA (EASTERN MEDITERRANEAN) IN RELATION TO HYDROGRAPHIC CONDITIONS

The temporal and spatial variability of particulate material, its production, transfer and sedimentation processes are studied at different locations in the Ionian Sea. In particular, the influence of the hydrological and dynamical structures on the production and transfer of biogenic particles to the sea floor is investigated. In fact the recent changes in the deep circulation of the Eastern Mediterranean (EMT) were shown to produce an uplifting of older water masses, with the nutricline rising up to the base of the photic zone in the Ionian Sea: this could possibly influence the biological productivity of this area. Total mass fluxes display a high spatial and temporal variability, with a well defined seasonal pattern and the biogenic component varies from site to site in relation to the hydrological and trophic conditions.

Comparison with previous biogenic fluxes shows significant differences in the phytoplankton assemblage composition of the settling material. In particular, some deep-living phytoplankton species display varying contribution to the biogenic flux and are thus shown to be highly sensible to changes in the water mass dynamics.

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TURBULENCE AND RESPIRATION RATES: EFFECTS BELOW THE KOLMOGOROV MICROSCALE (LK)

LK in the oceans sets a lower limit to an effect of turbulence on particle encounter rates to 0.7-0.07 cm. Nevertheless, experimental data suggest that picoplankton is affected by relevant levels of small-scale turbulence. However, enhanced encounter rates do not necessarily result in higher predator growth efficiencies if metabolic expenses under turbulence are enhanced as well. Growth of oligotrich ciliates has previously been shown to be affected negatively by small-scale turbulence but evidence is scarce. To test the effect of turbulence on respiration rates we incubated batch cultures of Strombidium sulcatum feeding on heterotrophic nanoflagellates (HNF) and bacteria as well as prescreened cultures in BOD bottles, using an orbital shaker. Respiration rates were higher under turbulence and correlated significantly just with HNF. Like previously established, turbulence had a harmful effect on ciliate growth rates resulting in higher respiration rates and lower growth with respect to the still control. HNF, in contrast, grew more efficiently under turbulent conditions. When released from grazing pressure, bacteria increased in biomass in the turbulent treatments but at lower efficiencies compared to the still control.

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THE USE OF DIGITAL HOLOGRAPHY TO OBSERVE ZOOPLANKTON BEHAVIOR

Digital in-line holography is utilized to observe free-swimming copepods and Daphnia and the local flow surrounding them. This technique uses a digital camera to record the interference patterns generated by particles illuminated with a collimated laser beam. Numerical reconstruction tracks the 3-D motion and in-focus images of the animals and the surrounding particles, which are used for local flow measurements, at the resolution of the CCD. Mirrors attached to the sides of the test section provide simultaneous orthogonal views. The measured feeding currents generated by a calanoid copepod vary markedly with swimming behavior. Horizontal drifting is accompanied by open streamlines, while sinking involves a recirculating flow. During maneuvers, the copepod utilizes its antennae to propel itself, and different parts of the body to stabilize its orientation. The measured flow enables us to determine the contribution of different parts of the body to momentum exchange with the surrounding flow, the forces involved required and estimate the energy expended during maneuvers. Interactions between species, including reaction to a swimming dinoflagellate that tries to escape, presence of large particles are demonstrated and discussed.

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CONTRIBUTION OF SAR11 BACTERIA TO DISSOLVED ORGANIC MATTER FLUX IN THE NORTH ATLANTIC OCEAN

SAR11 bacteria may account for 35% of bacterioplankton in the surface ocean, yet little is known about their involvement in marine biogeochemical cycles. Previous studies have reported that SAR11 bacteria are small and have few ribosomes, suggesting that SAR11 bacteria could be starving and playing only a limited role in the biogeochemical flux of dissolved organic matter. To determine the ecological activity of SAR11 bacteria, we used a combination of microautoradiography and fluorescence in situ hybridization (Micro-FISH) to measure the abundance and in situ assimilation of 3H amino acids and 35S-dimethylsulfoniopropionate (DMSP) by SAR11 bacteria in the coastal North Atlantic and the Sargasso Sea. We found that SAR11 bacteria were abundant in surface waters, accounting for 25% of all prokaryotes on average. More than half of SAR11 bacteria in these environments assimilated dissolved amino acids and DMSP, making them responsible for about 50% of amino acid and 33% of DMSP assimilation in surface waters. These data indicate that the SAR11 clade is highly active and plays a significant role in C, N, and S cycling in the ocean.

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IMPLEMENTING AN INTEGRATED OCEAN OBSERVING SYSTEM FOR THE UNITED STATES: STATUS AND PLANS

Congress has expressed support for the establishment of a sustained and integrated Ocean Observing System (IOOS) and has requested an implementation plan as part of the President's annual budget. The plan is to, "at a minimum (1) include an interagency governance structure; (2) define the roles and responsibilities of each agency in implementing and operating the system; (3) provide multi-year funding estimates by agency; and (4) include a process for regional coordination and technical support to ensure development of integrated regional systems with a national observing initiative." Ocean.US, the National Office for Integrated and Sustained Ocean Observations, has been charged by the National Ocean Research Leadership Council to formulate an implementation plan that responds to these mandates. The plan consists of three parts: (I) Purpose and Governance, (II) The Initial IOOS: Building on Existing Assets, and (III) Improving the IOOS: Enhancements and New Initiatives. Part I, II, and III address items (1) and (4), (2) and (3, short-term), and (3, long-term), respectively. This report provides an overview of the implementation plan and its status.

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GENOMIC STUDY OF THE PHYSIOLOGICAL BASES OF DIFFERENTIAL GROWTH IN INVERTEBRATE LARVAE

Variation in individual larval growth and survival has hindered efforts to predict recruitment success in the ocean. Insights into the causes of variation in these complex traits can be obtained through defined experimental crosses combined with quantitative genetics and genomics. We selected the bivalve Crassostrea gigas for studies of marine larvae because this species offers the unique advantage of having defined genetic families (inbred lines). We examined the genetic, biochemical, and physiological bases of differential growth rates by quantifying differences in the expression of all genes in slow- and fast-growing larvae of the same age, cultured in parallel under identical conditions of food and temperature. Of the 3.2 million cDNA transcripts that were expressed in all larvae studied, 220 were differentially expressed in fast-growing larvae. Several of these key “differential growth” genes appear to regulate fundamental processes such as macromolecular synthesis and turnover (protein synthesis and ubiquitination genes), and metabolic efficiency (mitochondrial enzymes). Understanding the genetic causes of variability in physiological performance will allow for better prediction of larval dispersal, recruitment, and population dynamics.

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DENSE WATER FORMATION IN THE SOUTHERN ADRIATIC SEA: WATER MASS STRUCTURES, PROPERTIES AND CIRCULATION IN THE EASTERN MEDITERRANEAN DURING 2001-2002

The recent changes in dense waters production and deep thermohaline circulation of the eastern Mediterranean have questioned whether climatic changes in wind stress curl and anomalies in the buoyancy and heat fluxes have influenced the upper thermohaline circulation and the water column stratification, respectively, in those regions prone to deep convection. The Southern Adriatic, which had shown a decrease of convective renewal of the bottom water between 1987 and 1995, returned to a state characterised by 'young' dense waters formed via deep convection along with dense waters flowing from the northern shelf region. Field observations conducted in autumn 2001 and spring 2002 as well as satellite images attest: (i) an evolution of the upper/external thermohaline cell circulation among the Adriatic/Ionian/Levantine system; (ii) a southward movement into the Ionian of a cold (fresh) water mass of Adriatic origin; (iii) a temperature/salinity front separating the Adriatic waters from the highly saline dense water previously discharged from the Cretan Sea (southern Aegean). The internal basin scale dynamics influence the diffusive and mixing processes among different water masses, altering the biochemical properties distribution.

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SEASONAL VARIATIONS OF DOC, CHLOROPHYLL A AND MICROBIAL ACTIVITY IN TWO LAGOONS IN CENTRAL ITALY: ORBETELLO LAGOON (TUSCANY) AND PAOLA LAKE (LATIUM).

The relationships between DOC, chlorophyll a and free bacteria abundance and activities (production, respiration and ectoenzymatic activity) have been investigated for one year, on a monthly sampling scale, in two lagoons. These eutrophic coastal systems receive important trophic loads from the drainage basins and are exploited for aquaculture activities. Both environments, showed higher Chl a (2.5-43.0 microgram l-1 in Paola Lake and 1.1-30.6 microgram l-1 in Orbetello) and DOC (2.8-6.0 mg l-1 in Paola Lake and 2.9-10.6 mg l-1 in Orbetello) with respect to coastal seawaters (0.01-5.3 microgram Chl l-1 and 0.9-3.4 mg DOC l-1). Bacterial abundance and production were similar in both the lagoons (0.2-6.0E+06 cells ml-1 and 0.03-1.6 microgramCl-1h-1), one order of magnitude higher than seawater (<0.7E+06 cells ml-1 and <0.14 microgramCl-1h-1). Notwithstanding these similar characteristics, ectoenzymatic activities showed significant differences in alkaline phosphatase /aminopeptidase ratio that let infer differences in trophic conditions.

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MESOSCALE VARIABILITY OF PHOTOSYNTHETIC PARAMETERS IN A HIGHLY DYNAMIC FRONTAL AREA (NORTHERN ADRIATIC SEA)

The Northern Adriatic Sea is strongly eutrophic mainly due to Po River discharge. Two different subsystems can be identified in a restricted area off the Po delta, separated by an ever-changing aline front. Recurrent algal blooms occur in the coastal area that is strongly influenced by the Po River, and very low biomass characterises the area outside the front. From 1996 to 1998 in the frame of the PRISMA2 Project, seven oceanographic campaigns were carried out covering all seasons in the area off the Po River delta. As data on phytoplankton physiology is lacking for the Northern Adriatic Sea the main aim of our study was to measure photosynthetic parameters in highly variable conditions ranging from eutrophic to oligotrophic areas, including a not well-understood frontal zone between them. CTD recordings were performed and size-fractionated chlorophyll a and phaeopigment concentrations were measured; PvsE experiments were conducted on samples collected along the water column. We discuss photosynthetic parameters taking into account phytoplankton size classes and the capacity of phytoplankton assemblages to respond to physical variations on short temporal and spatial scales.

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BACTERIA ASSOCIATED WITH TRICHODESMIUM COLONIES: PHYLOGENETIC DIVERSITY AND POTENTIAL ROLE IN IRON ACQUISITION

Trichodesmium are marine N2-fixing cyanobacteria that contribute significantly to new nitrogen pools in the tropical and subtropical oceans. These large, colonial phytoplankton provide a unique environment, characterized by a solid substrate combined with dynamic oxygen gradients and labile nitrogen and carbon sources, for many microorganisms. However, little is known about the phylogenetic or physiological diversity of the bacteria associated with Trichodesmium. We are interested in the potential for specific, perhaps mutualistic relationships between Trichodesmium and its associated microbes. In particular, we have hypothesized that bacteria closely attached to Trichodesmium may provide siderophores for use in iron uptake by the cyanobacteria. In order to identify bacteria that may have a specific relationship with Trichodesmium, clone libraries of SSU rRNA genes were analyzed for unique sequences that were present in the majority of the Trichodesmium colonies examined. One unique cluster of alpha proteobacteria SSU rRNA gene sequences was present in all Trichodesmium colonies tested from the Sargasso, Pacific and Caribbean. The distribution and diversity of these and other Trichodesmium associated bacteria, as well as their ability to produce siderophores, will be discussed.

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EFFECTS OF IRON LIMITATION ON THE ELEMENTAL COMPOSITION RATIOS IN PSEUDO-NITZSCHIA, A DOMINANT MARINE DIATOM DURING THE SERIES IRON ENRICHMENT EXPERIMENT

Phytoplankton cellular Si:N ratios have been suggested to increase under Fe limitation, due to either an increase in Si or a decrease in N uptake. During the SERIES Fe enrichment experiment in the subarctic Pacific, the addition of Fe resulted in a bloom of pennate diatoms dominated in cell abundance by the genus Pseudo-nitzschia. A return to low Fe concentrations and Fv/Fm values during the later half of the bloom suggests the phytoplankton were Fe stressed before full depletion of silicic acid, the cause of bloom termination. During this period, silicic acid to nitrate drawdown as well as bSi:PON depict an approximate 3Si:1N consumption ratio. Pseudo-nitzschia sp. was isolated from the bloom and grown in laboratory cultures to elucidate the causal factors resulting in this shift in the Si:N ratio. Fe-limited growth of Pseudo-nitzschia spp. resulted in an increase in the Si:N ratio, largely due to the decrease in the N cellular quota, confirming that the decrease in N uptake is the cause of the observed elevated Si:N ratio. This finding has important implications for biogeochemical cycling in HNLC regions.

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AN EDUCATIONAL WEB-BASED OCEAN CURRENT SITE

An educational web-based ocean current reference site is being constructed. Each major ocean current has a listing of important links, text and data plots. The text provides a detailed summary of observed velocities, transport, salinity, temperature, water mass characteristics, and seasonal variability for each current. Data plots include average and seasonal surface current fields derived from ship-drift, sea surface temperature maps, near-surface drifter trajectories, topographic maps, geography, video clips, circulation schematics, and output from numerical simulations by the HYCOM Consortium for Data-Assimilative Ocean Modeling. Examples for the Atlantic Ocean will be presented. A glossary of oceanographic terms, a tutorial on ocean circulation, a primer on ocean current observations, and a description of oceanography as a career are also on the site.

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ON THE USE OF STOCHASTIC BOUNDARY CONDITIONS IN NUMERICAL CIRCULATION MODELS

A second-order Auto-Regressive (AR) model parameterizing boundary conditions is developed and embedded in a simple quasigeostrophic ocean model. The parameters of the model were estimated using High-Frequency radar observations of surface currents off the coast of southern Florida. The AR(2) parameters for this near-shore domain correspond to a period of ten hrs and a turbulent decay scale of 3 hrs. Comparison of numerical simulations of western boundary flow with stochastic boundary conditions to simulations with traditional no-slip and free-slip conditions reveals significant differences in the formation of coherent mesoscale structures and the energetics of the western boundary current. In particular, different coherent structures, such as dipoles and submesoscale vortices, are simulated using stochastic boundary conditions, and the boundary current variability is more energetic and “episodic” compared to quasi-periodic circulation features in the simulations using conventional boundary conditions. The injection oh high-frequency vorticity, through the use of stochastic boundary conditions, leads to an increase in the low-frequency (O(1 yr)) component of the basin-scale averaged eddy kinetic energy.

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EFFECTS OF GEOCHEMICAL CUES ON ARENICOLA: ONTOGENETIC SHIFTS IN RECRUITMENT VS GROWTH

Laboratory experiments show that avoidance of disrupted habitats by new recruits of the polychaete Arenicola cristata is linked to local variation in surface chemical properties, with both low oxygen and high ammonium concentrations implicated as negative cues. Conversely, older arenicolid polychaetes (A. cristata and Abarenicola pacifica) may be attracted to elevated ammonium sediments. Field observations show an affinity of adult A. pacifica to regions of locally high ammonium concentrations (implantation of ammonium-spiked acrylamide gels columns) relative to control (unelevated) sediments. Lab studies of juveniles grown under different porewater ammonium concentrations and photic regimes show highest growth rates for A. cristata in elevated ammonium sediments in “light”. Sediment pigment analysis suggests growth is linked to light-driven benthic primary productivity. Juveniles exposed to elevated ammonium sediments in darkness had similar growth rates to juveniles in unspiked, “light” sediments; these rates and associated pigment concentrations were significantly lower than the light-elevated ammonium condition. The data suggest that geochemical effects on benthic infauna are spatially complex, and vary with organism age and resource dynamics.

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OPTICAL PROPERTIES OF OCEANIC CASE 1 WATERS: STILL AN ISSUE!!

During the late 1970’s, optical oceanographers successfully related variations in open ocean optical properties to changes in the chlorophyll a concentration. This ‘bio-optical assumption’ states that all optical properties of the open ocean (or Case 1 waters) are a simple and repeatable function of a single state variable, the chlorophyll concentration. Application of the

bio-optical assumption has provided a successful first order assessment of the optical properties of the open sea and remains a cornerstone of satellite sensed retrievals of the ocean biosphere. However, detailed observations over the past decade have demonstrated important divergences from this picture. Here, we review recent progress in the study of the optical properties of the open ocean using theoretical, field and satellite observations. Regional differences in bio-optical relationships are presented and interpreted in terms of their regulating processes. We introduce the emerging paradigm of an 'optical triangle' which relates the contributions of phytoplankton pigments (chlorophyll), biodetritus (chromophoric DOM) and particulate materials (particulate backscattering coefficients) to open ocean optical properties. Interestingly, the processes regulating surface manifestations of these three properties differ dramatically. Last, we show how blooms of distinct phytoplankton groups as well as the effects of atmospheric dust inputs can induce outliers from the standard bio-optical assumption. This review shows that many advances have been made over the past decade and point to new work to be done.

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RELATIONSHIP BETWEEN NUTRIENT LOADING AND ENVIRONMENTAL STATE FOR THE BALTIC SEA ENTRANCE

The Kattegat-Belt Sea waters form the entrance to the Baltic Sea. Nutrient loading heavily influences their environmental state and eutrophication problems like anoxia and decline in macro vegetation are widespread. Measures to reduce nutrient loading have been in place for two decades, and achieved some success. Key questions that arise are, what is an acceptable loading and what is the relationship between nutrient loading and the state of the marine ecosystem? Here we present an empirical modeling approach to answer these questions. A 14-year time series for transparency, chlorophyll and primary production was analyzed in relation to climate and nutrient loading (phosphorous and nitrogen). The models are able to explain about 90% of the inter-annual variation and show a consistent pattern in the response of the environmental parameters to changes in loading. Primary production is most responsive, with a 0.9% change per percent change in N-loading, and transparency the least, with 0.3% change per percent change in N-loading. This approach is a promising tool for elucidating the respective impact of external forcing variables (e.g. climate and loading) on marine ecosystems.

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EFFECTS OF FE, P, AND DUST ADDITIONS ON SILICON POOLS IN THE WESTERN TROPICAL ATLANTIC OCEAN

We investigated the effects of iron, phosphate, and dust additions on silicon pools in the western tropical Atlantic Ocean between 6º – 14º N and 48º - 58ºW. During a research cruise in April-May 2003, the nutrient environment of natural phytoplankton assemblages was manipulated in "mesocosms", 20 liter containers of seawater. Incubations of control and treatment mesocosms were terminal and samples were taken initially and after two and four days. Two experiments were conducted in each oceanic and lower salinity water, likely derived from the Amazon River plume. In the riverine-influenced mesocosms, biogenic silica concentrations (bSi) were generally unaffected by the treatments although they significantly decreased in one Fe treatment. We observed different results in the two oceanic mesocosms: in one experiment, dust addition resulted in increased bSi concentrations, while in the other, bSi concentrations increased relative to controls in all treatments. Thus, aeolian and riverine nutrient inputs to oceanic waters can have dramatic effects on diatom biomass in this region.

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THE MEASUREMENT OF PHYTOPLANKTON AND HETEROTROPHIC RESPIRATION IN THE OCEAN

There are many fewer observations of respiration in the ocean's plankton than there are of planktonic photosynthesis, because methods lack sensitivity and because autotrophic and heterotrophic components of respiration cannot be separately measured. Thus, the values reported for the ocean are all observations of "community" respiration. Here we propose a means whereby phytoplankton and heterotrophic respiration can both be estimated in ocean samples as reliably as we can estimate primary production. The calculation is relatively simple (based on the dark loss of carbon overnight), and we present tests of the method on data from two process studies from the Joint Global Ocean Flux Study (JGOFS): the North Atlantic Bloom Experiment (NABE) in 1989, and the Arabian Sea Expedition (in 1995).

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THRESHOLDS FOR PLANKTON YIELD IN COASTAL WATERS. SIGNIFICANCE OF INTEGRATED APPROACHES TO NUTRIENT INPUTS AND TURBULENCE CONDITIONS

We conducted a series of experiments to study the response of plankton to different turbulence and nutrient conditions. Natural plankton assemblages from Mediterranean and Norwegian coastal waters were enclosed in cylindrical containers and were enriched with a range of nutrient doses. Plankton response to nutrient additions was examined in turbulent and still conditions. Turbulence was generated by means of vertically oscillating grids. Mediterranean and Norwegian plankton communities showed differences in dose-response patterns. While in Norwegian communities the maximum achieved chlorophyll and particulate organic carbon increased with nutrient dose, in Mediterranean communities the response to nutrients leveled off at 8 micro Molar nitrate. We found turbulence to increase the chlorophyll and Particulate Organic Carbon maxima achieved. In Mediterranean systems the maximum effect of turbulence was found at intermediate nutrient loads, while in the Norwegian system the increase of biomass due to turbulence augmented with nutrient load. We will discuss the need of integrated approaches when defining thresholds for plankton responses to nutrient additions in coastal systems.

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CONTROLS ON THE CONCENTRATION AND STABLE ISOTOPIC OF GAS BUBBLE METHANE FROM ORGANIC-RICH MARINE AND RIVERINE SEDIMENTS

Variations in the concentration and stable isotopic composition of methane in gas bubbles from marine, estuarine and riverine anoxic sediments result from changes in production, consumption and transport processes. Rates of methane production and subsequent ebullition appear to control bubble methane concentration in NC coastal and estuarine sediments, Alaskan tundra lake sediments and Amazonian stream sediments. Dissolved N2 concentrations provide a direct measure of ebullition rates. The dominant process controlling methane stable C isotopic composition can be either production or oxidation. In tundra lakes methane oxidation appears to control variability whereas production processes appear to control variability in NC coastal and Amazonian stream sediments. Systematic seasonal variations in stable C isotopic variations are observed on monthly and annual time scales. Attempts to assess the magnitude and composition of methane gas bubble fluxes must consider temporal variability on these same times scales.

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CONNECTING THE NOAA NATIONAL MARINE SANCTUARIES TO CLASSROOMS THROUGH TELEPRESENCE

A remotely operated vehicle deployed in the National Oceanic and Atmospheric Administration's Monterey National Marine Sanctuary is controlled by visitors at the Institute for Exploration's Immersion Theater at Mystic Aquarium. Visitors to the theater experience the underwater ecosystem without even getting their feet wet. The National Marine Sanctuary Program, in partnership with the Jason Foundation for Education and the Institute for Exploration, is developing a technology-based education, outreach and science initiative called telepresence that can bring the national marine sanctuaries into aquaria, science learning centers, schools and homes across the nation. The telepresence program will integrate live video camera feeds with data streams as diverse as student-collected observations, satellite records, and measurements collected by monitoring stations in the Marine Sanctuaries. This framework will allow students to analyze the movement of satellite-tagged loggerhead turtles in the South Atlantic Bight, observe sea otters in the Monterey Bay kelp forest, listen to the songs of the Hawaiian Islands humpback whales, and interact with this information in its broader context to address current environmental and social challenges. By linking telepresence with system-wide monitoring, this initiative promises to excite students by bringing the Marine Sanctuaries and their vibrant ecosystems right into their classrooms.

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MOLECULAR DIVERSITY AND METABOLICALLY ACTIVE MICROBIAL COMMUNITIES OF A MUD VOLCANO SITE IN THE GULF OF MEXICO

Submarine “mud volcanoes” are defined as seafloor edifices that extrude/erupt mud and fluids. Although submarine mud volcanoes are distributed throughout the world, there is a surprising lack of knowledge regarding the microbial populations extant in these locales. As a part of our NSF Life in Extreme Environments funded project, the sediments of a mud volcano site in the northern Gulf of Mexico (GB 425) were obtained to characterize the microbial population structure and the metabolically active members of the extant communities. Nucleic acids (DNA and RNA) were extracted from GB 425 sediments and used to construct both cDNA (e.g. from genomic DNA isolation) and crDNA (e.g. from ribosomal RNA isolation) Archaea and Bacteria clone libraries at three distinct depths (0-2cm, 6-8cm, and 10-12cm). Archaea and Bacteria cDNA libraries were dominated by the Anaerobic Methane Oxidizing 2B clade (ANME-2B) and epsilon-Proteobacteria, respectively. Archaea and Bacteria crDNA libraries were dominated by ANME-2B and delta-Proteobacteria, respectively. Similar to previously described cold seep environments, rarefaction analysis of all libraries demonstrate that bacterial diversity is much greater than that of archaeal diversity. This study is one of the first to characterize microbial communities at the molecular level from a mud volcano site in the Gulf of Mexico.

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HOT SPOTS AND SPATIAL GRADIENTS IN THE MEDITERRANEAN TROPHIC REGIME: AN ANALYSIS BASED ON REMOTE SENSING.

The pioneering analysis of the spatial patterns of the autrotrophs distribution and activity in the Mediterranean, based on the coarse CZCS data set, has been recently revisited thanks to better quality and sampling frequency of the SeaWiFS time series. While most of the patterns detected in CZCS appear to be persistent features, the more refined observations by the SeaWiFS allow to better circumscribe the relevance of the few area were phytoplankton blooms occur in the basin to better reconstruct there dependence on the environmental forcing. Some of these areas have been more intensively studied to investigate the interannual variability of the phytoplankton blooms. This is the case of the southern Adriatic Sea bloom where the relation between atmospheric forcing and inter-annual variability of the bloom timing and intensity was investigated using a coupled physical-biological model and remote sensing data. It was demonstrated that fluctuations in SeaWiFS phytoplankton biomass could be reproduced only if the particular year’s nutrient pool is taken into account in addition to the variability of the atmospheric forcing. The possible impact of the EMT to the interannual variability of these enhanced blooms will also be discussed. The generally accepted feature of a strong trophic gradient among the Eastern and Western basin, may be better interpreted in light of the new data set as the result of a superposition of gradients at sub-basin scale.

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MODELING OF OCEAN CIRCULATION AND PROPERTY TRANSPORT THROUGH THE EASTERN ALEUTIAN ISLAND PASSES

Results from a regional ice-ocean model of the pan-Arctic region are analyzed to understand mass and property exchanges across the eastern Aleutian Islands. The model is configured at a 1/12-degree and 45-level grid extending from 30 N in the Pacific Ocean through the Arctic Ocean into the North Atlantic to about 45 N. Realistic daily-averaged atmospheric forcing for 1979-2001 is prescribed. The long-term mean ocean circulation and its seasonal to interannual variability are investigated. Monthly mean model output is used to calculate volume, heat and salt fluxes within the Alaska Stream and through the main eastern Aleutian passes. Comparisons of modeled hydrography, velocity, and sea surface height anomalies against in situ and remotely sensed data for selected time periods are presented. The role of mesoscale eddies propagating along the southern slopes of the Aleutian Islands on mass and property transport through some of the eastern passes is quantified. The relationships between variability of modeled upper ocean circulation, temperature and salinity distribution and some biologically relevant indices are investigated. Model limitations in representing narrow currents and small scale eddies are discussed.

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IMPROVING INDICATORS OF WATER QUALITY DEGRADATION IMPACTS FOR MANAGEMENT OF ESTUARIES AND COASTAL WATERS

Problems related to eutrophication such as low dissolved oxygen, harmful algal blooms and submerged aquatic vegetation loss are observed in 60% of U.S. estuaries (Bricker et al., 1999). An improved National Estuarine Eutrophication Assessment (NEEA) methodology is being used to assess these impacts in North Atlantic estuaries with the aim of providing improved decision support for management. These improvements provide the basis for more quantitative and reproducible results through use of environmental data related to estuarine condition rather than expert knowledge. Nonetheless, these indicators fail to convey the impact that degradation has on human uses of coastal systems. By combining bio-physical indicators with indicators of value related to human use, mangers will be better able to determine the efficiency/success of proposed management measures intended to reduce or reverse eutrophication effects. As an example, we develop an indicator of the value of recreational fishing in northeast estuaries that directly complements the NEEA eutrophication condition index and allows for a more complete assessment of estuaries.
(Bricker, Clement, Pirhalla, Orlando, Farrow. 1999. National Estuarine Eutrophication Assessment. NOAA, National Ocean Service, Silver Spring, MD)

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SBI DATA COMPARSION FOR 2002-2003: TEMPERATURE, SALINITY, DISSOLVED OXYGEN, AND SILICATE AT REPEATED SECTIONS IN THE WESTERN ARCTIC OCEAN

One of the objectives of the Arctic Shelf-Basin Interaction Program (SBI) is to identify seasonal and interannual variability in the waters over the Chukchi shelf, shelf break, and slope. We compare temperature, salinity, dissolved oxygen, and silicate data from four transects repeated during the three cruises in 2002 and one during 2003. The principal hydrographic features of each section are visible during each occupation. Close station spacing of 5 km on these transects during some SBI cruises was crucial to resolving mesoscale features. Variations in the property distributions from cruise to cruise may partly reflect changes in ice cover and cruise timing with respect to the annual biological cycle.

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TERRESTRIAL NUTRIENTS ON MICRONESIAN REEFS

The high islands of Guam, Yap, and Palau discharge significant amounts of NOx, NH4, reactive P, Si, and Fe from rivers to coastal reef communities. For Si, the dilution curves are typically conservative and Si is easily traced (to 1-2 uM) onto reef waters higher than 34 o/oo salinity. NOx and RP are typically lower than 50 nM, and Fe is delivered in a coagulate that remains suspended in heavily stratified surface waters out over the reefs. In the absence of uM levels of N and P, the relative enrichment in Si distinguishes these reef waters from adjacent upwelling, erosion of the thermocline by typhoons, and by ENSO- and internal wave-induced enrichment events.

In contrast, uplifted carbonate platforms such as Northern Guam, Rota, and Tinian have extensive aquifers that discharge nitrate-rich but Fe and Si-poor waters. These two geological settings provide a unique theater for comparative studies of the effects of different nutrients (e.g. NOx vs. NH4, low vs. high Fe) supplied to coral reef communities

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OVERVIEW: USING REAL-TIME OR NEAR-REAL-TIME DATA FOR EDUCATION

Almost 9% of 18-24 year olds in the US cannot find the Pacific Ocean on a map (http://www.nationalgeographic.com/geosurvey/). Scientists and educators need to work on issues like this as well as the difficulties of working with different state and national standards (that may not have much if any information about the oceans). Observatories have the potential to help reach the public and students. They will record the changing nature of the oceans, promote interdisciplinary research, and rely on novel and intriguing technology and tools that will engage a new generation of ocean scientists. Ocean science material is engaging even to very young students, but elementary and junior high teachers are frequently unfamiliar with the subject matter. (Only 3% of elementary school teachers have a college course in the geosciences.). Scientists are concerned about being overwhelmed with a flood of poorly validated and calibrated observatory data and the public is even more poorly prepared to deal with that flood of information. We know that there has never been a greater need for citizens informed about ocean issues and that ocean observatories can serve to illustrate many key concepts. However, much effort will need to be placed into providing the information in an easily assimilated context. This presentation will discuss some of the potential pros and cons with the expected flood of data coming soon to a terminal near you.

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TWO NOVEL SCYPHOMEDUSAE FROM THE DEEP SEA, REPRESENTING TWO NEW SUBFAMILIES WITHIN THE FAMILY ULMARIDAE.

This presentation will focus on two new scyphomedusae first observed in Monterey Bay, California with subsequent observations in the Gulf of California. These unusual medusae lack marginal tentacles and represent two new subfamilies (Stellamedusinae and Tiburoniinae) within the Family Ulmaridae. The new species vary in abundance, depth distribution, size, and coloration. Stellamedusa ventana is a relatively large scyphomedusa that reaches up to 9.4 cm in diameter. Specimens are rare, with only six observations in over a decade of extensive surveys of the Monterey Bay region. The white exumbrella and oral arms are covered with large nematocyst-laden projections which are able to capture food items of various sizes. Tiburonia granrojo may reach a meter in diameter and has a deep red coloration to the bell and arms. It also has a varying number (four to seven) of short, thick oral arms that extend beyond the bell margin. Tiburonia granrojo has been found in three areas in the North Pacific (Japan, Hawaii, US) suggesting a wide distribution.

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DISTRIBUTION OF OPTICAL CONSTITUENTS IN RESPONSE TO EPISODIC UPWELLING IN MONTEREY BAY

A primary objective of the Autonomous Ocean Sampling Network (AOSN) 2003 field experiment was to examine the ecosystem response to the Point Año Nuevo upwelling region. Towards this effort, a Wetlabs AC-9 meter, measuring absorption and attenuation at nine wavelengths, was incorporated into the underway system of the R/V Pt. Sur. Over 600 hours of underway AC-9, thermosalinograph and fluorometry data were collected between August 2nd and September 6th, providing surface maps of physical and optical parameters of Monterey Bay, CA. Weak southwesterly winds predominated through August 7th, transitioning to northwesterly winds > 10 knots. This caused a strong upwelling front to develop and persist for over two weeks. Sampling continued through the upwelling and followed its relaxation. To better understand the ecosystem response to the upwelling and subsequent relaxation, this study deconvolves spectral data into its relative optical constituents: CDOM, detritus, and three functional groups of phytoplankton. The dynamics of these constituents will be examined within the context of the upwelling event and their response to the changes in the larger scale physical environment.

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MODELING AND FIELD OBSERVATIONS OF ALGAL BLOOMS IN SSFB, 2: SPATIAL AND TEMPORAL VARIABILITY IN LIGHT

Spatial and temporal variability in light availability can help explain year-to-year variability in primary production. In 1990, a relatively large bloom (primary production of 67 g C m-2) occurred in South San Francisco Bay, but in 1991 a small bloom quickly terminated after a high wind event, resulting in primary productivity of only 18 g C m-2. These events motivated us to build into our evolving conceptual and numerical models of estuarine bloom dynamics explicit consideration of the wind, and its influence on the spatial and temporal variability of light in the estuary, and on the physical system that defines the growth habitat for phytoplankton in shallow coastal ecosystems. We specifically explored the processes influencing turbidity in the system, and in particular, the shoals. We propose that spatio-temporal variability in turbidity (and thus light availability) can be expressed as two indices for vertical and horizontal clearing of the shoal water column. These indices incorporate estuarine geometry (i.e. fetch, depth, width) and the interaction of processes operating over a range of timescales (i.e. wind, tides, sediment sinking, horizontal transport).

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THE ROLE OF OITHONIDS AND ONCAEIDS IN SUBTROPICAL/TROPICAL FOOD WEBS

The most abundant organisms of zooplankton communities in most marine epipelagic domains are metazoans that are generally neglected in planktonic studies because they occur in the size fraction that is not retained by the conventional 200 micron mesh nets and is not quantitatively represented in bottle samples. The adult component of this very small size fraction is dominated by cyclopoid and poecilostomatoid copepods, which are mainly represented by oithonids and oncaeids. We will present results on the small-scale vertical distribution and abundance of these two taxa collected from various locations in the open waters of the subtropical and tropical Atlantic Ocean. The samples were collected with multiple nets (64 micron mesh) in the upper 150 m water column in the late spring of 2000 and 2001. The patterns observed in the occurrence of oithonids and oncaeids are discussed in relation to the distribution of physical properties of the water column and the vertical structure of nanoplankton, which leads to an evaluation of the role of these small copepods within the epipelagic food webs in the warm ocean.

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INCREASING RIVER DISCHARGE IN THE EURASIAN ARCTIC: POTENTIAL CAUSES, AND CONSEQUENCES FOR BIOGEOCHEMICAL CYCLING IN THE COASTAL ZONE

While feedbacks between increasing arctic river discharge and global ocean circulation have been highlighted over the past year, the potential causes of these increases and their consequences for biogeochemical cycling in the Arctic Ocean have been given less attention. In this presentation we will consider the implications of changing Eurasian river discharge for biogeochemical cycling in the coastal zone in more detail. Increases in river discharge are no doubt accompanied by increases in the delivery of dissolved and particulate constituents to the coastal zone. But how does this affect biogeochemical cycling? The timing and location of constituent processing strongly depends on the seasonality of delivery. In addition, changes in the fluxes of individual constituents depend on what are the drivers of increasing discharge. The potential influences of increased precipitation, permafrost thaw, changes in fire frequency, and dam/reservoir construction on water and constituent fluxes will be evaluated. The results will then be discussed within the context of coastal biogeochemistry. Finally, we will summarize a new 4 year pan-arctic sampling effort to quantify constituent fluxes to the Arctic Ocean (the PARTNERS project).

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A MODEL FOR THE EFFECT OF FIDDLER CRAB BURROWING ON SEDIMENT MIXING AND RADIONUCLIDE PROFILES IN A SOUTHEASTERN SALT MARSH

Fiddler crabs are one of the principal agents of bioturbation in intertidal salt marshes. We examined the effect of fiddler crab burrowing on sediment reworking and the distribution of Pb-210 in a southeastern salt marsh. We present a modified version of the regeneration model of Gardner et al. (1987) to assess the effect of fiddler crab bioturbation on Pb-210 profiles. The modification takes into account the filling of abandoned fiddler crab burrows from both the infilling of surface sediment and the collapse of burrow walls. In this study we have validated the regeneration model by direct measurement of the parameters that characterize the dynamics of fiddler crab burrowing along a salt marsh topographic gradient. Direct field measurements of burrow density, turnover, and size were used as input to the model to produce predicted radioisotope profiles and then compared to measured profiles.

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LYTIC AND LYSOGENIC PHAGE-HOST INTERACTIONS IN SYNECHOCOCCUS ISOLATES.

A collection of 25 Synechococcus and 35 cyanophage isolates were obtained by the dilution method from natural seawater samples during a research cruise in the Gulf of Mexico during summer 1999. The Synechococcus isolates were tested for susceptibility to lytic infection by the cyanophages, which were initially, isolated using WH 7803 as host. The isolates ranged in susceptibility to the cyanophages from immunity to four of the 35 isolates (11%), to being immune to all cyanophages tested (100%). To date, eight isolates have been screened for lysogeny by exposure to the inducing agent Mitomycin C. Three isolates have demonstrated statistically significant increases in viruses over controls after induction. Despite the fact that one benefit conferred by lysogeny is homoimmunity, there has been no correlation between occurrence of lysogeny and resistance to lytic cyanophage infection. The three lysogenic Synechococcus isolates, designated GM9914, GM9904 and GM9923 were immune to 14%, 29% and 91% of the cyanophages respectively. However, the induced cyanophage from GM9914 has been examined by TEM and appeared to be a podovirus, unlike the lytic cyanophages isolates, which were myoviruses.

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ESTIMATING MOVEMENT AND ABUNDANCE OF ATKA MACKEREL (PLEUROGRAMMUS MONOPTERYGIUS) WITH TAG RELEASE DATA

A mark recapture experiment was conducted in Seguam Pass, Aleutian Islands, inside and outside a trawl exclusion zone to estimate local Atka mackerel (Pleurogrammus monopterygius) abundance around Steller Sea lion rookeries. In 1999 1375 tagged fish were released. A biomass of 76,679 metric tons (mt) was estimated outside the trawl exclusion zone. In 2000, 8773 tagged fish were released. An integrated tagging model estimated the biomass to be 117,900 mt inside and 82,057 mt outside the trawl exclusion zone. Movement rate from outside to the inside of the trawl exclusion zone was small (p=0.0056) and from inside to outside was potentially large (p=0.81) but associated with high uncertainty (95% CI: 0 -1). Tagging as a means of abundance and movement estimation seems to work well for Atka mackerel. Atka mackerel do not appear to move outside of their localized aggregations (< 70 km). This lack of movement might result in local adaptations to differences in small scale ocean conditions along the Aleutian Island chain.

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BLOOD AND TISSUE CHARACTERISTICS OF HEMISQUILLA CALIFORNIENSIS (CRUSTACEA: STOMATOPODA), A BURROW-DWELLING MANTIS SHRIMP WHICH ROUTINELY ENCOUNTERS HYPOXIA

Hemisquilla californiensis (HC) is a burrow-dwelling mantis shrimp which routinely encounters hypoxic conditions and can survive up to 48 hours or more in complete anoxia. We compared the properties of this species' tissue and hemolymph to those of the spot shrimp Pandalus platyceros (Caridea: Pandalidae) (PP), which inhabits an aerobic environment and dies within a few hours of anoxia, to find the biochemical adaptations that allow HC to survive in low oxygen. Both species accumulated lactate under anaerobic conditions, with the greatest levels in the hemolymph. HC accumulated lactate more slowly than did PP and tolerated a much higher lactate concentration in the blood before death. The buffering capacity of abdominal muscle and hemolymph in HC is no greater than that in PP, providing no added protection against acidification during anaerobiosis. However, HC tolerates a two-fold greater decrease in hemolymph pH before death than does PP. The capacity for survival in anaerobic conditions shown by HC is due both to a mechanism for reducing lactate buildup in the blood and to an increased tolerance for lactate and acidosis.

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BLUE WHALE FORAGING DIVES WITHIN DENSE KRILL SOUND-SCATTERING LAYERS OF THE MONTEREY BAY SUBMARINE CANYON.

Blue whales, in the waters off California, migrate through regions of seasonally high concentrations of krill. In 1996 and 1997, acoustic surveys and MOCNESS tows were conducted over the Monterey Bay Submarine Canyon to characterize the prey fields of foraging blue whales. These were then compared with whale diving patterns determined with time-depth recorders.
As observed during previous studies in this region, blue whales were found more frequently in areas of dense krill sound-scattering layers where the submarine canyon first drops off from the shelf. The sound-scattering layers of krill were orders of magnitude higher in density than the background levels observed in other deeper areas of the canyon or in shelf areas. The spatial extent of these scattering layers was quantified and visualized using the geostatistical technique of Kriging. Three-dimensional volumetric visualizations of blue whale foraging dives in relation to krill sound-scattering layers and the canyon topography will be presented.

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EDDY-DRIVEN SOURCES AND SINKS OF NUTRIENTS IN THE UPPER OCEAN: RESULTS FROM A 0.1 DEGREE RESOLUTION MODEL OF THE NORTH ATLANTIC

A nitrate-based model of new production is incorporated into eddy-resolving (0.1 degree) simulations of the North Atlantic. The biological model consists of light and nutrient limited production within the euphotic zone and relaxation of the nitrate field to climatology below. Sensitivity of the solutions to the parameters of the biological model is assessed in a series of simulations. Model skill is quantitatively evaluated with observations using an objective error metric; simulated new production falls within the range of observed values at several sites throughout the basin. Results from the "best fit" model are diagnosed in detail. Mean and eddying components of the nutrient fluxes are separated via Reynolds decomposition. In the subtropical gyre, eddy-driven vertical advection of nutrients is sufficient to overcome the mean wind-driven downwelling in the region and fuels a significant fraction of the annual new production in that area. In contrast, eddies constitute a net sink of nutrients in the subpolar gyre. Geostrophic adjustment to deep winter convection through mesoscale processes causes a net flux of nutrients out of the euphotic zone; the magnitude of this sink is sufficient to counterbalance the mean wind-driven upwelling of nutrients over much of the region. On the basis of these simulations it appears that the oceanic mesoscale has major impacts on nutrient supply to, and removal from, the euphotic zone.

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SUBMARINE GROUNDWATER DISCHARGE: AN OVERLOOKED PROCESS FOR THE TRANSPORT OF BIOACTIVE CONSTITUENTS INTO HAWAII'S COASTAL ZONE.

Submarine groundwater discharge (SGD) is direct discharge of subsurface fluids across the land-ocean interface and includes both fresh submarine groundwater and recirculated saline groundwater. In Hawaii SGD is now beginning to be recognized as an important process capable of transporting freshwater and bioactive constituents (e.g. nitrogen and phosphorous) to the coastal zone. We are using silica and chloride as natural chemical tracers to get a first approximation of groundwater input into two bays (Kaneohe and Maunalua) on the island of Oahu, and one bay (Kealakekua) on the island of Hawaii. Initial results show that at Maunalua and Kealakekua SGD is the dominant, and at certain times of the year the only, source of freshwater and nutrient input into the two bays. In Kaneohe Bay, pore water samples collected from sediment cores and hand dug pits exhibit depleted chloride concentrations that correlate with increases in dissolved inorganic nitrogen, phosphorus, and silica: the nutrients concentrations are at least 2 to 3 orders of magnitude greater than the overlying water column. The resulting concentration gradients results in an efflux of terrestrial-borne nutrients to the water column.

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BWF ARCHITECT AND ITS BEAR: MONTE CARLO MODELING AND ERROR ANALYSES OF BIOLOGICAL WEIGHTING FUNCTIONS REQUIRED FOR UVR-CORRECTED PRIMARY PRODUCTION MODELS.

We present BWF-Architect, an IDL-based code that combines field measurements of the spectral UVR inhibition of PAR-based production with determinations of spectral UVR exposures (290-400nm in nature), in order to derive biological weighting functions (BWFs) that quantify and predict UVR effects over a range of environmental circumstances. BWF-Architect is for use by scientists who use spectral UVR bandpass filters in their experimental design. BWF-Architect resolves an ideal spectral algorithm from an innumerable potential solutions via Monte Carlo modeling. BWF-Architect allows several degrees of freedom in setting fitting parameters and enables credible error analyses to accompany predictive modeling efforts. Currently we use a Rundle fit (with and without ozone-weighting) where the error envelope around a mean fit represents 500,000 possible solutions. We repeat one dataset analyses 20 times within a few hours. BEAR, an IDL-based code, imports BWF-Architect generated algorithms for further statistical analyses. BEAR estimates the value and error of operational and idealized Radiation Amplification Factors (RAFs), estimates of absolute dependency of a process on changes in atmospheric ozone concentrations. For examples, see Prezelin (ASLO-2004)

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FROM WIND TO WHALES: USING AN INTEGRATED OCEAN OBSERVATION SYSTEM TO UNDERSTAND CALIFORNIA'S UPWELLING SYSTEM

The Center for Integrated Marine Technologies (CIMT) has established a Coastal Ocean Observing System (COOS) in the Monterey Bay National Marine Sanctuary. CIMT is comprised of a comprehensive shipboard sampling scheme, mooring array, HF radar coverage and synoptic airborne radiometry and satellite based ocean color to provide 15 of the 20 most essential attributes of coastal marine systems as identified by Ocean.US. CIMT has addressed data management and communications concerns through readily available open source software to facilitate the creation of real-time visualizations of aggregate data sets originating from multiple data sources. The goal of CIMT is to develop this system to the point where it may be implemented in COOS sites nation-wide.

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THIN LAYERS AND THE TRANSPORT AND RETENTION OF MARINE PLANKTON IN COASTAL SYSTEMS

We present the results of a month long study of thin plankton layers in Monterey Bay, California. Our study reveals that thin layer dynamics are governed by physical processes from the mesoscale to the microscale. Seven individual thin layers of plankton were observed over a two week period during upwelling favorable conditions. These thin layers persisted on time scales of hours to days and were located predominantly in regions of reduced flow. In addition, though we observed internal waves modifying the vertical distribution of several of the thin layers, in no instances did the thin layers dissipate due to internal wave activity.

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CHEMICAL CHARACTERIZATION AS A TOOL FOR IDENTIFYING A DIAZOTROPH CONTRIBUTION TO DISSOLVED ORGANIC NITROGEN (DON) ACCUMULATING IN SURFACE MARINE WATERS

In large areas of the surface ocean dissolved organic nitrogen (DON) can be the most abundant form of reduced nitrogen. Yet the mechanisms leading to the production and accumulation of DON are unclear. It has been postulated that diazotrophs are a source of DON accumulating in surface marine waters. To address this hypothesis the chemical composition of HMW (>1kDa) and LMW (<1kDa) fractions of dissolved organic matter (DOM) isolated from various diazotroph-dominated sites in the Eastern Equatorial Atlantic and North Central Pacific Oceans were compared to data from other marine sites. Bulk compositional data were generated using NMR spectroscopy and elemental and isotopic analysis (d13C and d15N) while molecular level chemical and isotopic characterization of organic nitrogen was sought with monomer analysis, protein precipitations, gel electrophoresis and other biochemical techniques. Composition data from the field were further compared to DOM isolated from cultured Trichodesmium in order to ascertain the contribution from this particular diazotroph. Furthermore, DON isolated from Trichodesmium cultures was examined for its potential to serve as the sole nitrogen source for other marine phytoplankton.

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SCALE DEPENDENCE OF REACTION RATES IN POROUS MEDIA

In natural porous media, such as sediments or aquifers, a multitude of reactions takes place coupling different elemental cycles. Due to the system's complexity, an intuitive quantitative assessment of elemental turnover is often unfeasible and one has to resort to mathematical model simulations.
Such models commonly employ a continuum description of reaction and transport processes, and are often parameterized based on results from well-mixed laboratory experiments. However, when not taking into account the reactant distribution at the pore scale, reaction rates may not be estimated accurately. Here, the mismatch in reaction rate estimates associated with small scale heterogeneity is discussed based on a comparison between averages in representative elementary volumes and model results upscaled from explicit pore scale simulations. First, artificial porous media are generated and validated by calculating formation factors. Then, the consequences for biogeochemically relevant reaction kinetics are presented by comparing rates corresponding to the average concentrations in the REV to the ones obtained from averaging the rates within the pore space. Significant differences are observed in settings with fast nonlinear rate expressions and steep concentration gradients.

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EXOPOLYMERIC PARTICLES AND BACTERIAL ACTIVITY IN ARCTIC SEA ICE

Arctic sea ice is an important, structuring element of polar marine ecosystems and provides a vast low-temperature habitat for ice-associated bacteria. Recent studies show that sea ice sequesters large amounts of extracellular polymeric substances (EPS), contributing on average 30% to the particulate organic carbon pool. The ecological role of EPS in sea ice, however, remains largely unknown. Using in-situ incubations and a newly developed triple-staining method (Alcian Blue, DAPI, CTC) we determined the number of CTC reducing (i.e., actively respiring) sea ice bacteria living freely and associated with gel-like exopolymeric particles. Samples were taken three times at six different depths of Chukchi Sea coastal fast-ice during the winter-summer transition. Concentrations of exopolymeric particles showed strong vertical gradients and evolved during the ice algae bloom. It was found that exopolymeric particles harbored the majority (>60%) of the actively respiring bacteria. Hence, physi- and chemisorption may underlie biological viability. Our observations demonstrate that exopolymeric particles in sea ice are sites of increased bacterial activity and may act as hotspots of organic matter turnover in the sea-ice habitat.

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UNDERWAY PROFILING OF PHOTOSYNTHESIS IN NARRAGANSETT BAY, RI USING A FAST REPETITION RATE FLUOROMETER

In order to obtain high spatial resolution profiles of phytoplankton photosynthetic parameters in Narragansett Bay, a Fast Repetition Rate Fluorometer (FRRF) was deployed in an undulating towed sensor. Measurements were performed during a series of monthly monitoring cruises conducted jointly by the University of Rhode Island and National Marine Fisheries service between 1998 and 2003. Comparisons of FRRF-based estimates of primary production showed good agreement with the traditional radiocarbon method in controlled laboratory experiments, including diurnal studies in a 13 m3 mesocosm. Estimates of yearly carbon fixation in Narragansett Bay using the FRRF data also showed good agreement with historical estimates of primary production using the radiocarbon technique. The maximum production values in the bay occurred during the summer months of July and August. A north to south gradient of decreasing primary production was observed throughout the year corresponding to the gradient of decreasing nutrients and stratification.

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AGGREGATION AND RETENTION OF HETEROTROPHIC PROTISTS IN PREY PATCHES: INDIVIDUAL-LEVEL OBSERVATIONS AND POPULATION-LEVEL CONSEQUENCES

Recent field observations provide ample evidence that prey distributions of planktonic predators are non-uniform and patchy. The relative spatial distributions of predators and prey strongly affect trophic and demographic rates in planktonic communities. However, the abilities of different zooplankton species to respond to spatial and temporal fluctuations of prey are highly variable and largely unknown. To quantify predator responses to spatially heterogeneous prey, we developed video-based observation and computer analysis techniques that determine three-dimensional movement statistics of individual zooplankton predators in spatially-defined prey distributions such as linear gradients and horizontal thin layers. Using several species of heterotrophic protists as model predators, we quantified rates of aggregation to and length of retention within thin layers of phytoplankton prey in 24-hour experiments. Protists modified their movement behaviors and rapidly accumulated in thin layers of either prey cells or chemical cues of those cells (cell-free filtrate) and dispersed from the prey layer some hours later. The observed individual swimming behaviors provided parameters for a spatially-explicit model of protist distribution. Predictions from this model corresponded well to transients in experimentally observed distributions.

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UV PHOTOECOLOGY OF TOXIGENIC DIATOMS PSEUDO-NITZSCHIA AUSTRALIS AND MULTISERIES

A toxic bloom of Pseudo-nitzschia australis displayed a novel balance between severe UV-B inhibition and higher than usual UV-A enhancement of in situ primary production. The full range of UV-A wavelengths (320-400 nm) promoted enhanced primary production in near surface, high light intensity environments for this toxigenic diatom. This UV photoecology may be adaptive in that highest bloom biomass was observed at high intensity UV-A and PAR depths but just below the UV-B cut-off. A follow-up study with pure cultures in an outdoor UV growth facility supported the findings of the field study and further indicated that UV-B inhibition was related to inactivation of photosystem II while UV-A enhancement seemed to operate by yet unknown mechanisms outside of photosystem II.

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DEPENDENCE OF DIFFERENTIAL MIXING ON N AND RRHO

The extent to which temperature T and salinity S are mixed unequally by weak intermittent turbulence as prevails in the ocean interior is investigated by means of direct numerical simulation (DNS). A commonly held view, based on previous laboratory and numerical experiments and on microstructure observations, has been that the more microscopically diffusive component T is mixed more effectively than the less diffusive component S when both are stably stratifying. However, recent laboratory experiments (Jackson & Rehmann, JPO 2003; Hebert & Ruddick, GRL 2003) and a theoretical model (Canuto, et al. JPO 2002) have hinted that the opposite may occur, i.e. turbulent diffusivity of S may exceed that of T under at least some oceanographically relevant conditions.
This issue is examined by extending the DNS study of Gargett et al. (JPO 2003) to consider dependence on overall stratification (measured by Brunt-Vaisala frequency N), and on relative T and S contribution to stratification (measured by density ratio Rrho). A regime is identified in which turbulent mixing of S exceeds that of T.

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BIOTURBATION AND THE PRESERVATION POTENTIAL OF EVENT-BEDDING IN A GULF OF MEXICO SALT MARSH

Numerous studies have attempted to recreate tropical cyclone landfall frequency by examining coastal sediments for evidence of storm-induced deposition. Few of these studies have sought to establish or evaluate the preservation potential of storm beds in highly bioturbated sediments; intense mixing may destroy all but the thickest storm beds. St. Vincent National Wildlife Refuge, located in Apalachicola Bay, FL, provides a research area with minimal human impact and frequent occurrence of tropical cyclone landfall. Preservation potential is related to biologic mixing depth and intensity, storm layer thickness, and sediment accumulation rate. Storm deposition was detected by changes in bulk density, magnetic susceptibility, or lithology. Radioisotopes were used to quantify mixing depth and intensity as well as accumulation rates; mixed depths were ~5-20 cm, mixing intensity is estimated at ~10^1 cm^2 yr-1, and sedimentation rates are <3 mm yr-1. The most important control on preservation is the storm bed's initial thickness which is expected to be highly variable for each storm. Additionally, it may be possible to use the bioturbation depth and intensity to establish a reasonable estimate of initial thickness.

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INFLUENCE OF IRON ON DMS(P) CYCLING DURING A LARGE-SCALE IRON ENRICHMENT IN THE NORTH EAST PACIFIC (SERIES)

Rates of biological production and consumption of DMSP and DMS were determined during SERIES, a 21-day large-scale iron enrichment conducted in the North East Pacific HNLC region. The addition of iron rapidly induced a haptophyte bloom resulting in a large increase in particulate DMSP (DMSPp) concentrations. DMS concentrations also increased during the haptophyte bloom but were not significantly different from outside the Fe-enriched patch. Net DMS production rates and DMS yields were high but not significantly different from surrounding waters, suggesting that the bloom of DMSP-rich haptophytes did not significantly alter DMS dynamics. The haptophyte bloom was rapidly grazed leading to a rapid decline in DMSPp and DMS, coinciding with a short-lived peak in DMSPd bacterial consumption and a decrease in DMS gross production. The haptophyte bloom was followed by a diatom bloom during which low DMS gross production rates and yields maintained lower DMS concentrations in the Fe-enriched patch than in surrounding waters. These results indicate that during the crash of the haptophyte bloom and the subsequent diatom bloom, microzooplankton and bacteria rapidly metabolized DMSP with little conversion to DMS.

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MODELLING PLANKTON COMMUNITIES SUBJECT TO TURBULENCE

We will describe the modelling of enclosure experiments which investigated the effect of small-scale turbulence on plankton communities as part of the project NTAP (nutrient dynamics mediated through turbulence and plankton interactions). In the experiments natural plankton assemblages,taken from waters off the Norwegian coast, were subjected to various levels of turbulence and initial nutrient enrichment.
The model groups the plankton population as bacteria, autotrophic flagellates, diatoms, heterotrophic flagellates, ciliates and meso-zooplankton. Theory predicts that turbulence will increase the rate of nutrient uptake by diatoms and that low and moderate levels of turbulence will increase the rate of predation by meso-zooplankton but that high levels of turbulence will decrease it. In the experiments turbulence also decreased the amount of sedimentation by diatoms. Our model includes these three different effects of turbulence. Preliminary results show that the dominant effects of turbulence are the increase in diatom nutrient uptake and the reduction in diatom sedimentation, both of which lead to an increase in diatom concentration with turbulence, a result which agrees with experiment.

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EVALUATION OF GLOBAL RIVERINE FLUXES TO THE COASTAL ZONE

Estimates of global riverine fluxes to the coastal zone have greatly evolved since the pioneering work of Livingstone in 1963. In the late 1970's the development of new river density data bases and global runoff balance permitted a new set of budgets on major ions, particulate matter, carbon and nutrients. More recently the annual budgets of phosphorus and nitrogen have been spatialized at finer resolutions taking into account sources of nutrients and retention coefficients obtained through multiple regression analysis. While the ability to model the global hydrologic system has greatly improved, the major modeling limit is presently the lack of data (water analyses, human pressures, identification of reservoirs). As both sources and sinks of material are growing through human action, resulting trends will depend on local activities, and thus information on a sub-basin scale is needed. Anthropogenic factors are now equivalent or even exceeding natural control factors, thus defining a new era in the Earth's history – the Anthropocene.

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WHY DOES BIOTURBATION RESEMBLE FICKIAN DIFFUSION?

Macrofaunal bioturbation is generally large-scale and directional, so the basic assumptions underlying the biodiffusion analogy (i.e. Fick's first law) are violated. Hence, the theory favours the more general non-local exchange formalism. Nevertheless, tracer profiles observed in the field often resemble diffusive-type exponential profiles. This apparent contrast between practice and theory is termed the "biodiffusion paradox". To resolve this contradiction, we have constructed a series of eight non-local exchange models of deposit-feeding, accounting for four types of feeding behaviour and two types of locomotion. In order to investigate the conditions under which these models produce diffusive-like profiles, the corresponding integro-differential equations were numerically solved, and the output was compared to analytical benchmark solutions for the classical advection-diffusion equation. Corroborating theoretical considerations, smaller mixing lengths promote diffusive behaviour. In addition, random burrowing produces more diffusion-like profiles than unidirectional vertical burrowing. When only a single type of organisms is considered, significant deviations from diffusive profiles are observed. However, when parameters are tuned to more natural conditions, i.e. a community of different types of organisms in various size-classes, these deviations strongly diminish.

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TIME-SERIES OCEANOGRAPHY AT THE BERMUDA BIOLOGICAL STATION

BBSR is home to some of the longest open ocean time-series studies. Starting with the Hydrostation S time-series in 1954, an ever-larger series of ongoing ocean and atmospheric measurement programs have co-occurred near this location. Each has contributed to both the base knowledge in the marine and atmospheric science, while at the same time, the data and investigators associated with these studies have lead to some ground-breaking changes in the paradigms of the field. The co-location has also provided a synergy that has yielded further insights across fields. Some of these discoveries are linked directly to the data and the people involved. Others are facilitated by the identity of BBSR as a "visitor-focused" field station where housing and and labs are made available to people from many different institutions. The diverse people who cross paths at the combination of a marine lab and time-series stations produces a community of friends that go on to lead interdisciplinary research projects in many other areas. This combination of scientific, infrastructure and social features provides useful models for the development of other kinds of long-term observing systems and new generations of interdisciplinary research.

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PAST AND FUTURE EVOLUTION OF DIAGENETIC MODELS: A TUTORIAL

Modeling is a key component in most diagenetic studies. This prominent status of diagenetic models is due to their success in reproducing field observations, their ability to quantify (unmeasurable) processes and their impact on other disciplines. Early diagenetic models have evolved from one-component analytical models to multi-component numerical models and from molecular diffusion only to organism-induced or advection dominated transport. We are now at the stage that user-friendly public-domain codes are available, that data-assimilation techniques are being implemented and that multi-dimensional problems are studied. In this tutorial we will first give an overview of the history of diagenetic modeling and will then summarize the state-of-the-art. We will identify shortcomings in diagenetic theory, concepts and models and emphasize the need for dedicated experiments and theoretical studies that provide the foundation for further model developments. We will close with an overview of future developments.

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TEMPERATURE AND SALINITY TOLERANCE OF VIETNAMESE BAIT WORMS, NAMALYCASTIS SP.: IMPLICATIONS FOR ESTABLISHMENT OF A TROPICAL IMPORT IN THE SOUTHEASTERN USA

Large rag worms (Family Nereididae) of an undescribed species of the genus Namalycastis are imported from Vietnam and sold as fishing bait in the mid-Atlantic region of the USA. To determine where this tropical species could potentially become established, we investigated the temperature and salinity tolerances for comparison with coastal environmental data. Worms were maintained for several months in mud and plant detritus collected from mid-Atlantic salt marshes. Short-term laboratory experiments show that worms, while sluggish, survive temperatures as low as 13 C for 5 days and die quickly near 10 C. This lower limit is 7-10 C below that previously estimated for this species. Worms display a broad tolerance to salinity, surviving well from 1 to over 30 ppt when kept at 29 C. We have observed worms to fragment spontaneously under some conditions as well as the apparent regeneration of tail ends of some individuals. We conclude that temperature represents a strong determinant of their possible range. Moreover, these data greatly increase the potential range of this species along vegetated coastlines of the southeast USA.

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THE ROLE OF PHOTOCHEMISTRY IN A MESOSCALE FE ADDITION EXPERIMENT

The importance of photochemistry in marine biogeochemical systems has been established on many fronts. The absorption of ultraviolet (UV) solar radiation drives reactions that influence organic carbon cycles, ocean optical properties, trace gas dynamics, and trace metal redox and complexation chemistry. All four of these oceanic features can change dramatically during the ecological progression resulting from the addition of Fe to HNLC regions in the ocean. This presentation uses temporal UV optical data (spectral data for downwelling attenuation, water leaving radiance, and CDOM absorbance) collected at Ocean Station PAPA during the SERIES mesoscale Fe addition of July 2002 together with new and published photochemical efficiency data to calculate the magnitude of change expected for photochemical rates of Fe reduction, DOC photooxidation, and trace gas production and loss. Accurate quantitative calculations made from combining in situ optical data and appropriate quantum yield spectra are essential to the eventual full evaluation of photochemical significance to large-scale biogeochemical cycles.

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IDENTIFICATION OF METABOLICALLY ACTIVE MICROBIAL POPULATIONS ASSOCIATED WITH BEGGIATOA SP. MAT COMMUNITIES FROM GULF OF MEXICO COLD SEEP SEDIMENTS

A molecular-based approach was used to determine the composition of metabolically active microbial populations from two different Beggiatoa sp. mat communities present in sedimentary systems in the Gulf of Mexico. Ribonucleic acids (rRNA), extracted from three sediment depths (0-2, 6-8 and 10-12 cm) associated with overlying mat communities were collected from a research submersible (water depth 550-575 m). The metabolically active population was amplified with universal Bacteria and Archaea primers using a reverse transcription PCR (RT-PCR) method. Amplicons were obtained and used to generate clone libraries representative of populations at each sediment depth and at the two different pigmented (orange- and white-pigmented Beggiatoa sp.) mat communities. Analysis of 333 clones from the Archaea 16S crDNA library revealed that the sediments associated with these Beggiatoa sp. mats were dominated by ANME-2 Methanosarcinales (95% of total Archaea clones). In contrast to the archaeal results, bacterial diversity was considerably higher with the

dominant phylotype changing according to sediment depth. Differences between the orange- and white-pigmented mats are apparent as varying species prevalence within similar phylogenetic classes. This is the first phylogenetic-based description of metabolically active Bacteria and Archaea populations extant across a sediment depth profile associated with Beggiatoa sp. mat communities in the northern Gulf of Mexico.

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MICROBIAL RESPONSE TO SEASONAL PHYTODETRITUS DEPOSITION ON THE WEST ANTARCTIC PENINSULA CONTINENTAL SHELF: A COLD-LIMITATION HYPOTHESIS

Phytodetritus is deposited annually on West Antarctic Peninsula shelf sediments following the retreat of winter sea-ice. Much of this POM appears to be deposited rapidly on the seafloor, where it may degrade slowly due to low temperatures, and could represent a persistent “food bank” for detritivores. A seasonal study of the flux and fate of phytodetritus was conducted on the WAP shelf, sampling three stations along a cross-shelf transect in Nov 1999, Mar 2000, Jun 2000, Oct 2000, and Feb 2001. Fluorometric determination of chloropigments in sediments and sediment-trap material indicate occurrence of a highly seasonal deposition event. However, concentrations of labile organic material (Chl-a, EHAA) remain relatively high year-round, indicating presence of a sediment “food bank”. Microbial biomass (ATP) also remains high, with most seasonality limited to the top few cm. Sediment community oxygen consumption rates (~1.2 mol C/m2/yr) are comparable to rates measured in warmer temperate sediments, and do not fluctuate significantly throughout the year. We postulate that elevated concentrations of labile material are required to maintain microbial respiration rates due to low-temperature limitation of hydrolytic enzymes.

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INORGANIC CARBON ACQUISITION OF PHYTOPLANKTON POPULATION IN THE OLIGOTROPHIC ATLANTIC

Uptake of inorganic carbon species, CO2 or bicarbonate, by algae is the key factor to predict the response of oceanic biota to the anthropogenic CO2 emissions. Characterization of stable carbon isotopic composition of marine organic matter, depends largely on variations in the photosynthetic 13C fractionation, is thought to potentially provide insights into the mechanism of inorganic carbon acquisition in natural phytoplankton assemblages. In order to understand the algal physiology of carbon acquisition and its implication to biogeochemistry, we examined the 13C distribution of suspended particulate organic matter in surface waters of the subtropical and tropical Atlantic. The analysis of the variations in photosynthetic 13C fractionation implied that the mechanism for carbon uptake would differ between prokaryotic phytoplankton (mainly Prochlorococcus spp.) and the other eukaryotes in surface waters of the Atlantic, the former by active uptake of bicarbonate and the latter by passive CO2 diffusion. Such direct bicarbonate acquisition by Prochlorococcus spp., generally predominant over phytoplankton populations in the oligotrophic open ocean, would make the ocean productivity in this region insensitive to increase in atmospheric pCO2 levels.

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DEPLOYMENT OF A HETEROTROPHIC BIOLUMINESCENT BIOREPORTER TO ESTIMATE THE BIOAVAILABILITY OF IRON IN SEAWATER

Although bacteria are known to be critical to marine carbon cycles, it is only recently that interest in their role in marine Fe cycles has flourished. This surge of interest coincides with the discovery that more than 99% of the dissolved Fe in surface seawater is organically bound. Since the nature and origin of these ligands remains unclear, approaches to understanding the biological availability of these complexes need to be developed. To elucidate the differential bioavailability of Fe-ligand, we have developed a bioluminescent reporter. This study represents the first characterization of this organism in both a defined seawater medium as well as in marine surface waters. Laboratory characterizations have demonstrated that this reporter produces a linear response to Fe availability in our defined medium. Using this medium as a standard, we have performed two types of experiments to elucidate the availability of Fe in situ: Fe removal experiments using DFB and sequential dilution of surface water samples with our defined medium. Experiments deployed in the southern Pacific East Ocean have resulted in a classification of the surface seawater and have suggested the last El Nino event may have influenced surface water chemistry. Experiments in Subantarctic waters have also demonstrated that Fe availability may have been quite high while total concentrations (100-300 pM) were low.

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PHYTOPLANKTON DIVERSITY ALONG THE EASTERN-WESTERN NUTRIENT GRADIENT IN LONG ISLAND SOUND: TAXONOMIC AND PHYLOGENETIC APPROACHES

The historical high input of nitrogen compounds in the western Long Island Sound (WLIS) may have caused changes in phytoplankton abundance and species composition. To test the hypothesis, we analyzed microscopically and molecularly phytoplankton temporal distribution along the western-eastern axis in LIS. Results for 2002-2003 samples from the 10 sampling stations analyzed so far indicated predominance in phytoplankton by diatoms, especially during winter and autumn. Flagellates increased during spring/early summer and dinoflagellate increased in summer, both contributing to the diversified community structure during these seasons. Thalassiosira spp., Skeletonema spp., Thalassionema nitzschioides, Guinardia delicatula and Paralia sulcata were among the most abundant diatom species identified while Prorocentrum spp., Scripsiella sp. and Heterocapsa triquetra were the dominant dinoflagellates found in the samples. The <10um fraction analyzed using 18SrDNA revealed overall dominance by nanoplankton diatoms represented by lineages varying along the western-eastern axis, exhibiting high genetic diversity, and detected otherwise undocumented dinoflagellate and pelagophycean taxa. Shannon Diversity Index was slightly lower in spring and higher in autumn. Phytoplankton total cell concentration exhibited a clear gradient, decreasing from the western to the eastern LIS.

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STRUCTURE AND COMPLEXITY IN MICROSCALE FLUORESCENCE PROFILES

Variation in phytoplankton abundance below 10 centimeters may have ecological significance through grazing choice, nutrient competition and the spread of infection. To understand the magnitude and persistence of this variation we must know whether the fluctuations are random or created by specific mechanisms. Crucial to this determination is having a description of the pattern of variation. Using fluorescence measurements with 1mm sampling interval, we show that over distances of a few centimeters positive excursions from a baseline rise by a factor of ten, while negative excursions rarely drop by more than a factor of 2. From these results we conclude that microscale structure can be strongly influenced by processes of aggregation and clustering. Local sinking and shear appear to shape these small patches.

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CANADA'S ATLANTIC ZONE MONITORING PROGRAM: A MULTIDISCIPLINARY COASTAL OCEAN OBSERVING SYSTEM

The Atlantic Zone Monitoring Program (AZMP) was implemented in 1998 to collect and analyze the biological, chemical and physical data necessary to characterize and understand the causes of oceanic variability in Canada's Atlantic waters; to provide multidisciplinary data sets that could be used to establish the relationships among the biological, chemical and physical variability; as well as to provide adequate data to support the sound development of ocean activities. The sampling philosophy is based on seasonal sampling along sections to quantify the oceanographic variability; more frequent sampling at fixed sites to monitor the short term dynamics; fish surveys and remote sensing data for broader spatial coverage; and data from existing monitoring programs to complement AZMP data. Key to the field program is the oceanographic sampling at fixed sites (biweekly) and along sections (1-3 times/year) where standard variables are measured and phytoplankton and zooplankton samples are collected. The data and various products generated are available through the AZMP web site. As the length of the biological time series increases, various trends are becoming apparent.

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ANALYSIS OF COASTAL TIME SERIES (SEAWATER) TEMPERATURE OBSERVATIONS

The known rise in atmospheric carbon dioxide has led to an interest in the associated changes in temperature. We have analysed records from 3 databases of coastal temperatures, which may give insight into changes in terrestrial temperatures. Over the past 40 years there has been a significant upward drift in temperature, showing seasonal variations. Though temperatures appear to be similar, the rates of change are greater in the mid-summer and mid-winter periods, than in the transitional periods. The temperatures rise earlier in the spring. A 2-week shift is seen in both air and sea water temperatures. The basis for these seasonal differences is not fully understood. There is some degree of association between the seasonal rate of temperature rise and wind direction, but this is insufficient to explain the whole story. It is likely that the sea temperatures are driving the air temperatures, but the forcing mechanisms for this change are not clear. The general technique for averaging climate data over seasons loses this change.

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INTERANNUAL VARIABILITY OF SWORDFISH CATCH NORTH OF HAWAII

We have analyzed 7 years of pelagic swordfish catch and effort data from the Pelagic Fisheries Research Program. After integrating over the winter fishing season we find that the interannual variability in the catch per unit effort (CPUE) is substantial, with the catch rates varying by approximately a factor of two. We have used sea surface height data from the TOPEX/Poseidon altimetric satellite to show that an index that we refer to as an "eddy" index correlates highly with the swordfish CPUE. Despite the small number of degrees of freedom, this correlation appears to be significant. We will present possible explanations for the swordfish CPUE variability that are based on attempts to understand what large-scale oceanic variations give rise to the eddy index.

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IMPLICATIONS OF VARIABILITY AND UNCERTAINTY IN ACTIVE ACOUSTIC MODELING

Very few attempts have been made to address the impact of ocean variability and the resulting uncertainty in active acoustic modeling. This is a key issue in ocean acoustics since full knowledge of the environment can never be obtained. Although there is incomplete knowledge of the environment it is critical to understand what are the bounds of acoustic sensor performance. A report is provided that examines the generation of a distribution of ocean profiles based on a measured sample profile. From the distribution, a realization of a possible mean profile is extracted. The realization is then combined with a continuous internal wave field with an appropriate energy level, as well as spatial and temporal scales. This spatially varying field is then used within an acoustic model to generate estimates of propagation loss and reverberation. Distributions of the propagation loss and reverberation are built up over many realizations of the mean profile and internal waves. Preliminary results of our investigations and the implications of these results are discussed.

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DIEL PERIODICITY OF PHOTOSYNTHESIS COMPARED FOR DIATOM- AND PHYTOFLAGELLATE- DOMINATED ASSEMBLAGES IN CONTINENTAL SHELF WATERS OF THE WEST ANTARCTIC PENINSULA.

Diel periodicity in photosynthesis is widespread if not ubiquitous in marine phytoplankton communities. Lack of its recognition can lead to serious inaccuracies in estimates of primary production (Moline and Prezelin, 1997; Kim et al., 2003) and associated processes. As part of a strategy to measure/model time-corrected primary production for large regions of the continental waters of the west Antarctic Peninsula (WAP), we routinely incorporated 24 hour station monitoring of P-I parameters at several depths in hydrographically distinct locations within the overall transect grids. We present the comparative analyses of diel periodicity in Pmax, alpha, Ik, It, and the ratio It:Ik for diatom-dominated versus phytoflagellate-dominated water columns. Diatom-dominated communities were always associated with episodic, onshelf bottom intrusions of nutrient-rich Upper Circumpolar Deep Water (UCDW), which then upwells. Phytoflagellate-dominated assemblages arise because of succession during intervals between UCDW events. At any given time, a complex patchwork of these two distinctly different phytoplankton communities was commonly observed. Our aim is to assess whether a generalized pattern of diel periodicity might be reliably employed in bio-optical modeling when field data is not available.

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DIVERSITY OF MICROBIAL ASSEMBLAGES ALONG A TRANSECT FROM 42 N AND 43 S THROUGH THE INDIAN OCEAN

A transect from Italy to New Zealand, 42ºN to 43ºS, was sampled from 14 November to 16 December 2001, the MIPOT project (Mediterranean, Indian and Pacific Ocean Transect). A main aim was to study latitudinal changes in biogeochemical characteristics and microbial communities. CTD recordings and samples for inorganic nutrient concentrations, size fractionated HPLC pigment determinations as well as phyto- and microzooplankton samples were collected. Further, we determined the biochemical composition of dissolved and particulate organic matter, bacterial abundance and ectoenzymatic activity. The composition and physiological status of phytoplankton assemblages as determined by means of diagnostic and photoprotective pigments as well as the relationships between the autotrophic and detrital components were used for identifying biogeochemical provinces along the transect. In addition, microzooplankton abundance and, in particular, the distribution, diversity and trophism of loricate ciliates provided further evidence of differences in the microbial assemblages and trophic conditions between the oceanic provinces. The relationships between the detrital components, the autotrophic and heterotrophic microbial communities provide an insight in the functioning of the pelagic food web of the different oceanic basins.

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COPPER COMPLEXATION IN THE NORTH PACIFIC AND BERING SEA: RELATION TO THIOL DISTRIBUTION AND IMPLICATIONS FOR BIOAVAILABILITY

Copper complexation by organic ligands was characterized by cathodic stripping voltammetry in the north Pacific and Western Bering Sea in the summer of 2003. Results showed strong complexation in surface waters, in agreement with earlier studies, but also strong complexation at depths up to 1500m, in contrast with previous data reported by Coale and Bruland using a different method. At 3000m, however, there was no evidence of organic complexation. Deep water results have important implications for Cu - dependent microbial processes like denitrification and methane oxidation. Comparison with HPLC-derived thiol data provides insights about the nature of the chelators.

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RESOLVING NITROGEN, CARBON AND OXYGEN CYCLES FOR THE U.S. CONTINENTAL MARGIN WITH COUPLED CIRCULATION/BIOGEOCHEMICAL MODELS

A regional coupled 3D circulation/biogeochemical model has been configured to simulate the nitrogen, carbon and oxygen cycles for coastal ocean regions of the U.S. Continental Margins including the East Coast, Gulf of Mexico and West Coast. The model is the Regional Ocean Modeling System (ROMS) that has been developed to simulate both ocean circulation and biogeochemical processes. ROMS uses a discretization of the hydrostatic primitive equations in 3D-curvilinear, boundary-following coordinates with a variable free surface and a realistic equation of state. The circulation model is presently coupled to a multi-component biogeochemical and pelagic ecosystem model that includes variables such as oxygen, total carbon dioxide, alkalinity, nitrate, ammonium, large and small detritus pools (both N and C), phytoplankton, a time varying chlorophyll to phytoplankton ratio, and zooplankton. The code has been developed to afford easy user flexibility either through full biogeochemical model replacement or through individual model modifications. Numerical experiments were carried out to investigate the link between ecosystem function, nutrient supply and biogeochemical pathways for the U.S. Continental Margins. Model results will be presented and discussed in relation to satellite and in situ data comparisons and the effect that the pelagic ecosystem has on the carbon budget.

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DEVELOPMENT OF A NOVEL BIOFILM ASSAY FOR SCREENING BIOLOGICAL EXTRACTS

Marine flora have recently become an important source of possible natural products, as a result of the recent discovery of chemical defense strategies used by several seagrass and algal species to regulate microbial fouling. Improvements in extraction technology, separation science and spectroscopic instrumentation have made possible the isolation and structural identification of an array of secondary metabolites with functions such as feeding deterrents, pesticides, antiviral agents and finally, those impacting cell-cell communication. However, there is presently a lack of simple and reliable bioassays that can quantify the effect of secondary metabolites on biofilm formation. The present study presents a bioassay coupled with microscopic examination that promises fast, inexpensive, and efficient screening of secondary metabolites for their effect on biofilm characteristics.

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NEAR-SYNOPTIC AUTONOMOUS SPATIAL SAMPLING OF COASTAL MULTI/HYPERSPECTRAL APPARENT/INHERENT OPTICAL PROPERTIES

To better understand the inherent complexity of coastal environments, there is a need for near-synoptic in-situ mapping of physical, biological and optical parameters on relevant horizontal and vertical scales. Autonomous underwater vehicles (AUV) offer the navigation and payload capabilities to sample significant spatial domains in near shore environments at relevant resolutions. We have developed an AUV with an integrated sensor package that measures multi/hyperspectral apparent/inherent optical properties and a suite of traditional parameters, which provide a number of applications for coastal oceanographers. Multispectral upward irradiance and downward radiance sensors provide remote sensing reflectance and attenuation, and allow for near-synoptic spatial validation of aircraft and satellite ocean color products. A hyperspectral absorption meter distinguishes between optical constituents using absorption deconvolution techniques and phytoplankton taxa using similarity indices. Fluorescence, spectral backscatter, conductivity and temperature sensors provide traditional oceanographic measurements for validation and environmental context. Finally, an ADCP provides the 3D current structure around the vehicle as well as bottom bathymetry for validating the effects of bottom reflectance on leaving radiance. Data collected from AUV deployments in MA, FL and CA will be used to demonstrate these applications and the utility of the vehicle for coastal oceanography.

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INTERANNUAL VARIABILITY IN EKMAN TRANSPORT OF NUTRIENTS ALONG THE PERIPHERIES OF THE NORTH ATLANTIC SUBTROPICAL GYRE

Previous studies using climatological wind stress data have shown that Ekman transport can bring significant amounts of nitrate across the northern and southern boundaries of the north Atlantic subtropical gyre. In the present study, wind stress estimates derived from QuikScat satellite imagery collected from 2000 to 2003 are combined with nutrient measurements made during the Word Ocean Circulation Experiment to examine interannual variation in Ekman transport of nitrate into the north Atlantic subtropical gyre. Preliminary results indicate that there is significant interannual variability in nitrate transport across both the northern and southern boundaries. Annual anomalies in northern and southern boundary transport appear to be out of phase with each other so when annual nitrate transport across the northern boundary is anomalously high, the southern boundary transport is often anomalously low.

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ON THE HYDRODYNAMICS OF SOUTH SAN FRANCISCO BAY: WHY EVERYTHING FROM TIDES TO TURBULENCE MATTERS

South San Francisco Bay (SSFB) is a shallow, wind-whipped tidal lagoon that can also behave like a partially mixed estuary, or even in very wet years, a strongly stratified, estuary. Setting the stage for the other talks on SSFB, I will review a set of hydrodynamic processes of ecological significance operant in SSFB ranging from turbulence due to wind wave tidal flow interactions, to stratification dynamics, to large-scale mixing associated with spatial variability in tidal motions. Much of the behavior of the system is determined by its bathymetry, a narrow 10m deep channel cut through wide 2m deep shoals. Wind waves can be important in the shoals whereas stratification can be important in the channel. Finally, while tidal time-scale current variability can be accurately modeled, our understanding of inter-tidal residual flows, especially those associated with buoyancy driven exchanges between SSFB and the rest of San Francisco Bay, is rather limited. This limitation may hinder our ability to predict how SSFB may respond to future changes in freshwater inflows, geometry, or tidal prism that may occur naturally or by human design.

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ATMOSPHERIC CORRECTION OF OCEAN COLOR DATA IN CASE-II ENVIRONMENTS

We have developed an algorithm named Tafkaa for remote sensing of ocean color from space and aircraft that allows quick atmospheric correction of hyperspectral and multispectral data using lookup tables generated with a modified version of Ahmad & Fraser's vector radiative transfer code. Utilizing spectral bands beyond 1 micrometer allows us to derive atmospheric correction in shallow areas and in areas with high sediment loads. We present results of atmospheric correction of AVIRIS and MODIS imagery from a variety of coastal locations.

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QUANTIFICATION OF NITROGEN FIXATION BY UNICELLULAR DIAZOTROPHS IN OLIGOTROPHIC WATERS

Recent biological and geochemical studies have demonstrated that biological N2-fixation plays a critical role in supporting new production in oligotrophic areas of the ocean, though the identity and activity of oceanic diazotrophs remains poorly known. Recently, unicellular diazotrophic cyanobacteria have been found to comprise a significant fraction of the picoplankton community in the North Pacific central gyre, and a variety of molecular and isotopic evidence suggests that these unicells could make a significant contribution to oceanic new production. We carried out direct, stable isotope tracer measurements of nitrogen fixation by small diazotrophs in various parts of the Pacific, including the waters off Hawaii where the unicellular diazotrophs were first characterized. Nitrogen fixation by these small, frequently overlooked diazotrophs contributed about 500 micromoles new N per square meter per day across broad reaches of the Pacific. These rates are greater than those typically measured for larger, better known organisms such as the colonial cyanobacterium Trichodesmium and the heterocystous endosymbiont Richelia. Our data imply that small diazotrophs may support a significant fraction of total new production in the oligotrophic ocean.

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TOWARDS DATA ASSIMILATION FOR PRINCE WILLIAM SOUND, ALASKA OCEAN CIRCULATION NOWCAST/FORECAST SYSTEM

The Princeton Ocean Model(POM) has been implemented for Prince William Sound (PWS),Alaska with ca. 1km horizontal resolution and 20 sigma levels in the vertical. A Nowcast/Forecast System (NFS) has been established with wind-forcing from a mesoscale atmospheric model, heating/cooling from climatology, runoff from a hydrological model, tidal forcing from a regional model, and throughflow forcing from historical data at the open boundaries. The greatest uncertainities are associated with the latter. Because the local coastal sea level data are correlated with the historical throughflow data on the atmospheric synoptic and intra-seasonal time scales, and since the coastal sea level data are available in near-real-time, a basis is provided for coastal ocean data assimilation in PWS/NFS, as demonstrated here.

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TARGET STRENGTH AND PREDICTED BIOSONAR DETECTION RANGES OF THREE EXPERIMENTAL GILLNETS: A METHOD TO REDUCE MARINE MAMMAL BYCATCH

Small cetaceans are often caught as bycatch in gillnet fisheries. One potential method that has been shown to reduce harbor porpoise bycatch is the use of barium sulphate (hypothesized acoustically reflective) enhanced gillnets. To determine acoustic reflectivity, this study compared the target strength of two experimental gillnets; a barium sulphate and an iron oxide gillnet, with a comparable control monofilament gillnet at 0º, 10º, 20º, 30º and 40º. At normal incidence, all nets measured were not different in target strength and biosonar detection ranges are estimated to be relatively similar. As the angle of incidence increased, the experimental nets' echo strength remained the same while the control net echo strength decreased at a greater rate. Iron oxide nets maintained the highest target strength respective of incident angle. Biosonar detection ranges are estimated to be greatest for the iron oxide net and shortest for the control net at increased angles. Echolocating odontocetes may utilize acoustic reflections of experimental nets to a greater degree but due to the weak target strength of both nets, other mechanisms may also mitigate reduced odontocete bycatch.

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AN INSTRUMENT FOR HYPERSPECTRAL CHARACTERIZATION OF INHERENT OPTICAL PROPERTIES IN NATURAL WATERS

A newly designed instrument couples a high spectral resolution scanning source with proven sampling optics to provide in situ beam attenuation and absorption coefficients at 4 nm resolution from 390 nm to 730 nm. The dual-path instrument incorporates 25 cm length optical paths for detection of small concentrations of in-water biological and chemical components. This makes it well suited for in-water applications in both Case 1 and Case 2 environments. The attenuation measurement employs a collimated beam within the optical path that is refocused upon a narrow aperture receiver. The absorption measurement also uses a collimated beam propagated through a reflective tube onto a large area detector. This basic optical configuration is similar to that used on the commercially manufactured ac-9, a nine wavelength dual path absorption and attenuation meter, and as shown in a separate presentation, demonstrates similar optical performance to the ac-9.

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PHYTOPLANKTON PHOTOSYSTEM II ACCLIMATION AND ADAPTATION STRATEGIES IN MIXED AND STRATIFIED WATER COLUMNS.

Within deep mixed layers, under turbulent conditions, the daily integrated irradiance experienced by phytoplankton cells may be low, however the majority of light will be delivered during brief periods of high (near surface) irradiance. Data recently collected using the fast repetition rate (FRR) fluorescence technique at contrasting fully mixed and stratified sites in a shelf sea, indicated photosystem II (PSII) reaction centres with relatively low functional cross sections and high saturation light intensities under mixed conditions. A lagrangian particle tracking model was used to simulate the light history of phytoplankton cells, and further interpret the FRR data. It is suggested that the observed low functional cross sections represented an adaptation response to transient high light periods. The implication is that minimising damage of PSII reaction centres is an important aspect of the adaptive strategy. Further, variability in the turnover time of the PSII reaction centres is discussed. We conclude that within deep mixed layers PSII reaction centres may be adapted to high light while the rest of the photosynthetic machinery is acclimated to low light.

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DATA MANAGEMENT SUPPORT TO THE WESTERN ARCTIC SHELF BASIN INTERACTIONS (SBI) PROJECT

The UCAR Joint Office for Science Support (JOSS) provides data management support to the SBI Project. By working with the investigators since the project began, we have been able to establish useful data and documentation guidelines that streamline the exchange and integration of datasets among SBI scientists. JOSS provides support for real-time data collection and exchange during SBI cruises by customizing and implementing the SBI In-Field Data Catalog. The system is operated aboard ship and offers real-time ship track mapping display capabilities, station event logging and an easy
way to submit and share scientist logs and preliminary data from the cruises. Data are relayed via satellite to an SBI "mirrored" catalog running in Boulder, CO for access by the larger community and public. JOSS has produced high-resolution bathymetric maps, GIS-based cruise comparison databases and customized satellite products to aid in project analysis and synthesis tasks. Information on the status of SBI Phase 2 datasets will be provided. The authors will summarize the cruises to date using the GIS MapServer tool and describe future data management activities.

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COMPARATIVE PHOSPHORUS PHYSIOLOGY OF PROCHLOROCOCCUS ISOLATES

Prochlorococcus, a major prokaryotic primary producer in oligotrophic oceans, appear to have increased over the past decade in the North Pacific Subtropical Gyre, along with climate-related increases in N2 fixation and subsequent P-limitation. It is not clear whether this change is due to one or more genotypes of Prochlorococcus having a competitive advantage under conditions of P limitation. In order to gain insight into these issues, we compared the physiology of phosphorus acquisition and response to P-stress (alkaline phosphatase activity, APA) among axenic isolates of Prochlorococcus from different phylogenetic lineages (HLI MED4, HLII MIT9312, and LLIV MIT9313). All three isolates utilize inorganic P for growth, but only MED4 can grow using all organic P sources tested (beta-glycerophosphate, ATP, and cAMP). MIT9313 doesn't use any of these organic P compounds. MED4 also exhibit dramatic increases in APA as the cells become P-starved. MIT9312 and MIT9313 have much smaller, but measurable APA under P starvation. The P concentrations for these experiments still await measurement. Implications of this study with respect to conditions of P limitation in the oceans will be explored.

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LIPID METABOLISM IN INVERTEBRATE LARVAE: ISSUES WITH ACCURACY AND INTERPRETAIONS

Lipids are a major energy source for marine organisms. Analysis of marine lipid content has traditionally used saturated lipid standards for quantification. This practice may result in inaccurate measurements of lipid content for species in which unsaturated lipids comprise a large percentage of the total. We quantified saturated and unsaturated lipids with flame ionization detection (FID) and thin-layer chromatography. Significant differences were detected by FID, depending on the amount of fatty acid saturation (e.g., one vs. four double bonds). This makes choosing the appropriate lipids standards difficult for many organisms that have unknown fatty acid compositions with different degrees of bond saturation. We found that accurate quantification of such samples can be performed by first saturating the double bonds. This saturation frequently occurs unintentionally during lipid extraction protocols when oxygen is present in samples (e.g., during tissue homogenization). Saturated fatty-acid lipid standards are appropriate for analysis of such samples. Based on these procedures, we report results of lipid analysis and energy metabolism for larvae living in different oceanic temperature environments, ranging from warm tropical, to temperate, to cold deep-sea regions.

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SENSORY AND BEHAVIORAL ADAPTATIONS TO FLOW: LESSONS FROM CRUSTACEANS

For organisms that live in flowing or turbulent environment, many aspects of their sensory world is impacted by the presence of flow. Chemoreception and mechanoreception are two sources of information that is tightly coupled with the hydrodynamics of the environment. Crustaceans have a number of morphological and behavioral adaptations that allow them to extract relevant biological and ecological information in turbulent enviroments. I will review how one group of crustaceans (benthic decapods)have solved some of the constraints that hydrodynamics place upon sensory appendages and sensory information. By studying these adaptations, it is possible to understand the role that hydrodyanmics plays in shaping behavior and anatomy of sensory appendages.

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THE INFLUENCE OF IRON FERTILIZATION ON FLUXES OF ISOPRENE AND METHYL IODIDE FROM OCEAN TO ATMOSPHERE IN THE NE PACIFIC

During the SERIES experiment in the NE Pacific in July 2002 measurements were made both within, and outside the iron-fertilized patch, of a suite of atmospherically-reactive gases having an ocean source. In the case of isoprene an increase in concentrations in the water column in the patch was measurable within 5 days and remained until the final measurements after 13 days. A lower limit for its production rate is obtained from calculated fluxes into the atmosphere plus accumulation in the water column; biological losses are unknown. While there is evidence for methyl iodide also having a biological source, differences in its concentration between the patch and surrounding waters remained small and variable throughout the first 13 days of the experiment. However, comparison of the CH3I depth profiles with a non-biogenic trace gas, CFC11, does provide strong evidence for the differences between the "in" and "out" profiles on a given day being real. The implications of these results to identifying the source, or sources, of methyl iodide in the ocean will be discussed.

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DEVELOPMENT OF PHYTOPLANKTON BLOOMS FOLLOWING RAIN EVENTS IN A MODIFIED SUB-TROPICAL EAST AUSTRALIAN ESTUARY: A COUPLED HYDRODYNAMIC-ECOLOGICAL MODEL APPROACH

The development of phytoplankton blooms in the Wallamba River, NSW, was assessed immediately following rain events for up to 16 d at 5 sites. Salinity measurements made during the sampling period were used in a salt balance equation to create a one dimensional inverse model of the estuary. This allowed quantification of mixing terms which were then used to run the model forward in time with initial conditions of dissolved inorganic nitrogen and chlorophyll a being those measured on the first day of the sampling period after the rain event. Our model is well able to capture the transport mechanisms and by parameterizing phytoplankton growth can predict the timing, location and concentration of chlorophyll a maxima in the estuary after rain events. When a linear phytoplankton mortality term is included the results closely represent the observed demise of the bloom. We propose that much of this mortality term is due to predation by the pygmy mussel. Hence the pygmy mussel is acting as a biological filter removing much of the phytoplankton derived organic matter and increasing the estuary’s resistance to nutrient enrichment.

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GLOBAL MAPS OF PHYTOPLANKTON CARBON:CHLOROPHYLL USING AN EMPIRICAL RELATIONSHIP

Global carbon:chlorophyll maps are generated from satellite products (SST and Chl), modeled variables (mixed layer depth), and climatological interpolated fields (NO3) using an empirical model (Cloern et al, 1995). The resulting maps show large spatial and temporal variability in the range of 10 to more than 200 gC:gChl. The variability of this ratio can have profound effects in global marine ecosystem models which assume a constant ratio. The empirical relationship is sensitive to the half-saturation parameter for nitrate (Kn), which also has a large degree of variability. Despite these shortcomings, it is now possible to characterize the dynamic behavior on a global scale of an important variable in global carbon transfer modeling.

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PHYTOPLANKTON VARIABILITY AND THE WINTER BLOOM ON THE WESTERN AUSTRALIAN SHELF: CHARACTERISTICS AND CAUSES.

The eastern Indian Ocean and the waters off Western Australia (WA) are unique in terms of both their biological and physical oceanographic character. Driven by an oceanic pressure gradient, the eastern boundary current is poleward-flowing and downwelling conditions prevail. While the phytoplankton productivity of the region does not compare with other eastern boundary current regions, significant spatial and temporal variability in phytoplankton distribution does exist and the region supports commercially important fisheries. The key feature of phytoplankton variability is a winter bloom on the shelf and the advection of shelf communities offshore in mesoscale features. The cause of the winter bloom is not clear but we hypothesize it can be related to a number of potential nutrient inputs: rainfall and river runoff, advection, vertical mixing, benthic sources, or groundwater input. Using in situ data and a suite of remotely sensed data products (SST, SSH, and ocean color), we explore the seasonal and spatial variability of phytoplankton off the coast of WA to determine possible drivers for the winter bloom on the shelf.

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DOC PHOTODEGRADATION AND THE ENHANCEMENT OF MICROBIAL RESPIRATION IN RIVERINE, ESTUARINE AND COASTAL WATERS

Sunlight-initiated photochemical reactions are important in the cycling of dissolved organic carbon (DOC) in surface waters. Upon irradiation, a fraction of the DOC pool is remineralised directly to dissolved inorganic carbon (DIC). Irradiation also changed the bioavailability of the DOC, altering the rate of microbial uptake and respiration, and therefore the turnover of DOC in natural waters. In the present study, microbial O2 consumption (respiration) and microbial productivity (radiolabeled leucine assimilation) were measured in the field at estuarine and coastal sites in the Northwest Atlantic during July 2002. Abiotic photo-consumption of O2 and photoproduction of DIC were also determined. Sunlight irradiation of estuarine and coastal waters increased microbial respiration (0.0-1.2 uMh-1), enhancing the remineralization of DOC. The enhancement of respiration rates was similar to abiotic rates for photoproduction of DIC (0.03-1.50 uMh-1) and the abiotic photo-consumption of O2 (0.03-1.20 uMh-1). By

measuring both respiration and productivity, we found that microbial uptake and remineralization of DOC increased as a result of irradiation in most samples. This result contrasts many previous studies where only bacterial productivity was monitored, and suggests that these processes can significantly impact carbon cycling in estuarine and coastal waters

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DETERMINANTS OF DIVERSITY PATTERNS OF CORAL REEF FISHES

Explaining the distribution of biodiversity on earth is controversial and remains one of the major challenges for ecologists and conservationists. Here we use a reef-fish database gathered from locations across the Indian and Pacific Oceans to examine the effects of speciation and dispersal on spatial patterns of diversity. We found that (1) most species that occur at these sites were also present in a definable center of origination at the mid-IndoPacific region (IPR), (2) that the number of species decline as the distance from the IPR increases, and (3) that as distance from the IPR increases, so is the dispersal abilities of these species (sites far apart from the IPR tend to comprise few species with long larval periods). This suggests that new species spread far from an oceanic 'hotspot' of diversity, a process that seems to account simultaneously for large-scale gradients in species richness and the structure of local communities.

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POC EXPORT IN THE WESTERN ARCTIC OCEAN

The magnitude and variability (spatial and seasonal) of POC exported from the upper waters of the Chukchi-Beaufort Seas during the SBI-II 2002 field program was quantified using measurements of Th-234/U-238 disequilibrium and large particle (>53 µm) POC/Th-234 ratios. Large volume (200-1000 L) water samples were collected from 36 stations and 184 depths during May-June and July-August. Results are characterized by: 1) enhanced particle export in the shelf and slope waters; 2) higher particle export in the southeast sections near Barrow Canyon (West of Hanna Shoal), and; 3) a marked increase in particle export at all stations during the summer. POC export fluxes at 50 m were calculated using a 1-D steady-state model and multiplying the Th-234 deficit by the large particle POC/Th-234 ratio. POC fluxes exhibit a marked seasonal and spatial variability, averaging 1.8 ± 2.3 mmol m-2 d-1 (0.031-5.7 mmol m-2 d-1) in spring and 10.6 ± 9.3 mmol m-2 d-1 (0.56-39 mmol m-2 d-1) in summer. Export fluxes represent 13 ± 15% and 32 ± 24% of primary production in spring and summer, respectively.

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PLANKTONIC BIOMASS AND PRODUCTION IN OLIGOTROPHIC WATERS OF THE N ATLANTIC SUBTROPICAL GYRE: SIZE-FRACTIONATED MEASUREMENTS AND METABOLIC BALANCE

The biomass and metabolism of the planktonic microbial community was assessed in subtropical and tropical domains of the eastern N Atlantic subtropical gyre (autumn 2001). Picoplankton contributed 70 +- 3% SE of total chlorophyll a, with Prochlorococcus as the dominant group and an increasing importance of picoeukaryotes and Synechococcus in tropical waters. Autotrophic plankton clearly exceeded heterotrophic bacterial biomass, contradicting previous claims of marked inverted biomass pyramids. Primary production (153-337 mg C m-2 d-1) was mostly due to cells >2 um (59 +- 3%), with a sginificantly greater share of microphytoplankton in the tropical domain. Bacterial heterotrophic production (6-22 mg C m-2 d-1) was always <10% of primary production, likely related to the high proportion of inactive bacteria according to DNA content (56 +- 2%). Despite the covariance between bacterial and primary production, bacteria required the existence of organic matter inputs other than dissolved primary production. Given that community respiration (116 +- 32 O2 m-2 d-1) also exceeded gross primary production (58 +- 32 mmol O2 m-2 d-1), our results confirm the net heterotrophic balance of the oligotrophic NE Atlantic.

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NUTRIENTS AND PRIMARY PRODUCTION ALONG THE EASTERN AND CENTRAL ALEUTIAN ISLAND ARC

Within the Aleutian Island Arc there are shallow (eastern) and deep (central) passes which permit interchange and mixing between the Pacific Ocean and the Bering Sea. Mean transport is to the north; with waters of the Alaskan Coastal Current dominating transport in the eastern passes (east of Samalga Pass), and waters of the Alaskan Stream dominating transport in the central passes. Mooring data collected near the bottom of Seguam Pass shows a strong relationship between salinity and nitrate in 2001 and 2002, although the slope of this relationship varies between years. In 2001, the less saline waters have significantly lower nitrate than in 2002. In agreement with mooring results, hydrographic data show a greater drawdown of nitrate in 2001 compared to 2002, and regions of significant nitrate drawdown are consistent with regions of high primary productivity. In general, post-bloom production is highest in the eastern passes, and these results are consistent with the hypothesis of a significant ecological boundary at Samalga Pass. These results are compared to east-west trends in paleoecological data of Aleutian Islands.

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VARIABILITY OF OPTICAL PROPERTIES IN OLIGOTROPHIC CASE 1 WATERS

The optical properties of Case-1 waters are considered as rather well known and amenable to a simple modeling, based on a two-component system (water plus a biogenous compartment, indexed on chlorophyll concentration). This simplified approach, which has proven to be efficient and successful in many circumstances (e. g. for the development of algorithms used in ocean color is yet acknowledged as being only a first approximation. Several oligotrophic tropical areas have been investigated (Atlantic, Pacific, Med-Sea, particularly); the results (in terms of diffuse attenuation coefficients and reflectance) reveal systematic differences between zones, as well as deviations compared to the "average" model. This is especially true in the blue and near-UV spectral domain. These deviations are analyzed in view of identifying and quantifying their main causes among those possible, such as the varying composition of algal assemblages, the varying proportions between algae and associated particles, or between particulate and dissolved (colored) materials, and the occasional presence of exogenous (eolian) particles. Tuning the average model, or specifying the expected error-bars could result from such investigations, once made more systematically.

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FOOD WEB SIZE, COMPLEXITY AND FUNCTION

Random, steady state food webs of varying size and complexity (up to 2000 species and 1.3 million connections) were generated with and without ecologically realistic constraints. Trends in structural and functional properties (biomass, net productivity, production efficiency, flow diversity, etc.) were analyzed as functions of taxonomic diversity, connectivity, and gross primary production (GPP). Webs with and without ecologically realistic constraints differed from one another in a number of ways. In both cases, however, no limits on species diversity were found, but the probability of generating a feasible web diminished with increasing size. As diversity increased, total ecosystem biomass declined to a lower asymptote, equivalent to about 6.4% of annual GPP. Thus, turnover rate of total biomass increased and biomass per species declined with increasing network size. Consumers and producers behaved differently. For example, consistent with the 2nd law requirement that producer turnover must increase (at a fixed GPP) in order to support higher connectivity, the ratio of producer:consumer biomass approached zero with increasing diversity. Data from 32 real food webs having at most 125 species clustered at the low end of the spectrum of response variables, but the trends among real and theoretical webs with realistic ecological constraints were similar and indicate that the structure of a food web and its function are closely related.

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THE NET METABOLIC BALANCE OF THE OPEN OCEAN: A TEST OF THE NUTRIENT LOADING HYPOTHESIS

It has recently been suggested that net autotrophy in the oligotrophic North Pacific Ocean is episodic, and decoupled from the more constant rate of respiration (R). To test this hypothesis, we conducted a series of nutrient loading experiments wherein nutrient sufficient deep water was mixed, in variable proportions, with surface waters collected from selected oligotrophic stations. Several results, consistent with the ecological predictions of the hypothesis, were obtained including: (1) nutrient additions selectively stimulated the growth of larger phytoplankton, including diatoms, (2) gross primary production (GPP) increased dramatically while respiration remained relatively constant, and (3) the system under investigation shifted temporarily from net heterotrophic (GPP < R) to net autotrophic (GPP > R) in its metabolic balance. These results indicate that stochastic loading of nutrients, as might occur from aperiodic mixing events, can rapidly alter microbial community structure, decouple organic matter cycles, and lead to a time- and space-dependent mosaic of microbial metabolism in the open sea. A proper accounting of both phases will be needed to achieve accurate estimation of the net metabolic balance in these ecosystems.

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SEASONAL CYCLE OF PHYTOPLANKTON UV ABSORPTION AT THE BERMUDA ATLANTIC TIME-SERIES STUDY (BATS) SITE

Measurements of the phytoplankton absorption coefficient, aph, at the Bermuda Atlantic Times-series Study (BATS) site demonstrated a seasonal pattern of absorption in the UV. This was evidenced as peaks between 313 to 335 nm in aph from the surface waters in the summer months that were smaller or absent in the winter. These peaks were most probably caused by pigments such as mycosporine-like amino acids. UV Pigment expression in the surface samples, approximated from aph(319)/aph(365), was linearly related to the irradiance exposure at 324 nm, r2 = 0.81. Irradiance exposure was estimated using a layered-mixing model parameterized with the calculated mixed layer depth and modeled surface irradiance. Modeled UV irradiance, calculated using satellite- derived atmospheric data and an atmospheric radiative transfer model, was not significantly different from the measured monthly mean surface irradiance. These results suggest that UV pigments are potentially ubiquitous throughout the world's oceans and may be an important source of highly colored dissolved organic matter. UV pigments may also be important in higher trophic levels if bioaccumulation, which has been demonstrated in other regions, occurs.

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USING DINOSTEROLS IN PALEOECOLOGICAL STUDIES: AN EXPLORATORY APPROACH

Recent evidence suggests that the degree of saturation of dissolved oxygen in the bottom waters of St-Lawrence estuary has decreased to levels that are becoming limiting for biological life. However, such marked decrease could either be induced by an increased production in surface waters, or by a decrease in dissolved oxygen content of deep water mass penetrating into the St. Lawrence estuary from the North Atlantic Ocean. To discriminate between these possibilities, we will use dinosterol biomarkers to assess potential changes in the source of organic material. In this project, we will explore the possibility of using various dinosterols (from cultured species and cysts microscopically isolated from St-Lawrence Estuary and Gulf sediments) to monitor changes in dinoflagellate assemblages in the surface waters. Following extraction with non-polar solvents, various dinosterols will be characterized by gas chromatography-mass spectrometry (GC-MS) and quantified by GC. This chemical approach will be compared to the classical but tedious epifluorescence microscopic counting technique currently used in paleoceanography laboratories. If successful, this approach will considerably reduce time and money involved in the assessment of ecological changes using dinoflagellates.

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PRIMARY PRODUCTION CALCULATIONS IN THE MID-ATLANTIC BIGHT, INCLUDING EFFECTS OF PHYTOPLANKTON COMMUNITY SIZE STRUCTURE

An absorption based primary production model that includes the effects of phytoplankton community size structure has been developed for continental margin and adjoining Gulf Stream waters of the Mid-Atlantic Bight (MAB). The model utilizes, previously determined seasonal cycles of phytoplankton community size structure, representative absorption spectra, remotely sensed chlorophyll concentration, sea surface temperature and photosynthetically active radiation, in situ determination of mixed layer dynamics, and previously determined nitrate concentration. Primary production was calculated every month for 5-years for study areas representing shelf, shelf-break, slope and Gulf Stream waters. The calculations included both light-limited and nutrient-limited conditions of the MAB seasonal cycle. Differences observed between study areas were largely driven by differing chemical and physical processes. Temporal variability at interannual scales correlated well to wind mixing intensity, while trends in temporal variability at seasonal scales were not discernable. Relative to cell size seasonality, primary production was regulated more by biomass than light acquisition capability. In comparison with in situ depth dependent data, we quantified approximately 40 percent of production was missed by satellite based estimates.

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IN-CLASS ACQUISITION OF REAL-TIME AVHRR SATELLITE DATA DIRECTLY FROM POLAR-ORBITING SPACE PLATFORMS: AN INEXPENSIVE AND MULTIDISCIPLINARY EDUCATIONAL APPROACH

The close interaction between researchers and educators is of primordial significance for ensuring effective science education within public schools. In an effort to support science education programs, NOAA CoastWatch - Central Pacific Node is currently supporting the installation of inexpensive (~$350) AVHRR-APT satellite receiving stations at three high schools located within the island of Oahu (Hawaii). The daily acquisition and interpretation of satellite imagery directly in the classroom environment will provide educators with the opportunity to readily integrate numerous concepts from different scientific fields (including environmental science, geography, geology, oceanography, atmospheric science, meteorology, physics, etc.) in the class curricula, providing students with the possibility of actively participating in satellite remote sensing activities. The objectives of these activities include the further development of the student's analytical and theory-formulation skills and most importantly, to gain a broader and more complete views of the sciences as a whole. Additionally, CoastWatch – Central Pacific Node provides updated near real-time satellite oceanography data through a new user-friendly Internet portal, designed to enhance the distribution of satellite data resources to researchers, educators and general users.

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SELF-SHADING OF UPWELLED RADIANCE BY MOBY AND INSTRUMENTS WITH OTHER SHADOWING SHAPES

The standard protocol for correcting self-shading by an in-water upwelled radiance radiometer assumes that the nadir-viewing sensor aperture is located at the center of a circular instrument base. This concentric geometry is not realized when a sensor is mounted under a horizontal boom (as on MOBY), or near the edge of a cylindrical buoy hull or instrument. With such configurations and clear-sky conditions, a simple expedient is to apply the standard protocol using an "effective instrument radius" computed as the distance to the edge of the shadowing structure in the direction of the solar azimuth. This simple correction, applied to MOBY upwelled radiance measurements, is compared to geometrically accurate self-shading corrections determined using adjoint (backward) Monte Carlo radiative transfer solutions for Case I inherent optical properties (IOP). For each IOP profile, corrections are determined for a range of solar zenith angles and wind speeds. The correction models are also compared, for Case-I and Case-II examples, to sequences of upwelled radiances measured with systematic variations in self-shading induced by mounting shadowing disks of varying sizes on a fiber-optic radiance probe.

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DOES NITROGEN REGENERATION FROM THE N2 FIXING CYANOBACTERIA TRICHODESMIUM SPP. FUEL KARENIA BREVIS BLOOMS IN THE GULF OF MEXICO?

Blooms of the toxic dinoflagellate, Karenia brevis, occur in the oligotrophic waters of the eastern Gulf of Mexico where known nitrogen (N) sources are insufficient to support observed biomass accumulations. Large K. brevis blooms frequently co-occur or occur subsequent to blooms of the N2 fixing cyanobacteria, Trichodesmium spp. Trichodesmium alleviate N limitation where they occur by using atmospheric N2. Much of the recently fixed N2 is regenerated as NH4+ and dissolved organic N (DON). This regenerated N is then available to support the growth of other cells. We hypothesized that N regenerated from N2 fixation provides the N necessary to support blooms of K. brevis in the Gulf of Mexico, and have conducted a combination of field and laboratory investigations to demonstrate a viable nutritional link and to quantitatively assess the role of Trichodesmium in providing N to support the growth of K. brevis. Preliminary results demonstrate that Trichodesmium fix N2 at high rates with more than 50% of this new N released as NH4+ and DON and that K. brevis can use this to support growth.

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ROLE OF BIOCHEMICALS IN ZOOPLANKTON NUTRITION: CONCEPTS, METHODS AND THEIR LIMITATIONS

Recently the role of biochemicals in zooplankton nutrition is becoming increasingly clear. A large degree of variability in growth and egg production of zooplankton can be attributed to chemicals in the food; both beneficial and toxic. Therefore, those biochemical food constituents may be key components in determining zooplankton food quality, and thus the efficiency with which biomass is transferred in the food web. Despite their importance, the ecological understanding of potential limiting biochemical resources is still in its infancy. In the

presentation, nutrition is viewed conceptually including biochemical aspects. Further, methods are compared designed to reveal the importance of biochemicals in zooplankton nutrition. The strengths and weaknesses of the methods are highlighted.

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BIOTURBATION OR NOT BIOTURBATION: EXTREME LABILE ORGANIC LOADING IN COASTAL AREAS

GESAMP (2001) concluded that marine eutrophication is the most severe problem affecting the oceans. Organic matter (OM), after a major portion is oxidized in the water column, enters the seafloor and becomes available to benthos. We report here the effects of extremely labile OM on benthic communities in Southern Chile. Two fjords were visited with different OM loading regimes. Microelectrodes (oxygen, sulfide, pH, Eh), radionuclides and textural features (grain size, magnetic susceptibility) were used to characterize the benthos. More than 60% of Pillan Fjord is azoic with H2S presence, textural changes and atypical Pb-210 profiles. Oxygen consumption was 701-1209 mmol O2/m2/day in affected areas; equivalent to the mineralization of 0.35-11.2 gC/m2/day compared to control stations values of 37.5-152 mmol O2/m2/day. Reñihue fjord shows no clear textural changes and lower oxygen consumption rates (222-489 mmol O2/m2/day) that yield carbon mineralization of 1.2-4.5 g C/m2/day. However, Reñihue benthos is close to the 1-kgC/m2/day threshold to become azoic, like Pillan today. Pb-210 profiles, sediment TOC/TON and sedimentological changes support the hypothesis that eutrophication started less than a decade ago.

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THE ALASKA OCEAN OBSERVING SYSTEM: IMPLEMENTING IOOS IN THE NORTHEASTERN PACIFIC & ARCTIC

Alaska Ocean Observing System (AOOS) is the parent body of regional ocean observing systems covering three major areas; 1) Arctic Ocean, Beaufort and Chukchi seas, 2) Bering Sea and Aleutian Islands, and 3) Gulf of Alaska and Southeast Alaska. AOOS plans to become part of the U.S. national federation of coastal observing systems under Ocean.US. The strategy of AOOS uses partnerships among university, private non-profit and governmental entities to build observing systems from existing and newly created elements to support IOOS objectives. Existing observing system elements include two of the longest uninterrupted time series in the North Pacific; 1) temperature and salinity at depth at Seward Line station one (Institute of Marine Science/SFOS University of Alaska Fairbanks & Gulf Ecosystem Monitoring, GEM, EVOSTC) and 2) shelf and shelf break macronekton distribution and relative abundance (Alaska Fisheries Science Center/NOAA). Newer elements include continuous plankton recorder (CPR) transect of the Gulf of Alaska (GEM) and ocean current nowcast/forecast system for Prince William Sound (Oil Spill Recovery Institute/Prince William Sound Science Center).

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COMPARISON OF STANDARD AND MOLECULAR METHODS FOR CAMPYLOBACTER IDENTIFICATION AND ENVIRONMENTAL SOURCE IDENTIFICATION

Fecal contamination of urban ocean beach waters is a growing public health concern. Since 1999, Huntington Beach, CA has had a significant number of beach closures due to high levels of fecal indicator bacteria. Large numbers of waterfowl gather daily at a constructed wetland in a marsh that discharges into the ocean at the beach. The purpose of this study was to characterize Campylobacter spp. in both bird feces and water samples in this wetland. Over one year, 170 bird fecal samples from marsh sandflats and 24 water samples from adjacent estuarine waters were analyzed. Campylobacter presumptive positive samples were confirmed by standard microbiological and biochemical methods. Concentrations ranged from non-detectable to >500 MPN/g in bird feces and from non-detectable to 1.15 MPN/100ml in water. Multiplex PCR and Pulsed Field Gel Electrophoresis were used to definitively identify and characterize the presumptive positive isolates. These methods identified fewer Campylobacter-positive samples. The results of this study indicate that these waterfowl are a source of fecal contamination with Campylobacter, but not to the extent that the standard Campylobacter culture and identification methods suggest.

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A MODEL FOR VERIFYING MID-OCEAN BALLAST WATER EXCHANGE USING NATURALLY OCCURRING CHEMICAL TRACERS

We are developing a statistical model, based upon chemical characteristics of coastal and oceanic water, that aims to verify whether ships comply with regulations for ballast water management. To reduce the chances of importing harmful non-indigineous species (NIS), ships intending to discharge foreign ballast water perform mid-ocean ballast water exchange (BWE). During BWE, a ship replaces the coastal water in its ballast tanks with water drawn from the open ocean, which is considered to harbor fewer NIS capable of establishing viable populations in coastal environments. We are measuring concentrations of six trace elements, radium isotopes, colored dissolved organic matter and salinity along ocean transects and in ballast tanks subjected to varying degrees of BWE. Our method deduces the source of ballast water according to the statistical departure of tracer concentrations in ballast tanks from baseline concentrations in the ocean. In the first phase of this research, several tracers when used in concert were able to detect BWE. We are now expanding the data set to include additional global regions, and test the robustness of these results as a verification assay.

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CHROMIUM OXIDATION BY MN-OXIDIZING BACTERIA FROM THE BLACK SEA

Cr(VI) reduction to the less soluble and nontoxic Cr(III) is desirable for the detoxification and immobilization of chromium pollution. However the long term stability of Cr(III) may be impacted by the presence of environmental oxidants such as bacterially-produced Mn oxides which are common at oxic/anoxic interfaces, like that found in the Black Sea. Our research focuses on the ability of Mn-oxidizing bacteria to oxidize Cr(III), either by direct or indirect means. Experiments with well-characterized strains of Bacillus and Pseudomonas as well as consortia and isolates from the 2003 Black Sea cruise (R/V Knorr) suggest that bacteria may accelerate rates of Cr oxidation over those which would occur abiotically from the bacterially-produced Mn oxides. Several isolates from the Black Sea incubations were tested for sensitivity to Cr(VI), the end product of Cr oxidation, and showed only slight inhibition at 50 uM. Results showed a decline in Cr(III) oxidation in the presence of azide, an inhibitor of enzymatic Mn oxidation, which is consistent with the involvement of the Mn-oxidizing enzyme, either directly or by the production of a reactive Mn species.

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OCEAN OBSERVATIONS OF THE DISSIPATION SPECTRUM OF SALINITY FROM VERTICAL AND HORIZONTAL MICROSTRUCTURE PROFILES

It has only recently been possible to directly measure the irreversible turbulent flux of salt and the dissipation rate of salinity variance in the ocean. Gradient spectra of heat and salt may simultaneously be determined using a combined fast conductivity/temperature probe, from which the eddy diffusivities for heat (KT), salt (KS), and their ratio can be calculated. Significant deviations of KS/KT from unity are hypothesized to occur at low turbulence intensities. In order to determine the dependence of KS/KT on buoyancy Reynolds number, scalar gradient spectra and ancillary turbulence measurements were obtained from the towed microstructure instrument MARLIN during the Hawaii Ocean Mixing Experiment. These encompassed a variety of turbulence intensities at a range of depths in the deep ocean. A preliminary analysis of KS/KT from these horizontal tows and from vertical microstructure profiles on the Oregon coast will be presented.

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DOC USE AND PLANKTON METABOLISM IN THE NW MEDITERRANEAN COAST

A study was conducted to assess the annual variability in planktonic metabolism and DOC utilization in an oligotrophic Mediterranean Bay and to test the role of elevated DOC concentrations in driving planktonic metabolism off balance. The community was net heterotrophic in autumn, winter and the first summer studied and shifted to net autotrophic towards the last third of the study period (spring and summer 2002, an anomalous period characterised by frequent storms that stimulated autotrophic processes in the Bay, leading to the development of a bloom of Synechoccocus). Use of DOC was consistent with the trophic state of the system, as DOC consumption was observed when the system was net heterotrophic and DOC release when the system shifted to autotrophic. Bacterial respiration accounted for on average 51.76 % of R, and increased with the %HDNA bacteria (percentage of actively metabolizing bacteria). On annual basis, the planktonic community was net heterotrophic, suggesting that the system imports DOC. In particular, the organic carbon import may come from the excess production of the underlying Posidonia oceanica meadow.

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ALTERATION OF WETLAND TROPHIC FUNCTION BY A PLANT INVADER

The tidal flats of San Francisco Bay have recently been invaded by a hybrid between the Atlantic Cordgrass (S. alterniflora) and the native Pacific Cordgrass (Spartina foliosa). Mensurative studies as well as transplant experiments revealed significant changes in sediment and macrofauna properties at site experiencing a 30-year invasion. Densities of sediment-dwelling fauna were reduced by 75 % in the invaded- relative to uninvaded areas. Invaded sediments showed a strong shift in macrofauna composition, with losses of surface-feeding bivalves and amphipods, and dominance by subsurface feeding polychaetes and tubificid oligochaetes. Isotopic enrichment experiments, using 15N-labeled Spartina and 13C-labeled algae, indicate that the successional changes observed were related to the introduction of a novel food supply (invader detritus) and loss of traditional food sources (algae). Species that consume plant detritus, directly or indirectly, are favored during invasion over those that prefer algae. Thus, invasion has induced trophic succession, from a primary production-fueled system to a detritus–based food web. As the world's most invaded estuary, San Francisco Bay offers a preview of the complex responses of coastal ecosystems to plant invasions.

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PRIMARY PRODUCTION IN A SHELF EUPHOTIC ZONE THAT INCLUDES SURFACE SAND SEDIMENTS

On the mid-to-outer continental shelf of the South Atlantic Bight, the chlorophyll maximum layer is typically located at the sediment surface and there is a tight coupling between daily irradiance at the sea floor and areal primary production by benthic microalgae (BMA, predominantly diatoms) in the sand sediments. Here we focus on the short-time scale and daily photosynthesis-irradiance (P-E) responses of BMA compared to phytoplankton, and assess the overall areal efficiency of light utilization for photosynthesis in this system. P-E responses of BMA were characterized in ship and lab experiments (modified "photosynthetron" approach) and in situ (benthic chambers with PAR and oxygen sensors). Lab experiments also showed that BMA in sub-euphotic sands are capable of rapid recovery of photosynthetic capacity when exposed to light. By combining measurements of the sediment euphotic depth (micro-irradiance profiles), sediment and water column chlorophyll and primary production, and irradiance, we conclude that the overall efficiency of light utilization for photosynthesis on the shelf is enhanced when the euphotic zone extends to the sediments.

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MERIDIONAL DISTRIBUTION OF COLORED DOM IN THE NORTH ATLANTIC OCEAN

Preliminary results from three meridional sections in the North Atlantic covering 62N to 10N suggest that the open ocean depth distribution of chromophoric dissolved organic matter (CDOM) can be described using just two distinct patterns. The first predominates temperate waters, and consists of a simple decrease in CDOM oncentration (assessed as absorption coefficient at 325 nm) with depth between the surface and 1000m. The second pattern is found in subtropical waters, where a near- surface CDOM minimum and a subsurface maximum lies just below the seasonal thermocline. A minimum in CDOM is also found in the subtropical mode water between the seasonal and permanent thermoclines. Our results point to solar bleaching as the primary control on CDOM concentration in surface waters, with productivity playing a secondary role. These results will be discussed in the context of the large-scale physical oceanographic and primary productivity patterns that may affect the open ocean CDOM distribution.

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GRID-GENERATED TURBULENCE IN A MESOCOSM ECOSYSTEM EXPERIMENT

In two different mesocosm experiments turbulence was created by oscillating grids. Utilizing two different frequencies, two levels of turbulence ("high" and "low") were created in a total of eight mesocosms in both experiments. In each experiment a two-layer density structure was created. We succeeded in reproducing important characteristics of turbulence found in nature, provided that the grid scale was markedly larger than the turbulent micro scale. The turbulence levels without grid-turbulence were measured to be much too high to be acceptable as a "no-turbulence" experiment. A third experiment was designed to investigate the effects of larval size (ontogeny), light and turbulence on the attack rate and swimming activity of herring larvae. In general moderate turbulence had a positive effect on prey attack rate, but this effect was dependent of light intensity and larval size.

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TURBULENCE, PREDATORS, AND THE TRANSPORT OF JUVENILE ATLANTIC SURFCLAMS, SPISULA SOLIDISSIMA

Surfclams are abundant in sandy sediments on the continental shelf of the Mid-Atlantic Bight to depths of 40 m. On the inner shelf, larval settlement is generally high in July but the high settlement densities are quickly decimated by predators, including the abundant hermit crab, Pagurus longicarpus. Several bivalve species exhibit escape behavior in response to the presence of a predator. In juvenile surfclams, this behavior consists of leaping out of the sediment into the water column where they may be transported out of the predator's reach. The roughness elements that characterize surfclam habitat, such as ripples and varying amounts of shell hash, create spatial variation in the degree of turbulence in the near bed flow regime. This variability in the flow regime can affect the interactions between predators and their prey. Laboratory flume experiments manipulated the flow through changes to the bed (flat vs. shell hash), and the use of different flow speeds. These experiments examined several aspects of the interactions between the flow regime and predation, including predator (P. longicarpus) feeding success, and prey behavior.

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COASTAL EUTROPHICATION: THE GOOD, THE BAD AND THE UGLY

Eutrophication occurs naturally in some of the most productive coastal waters of the oceans, such as off the coast of Chile and northwest Africa. The enrichment of surface waters in regions of upwelling by nutrients gives rise to phytoplankton blooms that support very productive food webs, fisheries and aquaculture. However, in coastal areas where anthropogenic eutrophication occurs as a result of agricultural practices or domestic and industrial effluents, the impact of nutrient enrichment is mainly negative. A cascade of direct and indirect effects that can be lethal includes harmful algal blooms and anoxia as well as nuisance algal blooms. The two main outcomes of anthropogenic eutrophication are the development of dense phytoplankton or macrophyte blooms, but neither lead to the productive food webs observed in the situation of natural eutrophication. A comparison of the combination of physical, chemical and biological variables may allow us to predict which of the various scenarios is likely to develop and suggest best management practice for remediation.

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IMPACT OF RAINSTORMS ON COASTAL WATER OFF SOUTHERN CALIFORNIA OBSERVED BY SEAWIFS

Spatio-dynamical features of the freshwater plumes produced after rainstorms by small rives of southern California are analyzed on the basis of 1-km spatial resolution satellite observations collected in 1997-2003 by SeaWiFS optical radiometer. The area of each plume is detected by the backscattering characteristics of water surface. Rainstorm magnitude is estimated from atmospheric precipitation averaged over the area of each watershed. The characteristics of each plume (size, persistence time, propagation speed and direction) are compared to meteorological (rainstorm magnitude, wind) and hydrological (surface circulation pattern) information. The impact of river discharge on coastal ecosystems resulting in variations of phytoplankton biomass visible in remote sensed surface chlorophyll concentration is discussed. In different watersheds the behavior of river plumes is substantially different.

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A CLASSIFICATION OF PHYTOPLANCTON PIGMENTS ASSEMBLAGES FROM THE GEOCHEMISTRY, PHYTOPLANKTON AND COLOR OF THE OCEAN WORLDWIDE SAMPLING (GEP&CO, 1999-2002)

While chlorophyll concentration tells us the magnitude of biogeochemical fluxes, the nature of phytoplankton populations modulates the ratios of elements in these fluxes. We use pigments determinations as indicators of phytoplankton species. Pigments data have been collected at the sea surface on 12 quarterly cruises from France to New Caledonia. Concentrations are first normalized to the sum of chlorophyll a plus divinyl chlorophylla a, then centred and normalized for each pigment, and finally classified using neuronal methods. The resulting groups generally correspond to well-known ecosystems (such as the north Atlantic in spring or winter, the equatorial Pacific, or the south Pacific oligotrophic gyre). However, a priori defined oceanic provinces at a given season are often occupied by several groups. The differences between groups are identified using CHEMTAX, and discussed using ancillary data collected at the same time. The variability evidenced here misses the Coccolithophorids and Trichodesmium blooms. It is however a realistic representation of what ocean color algorithms should try to retrieve in most of the open ocean.

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TRANSPORT AND TURNOVER OF NITRATE BY NITRATE ACCUMULATING BACTERIA IN SEDIMENTS

Beggiatoa sp. and other large sulphur oxidizing bacteria are known to accumulate nitrate in the cells at concentrations up to 500 mM. To know the efficiency of nitrate transport and turnover we studied chemotaxis, uptake, leakage, and reduction of nitrate by Beggiatoa trichomes under different environmental conditions. Distribution of nitrate within single trichomes and the possibility of intercellular nitrate transport was also examined with nitrate biosensors adapted to analysis of picomole quantities. In summary the results verified that bacterial transportation of nitrate can be a of biogeochemical significance in sediments with large populations of Beggiatoa sp.

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FUNCTION OF PELAGIC ECOSYSTEMS IN GREENLAND COASTAL WATERS

Based on annual cycles of the pelagic food webs in west and east Greenland coastal waters, the dynamic of the pelagic food web in relation to ice cover will be discussed. On the western site ice cover last 3 to 6 months, in contrast the eastern site only opens 2 to 3 months around midsummer. Calanus spp. dominates the mesozooplankton grazers in both areas. However, the microbial food web is a significant element in the pelagic carbon and nutrient cycling also. Calanus has a pronounced effect on the food web structure. On the western site the Calanus leave the productive surface layer around mid summer, releasing the grazing pressure on the lower trophic levels. In contrast Calanus are present trough out the open period on the east,

making no predator free window available for of the lower trophic levels. Consequently the duration of the ice cover has profound effects on the succession of and match/miss math of different trophic levels in the plankton. A simple model illustrates the potential implications of changes in ice cover on the food web structure and carbon cycling in these arctic ecosystems.

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DIFFERENCES OF MATING BEHAVIORS BETWEEN DAPHNIA PULEX AND DAPHNIA MAGNA

The question is whether the mate-seeking behavior of Daphnia is determined by their environment or by phylogeny. I have observed pre-mating and mating behaviors of D. pulex and D. magna. I used 2D and 3D optical systems which allowed for obtaining simultaneously front and side views and shadow graphs to register sequences of mating processes. All observations were done with a near-infrared illumination at a wavelength of 890nm. D. pulex and D. magna showed different behaviors to find their mates. D. pulex showed synchronized signals between the speed patterns of male and female. However, D. magna displayed random searching behaviors without any synchronization of swimming speed. The new question then is whether or not the possible presence of turbulence determines which spaces are available for mating and, therefore, whether or not turbulence separates niches via the mating game. Video clips will illustrate the results.

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AN INVESTIGATION OF THE MESOSCALE EDDY DYNAMICS ALONG THE WEST SPITSBERGEN SLOPE

The slope along West Spitsbergen is identified as a wave-guide, trapping energy within the slope geometry and trapping energy along the slope. The northward flowing West Spitsbegen Current (WSC) is trapped along the slope and is the largest heat source from the ambient oceans to the Polar Ocean. The Atlantic Water of WSC losses approximately three times as much heat (1050 W/m2) laterally to the surrounding below 100 meters depth than directly to the atmosphere on its path along the West Spitbergen slope. In summer and fall 2002 the shelf areas along West Spitsbergen were flooded with Atlantic Water, and hence, the heat content on the shelf and in the fjord systems increased and influenced the ice growth the following year. This also influenced the local ecosystems since the usually Arctic type fjords were transformed into Atlantic ecosystems. Current time series across the slope at 79-degree north, collected between September 1997 and September 1999, are used in order to quantify the eddy dynamics and to characterize the instability processes responsible for water mass exchanges across the temperature-salinity front between the slope and the shelf areas.

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FATE OF NUTRIENTS AND THE COMPOSITION AND SIZE OF PHYTOPLANKTON IN THE MESOPELAGIC WATERS OF SURUGA BAY, JAPAN, DURING INCUBATION EXPERIMENT

Interactions between nutrient and phytoplankton (larger than 2um) were investigated in unaltered seawater from 10, 400 and 700m depths of Suruga Bay for 11 days. After two days of incubation nutrients declined rapidly accompanied by a massive growth in abundance and species composition of diatoms in the mesopelagic waters. Nitrate declined much rapidly than silicic acid and was nearly exhausted by 4-7 days. Diatoms smaller than 5um (mainly Thalassiosira minima) became numerically most abundant when nitrate was replete, but when regenerated nitrogen (ammonium) was the main source, diatoms of size 5-100um (mainly 5-15um) became numerically most abundant and their biomass also increased. Different species of Chaetoceros replaced the previously dominant Thalassiora minima. In surface water nutrients declined rapidly without any lag and despite the growth of other groups of phytoplankton, the diatom Nitzschia pungens (of size 5-15 um) remained numerically abundant throughout incubation. The Si:N drawdown ratio, which was 0.5 for 400m and 0.2 for 700m during day 2-4 of incubation, decreased with increasing abundance of diatoms smaller than 5 um both in terms of numbers and carbon biomass.

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IRON LIMITATION PROCESSES IN THE NW SUBARCTIC PACIFIC

Estimates of the vertical input of iron from below to surface in subarctic North Pacific indicate the higher iron supply in the western than eastern region, as atmospheric iron input. Comparison of vertical profiles of size-fractionated iron between the western and eastern subarctic North Pacific clearly showed higher labile particulate iron concentrations towards the west and this result also strongly supports the higher iron supply in the western region. Additionally, the results of the SEEDS experiment, meso-scale iron enrichment experiment in the western subarctic North Pacific, clearly showed that artificially enriched iron in the dissolved fraction was rapidly transformed to suspended labile particulate iron during phytoplankton growth and was retained in the surface mixed layer. Probably, this same transformation process occurs after natural iron supply, such as atmospheric deposition and vertical mixing, and the labile particulate iron is retained in the western region. Furthermore, this transformation process reduces dissolved concentration of iron and its bioavailability. Therefore, the transformation process is important for understanding how phytoplankton became iron limited and the biogeochemical iron cycle in the western subarctic North Pacific.

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DENSE WATER FORMATION IN THE AEGEAN SEA DURING THE EASTERN MEDITERRANEAN TRANSIENT

The Aegean Sea has been identified a source of intermediate and deep waters for the Eastern Mediterranean sea. The water mass formation processes in the basin are studied using a 3-D numerical ocean model; the simulations cover the 80's and early 90's when major anomalies that affected the thermohaline circulation of the Mediterranean Sea were recorded. Sensitivity studies that focus on the role of fresh water budget are presented and the results are evaluated against available hydrological data of the same period. The very cold winters of 1987, 1992, 1993 and the extended dry period 1989-1993 are identified as the main driving mechanisms. The reduced inflow of the relatively fresh waters of Black Sea origin during the same period and the increased inflow of saline waters from the Levantine Sea after 1992 were additional preconditioning mechanisms. The locations and mechanisms of formation processes are identified trough combined analysis of oceanographic data and model results from March 1987. Open ocean convection in the central and north Aegean Sea is the main mechanism, while the contribution of shelf areas is limited. Intermediate water is found to be formed in the southern Aegean Sea during cold winters as well as in the central and northern Aegean during mild winters. The total volume of dense water formed during 1979-1994 corresponds to an annual formation rate of 0.24 Sv for deep water and 0.34 Sv for intermediate water.

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CONTAMINANT TRANSPORT PROCESSES IN THE CENTRAL SOUTHERN CALIFORNIA BIGHT

Along heavily-urbanized segments of the coastal ocean, such as the Southern California Bight, contaminants enter coastal waters from many sources. Rivers, marshes, harbors, storm-water discharges and sewage outfalls deliver many types of pollutants into these waters, ranging from pesticides such as DDT to bacteria and nutrients. Many of these pollutants remain dissolved, suspended or sorb onto fine sediments. Hence, both water circulation and sediment-transport processes govern their fate. Coastal ocean processes that have strong bottom currents, such as surface waves, internal bores and/or internal tides may resuspend the contaminated sediments. Tidal and subtidal currents then carry these contaminated materials and other suspended or dissolved pollutants in the water column along and across the shelf. The fate of these pollutants depends not only on current patterns, but on how long the material remains suspended. The combination of different transport processes and classes of pollutants result in varied fates. In this talk we will discuss the transport and fate of several pollutants in the central Southern California Bight.

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COMBINING TRADITIONAL AND NOVEL MOLECULAR METHODS TO DISCRIMINATE AND QUANTIFY FECAL CONTAMINATION IN RECREATIONAL AND SHELLFISH HARVESTING WATERS

Microbiological water quality of beaches and shellfish harvesting areas is typically determined by measuring indicator bacteria, such as total and fecal coliforms (or E. coli), and enterococci , to infer the presence of microbial pathogens. Bacterial indicators are used to infer the presence of human pathogens associated with fecal contamination, but they generally provide little information on the source. We have been combining "traditional" water quality assessments with Quantitative PCR (Q-PCR) to determine loading of fecal contamination, and to quantify enteroviruses, canine parvovirus, and Enterococcus spp. (fecal streptococci) to deduce the types of fecal contamination present. Our results are a component of a large collaborative project that includes flow-weighted measurements of runoff, and the use of other microbial source tracking approaches to define sources of fecal contamination stemming from non-point source runoff from 3 different land-use types: silviculture, residential, and agriculture. We will demonstrate the use of this data in building a hydrological model in a small coastal watershed in eastern North Carolina, USA, aimed at successful mitigation of water quality problems in both recreational and shellfish harvesting waters.

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MEASURING SEASONAL VARIATION IN THE DISSOLVED ORGANIC CARBON (DOC) POOL OF THE COASTAL, OFFSHORE, AND ESTUARINE REGIONS OF THE GULF OF MAINE

Chromophoric dissolved organic matter (CDOM) refers to the portion of the dissolved organic carbon (DOC) pool that absorbs light exponentially in the ultra violet and visible region of the electromagnetic spectrum. DOC concentrations and CDOM absorption were measured seasonally in the coastal, offshore and estuarine regions of the Gulf of Maine at salinities ranging from 0-32 ppt. A miniature USB spectrometer coupled to a liquid waveguide capillary flow cell was used to measure absorption by CDOM and particulate matter. The waveguide requires a small sampling volume (.26ml) that can be introduced using a peristaltic pump. This setup allowed continuous flow-through measurements to be made across large salinity ranges. DOC measurements were made on equivalent water samples by using the High Temperature Combustion/Direct Injection Technique (HTC/DI). Regression analysis was performed to develop relationships between DOC concentration and CDOM absorption. Other relationships between CDOM absorption and the spectral shape coefficient S were explored to gain information on the source of the CDOM. The DOC concentration ranged from 1.5-14 mgC/l while the absorption coefficient for CDOM at 400 nm ranged from (.05-10/m).

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DIVERSITY OF SUB-OXIC N-CYCLING MICROBES IN THE BLACK SEA

The goals of this project are to discover, isolate and characterize bacteria that carry out nitrogen transformations in the suboxic zone of the Black Sea. Samples were collected in April 2003 from several depths where the chemical transformations of interest occur. Direct acridine orange counts of fixed samples from these depths ranged in concentration from 3.3 x 103 to 3.9 x 104. Water from these depths was used for enrichment cultures using extinction-dilution procedures for metabolic groups that carry out the nitrogen transformations, including denitrification, nitrogen fixation and the anammox reaction. Filters were also taken at each of the depths for molecular studies including 16S rDNA sequencing. Enrichments for denitrifiers growing on glucose and organic acids as well as the anammox reaction show significant growth above the initial total counts and some show turbidity. Pure cultures of denitrifiers as well as anammox bacteria from consortia of the annamox reaction are being identified on the basis of 16S rRNA sequences. A comparison are being made between the identification of pure cultures and the composition of the 16S rDNA community libraries.

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EXISTENCE OF ENDOPEPTIDASES AND EXOPEPTIDASES IN SEAWATER: IMPLICATION OF EFFICIENTLY DOWNSIZING OF DOM BY MICROBIAL EXTRACELLULAR ENZYMES?

Proteolytic enzymes (proteases) in the seawater should play an important role on fates of dissolved organic carbon and nitrogen. Heterotrophic bacteria are possible sources of enzymes in natural seawater because extracellular enzymatic hydrolysis is a critical step in the microbial utilization of polymeric dissolved organic matter. In the most studies about protease in the seawater so far, leucine-aminopeptidase activity was solely measured as a representative of protease activity. There is little qualitative information about proteases existing in natural seawater. In this study, we investigate what types of proteases are in the natural seawater by using various peptide analogue fluorogenic substrates. The results indicate the existence of trypsin-type and chymotrypsin-type enzymes as well as aminopeptidases (such as leucine-aminopeptidase). Trypsin and chymotrypsin are endopeptidases, which can cleave peptide bond in the inner regions of polypeptide, while aminopeptidase is exopeptidase that hydrolyzes peptide bond adjacent to N-terminal. The existences of trypsin- and chymotrypsin-type enzymes imply that heterotrophic bacteria in natural seawater efficiently downsize high molecular weight polypeptides to suitable size for cross-membrane transport by using endo-type peptidases as well as exo-type peptidases.

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CORRELATION BETWEEN FECAL INDICATOR BACTERIA LEVELS AND OPTICAL PROPERTIES OF COLORED DISSOLVED ORGANIC MATTER (CDOM) IN POLLUTED COASTAL WATERS

Doheny State Beach (Dana Point, Southern California) has consistently failed water quality tests due to high levels of fecal indicator bacteria in the surf zone. Two possible sources of bacteria, urban runoff and birds, were investigated. Water samples were taken for two 24-hr periods- January (dry) and March (wet rainfall event) – at the creek, coastal lagoon and beach. We measured the optical properties of CDOM as a potential rapid response detection method to trace source waters at this site. CDOM consists of complex organic macromolecules found in surface waters from terrestrial (degradation of plant material) and marine sources (phytoplankton/marine bacteria exudates). E. coli bacteria counts were measured with standard methods. A single source of water with highly variable levels of bacteria was identified, indicating that shore birds in the lagoon are the major source of bacteria to the surf zone. During the rain event, elevated levels of bacteria and changing CDOM optical properties indicated a second source from urban runoff into storm drain outlets in the creek. The optical properties of CDOM may potentially be used as a rapid-response in situ system to track source waters and associated bacterial levels at beaches with consistently poor water quality to better protect the beach-going public. Future research focuses on further development of these CDOM/bacteria correlations and measuring other tracers for anthropogenic pollution sources.

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SMALL-SCALE VARIATION IN HYDRODYNAMIC FORCES ON WAVE-SWEPT ROCKY SHORES

Hydrodynamic forces imposed by breaking waves are some of the most obvious stresses in the intertidal zone of wave-swept shores. Previous studies have indicated that surface topography can influence the distributions of organisms that are of small relative to the bumps and cracks of the rock surfaces. Although many investigators have suggested that surface features should provide a reduction in hydrodynamic forces, this has not been directly tested at an appropriately small size scale. I have deployed dynamometers that record the maximum forces experienced by objects that are smaller than 1cm in diameter. By deploying many of these meters at close spacing, I show that there are differences in the hydrodynamic environment between locations only centimeters apart. Understanding the hydrodynamic environment that is relevant to many organisms on rocky shores (those with a body size of about 1 cm) is highly complex and strongly influenced by local substratum topography.

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MOLECULARLY IMPRINTED POLYMERS (MIP) BASED SENSORS FOR THE DETECTION OF SAXITOXIN

Molecularly Imprinted Polymers, MIPs, are man-made mimics of antibodies that can selectively recognize an analyte. Fullerene containing MIPs are conducting polymers enabling recognition of the analyte to be transduced into an electronic signal. The electrical conductivity is achieved through the percolation of an array of fullerene containing units. If the MIPs are inserted into an electrical circuit, binding of the analyte can result in a measurable electric signal. We are currently developing fullerene containing MIPs, and assessing their capacity to detect saxitoxin. We will present preliminary results about MIP preparation, sensor elaboration and detection of model analytes.

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HOW TO ESTIMATE ECOLOGICAL ROLES OF COMMERCIALLY IMPORTANT FISHERY SPECIES AND HUMAN IMPACTS ON ECOSYSTEM FUNCTIONING USING STABLE-ISOTOPE RATIOS

The Uwa Sea is famous as a good fishery, located in the Bungo Channel, South Japan. Through the channel, nutrient enriched water mass is transferred from a slope of continental shelf, due to the bottom-intrusion mechanism mediated by the Kuroshio Current, making there highly productive. Acropoma japonicum (Pisces: Percichthyidae) is a commercially important fishery resource. This fish is a bottom-dwelling carnivore, shifting its prey items from small benthic invertebrates to pelagic fishes with its growth. It predominates in the demersal fish community but its decrease in CPUE has been noticeable in the last decades. It is a matter of concern how human activities will threaten its sustainable yield. There exist two major anthropogenic threats: one is overfishing and another global climate changes caused by industrialization. The former can have direct effects on its population and the latter indirect effects through oceanographical changes that influence the primary production. Here we attempt to estimate its ecological role in the marine ecosystem and human impacts on it, using stable-isotope ratios of carbon and nitrogen, which reflect a material flow on the food web.

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SENSIVITY OF BIOPHYSICAL MODELING TO MODEL'S VERTICAL COORDINATE REPRESENTATION

A Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) model is coupled to the Hybrid Coordinate Model (HYCOM) to make assessments of the sensitivity of plankton dynamics modeling to the choice of the model's vertical coordinate representation. An idealized two-dimensional domain (vertical cross section of a meridional channel with free surface and irregular bottom topography) is adopted for this study. The wind stress is chosen to produce upwelling (downwelling) in the west (east) channel's coast. HYCOM's flexibility to the vertical coordinate choice is exploited to perform numerical simulations using: (i) fixed z-levels, (ii) ρ-coordinates (MICOM mode), (iii) following topography σ-levels, and (iv) hybrid (z-, ρ-, and σ-coordinates) layers (standard HYCOM mode). Particular attention is paid to the effects of diapycnal mixing and mixed-layer representations on biophysical interactions modeling in the different experiments. Future experiments will be the inclusion of a nine-component biological model as well as an application to the coast of California.

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GROWTH ENHANCEMENT OF BACTERIA BY A NATURAL IRON CHELATOR, DESFERRIOXAMINE B (DFOB)

Heterotrophic and autotrophic picoplankton utilize iron-binding ligands known as siderophores to acquire iron. We report carbon stimulation of marine bacteria in seawater cultures from the oligotrophic Sargasso Sea using a commercially available siderophore called desferrioxamine B (DFOB). Upon enrichment with DFOB, bacterial growth rates increased relative to cultures receiving either glucose or inorganic nutrients. When cultures were amended with varying concentrations of DFOB, bacterial growth responded in a dose-dependent fashion. Using fluorescent in situ hybridization (FISH), we observed differential shifts in bacterial community composition in cultures receiving either glucose or DFOB. Alteromonas macleodii dominated the glucose-amended culture comprising up to 60% of DAPI-stained cells, whereas SAR11 cells dominated (45%) the DFOB-amended culture. From these proof-of-principle results we hypothesize that specific bacterial taxa utilize siderophores as a direct source of carbon. A possible corollary to this is that siderophores may also facilitate growth by enabling bacteria to catabolize pre-existing semi-labile dissolved organic carbon (DOC). We discuss the biogeochemical implications of these scenarios as they relate to larger carbon cycle dynamics.

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INTERACTIONS BETWEEN METABOLISM, GEOCHEMISTRY AND BACTERIAL DIVERSITY IN CULTURES OF THE MARINE DINOFLAGELLATE PROROCENTRUM MINIMUM

Two batch culture systems for growing the marine dinoflagellate Prorocentrum minimum were compared. In one, inorganic carbon (Ci) and oxygen (O2) concentrations were kept constant by aeration. In the other system, Ci and O2 were allowed to change as a response to metabolic processes. If excess nutrients were supplied to the undisturbed culture, the algal metabolism skewed the Ci equilibrium system towards carbonate, and stopped at pH 9.6. The O2 concentration rose initially, but then decreased rapidly, indicating high respiratory activity during late stages of the bloom. In the aerated culture the carrying capacity for algal biomass was much higher, but the bloom seemed to be halted by some factor other than nutrient limitation. This factor could be excreted secondary metabolites. Development of bacterial communities was distinctly different in the two culture systems, both in terms of diversity and production. Aeration seemed to promote bacterial diversity and, initially, production. Later, bacterial metabolism decreased in the same manner as for the algae. In the undisturbed system bacterial diversity and production were lower but productivity increased as the bloom developed.

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REAL-TIME QUANTIFICATION OF MICROBIAL DEGRADATION OF COPEPOD FECAL PELLETS BY ISOTHERMAL MICROCALORIMETRY

Approximately one third of the ingested material ends up as fecal pellets in marine copepods. The pellets either sediment or are mineralized in the pelagic. The destiny is crucial for understanding the vertical flux and the pathways in carbon flow, and mineralization rates is important to determine. Historically fecal pellet degradation has been studied by video measurements, isotopic labeling, or bacterial growth. We want to introduce isothermal microcalorimetry to describe microbial degradation by heat-flux in real-time. We incubated preparates of 300-500 fecal pellets originating from the laboratory cultivated copepod Acartia tonsa fed Rhodomonas salina in excess for 24 h. The microbes grow at 0.28 h-1 and the specific degradation rate was 0.05 h-1 (17 degree). These process rates are very high presumably reflecting a 100 per centage active bacterial population. The limiting factor was not inorganic nutrients (N and P) but DOC (glucose). The bulk fraction of substrate for the microbes seems to be DOC as compared to the more structural components. The bacteria seems to be associated with the copepods body surface and/or from the intestinal systems perhaps covering the pelets itself. Perspectives of the methodology will be discussed.

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QUANTUM YIELD INVESTIGATIONS IN THE PACIFIC OCEAN IN RELATION TO REMOTE SENSING TECHNIQUES

One of the primary objectives of ocean color remote sensing from satellites has been to make accurate global estimates of ocean chlorophyll concentrations that can be used to model primary production and in turn, carbon fluxes. Primary production rates are dependent on carbon uptake efficiencies (quantum yield of photosynthesis) that vary as a function of phytoplankton composition, nutrients, temperature, light history, and mixing. This creates a challenge when modeling remotely sensed uptake efficiencies since they do not always correlate with standard satellite products such as chlorophyll or SST. P vs E experiments were conducted around Hawaii and the Gulf of California during MOBY/MOCE cruises to measure quantum yield in a variety of water types. Exploiting the in situ absorption properties of specific phytoplankton pigments and the correlation between quantum yield and the ratio of phytoplankton photo-protective pigments to total phytoplankton pigments (Babin et al., 1996), a relationship between normalized water-leaving radiances and maximum quantum yield has been developed and is presented. This relationship can potentially be applied to improving primary productivity estimates using remote sensing techniques.

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EFFECT OF COPEPOD GRAZERS ON ALKALINE PHOSPHATASE ACTIVITY IN TRICHODESMIUM SPP. FROM THE GULF OF MEXICO

Dissolved inorganic phosphorus (DIP) concentrations in the Gulf of Mexico are often below detection limits in oligotrophic regions where the nitrogen fixing cyanobacterium Trichodesmium is abundant. Trichodesmium is capable of hydrolyzing dissolved organic P (DOP) compounds and the inorganic products from hydrolysis may provide a source of P for growth. Alkaline phosphatase activity was investigated in Trichodesmium from the Eastern Gulf of Mexico. P regeneration by surface microbial populations can meet between 91-100% of measured P uptake requirements in offshore oligotrophic stations compared with 13.5% at the mouth of Tampa Bay. Measurements suggest that utilization of organic P is a significant Trichodesmium P acquisition strategy. Trichodesmium exhibited phosphatase activity at ambient inorganic phosphate and DOP concentrations up to 1.29 and 0.14 uM, respectively. Trichodesmium has two main copepod grazers, Macrosetella gracilis and Miracia efferata. Grazing activity of both of these copepods may also play a significant role in P supply to Trichodesmium, as phosphatase activity increased significantly in the presence of these grazers. This may be due to an increase in organic substrate from excretion and/ or sloppy-feeding.

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APPLICATION OF THE REGIONAL OCEAN MODELING SYSTEM TO ESTIMATE THE RESIDENCE TIMES AND FLUSHING RATES OF SANTA MONICA BAY, CA.

Trajectories of neutrally buoyant Lagrangian floats calculated using the Regional Ocean Modeling System (ROMS) were used to study the spatiotemporal patterns of residence times and flushing rates within Santa Monica Bay, CA. A fifteen-month simulation in one-way nested mode used the US West Coast (20 km resolution), Southern California Bight (6 km resolution), and Santa Monica Bay (2 km resolution) model grids. Approximately 550 floats were released every five days, one float at each node within the bay on the innermost grid at 200, 100, 60, 30, 10, and 1 meter depths. Float positions were recorded approximately every five hours and used to estimate bay-wide and sub regional residence times as well as flushing rates and escape fates. Residence times were classified according to month, season, and modes of dominant horizontal currents. Flushing is fastest in the spring (bay-wide residence time of 9.1 days). Flushing in the winter is relatively rapid in the first five days, after which flushing decreases, resulting in a bay-wide residence time of 14.6 days.

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EUTROPHICATION INDUCED CHANGES IN PLANT-HERBIVORE INTERACTIONS IN THE NORTHERN BALTIC SEA

The isopod Idotea baltica is common in the Fucus vesiculosus belt in the Baltic Sea. Since the decline of Fucus biomass in the late 1990s Idotea switched to Furcellaria lumbricalis as a habitat. Concurrently, a notable increase in the abundance of filamentous macroalga Pilayella littoralis and the isopods was observed. Experiments on habitat selection and feeding indicated that Pilayella contributed practically 100% of the diet of the isopod. When the biomass of Pilayella declined in the field invertebrate grazing on Fucus vesiculosus increased. The response of Idotea to the predator Palaemon adspersus varied between the algal communities differing in their dominance structure. The mortality of the isopod was lowest in Pilayella, highly variable in Fucus and highest when the two algae occurred together. The result indicates that the predator avoids eutrophicated algal communities allowing the isopods to build up dense populations. Cosequently, in removing fast growing filamentous algae, isopods protect slow growing Furcellaria and Fucus against a nuisance alga Pilayella.

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A LIPOSOME-BASED NANODEVICE FOR SEQUESTERING SIDEROPHORE-BOUND FE

Nanometer-scale engineered liposomes provide a powerful platform for developing chemical sensors for in-situ applications in marine systems. We present here preliminary findings on liposome-based nanodevices designed to sequester iron that is complexed by the siderophore deferriferrioxime B (DFB). Previous work shows that iron availability to eukaryotic phytoplankton can vary inversely with DFB additions, so quantifying DFB-Fe concentrations might provide key insights to the nutritional scenario facing these organisms. The liposome-based devices are selective for DFB-Fe and form chemically and coagulation stable suspensions in synthetic buffers and full seawater for several weeks. Iron uptake was measured when the ionophore carrier molecule Lasolocid acid was incorporated into the liposome membranes although uptake efficiencies decreased with increasing salinity. Liposome devices fabricated from only natural phosphatidyl choline proved to be fragile but their robustness was increased markedly by incorporating polymerizable diacetylene phospholipids. These findings serve as a foundation for developing self-reporting iron acquisition devices that can be calibrated against iron uptake by marine phytoplankton to provide an analytical measure of Fe availability in seawater.

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HUMAN PRESENCE AND IMPACT IN THE PREHISTORIC ALEUTIAN ISLANDS

The Aleutian Islands represent a model ecosystem in which to track human-environment interactions. Genetic evidence demonstrates population continuity from early colonization 9,000 BP to the present. Archaeological research indicates prehistoric hunting may have led to substantial alterations in the distribution of prey species, while stable isotope analyses indicate significant differences in diet between prehistoric populations of the eastern and western parts of the chain. Human activity may drive changes in local ecology by altering prey species distributions. Similarly, the human demographic profile may reflect adaptation to a changing resource base as a result of environmental change. Continuing archaeological and genetic research is aimed at obtaining more precise estimates of prehistoric human population density in the region and its temporal variation. To evaluate the prehistoric population's impact on local ecologies, we are also using genetic methods to assess local and regional evidence for abrupt declines in prey species in the past. Through this deep-time lens we aim to place the current changes in Aleutian ecology in the context of the varying spatial and temporal scales of which they are a part.

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SEASONAL VARIABILITY OF INTERNAL WAVES ON THE NEW JERSEY CONTINENTAL SHELF - OBSERVATIONS

Internal waves have been observed on the New Jersey Shelf during both summer and fall seasons. During the summer time the internal wave field was dominated by mode 1 nonlinear depression waves. In the fall the mixed layer became deeper and depending on the phase of the internal tide the internal wave field was either one of depression or elevation. Also mode 2 interfacial internal waves with associated mixing were present. Shear instabilities were detected during both summer and fall seasons. The summertime instabilities were associated with nonlinear internal waves of depression. The fall shear instabilities appeared near water mass boundaries and were not always associated with large amplitude internal waves. Observations were made with a high frequency acoustic flow visualization system. The changing internal wave dynamics are anticipated to cause summer and fall time differences between the complex properties of the acoustic field. An experiment to quantify the difference between the summer and fall time acoustic signal properties will be outlined.

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MODELED BIOLUMINESCENCE RESPONSE DURING AN UPWELLING-RELAXATION PERIOD IN MONTEREY BAY, CA

Bioluminescence has been used as an approximation for biomass in the coastal ocean and improved models of its response to changes in the chemical and physical structure of the water column provides the opportunity for better understanding coastal ecosystem dynamics. Previous models have used biological and physical parameters to predict bioluminescence. However, inclusion of additional parameters, such as nitrate concentration and CDOM fluorescence, may improve our ability to predict the response of bioluminescence to physical, chemical and biological changes. During the AOSN-2 field season in August 2003, an Acrobat towfish, equipped with a Multipurpose Bioluminescence Bathyphotometer (MBBP-G3), In Situ Ultraviolet Spectrophotometer (ISUS), CTD, optical backscatter sensor, and chlorophyll-a and CDOM fluorometers collected data over 9 nighttime transects in Monterey Bay, CA. This study uses multiple regression analysis to find the best-fit model to describe the relationship between bioluminescence, bio-optical, physical and chemical parameters. Hierarchical agglomerative cluster analysis is also used to identify ecotones and to determine whether ecotones are characterized by unique bioluminescence signals. Results will be discussed within the context of the upwelling conditions that persisted over much of the study region.

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VIRUSES, PROKARYOTES AND VIRAL-MEDIATED MORTALITY AT DEEP-SEA HYDROTHERMAL VENTS

Water samples collected from three actively venting sites and surrounding plume water along the Endeavour Ridge, Canada, were analysed to determine the distributions and abundances of prokaryotes and viruses and estimate the potential rate of infection. Samples collected from the plume had 0.33 million cells/ml (s.d.=0.08 million) and 2.8 million viruses/ml (s.d.=0.14 million), while samples from actively venting sites had higher mean abundances, but larger variability (1.13 million cells/ml, s.d.=1.14 million, 22.7 million viruses/ml, s.d.=24.3 million). Nonparametric analysis found abundances of cells and viruses to be significantly different between sites (p=0.043, p=0.0003). Within two of the sites, samples from diffuse flow had higher abundances of prokaryotes (p=0.013 p=0.052) and viruses (p=0.054, p=0.0004) than samples collected from smokers. Potential infection rates were calculated using contact rates and a conservative estimate of successful infection. Based on these estimates, the percentage of infected cells could range from 2.9% (s.d.=1.0%) in the plume, to as high as 92% (s.d.=32%) at an actively venting sulfide structure. These data suggest that viral-mediated microbial mortality can be substantial at deep-sea hydrothermal vents.

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DRAMATIC CHANGES IN SEDIMENT DISCHARGE AND RUNOFF FROM A RAPIDLY URBANIZING COASTAL WATERSHED

The southern California landscape has undergone dramatic urbanization and population growth during the past 60 years and currently supports almost 20 million inhabitants. Here we show that these anthropogenic changes have imparted an over 10-fold decrease in suspended sediment concentrations for the region's largest river, the Santa Ana between 1967 and 2001. The decrease does not, however, represent alteration of the total sediment flux to the ocean, but rather a dilution of sediment primarily by increases in runoff from the urban impervious surfaces. We hypothesize that the observed decreases in sediment concentrations have changed the buoyancy of flood discharge into the ocean from negative (i.e. hyperpycnal) to positive (i.e. hypopycnal). Thus, not only is landscape urbanization responsible for altering runoff patterns, but it may have also been responsible for changing the dispersal mechanisms and fate of sediment on the continental shelf. Similar increases in runoff with urbanization in neighboring watersheds indicate that sediment dilution may be a regional phenomenon.

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DISTRIBUTION OF A HOLOPELAGIC ISOPOD IN THE CALIFORNIA CURRENT SYSTEM: IS DISSOLVED OXYGEN CONTROLLING THEIR DISTRIBUTION?

Acanthamunnopsis milleri is a holopelagic isopod that occurs from 150 to 400 m off the U.S. West Coast at densities reaching 180/hour ROV observation, making it the most abundant pelagic munnopsid off California. Acanthamunnopsis milleri was conspicuously absent from Gulf of California waters during a spring 2003 ROV Tiburon expedition, raising questions about the southern extent of their distribution and what barriers prevent their dispersal south. Plankton tows to 300 m made between Monterey, CA and La Paz, Mexico revealed the presence of A. milleri at every station from 30 degrees N to Monterey (36.42 degrees N). CTD data revealed dramatic differences in the oxygen content of the upper water column consistent with mixing low oxygen Eastern Tropical Pacific and California Current System waters. Acanthamunnopsis milleri was found only at oxygen levels greater than 1.0 ml/L and did not shift its vertical distribution shallower to oxygen-rich water as other animals appeared to do. Vertical structuring of pelagic animal populations by the oxygen minimum zone and currents off Baja, Mexico are discussed in relation to horizontal distribution of A. milleri.

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TRANSPORT AND PHOTOCHEMICAL DEGRADATION OF CHROMOPHORIC DISSOLVED ORGANIC MATTER IN THE MACKENZIE RIVER-DELTA SYSTEM

Western Arctic shelves are dynamic regions of the coastal ocean where riverine discharge of chromophoric dissolved organic matter (CDOM) mixes with saline marine waters; the biogeochemical implications for this freshwater-saltwater transition zone (FSTZ) are not clear. We are examining the flux and photoreactivity of CDOM into the Beaufort Sea in an effort to understand the biogeochemical implications for heterotrophic communities of terrigenous C loading into Arctic shelves. Based on an initial transect of the Mackenzie River and Delta in 2002, we have calculated upper constraints on the photochemical degradation of DOM transported from the Mackenzie River through the FSTZ in the Mackenzie Delta to the Beaufort Sea. We observed a sharp decline in CDOM across the FSTZ and we have measured a DOM photooxidation rate in the Mackenzie River at 13 uM C per day. While sun angle is lower at polar latitudes than at temperate latitudes, the photoreactivity of Mackenzie River CDOM appears to be much higher than temperate rivers, suggesting that photochemical reactions may play a major role in modifying riverine DOM during transport to the Arctic shelf.

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DETERMINATION OF PRIMARY PRODUCTION IN LAKE ERIE BY MULTIPLE PROXIES

Determination of the rate of gross primary production within aquatic environments is one of the most fundamental measures of ecosystem health and ecology. While the use of C-14 labeled bicarbonate in incubation has been the standard for quantifying rates of primary production for the past 50 years, recent studies based on incubations with O-18 labeled water have shown rates of primary production 2-10 times greater. Consequently, we conducted simultaneous estimates of primary production in Lake Erie in July of 2003 using C-14 labeled bicarbonate, light-dark bottle incubations and O-18 labeled water. Concentrations of oxygen in the light dark bottle incubations were determined by automated Winkler titrations. All three approaches were initiated using a common reservoir of water and incubated simultaneously at the same light level. Three stations in Lake Erie were sampled that ranged from 1 to 20 ug-Chl/L. Rates of primary production based on C-14, light-dark bottles, and O-18 labeled water for the eastern basin (5.33, 4.23, and 5.45 mgC/m3.hr, respectively), central basin (4.47, 1.59, and 3.97 mgC/m3.hr, respectively) and Sandusky Bay (332.0, 520.61, and 476.4 mgC/m3.hr, respectively) were of comparable magnitudes and did not show consistent differences between stations. Additional results from a cruise in August will be presented and discussion will focus on the comparisons of rates based on C vs. O measurements.

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FLUOROMETRIC ALGORITHM FOR DETERMINING PHOTOSYNTHETIC PHYTOPLANKTON CHARACTERISTICS

The observation and interpretation of induced by artificial light fluorescence of phytoplankton has been performed. It appears to be a convenient and accurate method of determining the photosynthetic characteristics of phytoplankton. Fluorometric algorithm of determining the photosynthetic phytoplankton characteristics is presented. Measurements were carried out in situ with submersible cllasical and Pump Probe fluorometers. The temperature and downward irradiance in the PAR spectral range were also measured with equipment connected to the fluorometer.The chlorophyll concentration and the phytoplankton mean light absorption coefficients can be determined using the measured initial fluorescence, and optical depth. The determination of primary production, photosynthesis quantum yield and the absorbed by photosynthetic pigments energy require measurements of the initial and maximal fluorescence as well as the temperature and irradiance. This was obtained by means of the Pump Probe in situ fluorometer. The determination of the primary production during longer periods of time required additional pyranometric measurements. The presented methods are far more accurate than the previous ones, which were based on the statistical correlations between photosynthetic characteristics and measured fluorescences.

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CDOM EFFECTS ON THE UNDERWATER LIGHT FIELD: SIMULATIONS OF ULTRAVIOLET RADIATION INCIDENT UPON CORAL REEFS

CDOM (Colored Dissolved Organic Matter) absorbs strongly in the ultraviolet and blue regions of the electromagnetic spectrum and has a strong effect on the underwater light field. Due to it's absorption properties, CDOM protects marine organisms from the harmful effects of UVR (ultraviolet radiation), which has been implicated in the bleaching of reef building corals and been shown to adversely affect the health of marine organisms. The focus of this study is to estimate dose rates of harmful UVR near various reef sites worldwide using values of CDOM absorption and chlorophyll concentration obtained from MODIS (Moderate Resolution Imaging Spectroradiometer) data as inputs into the Hydrolight radiative transfer model. Modeled downwelling irradiance values were weighted by the action spectrum of Setlow to estimate biologically-effective doses of UVR at depth. Simulations were done based on three-month means of CDOM absorption and chlorophyll concentration to examine seasonal variability.

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INTERANNUAL CHANGES IN THE SEASONAL AND REGIONAL POPULATION OCCURRENCE OF CALANUS SINICUS IN THE KII CHANNEL, THE PACIFIC SHELF WATER OF SOUTHWESTERN JAPAN

Analysis of monthly data for 12 yr (1987-1999) collected from 12-21 stations in the Kii Channel, which is an entrance of the Inland Sea of Japan opening out onto the Pacific Ocean, was conducted to examine the interannual change in the seasonal population size of Calanus sinicus. The annual seasonal variation of C. sinicus was roughly the same throughout the period. However, interannual differences were notable in early summer, and these differences appeared to be related to interannual differences of water temperature. To confirm the influence of temperature, the regional occurrences of C. sinicus in early summer were compared between cold and warm years. In cold years, C. sinicus occurred abundantly throughout the area (average: 1545 indiv. m-3). Whereas, in warm year, its abundance was below 268.1 indiv. m-3. In intermediate year (1996), when temperature was higher in the outer area, but lower in the inner area, C. sinicus occurred considerably less (26.3 indiv. m-3) in the former compared to the latter (502.3 indiv. m-3). These results indicate that early summer temperature is critical to determine the population size and regional distribution of C. sinicus in the Kii Channel.

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DETERMINING TAXON–SPECIFIC PARTICULATE ORGANIC CARBON WITH OPTICAL BACKSCATTER.

Southern Ocean waters play a key role in global carbon cycle, accounting for a significant amount of global CO2 exchange with the atmosphere. The Ross Sea region of the Southern Ocean is highly productive and dominated by two phytoplankton taxa, diatoms and Phaeocystis antarctica, which exhibit different carbon uptake characteristics. An empirical method was used to extract backscatter values from in-situ bio-optical measurements collected during two cruises (1996-98) to the southwestern Ross Sea as part of the Research on Atmospheric Variability and Ecosystem Response in the Ross Sea (ROAVERRS) program. Results from both cruises show that there is a significant difference in the relationship between POC and optical backscatter for the P. antarctica and diatom dominated regions. The taxon-specific relationship between backscatter and POC, as well as that of remote sensing reflectance to backscatter enabled us to develop an empirical algorithm for determining taxon-specific POC abundance for the Ross Sea region from ocean color imagery.

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MOLECULAR PHYSIOLOGICAL BASES OF HIGH GROWTH EFFICIENCY IN INVERTEBRATE LARVAE FROM COLD ENVIRONMENTS

Growth efficiency, measured as biomass production per unit of consumed food, is reported to be high in many planktonic organisms living in cold environments. In larvae of Antarctic invertebrates low metabolic rates do not result in correspondingly low rates of macromolecular synthesis and growth potential. We selected several species of Antarctic echinoderms for this study because of their 4-fold difference in larval size, their different life history strategies (feeding and non-feeding larval stages), and because of their experimental tractability for studies of protein metabolism. At –1.5C these organisms had high rates of protein synthesis (~ 1% per hour of whole-body protein content) with low metabolic energy expenditure. These synthesis rates at –1.5C are comparable to values for temperate echinoderms at 15C, indicating that very high rates of synthesis can occur in extreme cold. Analysis of the protein synthetic machinery in cell-free preparations of Antarctic species revealed elevated rates of peptide elongation and high numbers of ribosomes engaged in protein synthesis. Rapid ribosomal transit times and low protein synthesis costs are the bases for unique physiological capabilities in these Antarctic organisms.

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SURFACE VELOCITY PATTERNS IN MONTEREY BAY FROM HF RADAR DURING THE AUTONOMOUS OCEAN SAMPLING NETWORK (AOSN) EXPERIMENT

Observations from four CODAR-type HF radar systems were used to provide real-time maps of surface currents around Monterey Bay as part of the AOSN experiment. Products available included hourly and daily averaged maps plus hourly updated trajectories from a real-time normal mode analysis. During August 2003, these products were used to help plan instrument deployments and as a check on forecasts from two independent modeling groups. Since that time, radial velocity estimates from each radar site have been reprocessed using antenna calibration data and these improved estimates have been used to remap the two-dimensional surface currents. The velocity maps show distinctive circulation patterns under the contrasting upwelling- and downwelling-favorable wind regimes. Within the dominant upwelling-favorable conditions, flow in the southern portion of Monterey Bay is sensitive to offshore conditions and, as such, is a good diagnostic for model skill. Statistics of the spatial divergence patterns from the normal model analysis reveal consistent regions of divergence near the upwelling center north of Monterey Bay and over the head of the Monterey Submarine Canyon in the first and second EOF modes, respectively.

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FROM SMALL SCALES TO THE BIG PICTURE

In some large-scale multidisciplinary oceanographic studies general quantifications of community activities will suffice to achieve the overall goal. An understanding of the mechanisms underlying such activities/processes is then usually limited. However, a comprehensive knowledge of the governing processes is essential to determine the causes of variability. At the Marine Zooplankton Colloquium 1 (1988) the "characterization of individual small-scale behaviors" as well as "the determination of environmental variability" were among the principal issues. The behavior of individual zooplankton is species-specific, and is affected by environmental variables such as food quality and quantity, as well as predation. Once we quantify the abundant metazooplankton species and their stages of an epipelagic community, we should be able to approximately project the general future of these zooplankton taxa over several days to even a week, taking the behaviors and several environmental variables into account. The variability of such metazooplankton community processes is seen as a function of species composition and environmental variables affecting the species behavior. Examples may illustrate this presentation.

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A MODEL LINKING CHLOROPHYLL-NITROGEN DYNAMICS TO THE REDFIELD N:C RATIO

The Redfield N:C ratio is a fundamental quantity in marine biogeochemistry as a key determinant of the efficiency of the biological carbon pump. The Redfield N:C ratio is often associated with the N:C ratio of light-limited phytoplankton but no convincing explanation has been put forward for its value and remarkable constancy throughout most of the world ocean. Phytoplankton growth models used to represent primary production within larger biogeochemical models have therefore been unable to predict the Redfield N:C ratio. The model presented here is based on the hypothesis that algal cells maximize growth rates by optimally allocating their available nutrient and energy resources among the competing requirements for nutrient uptake, metabolism, and growth. The resulting formulation is the first to adequately describe the behaviour of carbon, nitrogen, and chlorophyll under both nutrient- and light-limiting conditions. The Redfield N:C ratio is shown to be closely related to the N:C ratio maximizing light-limited growth, which is narrowly constrained. Thereby the model yields the first explanation for the Redfield N:C ratio and its global constancy.

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VARIABLE RESPONSES OF HETEROTROPHIC BACTERIA TO SURFACE SOLAR IRRADIANCE IN THE PACIFIC OCEAN

We investigated the responses of bacterioplankton to solar irradiance from Barrow Alaska (7O N, 163 W) to Lyttleton NZ (43 S, 172 W), from August to October 2003. Unfiltered surface samples amended with 3H-leucine and 3H-thymidine (10 nM) were exposed to ambient UVB+UVA+PAR, UVA+PAR and PAR for 4 hours at solar noon. From 70 N to 47 N, leucine incorporation rates in all light treatments were similar to dark rates. Thymidine incorporation was inhibited (~25% reductions relative to dark rates) in UVB+UVA+PAR and UVA+PAR treatments. PAR exposure thymidine incorporation rates were similar to dark rates. Between 43 N and 31 N, leucine incorporation was enhanced relative to dark rates in UVB+UVA+PAR, UVA+PAR and PAR treatments (~18%, ~37%, ~57% increases, respectively). Thymidine incorporation was inhibited in UVB+UVA+PAR and UVA+PAR treatments (~20% and ~27% reductions, respectively) but enhanced (~20% increases) in PAR treatments. Light-enhanced leucine incorporation (up to 2-fold greater than dark rates) was also observed at 7 and 2 N. Preliminary evidence suggests that light-enhanced prokaryotic leucine incorporation may be prevalent in the central North Pacific and related to community structure.

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DYNAMIC EVOLUTION OF THE EQUATORIAL UNDERCURRENT AT THE GALAPAGOS ISLANDS DURING 1993-1994 AND IN APRIL 2000

Water property data from CTD casts collected during monthly cruises around the Galapagos Islands between April 1993 and March 1994, and in April 2000, are presented. We use hydrographic sections from the western side of the archipelago, where topographic upwelling of the Equatorial Undercurrent (EUC) occurs year round, to present the annual cycle and evolution of the EUC during a period of transition from El Niño (March to October 1993) to La Niña (December 1993 to March 1994) conditions. In particular, we describe the topographic impact of the islands on the distribution of water masses and EUC evolution. These observations are contrasted with the La Niña conditions prevalent in April 2000. Satellite-derived measurements of sea surface temperature, sea surface height, and ocean color, along with observations from the TAO array, are used to provide large-scale context for the Galapagos observations. We comment on the ecosystem implications of the island influence on local circulation and water properties.

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ECOLOGICAL INSIGHTS FROM GENETICS AND GENOMICS

Molecular genetics and genomics have developed powerful tools for investigating the functions of predicted open reading frames (genes) in organisms. Genomic analysis can provide insights into function by characterizing the relatedness of the gene to previously characterized genes, providing information on upstream regulatory regions, and by providing information on predicted secondary structure. The tools of molecular genetics then allow the manipulation of the gene of interest, for example its inactivation in the organism to test its predicted function under different physiological conditions. Some examples of how these tools have provided insights into processes of ecological interest will be presented.

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SUPPORTING STUDENT LEARNING DATA: THE VIRTUAL GEOPHSYICAL EXPLORATION ENVIRONMENT.

Access to scientific data isn't enough to enable learning—students also need an array of supporting materials: curricula to guide their explorations, tools to manipulate the data, and resources to that teach relevant scientific concepts. The Virtual Geophysical Exploration Environment (VGEE) integrates these elements in an inquiry-based online curriculum focused on El Nino. This integration builds on internet-enabled applications. The visualization environment, the Integrated Data Viewer (IDV), is installed, configured, and updated over the internet. Online data is accessible via Thematic Real-time Earth Environmental Data Servers (THREDDS). Along with relevant instructional resources, the IDV and the THREDDS data are embedded into an online curriculum discoverable in digital libraries. This means that students can discover real-time data along with the tools and curricula that enable them to learn from the data. Finally, the VGEE also provides an architecture that can support other data-based curricula. The IDV can be easily customized for different students and subjects. By negotiating protocols and providing semantics, THREDDS provides transparent access to a variety of distributed data. DLESE provides a forum to organize these development resources and connect educators, developers, and data providers.

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A NUMERICAL BIOPHYSICAL MODEL OF CONNECTIVITY AMONG CORAL REEFS: QUANTITATIVE PREDICTIONS OF LARVAL FISH DISPERSAL PATTERNS

Dispersion of larvae is the dominant mechanism of connection among open marine populations and the communities they form. Predictive understanding of the process may lead to better management of marine resources and biodiversity. Empirical evidence shows that larval dispersion (and retention) cannot be modeled solely as the advection of passive particles. Larval recruitment depends on the interaction of physical transport mechanisms (advection/diffusion) and active larval behaviours (vertical migration, orientation, swimming, habitat selection). Our coupled bio-physical model estimates the dispersal trajectories of fish larvae among isolated coral reefs based on the interaction between their time and location-dependent sensory and swimming abilities, and the evolving 3-D physical flow field. Lagrangian tracking of an ensemble of passive particles within the upper two layers of a 3-level, spatially-nested ocean circulation model (CANDIE, 3km cell, 7.5min time step) establishes the setting for a transition matrix based on a 1st order Markov Chains model that predicts the proportional probability of initial spawn at a source reef arriving at various distant reefs as a function of advection and their swimming velocity in response to current-independent and dependent cues within a sensory zone around each reef in the model domain.

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TWO BIOPHYSICAL COUPLED MODELS OF RECRUITMENT VARIABILITY: LEVEL OF COMPLEXITY OF PROCESSES MODELLED, USE OF DATA AND PREDICTIVE VALUE OF THE MODELS

We describe two spatially explicit biological models coupled to hydrodynamic models, used to study spatial and temporal recruitment variability and early life history of anchovy (Engraulis encrasicolus) in southern Benguela and walleye pollock (Theragra chalcogramma) in the western Gulf of Alaska. We discuss the level of complexity of the biological processes modelled, the use of data for setting initial conditions, parameterization, design of the biological functions, validation of the models with data and the predictive value of the models. Both of the individual-based models (IBMs) were coupled with hydrodynamic models, but only the IBM for pollock was coupled to a nutrient-phytoplankton-zooplankton model simulating the dynamics of the pollock prey. We also discuss the outputs of both IBMs (spatial and temporal distribution of anchovy and pollock), proxies for recruitment, and the feedback between modelling and data collection.

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DECOUPLING OF FE AND PHOSPHATE IN THE GLOBAL OCEAN

We formulate a mechanistic model of the coupled oceanic iron and phosphorus cycles. The iron parameterization includes scavenging onto sinking particles, complexation with an organic ligand and a prescribed aeolian source.
We implement this biogeochemical scheme in a coarse resolution ocean general circulation model (GCM) using scavenging rates and conditional stability constants guided by laboratory studies and box model sensitivity studies. The GCM reproduces the broad regional patterns of iron and phosphorus. The high macro-nutrient concentrations of the Southern Ocean emerge from the explicit iron limitation of the model. The model also qualitatively reproduces observed inter-basin gradients of deep,dissolved iron with the lowest values in the Southern Ocean. We define a tracer, Fe* = FeT - R*PO4, where FeT is the dissolved iron concentration and R is an assumed iron:phosphorus Redfield ratio. Fe* quantifies the degree to which a water mass is iron limited, relative to phosphorus. Surface waters in high nutrient, low chlorophyll regions have negative Fe* values, indicating Fe limitation. In these regions the aeolian dust flux is not sufficient to compensate for the deficit of iron in upwelled waters which have accumulated phosphorus and lost iron to scavenging during their transit through the deep ocean. The extent of this decoupling of iron and phosphorus is determined by the availability and binding strength of the ligand relative to scavenging.

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INFECTION OF THE BLOOM-FORMING DINOFLAGELLATES ALEXANDRIUM AFFINE AND GONYAULAX SPINIFERA BY THE PARASITE AMOEBOPHRYA

The bloom-forming, thecate dinoflagellates Alexandrium affine and Gonyaulax spinifera were heavily infected by the parasitic dinoflagellate Amoebophrya in early autumn of 2002 in Korean coastal waters. This is the first documentation of Amoebophrya infections and its developmental stages in A. affine and G. spinifera from natural field samples and cultures. Parasites of the two dinoflagellate hosts differed in their site of infection, developing in the nucleus of G. spinifera but in the cytoplasm of A. affine. Developmental stages of two parasite strains from the hosts were in accordance with previous descriptions of Amoebophrya infecting dinoflagellates. A prominent feature of Amoebophrya infection in A. affine from natural field samples was the presence of abnormally 'giant cell' in the long chained cells, with the

largest cells reached up to 60 micrometers in width. The ecological roles of Amoebophrya in terms of biocontrol of harmful algal blooms and host specificity will be discussed.

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AMMONIUM SUPPRESSION OF PRIMARY PRODUCTION IN THE DELAWARE ESTUARY: EVIDENCE FROM MESOCOSM EXPERIMENTS

Anthropogenic impact on coastal and estuarine waters can be seen not only in increases in the total nitrogen load but also in shifts in the nitrogen species available to the microbial community. It is well understood that with appreciable NH4 concentrations, NO3 uptake may be inhibited. This may result in lower primary production than suggested by nutrient availability by making a large fraction of the dissolved inorganic nitrogen unavailable to phytoplankton. Using large mesocosm experiments in the Delaware Estuary we have shown that there are significant differences in the response of the microbial community grown on either NO3 or NH4. Over the course of 34 hours, we found that dissolved inorganic carbon drawdown was 3 times higher when phytoplankton were supplied with only NO3 compared with phytoplankton grown on NH4, while nitrogen assimilation rates of NO3 and NH4 were similar. The increased carbon production resulted in a 2.5-fold increase in particulate carbon and nitrogen, as well as a 34 uM build up of dissolved organic carbon. Chlorophyll a measurements show that there was a significant build up in autotrophic biomass in the NO3 treatment with a shift towards larger cells compared with the NH4 grown cells. Our results suggest that the form of nitrogen available to phytoplankton will result in a profound effect on organic carbon production, and changes in the structure of the microbial community.

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A PEPTIDE NUCLEIC ACID (PNA)-BASED FLUORESCENT IN SITU HYBRIDIZATION METHOD FOR WHOLE CELL DETECTION OF CROCOSPHAERA SP. (SYNECHOCYSTIS SP.) WH8501

A PNA-based FISH method was developed for the detection of Crocosphaera sp. (Synechocystis sp.) WH8501. Recent work has shown that the distribution of this organism is much broader than previously suspected. Hence their contribution to marine nitrogen budgets via nitrogen fixation has likely been underestimated. In marine habitats Crocosphaera sp. (or Synechocystis sp.) are relatively small with high natural autofluorescence due to the abundance of phycoerythrin photosynthetic pigments. We have developed a method for rapid population analysis by either flow cytometry (FCM) or epifluorescence microscopy using fluorescently-labeled PNA probes. Cultured Crocosphaera was hybridized with strain specific probe pWH8501, nonspecific eukaryotic probe and without probe. The fluorescence of cells with pWH8501 was unambiguously highest. Hybridized cyanobacterial control strains with one to three mismatches with the probe pWH8501 had distinctly lower fluorescence levels. Experiments will be done on natural samples subsequently. Currently, little is known about the ecology, distribution or abundance of Crocosphaera sp., and it will be useful to have the tools to rapidly determine their identity and abundance in space and time.

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TO WHAT EXTENT CAN PLANKTON BEHAVIOR AFFECT ITS DESTINY?

While plankton have often been thought to be passive tracers, completely at the mercy of physical processes, the commonness of plankton patches, as well as field studies showing evidence of planktonic movement against the mean flow, suggest the importance of some other factor. Although physical processes may determine large scale plankton patterns, individual plankton behavior such as predation or vertical/horizontal migration may dominate at smaller scales. Using a hydrodynamic model to create various flows in a channel, we model plankton behavior with an individual-based model and explore the extent to which biological processes can counteract physical drivers. In particular, we are interested in studying how different plankton migration behaviors affect biological retention time under a variety of flow regimes and whether a combination of physical/biological regimes exists that will allow the plankton to stay in the study system (avoid washout) 'forever.' Time scales involved are on the order of a week in order to avoid population change issues.

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CHARACTERISTICS AND COMPOSITION OF EXOPOLYMERIC GELPARTICLES

Heterotrophic and autotrophic micro-organisms release a wide variety of substances, some of which spontaneously form gel-like particles, e.g. polysaccharide-rich Transparent Exopolymer Particles (TEP) and protein-rich Coomassie Stained Particles (CSP). We investigated the production, size frequency distributions and composition of TEP and CSP in three mesocosms dominated by heterotrophic micro-organisms (tank 1), by Phaeocystis spp. (tank 2) or by diatoms (tank 3), respectively. Whereas concentrations of TEP and CSP were small in tank 1, TEP and CSP were abundant in tanks 2 and 3. Especially during the decline of Phaeocystis TEP formed abundantly, but CSP concentration and size distributions were not affected. Changes in the size distributions suggested that coagulation dominated TEP dynamics in tank 3, whereas production of new (small) particles determined CSP size distributions in the same tank. A stepwise multiple regression analysis suggests that TEP in tank 3 may be rich in Fucose and Rhamnose, whereas TEP in tank 1 stood in no relation with the any of the sugar monomers, and TEP in tank 2 appeared related to concentrations of 5 different sugars.

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BUDGETING BIOGEOCHEMICAL CYCLES – SOME TRIPPING STONES

Budgeting or modeling biochemical cycles we generally ignore processes on the event scale. But biogeochemical cycles on regional or global scales are driven by micro-scale processes and require an understanding of particle interactions. Example 1: Dissolution rates of diatom frustules vary depending on the state of aggregation. Silica dissolution rates are significantly lower, if diatoms are enclosed in large aggregates, compared to freely dispersed cells. Within aggregates, the normalized bacteria concentration is reduced, the viability of diatoms increased and concentration of silicic acid elevated compared to free cells. Example 2: Organic material exists as a size continuum and large particles form abiotically from material passing 8 kdalton filters impacting aggregation dynamics, providing additional food for zooplankton and changing flux estimates. Example 3: Deep POC fluxes have been shown to be tightly associated with respective fluxes of ballast minerals. We propose that POC fluxes determine the fluxes of minerals, rather than vice versa. However, this suggestion can only be evaluated, if size distributions and sinking velocities of mineral particles in the deep ocean can be estimated.

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PARTICLE IMAGE VELOCIMETRY ANALYSIS OF RAIN INDUCED MIXING OF THE OCEANIC BOUNDARY LAYER

The impact of turbulence and momentum transfer in the ocean boundary layer due to rain is examined. The experiments were performed in the large wind wave channel at the Air-Sea interaction Laboratory of the University of Delaware. This initial experiments were aimed at proving validity, necessity, and feasibility of further research. Velocities in the water column and subsequent Turbulent Kinetic Energy (TKE) profiles are obtained using Particle Image Velocimetry. It was determined that , for a given raindrop size, the depth and magnitude of the TKE is proportional to wind speed. Rain induced TKE is increased by rain rates of less than 86 mm/hr. However, for tested rates above 86 mm/hr, the turbulent energy appears to be damped. Rain is also shown to damp the TKE levels in the very near surface layers, while simultaneously increasing the depth at which the maximum TKE is found.

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EVIDENCE FOR CENTIMETER AND MILLLIMETER SCALE PHYTOPLANKTON STRUCTURE

The potential influence that microscale phytoplankton heterogeneity can have in biogeochemical cycling processes in the ocean, has led researchers to focus on phytoplankton distributions over centimeter scales. Here we show for the first time, employing the high-resolution fluorometer, FluoroMAP, that fluorescence is variable over centimeter and millimeter scales in two environments of differing mixing intensities. For both sites, profiles exhibited rare concentrated regions. Variation in the fluorescence signal persisted down to the smallest scale measurable by FluoroMAP ( 1.5 mm), with the parameters of peak morphology, width and height, distinguishable. Changes in fluorescence intensity for peaks less than 2 cm were up to 300 fold greater than fluorescence changes over the sampled water column (1.2 times/m). Peak width was 1.7 fold lower in the turbulent environment compared with the low energy environment. Subsequently, turbulence was suggested as the majoring structuring process limiting peak size. Results from this study demonstrate the existence and persistence of patches. This observed variation in microscale phytoplankton patches is envisaged to be sufficiently large to potentially influence the dynamics and ecology of phytoplankton communities.

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THE PHAGE HSIC GENOME: AN ECLECTIC COMBINATION OF GENES IN A PSEUDOTEMPERATE SIPHOPHAGE

The genome for the marine pseudotemperate siphophage HSIC has been sequenced using a combination of linker amplification library construction, restriction digest library construction, and primer walking. Phage HSIC enters into a pseudolysogenic relationship with its host, Listonella pelagia, characterized by sigmoidal growth curves producing > 10e9 cells/ml and >10e11 phage/ml. Southern transfers of host chromosomal preparations suggested that chromosomal integration occurred. The genome (37966 bp; G+C = 43.97) contained 47 putative ORFs, 17 of which had significant BLASTP hits in GenBank, including a beta-subunit of DNA polymerase III, a helicase, a terminase, several phage-like structural proteins, and a haemagglutinin. No evidence of a cos-site could be found, and restriction analysis suggested the genome in the phage exists as a covalently closed circle. Because BLASTP hits were obtained for homologous genes from a wide range of microbes and phages, the phage HSIC genome appears to be a mosaic of genes from widely diverse microbial sources, and not closely related to any phage genome sequenced to date.

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DETECTION OF METHANE LEAKAGE FROM THE ARCTIC SHELF

The Arctic shelf is currently undergoing dramatic thermal changes caused by the continuing warming associated with the Holocene sea level rise. During this transgression comparatively warmer waters flooded over relatively cold Arctic permafrost areas. The resulting thermal pulse is still propagating down into the submerged sediment and should be decomposing gas hydrates. We looked for gas venting from the Arctic seafloor during a September 2003 cruise. Because the entire shelf is prohibitively large, the primary focus was offshore pingo–like features (PLF) northeast of the Mackenzie River Delta. Eighty-one vibracores were collected, primarily from the crests and flanks of eight PLF. Methane concentrations were systematically elevated in cores from the PLF, sulfate depletion occurred in as little as one meter sub-bottom, and ROV surveys revealed that streams of gas bubbles composed predominately of methane are coming from the crests of at least two PLF. While it is premature to conclude that this methane is related to gas hydrate decomposition, the methane is venting where we predicted it would occur if it was coming from decomposing gas hydrate.

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PREDATOR-PREY ENCOUNTERS IN TURBULENT WATERS

With reference to studies of predator-prey encounters in turbulent waters, we demonstrate the feasibility of an experimental method for investigations of particle fluxes to an absorbing surface in turbulent flows. We analyze data from a laboratory experiment, where an approximately homogeneous and isotropic turbulent flow is generated by two moving grids. The simultaneous trajectories of many small neutrally buoyant polystyrene particles were followed in time. Selecting one of these to represent a predator, while the others are considered as prey, we obtain estimates for the time variation of the statistical average of the prey flux into a suitably defined “sphere of interception”. The variation of this flux with the radius of the sphere of interception, as well as the variation with basic flow parameters, are well described by a simple model, in particular for radii smaller than a characteristic length scale for the turbulence. Also the Eulerian counterpart of the problem has been analyzed, and the particle fluxes from the two studies compared. Further generalizations of the investigations are outlined.

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DELINEATING THE RESPONSE OF PHYTOPLANKTON DURING THE SOUTHERN OCEAN IRON EXPERIMENT BY EXAMINING CHANGES OF PHOTOCHEMICAL EFFICIENCY

Phytoplankton production in the Southern Ocean is controlled by complicated interactions of light, nutrients, and iron availability. In early 2002, the Southern Ocean Iron Experiment (SOFeX) was completed in the Southern Pacific (along ~ 170º W). Two iron-enriched patches were created North and South of the Polar Front with initially distinct silicic acid concentrations. Pulse amplitude modulated (PAM) fluorometry was employed for measuring phytoplankton electron transport chain between Photosystem II and Photosystem I for the whole phytoplankton assemblage and on a single-celled basis. Rapid light curves were also employed to examine changes in light harvesting during the course of the enrichment experiment. Bulk and size-fractioned measurements of photochemical efficiency showed the release of phytoplankton from iron limitation. For single-celled analysis with PAM, a time course from the South Patch will be presented along with late North Patch data. For the Southern Patch, distinct increases in photochemical efficiency were detected for all diatom genera analyzed. These single-celled responses are then modeled to delineate the maximum quantum yield achieved and the genera-specific saturation rate constant based on time.

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VARIATIONS IN PHYTOPLANKTON PRODUCTION AND COMMUNITY STRUCTURE AND ITS RELATIONSHIP TO ENVIRONMENTAL CONDITIONS IN COASTAL WATERS OF VANCOUVER ISLAND

A better understanding of the links between phytoplankton abundance, productivity, community structure and environmental conditions is required to predict potential future responses of the carbon cycle to climate change. In this study, we examine concurrent physical and biological time series (currents, salinity, temperature, fluorescence and PAR) from moored instrumentation and shipboard surveys observations of coastal waters of Vancouver Island. The data is analysed to determine variability in phytoplankton abundance from seasonal to episodic events that dominates the dynamic of coastal ecosystem. To complement these observations, a simple plankton model is used to elucidate linkages between biological productivity and temporal variability in the environment. Model results are presented to illustrate the potential responses of plankton communities to changes in environmental factors such as light, nutrients and mixed layer depth.

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MALE DAPHNIA ATTACHMENT FORCES DURING MATING EXAMINED BY ATOMIC FORCE MICROSCOPY (AFM)

The first antennae of male Daphnia pulex and male D. magna were examined using Atomic Force Microscopy (AFM). This innovative technique uses a cantilever probe to scan a surface. The probe’s oscillation measures the topography and the attractive forces of a sample. Previous video observations showed that mating occurs when the male and the female Daphnia are positioned ventrally. However, the much smaller male approaches the larger female from behind, attaches to her carapace, and then progresses to the female’s ventral side. We hypothesize that the male accomplishes this task by using some adhesive forces of the carapace rim and its enlarged first antennae. SEM imagining has shown minute hairs on these appendages. The questions are then: (1) what are the attractive forces of these hairs with the female’s carapace, and (2) how is the male able to maneuver to the female’s ventral side while she continues to swim?

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RE-EVALUATION OF PREFORMED ALKALINITY IN THE OCEANS FOR ESTIMATING THE ANTHROPOGENIC CO2 INVENTORY

Preformed alkalinity is a key parameter in estimating the anthropogenic CO2 inventory in the ocean. Currently, a single empirical equation has been derived from available surface water data and applied to all three major oceans. However, regional variations of preformed alkalinity within each ocean could result in significant changes in the estimates of anthropogenic CO2 inventory. In this poster, we present results of re-evaluation of preformed alkalinity. Empirical equations for AOU-corrected preformed total titration alkalinity (Alk*) as functions of salinity and potential temperature in source regions of the deep ocean waters (North Atlantic, Southern Ocean, and North Pacific) are estimated. The results from the three regions are all different. In order to estimate anthropogenic CO2 inventory in the oceans, it is necessary to sort out the Alk* contributions from different sources.

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ALONGSHORE VARIABILITY OF THE CALIFORNIA CURRENT SYSTEM FROM CENTRAL TO BAJA CALIFORNIA IN WINTER AND SPRING 2003: PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES

Sixteen stations along the continental slope of western North America were occupied in winter and spring of 2003 and form a meridional section from Monterey Bay, California (36.7 N, 122.4 W) to Cabo San Lucas, Mexico (23.0 N, 110.4 W). Our purpose was to document variability of euphotic zone and California Undercurrent (CU) properties along the section. In particular, because the CU provides source waters for coastal upwelling, we were curious to observe evolution of CU properties as it flows northwards from the Eastern Tropical Pacific, and to determine whether such changes might affect euphotic zone properties under non-upwelling (winter) or upwelling (spring) conditions.
CTD casts to 1000 m were conducted at all stations and profiles of temperature, salinity, oxygen, fluorescence, transmissivity, macronutrients, TCO2, DOC, POC, flow cytometry counts, HPLC pigments, ATP, chlorophyll, and primary production were obtained. FRRF and iron profiles were obtained at a subset of stations, as were vertically-stratified Tucker Trawl samples of zooplankton. Continuous underway surface measurements were made of iron, pC02, temperature and salinity. An initial description of these data sets is presented here.

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PHOTOSYNTHETICALLY AVAILABLE RADIATION (PAR) IN THE NAVY COASTAL OCEAN MODEL (NCOM): ECOSYSTEM SENSITIVITY TO PAR TEMPORAL/SPATIAL RESOLUTION AND DATA SOURCES

We examine the sensitivity of a coupled bio-physical simulation model of the California Current System (CCS) to photosynthetically available radiation (PAR) fields used to force the biological component. A regional, high-resolution, circulation model (NCOM-CCS) has been coupled to the nine-component ecosystem model of Chai et al. (2001) and modified for this temperate coastal system. A baseline case with constant PAR is used for comparison. The Comprehensive Ocean-Atmosphere Data Set (COADS) provides monthly climatological PAR fields, allowing us to examine the effects of weather (clouds, etc.) on the model. The first set

of sensitivity studies uses monthly mean, daily averaged, and hourly clear-sky PAR fields computed with a radiative transfer model (RADTRAN) to examine the effects of temporal resolution of the PAR input to the model. The COAMPS (Coupled Ocean Atmosphere Mesoscale Prediction System) Reanalysis atmospheric model for the Eastern Pacific supplies hourly solar shortwave radiation values (PAR is a constant fraction of shortwave radiation) at the ocean surface. The ecosystem response in the atmospheric model based solutions is compared to the response in the climatology based solutions.

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OF SHIPS, NETS AND OCEAN CURRENTS: THE SIGNIFICANCE OF TRANSPORT IN UNDERSTANDING THE DISTRIBUTION AND POPULATION DYNAMICS OF PLANKTON

Plankton surveys are assumed to provide a synoptic view of the distribution and abundance of the organisms sampled but the reality is that as our ships sample the ocean, the water below is moving. The accuracy and precision of the distributional picture that emerges is affected by the duration and path of the survey, the size of the study area and distance between sampling locations, and the precision of the instruments used to collect specimens. With the development of increasingly complex circulation models, the reconstruction and projection of transport of plankton and integration of adaptive sampling are becoming increasingly important in the study of plankton population dynamics. This presentation will focus on the progress of bio-physical studies of plankton transport and identify the issues that need to be resolved to increase our confidence in the forecasts of changes in plankton distributions. Model complexity, as well as the scale and resolution of the sampling schemes used in the study of plankton dynamics will form the basis from which progress will be evaluated.

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REAL-TIME MONITORING OF CHROMOPHORIC DISSOLVED ORGANIC MATTER (CDOM) AND WATER QUALITY IN THE NEPONSET RIVER: USE IN LOCAL MIDDLE SCHOOL CLASSROOMS.

Recent temporal studies of chromophoric dissolved organic matter (CDOM) of riverine endmembers have shown variability on hourly to weekly timescales depending on water flow and other factors. In an effort to provide valuable data to researchers as well as creating a link between ocean science research and the middle school classroom, we are installing a monitoring station in the Neponset River, the second largest river flowing into Boston Harbor. The sensors will be mounted above the Lower Mills dam, located between the Boston and Milton school districts, and the data will be transmitted to a server at UMass Boston and displayed on the Web.
Through interactions of the New England Regional Center for Ocean Science Education Excellence (NER-COSEE) and the Watershed Integrated Sciences Partnership (WISP; an NSF GK-12 program), several middle school teachers will be able to integrate this real-time data stream of CDOM, dissolved oxygen, temperature, salinity and live web cam images for teaching standards-based curriculum in science and math. Results of initial implementation of lesson plans and weekly student sampling to groundtruth the monitoring data will be discussed.

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SEAGLIDER MEASUREMENT OF EPHEMERAL AND UNPREDICTABLE EVENTS

Seaglider, a small (1.8 m, 52 kg) underwater glider that moves horizontally and vertically using buoyancy and wings, was deployed off the Washington coast for a total of 80 days in 2002. Seaglider autonomously measures chlorophyll fluorescence, optical backscatter at two wavelengths, dissolved oxygen, and physical parameters (temperature, conductivity, and pressure). At the conclusion of each dive cycle, it reports data and position home via Iridium satellite phone. During the autumn deployment of 2002, thin layers of phytoplankton and high optical backscatter, were observed. These layers were one to several meters thick, and were characterized by increased values of chlorophyll fluorescence and optical backscatter on the order of a factor of three-to-ten over ambient concentrations. The ability of autonomous platforms such as the Seaglider to observe widespread but, as yet, unpredictable or ephemeral events demonstrates the power of these platforms to contribute to the evolving Ocean Observing Systems as well as to programs designed to monitor such events as harmful algal blooms.

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CLIMATE-BASED ASSESSMENT AND FORECASTING FOR ECOSYSTEMS IN THE GULF OF MAINE

There is a growing awareness in the oceanographic community that major year-to-year changes marine populations can be driven by climate variability. Often, the physical conditions responsible for population changes can be observed or forecast on scales of months-to-years before their biological effects are felt. Thus, understanding the connection between climate variability and marine populations offers a path to developing ecological forecasts. Recent work in the Gulf of Maine has identified a leading mode of physical variability that can be forecast using the North Atlantic Oscillation. This physical mode has, in turn, been linked to changes in the ecosystem, including copepods and right whales. This example demonstrates the potential of using climate variability to forecast ecosystem properties.

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PLANKTON COMMUNITY LEVEL RESPONSES TO TURBULENCE AND NUTRIENT LOAD: IMPLICATIONS FOR COASTAL ZONES

There is evidence that turbulence affects plankton community metabolism differently depending on nutrient load. We examined the combination of turbulence and nutrient enrichment in mesocosms in Espegrend, Norway. Mesocosms of 2.6 cubic meters were placed onshore allowing for proper control of turbulence by means of vertically-oscillating grids. Turbulence levels spanned 4.7 orders of magnitude in energy dissipation rate while nutrient load ranged from 0 to 16 µM in terms of nitrate. Phosphate was added in Redfield ratio and silicate at the same molarity as nitrate. Nutrient load increases the proportion of autotrophic biomass while turbulence slightly increases heterotrophic biomass. We will discuss these results in the framework of coastal zones addressing the total biomass produced, the partitioning into autotrophic and heterotrophic components, and the export of organic carbon from the system.

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REGIONAL AND SEASONAL CHANGES IN THE FOOD QUALITY OF SESTON AND ITS IMPLICATION FOR LIPIDS AND PRODUCTION OF COPEPODS IN THE BALTIC SEA

This investigation, conducted in the framework of the German Globec-project, examined the biochemical composition of seston in the Baltic Sea. The study concentrated on the seasonal dynamics of food quality in terms of fatty acid composition. Monthly samples were taken year-round since early March 2002 covering the entire Bornholm Basin. It was assumed that food quality is reflected in lipid accumulation and fatty acid composition, as well as egg production of the dominant copepods Pseudocalanus acuspes, Temora longicornis and Acartia longiremis. Preliminary results show that the variability of fatty acid levels (percentage composition) remains generally low. Saturated and monounsaturated fatty acids, mainly 16:0 and 18:1(n-9), comprise over 50% of total fatty acids during all seasons. Seasonal fluctuations are most strongly pronounced in the halocline, the suggested hydrographical layer of P. acuspes reproduction, with maximum amounts of the polyunsaturated fatty acid 22:6(n-3) in late spring and minimum levels in autumn. Aside from this spring peak, the vertical structure is characterised by a general decrease of polyunsaturated fatty acid with increasing depth. Energetic implications with regard to higher trophic levels are discussed.

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FLOWCAM TECHNOLOGY: DIGITAL IMAGING FLOW CYTOMETRY FOR OCEANOGRAPHIC RESEARCH

The FlowCAM is a continuous imaging flow cytometer which is being used extensively for monitoring of phytoplankton in coastal waters and off-shore. Marine applications include discrete samples or continuous in-situ analysis of phytoplankton and zooplankton. Different types have been used in-situ, on floats, or on the laboratory bench. The submersible FlowCAM is used to profile the water column and provide rapid comparison of plankton community structure at different depths. The Benchtop FlowCAM has been used at sea to monitor particulates and plankton from discrete samples or from the ship's sea chest. Sea chest monitoring has permitted analysis of plankton dynamics over transects The FlowCAM has been used extensively in ship and shore based laboratories to rapidly and easily monitor cell cultures, particles in liquids and grazing experiments. Discrete samples or continuous processes may also be monitored.

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MEDFLUX: VERTICAL PARTICLE FLUX SAMPLING IN THE TWILIGHT ZONE

We used two types of sediment traps to collect the vertical particle flux at the French JGOFS DYFAMED site (western Mediterranean Sea). A conical (8 m long, 2 m to 25 cm diameter), free-floating, NetTrap collected large amounts of material in a short period of time (~1 g in 72 h). The trap has a closing mechanism and maintains a depth (200 m) just beneath the euphotic zone using a string of small surface floats. Three deployments over a ten-day period each collected enough material for a variety of isotopic and organic analyses, and elutriator-based, particle settling experiments. We also deployed arrays of our standard, bottom-tethered indented rotating sphere (IRS) traps operating as either a time-series collector or a sinking velocity separator. The sinking velocity mode consisted of rotating the IRS once each day to pass collected particles into the trap interior, and then cycling the collection cups, allowing collection of particles based on sinking rates (from 0.7 – 980 m d-1) over a month-long period. We will compare mass and elemental fluxes from the free-floating, time-series and settling velocity collection modes.

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ATMOSPHERIC SULPHUR MEASUREMENTS ASSOCIATED WITH IRON ENRICHMENT OVER THE NORTH PACIFIC OCEAN

Atmospheric measurements were taken in the North Pacific Ocean in July 2002 as part of the SOLAS Sub-Arctic Ecosystem Response to Iron Enrichment Study (SERIES). An Aerodyne Aerosol Mass Spectrometer was used for the first time in an open marine environment to measure real-time mass concentrations and size distributions of particulate sulphate (SO4), methane sulphonic acid (MSA), nitrate, ammonium, and organic species. Gas-phase concentrations of DMS and SO2 were also measured. The interest here is the relationship among DMS, SO2, MSA and SO4 as a result of the water enrichment. Particulate sulphur contrbutes to a radiative cooling of the atmosphere. During a period of higher DMS concentration, linked with the patch fertilization, the DMS and MSA are anti-correlated suggesting the conversion of DMS to MSA on relatively short time scales. The links among atmospheric gas-phase DMS, gas-phase SO2, particulate MSA and SO4 are explored through the application of a simple box model in the context of the observations.

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THE CHUKCHI-BEAUFORT SHELF/SLOPE BOUNDARY

The dynamic structure of the Chukchi-Beaufort shelf and slope is determined by the variable upstream forcing of Pacific waters through Bering Strait and over the Chukchi shelf. Fall measurements show shelf bottom waters enriched in sediments, nutrients, and chlorophyll entering the upper halocline along the Chukchi shelfbreak and through Barrow Canyon. Some of this outflow contributes to a narrow, subsurface current setting eastward over the continental slope between 75-200 m depth, distributing Pacific waters around the Canada Basin margin. Several eddies with diameters of ~15 km, vertical extent of ~150 m, and core water properties identical to shelf bottom waters were found within the upper halocline over the slope. These were spawned by the slope current and will presumably propagate seaward to ventilate the interior Canada Basin.

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MEASURING SPATIAL AND TEMPORAL SCALES OF ZOOPLANKTON DISTRIBUTIONS USING HIGH-FREQUENCY ACOUSTICS: METHODS, BENEFITS AND LIMITS

Measurements of zooplankton distribution and variability have been significantly enhanced by the use of high-frequency acoustical sensors. In the late 1980s, Mike Mullin emphasized the challenges facing biological oceanographers in describing plankton distributions and their dynamics. He encouraged his students and peers to pursue the development of applicable new technologies. The development of novel acoustical sensors for zooplankton was, in part, a response to his clear vision of how progress could be made in zooplankton ecology. We will discuss variations in sensor design and use depending on the study to be undertaken. Acoustical sensors are now being used to define zooplankton distributions at spatial scales from hundreds of kilometers down to meters, defining basin-wide and meso-scale horizontal structures. Vertical layering of zooplankton and micronekton is characterized at a variety of scales in various oceanic and coastal systems. Moored instruments are being used to describe seasonal and daily variability as well as minute-to-minute variations. We assess and illustrate the state-of-the-art and discuss some of the advantages and limits to these methods.

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NON-LOCAL TURBULENT MIXING MODELS: EMPIRICAL PARAMETERIZATION AND POTENTIAL APPLICATIONS FOR MODELING

Non-local mixing models provide an improved theoretical framework for evaluating the effects of mixing. By using non-local models, for example, it is possible to evaluate the effects of anisotropic mixing, which can be especially important when considering the effects at the ecosystem level. Although non-local mixing models have apparent advantages, they have not been widely used because the high complexity and the difficulty for obtaining reliable parameterization. In this study, a new parameterization of non-local mixing model is proposed. The method obtains empirically the coefficients of the transilient matrix, which is the discrete descriptor used in the non-local mixing model. The parameterization is based on the microstructure data analysis, in particular the Thorpe displacement profiles, and is decomposed in three main steps: turbulent patch identification, turbulent patch characterization and data integration. The proposed method has been tested comparing the results obtained with field data and those obtained through numerical simulation. The final results indicate that the estimated transilient coefficients, and the mixing parameters derived from them, are in accordance with those expected from the background external forcing, the observed thermal structure and the parameters obtained from the numerical model.

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CHANGES IN THE COMPOSITION OF HARMFUL ALGAL TOXINS DURING BUBBLE-MEDIATED PRODUCTION OF BIOTOXIN-CONTAINING MARINE AEROSOL IN THE SURF ZONE

The dinoflagellate responsible for harmful algal blooms in the Gulf of Mexico and along the U.S. Atlantic coast, Karenia brevis (formerly, Gymnodinium breve), produces a suite of polyether neurotoxins called brevetoxins. A unique characteristic of these harmful algal blooms is the associated airborne (aerosolized) biotoxin component that causes severe respiratory irritation to humans and other mammals. Breaking waves in the turbulent environment of the surf zone entrap air bubbles that, through hydrophobic adsorption to bubble surfaces, effect bubble-mediated transport of the brevetoxin molecules to the sea surface. The brevetoxins are then incorporated into marine aerosol in association with film and jet drops ejected from the bursting bubbles. Brevetoxins collected from the surf zone water and in air along the beach, during a red tide bloom event, exhibited a change in the composition of the major toxin molecules during the transport process. Understanding these processes (selective adsorption to bubble surfaces or chemical alteration during transport) provides insight into sea to air transport of dissolved organic molecules in the surf zone as well as marine biotoxins impact on human health.

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SPECIES-SPECIFIC GRAZING BY CALANUS PACIFICUS AND PSEUDOCALANUS NEWMANI DURING PHYTOPLANKTON BLOOMS IN DABOB BAY, PUGET SOUND (WA)

Laboratory studies in the last decade have shown that female copepods may have reduced reproductive success when fed high concentrations of diatoms, compared with non-diatom diets. However, this phenomenon appears species specific, and field studies have shown that copepod recruitment varies regardless of bulk in situ diatom concentrations. As part of a larger project studying copepod reproductive response to diatom blooms, we measured grazing by two calanoid copepods common in the boreal Pacific: Calanus pacificus and Pseudocalanus newmani. These species differ in size, reproductive strategy, and distribution, suggesting that their feeding behavior and physiological response to feeding will differ depending on prey abundance, distribution, and composition. To examine this hypothesis and how it may affect in situ reproduction, we incubated copepods in raw seawater from Dabob Bay, WA, and measured grazing rates on specific phytoplankton and microzooplankton taxa. Our results suggest that these copepods feed selectively on available prey, and the dominant taxa during blooms are not necessarily those grazed most heavily by the copepods.

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USING HYPERSPECTRAL AIRBORNE AND SPACEBORNE SENSORS TO MONITOR CASE-II WATERS OF VANCOUVER ISLAND

Hyperspectral data have been collected using the Compact Airborne Spectrographic Imager (CASI) and EO-1’s Hyperion sensor to develop a means of monitoring the optical water constituents of Vancouver Island’s CASE-II waters. This is accomplished through the development of semi-empirical based algorithms linking above water reflectance with in situ measurements of chlorophyll-a, total suspended solids, and dissolved organic carbon. The inland waters of Lake Cowichan have been imaged with the CASI and the coastal waters of Cowichan Bay have been imaged with both the CASI and Hyperion sensor. Water samples were collected from both water bodies concurrent with the CASI overflight during a field campaign in August 2003. Atmospheric and air-water interface corrections have been applied to the resultant images and maps based on data from each instrument are presented, showing the distributions of the each of the three water quality parameters considered. The algorithms are verified using sample data collected during the field campaign, but not considered in the algorithm development process.

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GROWTH RATES OF EUPHAUSIIDS IN THE NORTHERN GULF OF ALASKA IN 2001-2003

Growth rates of the three most abundant euphausiid species (Thysanoessa inermis, T. spinifera and Euphausia pacifica) in the northern Gulf of Alaska were measured from March through October in 2001, 2002 and 2003. Shipboard experiments were conducted to obtain in situ growth rates using the instantaneous growth rate technique, which involves incubating individual animals at ambient temperature and food, and measuring the change in length of the uropods after molting. The highest mean growth rates (over 5% of length change per molt) were observed during the phytoplankton bloom on the inner shelf in late spring for coastal T. inermis and on the outer shelf in summer for more oceanic T. spinifera and E. pacifica, suggesting tight coupling with food availability. The molting rate appeared to be strongly influenced by temperature ranging from 14 days at 5C to 5 days at 12C. The in situ growth and molting rates were similar to those obtained for specimens reared in the laboratory under food satiated conditions and controlled temperatures.

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BIOCOMPLEXITY: REGIONAL VARIABILITY IN REPRODUCTIVE TIMING, SETTLEMENT AND RECRUITMENT OF AN INTERTIDAL BARNACLES IN THE US NORTHEAST COAST

The intertidal barnacle Semibalanus balanoides settles from January to May in the Woods Hole region (~41.5 deg N – 70.6 deg W). We followed the daily settlement of cyprids and the recruitment of young barnacles in 2002, and found very high mortality, with only 0.3% percent survivorship after 5 months, after which, there was very little mortality. All survivors settled within a narrow settlement window of about 3 weeks, implying strong selection and that settlement timing is critical for recruitment. Because larvae of Semibalanus are meroplanktonic and they can potentially disperse long distances, understanding settlement timing at a single site requires understanding regional patterns in reproductive output and larval dispersal. Our research program is investigating latitudinal variability in reproductive stage, settlement and recruitment in sites from Rhode Island, US, to Nova Scotia, Canada. These results show a latitudinal gradient in the timing of reproduction and settlement. We are also investigating the factors affecting the dispersal of the meroplanktonic larvae. A related study in the Californian coast is addressing the same questions, and will permit a comparative approach.

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QUANTITATIVE IMPORTANCE OF MACROFAUNA: A TEST OF SIEVE MESH SIZE BIASES ON SAMPLING IN A HIGH BENTHIC BIOMASS AREA

The effects of sieve mesh size on estimates of benthic standing stocks was examined on the continental shelf of the Bering and Chukchi Seas, which has high benthic biomass. These biomass estimates are important for evaluating impacts of benthic population changes on apex predators such as walruses, whales and diving ducks. Sediment grab samples were sieved on 1.0mm mesh, and materials passing through that screen were sieved through 0.5mm mesh at 16 stations occupied on the CCGS Sir Wilfrid Laurier in July 2003. Both mesh sizes retain similar ranges of total individuals at each station. The total mass collected on the larger 1.0 mm screen ranged from 95 - 99% of biomass collected on both screens. We are currently evaluating benthic faunal diversity for the two screen sizes. It appears that sampling with a 1.0mm mesh is small enough to adequately estimate benthic biomass on these continental shelves. In the future, we will investigate the validity of the 1.0 mm screen size in deeper waters, such as on the outer continental shelf being studied in the Shelf-Basin Interaction program.

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LAKE ERIE TROPHIC STATUS AND PRIMARY PRODUCTION: EVALUATION BASED ON DELTA 18O OF O2 AND THE DELTA O2/AR

In 2002, we determined the concentration and isotopic composition of O2 at 4 stations in Lake Erie. The lowest isotope values of –6.0‰ and O2 fractional saturations of 1.2 indicated a period of high primary production in the western basin in July. Isotope values as great as +7.5‰ were observed at depths exceeding 35m in the eastern basin, which strongly indicates a predominance of respiration. d18O of O2 and concentration measurements can be modeled to yield the ratio of respiration to photosynthesis(R/P). R/P is a measure of trophic state and provides an indication of the flux of CO2 to the atmosphere. R/P values varied from as low as 0.45, consistent with eutrophic conditions, to values as high as 3.49, indicating heterotrophy. We determined gross primary production based on incubations with 18O labeled water. Values of primary production ranged from 1.23 uM-O2/day at station 78M in September to a maximum of 6.65 uM-O2/day at station 91M in August. A comparison of in situ vs in vitro incubations was performed at 78M and the in situ value of gross primary production (1.05) was approximately half of that observed in vitro (1.97). Based on mass spectrometric measurements of surface O2 to Ar ratios and wind speed data we determined the biologically-forced flux of O2 (BFO) into or out of the lake. Values for BFO varied from -122 to 2 mmol/m2.day in August, indicating net heterotrophy, and from 337 to 646 mmol/m2.day in September, indicating net autotrophy.

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ON THE RELATIVE IMPORTANCE OF PARTICLE-BOUND FECAL INDICATORS FOR WATER QUALITY ASSESSMENT.

The culture-based microbiological detection methods currently in use for water quality assessment do not allow for the fact that some bacteria are particle-associated. Particle-assocation, however, can be a very efficient strategy against environmental stresses (e.g. UV radiations, nutrient limitation,etc…). Particle-bound organisms may remain more active and thus potentially more threatening to human health. The phase distribution (free-living versus aggregated) of the microorganism also controls the transport, the residence time and the bioavailability of such pollutants. We show data highlighting the importance of particle-bound fecal indicator microorganisms (Enterococcus faecalis, Clostridium perfringens) in a tropical stream. The data suggest that between 5 and 30% of the colonies originate from particles during low flow background conditions. The data also support the idea of species-specificity of particle attachment, which raises questions about the quality and choice of the indicators in use. Finally, we discuss the methodological and logistical difficulties associated with quantifying particle-bound organisms.

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RECOLONIZATION AND SUCCESSION OF BACTERIAL ASSEMBLAGES FOLLOWING DISTURBANCE OF MARINE SEDIMENTS BY DEPOSIT FEEDING

Benthic invertebrate ingestion has been shown to reduce bacterial biomass, modify activities and compositions of bacterial assemblages, as well as alter physical attributes of the sedimentary matrix. Although usually thought of as a predator-prey interaction, we argue that treatment of deposit-feeder ingestion as a disturbance is more appropriate. Primary objectives of the research presented here were to test whether deposit-feeder ingestion constitutes a disturbance, determine the mechanisms by which bacterial assemblages recolonize egesta, and to elucidate patterns of succession. In intertidal sediments, recovery could be due to regrowth of bacterial populations surviving gut passage or to migration from adjacent sediments. We used field manipulative experiments to exclude migration by isolating fresh fecal coils of four deposit-feeding species from sediments in South Carolina and Maine, USA. We then followed quantitative and qualitative recovery through time using epifluorescence microscopy and PCR-DGGE analysis of 16S rDNA. Findings indicate that 1) the nature of disturbance to bacterial assemblages varies among deposit-feeding taxa, 2) recovery in biotically disturbed sediments is typically dominated by immigration, and 3) recovery is incomplete during the period of tidal emersion.

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SMALL-SCALE FLUID FLOW AROUND AND WITHIN SINKING MARINE SNOW.

Oceanographic models including sinking marine snow often consider these to be solid spheres, and hydrodynamic conditions to be described by Stokes flow, i.e. the Reynolds (Re) number is <<1. Marine snow, however, are porous (p > 0.99), and Re ranges between 1 and 20. Here, small-scale fluid flow within and around model particles and diatom aggregates was visualized using Particle Imaging Velocimetry (PIV). Re ranged between 1 and 10. Fluid flow could be directly observed within porous (p > 0.99) model spheres. Mean interstitial fluid velocity was 1.17 times that calculated assuming Stokes flow. Downstream fluid flow velocities behind porous spheres were up to 20 times higher than those behind solid spheres at Re~3. The difference was largest within 0.2 radii from the surface, but it rapidly decreased and no difference in fluid flow distribution was detectable 2 radii downstream of the two types of spheres. In contrast, fluid flow was greatly retarded in the vicinity behind oblate-shaped solid particles compared to that behind solid spheres. The observations and analysis were used as references to similar measurements in diatom aggregates.

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EGG PRODUCTION AND HATCHING SUCCESS OF CALANUS GLACIALIS/MARSHALLAE: A DOMINANT COPEPOD IN THE SBI STUDY REGION DURING 2002

Egg production rates of dominant copepod species were determined during the two 2002 Western Arctic Ocean Shelf Basin Interactions (SBI) process cruises. Calanus glacialis, an Arctic species, and Calanus marshallae, a Pacific species, are similar morphometrically and were not differentiated. Egg production rates and egg hatching success for C. glacialis/marshallae were determined in both shelf and basin regions. Results indicate that egg production on the shelf may be initiated earlier, reach higher levels, and last longer than in the adjacent basin. Egg production rate, which appeared to be fueled by phytoplankton, ice algae, and microzooplankton, was correlated with ingestion. Egg production dropped off markedly at the end of the second process cruise because of decreases in both spawning frequency and clutch size suggesting that this was the end of the reproductive season for this species. Hatching was similar in both shelf and basin regions and usually greater than 80%. Egg production rates for C. glacialis/marshallae observed on the shelf exceeded those observed for this species in the adjacent basin and during 1997-1998 further to the north in the Arctic Basin.

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REQUIREMENTS OF DOCKED AUV FOR SCIENCE MISSIONS

In this paper, we present a technological development of AUV docking systems motivated by science requirements. Twenty-seven case studies have been drafted after meeting with marine scientists from a wide range of oceanographic fields such as Physical Oceanography, Midwater Ecology, Biological Oceanography, Molecular Biology, Marine Microbiology, Geology, Ocean Chemistry, Evolutionary Biology, and Benthic Ecology. These science cases spread over coastal ocean, deep-ocean, mid-ocean ridge, and polar ocean. All these science missions can be significantly benefited from new and improved sets of data and samples that will be collected by using a docked AUV.
The case studies are organized to address science issue, significance of the problem, required data and measurements to address the scientific issues, non-docked method for acquiring data, and benefit of using docked AUV. The science missions are broadly classified into two categories, based on the data collection methodology, namely: Data Collection - in situ data collection such as temperature, salinity, depth, current, chlorophyll density, bioluminescence, etc., and Sample Collection – collect samples quickly and then analyze the samples in laboratory, process data and archive it; examples are microbial organisms, Harmful Algal Blooms (HABs), larvae, sediment, and rock sample collection.
More than twenty science sensors (in addition to navigational sensors) are identified and evaluated for these science missions. The payloads for the AUV and the docking system are discussed in detailed. Functional requirements for a general purpose docking system are identified and various subsystem development approaches are explained in this paper.

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OBSERVING ECOSYSTEMS WITH SATELLITE REMOTELY SENSED OCEANOGRAPHIC DATA AND FLEETS OF ANIMALS WITH ELECTRONIC TAGS

We will present approaches being developed to describe the habitat of large pelagic animals and the dynamics of this habitat with a combination of fleets of pelagic animals instrumented with electronic tags and indices from satellite remotely sensed oceanographic data. The tag data provide information on the habitats animals are using. The satellite oceanographic data provide a description of the ocean features used by pelagic animals and the dynamics of these features. We will present results from our work with sea turtles, bigeye tuna, and moon fish and applications of satellite ocean color, altimetry,and wind data.

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ECOSYSTEMS, FOOD WEBS, AND FASHIONS

Investigators need to look routinely beyond single causes for events at the ecosystem level, and beyond single paradigms of system organization, i. e. top-down versus bottom-up controls, or processes involving only macroorganisms or only microorganisms. Examples illustrate the value of considering all of the above, as well as relevant hydrography and climate, to understand system function more fully and to manage resources better. Recent investigations show interactions of top-down and bottom-up control processes to be the norm. Food webs of macroorganisms and microorganisms are interconnected, and events within the microbial web are as likely have significant consequences for macroorganisms, as are events among macroorganisms likely to have significant consequences for microorganisms. New insights now being developed into marine ecosystems integrate population interactions, nutrient supply, climate variability, and both physical and biological system structure.

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EFFECT OF HARD CLAM DENSITY (MERCENARIA MERCENARIA) AND TIDAL SHEAR STRESS ON SEDIMENT DESTABILIZATION AND WATER QUALITY

To test how hard clam density and high bottom shear stress affect sediment destabilization and water quality, we performed comparative ca. 4-week ecosystem experiments in STORM mesocosms using high instantaneous bottom shear stress and realistic water column turbulence levels: (1) Tidal Resuspension vs Tidal Resuspension+50 Clams, and (2) Tidal Resuspension+50 Clams vs Tidal Resuspension+10 Clams. We measured water quality variables such as TSS concentrations, particulate and dissolved nutrients, light levels, and sediment chlorophyll a concentrations. 50 clams initially destabilized the sediment compared to the no clam and the 10 clam treatments increasing TSS levels to about 150 mg/L. Over time, however, TSS levels decreased in the 50 clam treatments to similar levels as in the zero and 10 clam treatments (about 50 mg/L). TSS levels affected light in the water column and at the sediments. Dissolved inorganic nitrogen and soluble reactive phosphorus levels were significantly higher in the mesocosms with 50 clams, however, this was driven by the TSS dynamics. Thus, complex direct and indirect processes as affected by clam density and bottom shear stress affected overall water quality.

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COPROPHAGY IN COPEPODS AND IN A NATURAL ZOOPLANKTON COMMUNITY

Sediment trap studies have revealed that often only a minor fraction of the zooplankton fecal pellet production leave the upper ocean, and it has been suggested that copepod grazing on pellets (coprophagy) is the reason for this. A simple model is here used to estimate rate of coprophagy from lab and field observations. In the lab Acartia tonsa and Temora longicornis have coprophagous behavior and clear fecal pellets at a rate of 10-15 ml/female/d. Observations of fecal pellet production, sedimentation, and abundance collected during a 10-d late summer study in the North Sea revealed that less than 5 % of the fecal pellet production in the upper 50 m was lost as flux below 50 m depth. Estimates of coprophagy rates showed, however, that the zooplankton community > 200 um could account for only a few percent of the fecal pellet loss. Thus, plankton organisms < 200 µm must be responsible for the degradation of the fecal pellets.

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DISCRIMINATION BETWEEN CTC-ACTIVE BACTERIA AND PROCHLOROCOCCUS FROM NATURAL SAMPLES USING DUAL BEAM FLOW CYTOMETRY

The respiratory activity of marine bacteria is an important indication of the ecological functioning of these organisms in the natural environment. A current method to measure single-cell-activity of bacteria utilizes an intracellular fluorescent probe 5-cyano-2,3-ditolyl-tetrazolium chloride (CTC) that is reduced intracellularly in respiring cells to an insoluble, red fluorescent CTC-formazan-precipitate (CTF). We measured CTC respiratory activity along a trophic gradient from the Gulf of Maine to the oligotrophic Sargasso Sea over the course of a year. Samples for respiring marine bacteria containing CTF were analyzed using a benchtop flow cytometer with blue-laser excitation (488nm). At oligotrophic stations both marine bacteria and the cyanobacterium, Prochlorococcus, were present. Using only blue excitation the flow cytometer was unable to discriminate between these two groups due to the presence of overlapping red fluorescing compounds, chlorophyll and CTF. Using the dual-laser excitation flow cytometry the two cell populations were successfully discriminated, since the emission of CTF is higher than chlorophyll when excited with green light (514nm). It is now possible to accurately enumerate respiring bacteria in oligotrophic samples allowing for spatial and temporal differences in bacterial activity to be determined.

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RECOVERY AND CHARACTERIZATION OF THE DISSOLVED PROTEINS IN SEAWATER USING TANGENTIAL FLOW ULTRAFILTRATION AND TANDEM MASS SPECTROMETRY.

Proteins, as biopolymers, are probably the most characterizable portion of marine DOM at the molecular level. An extremely small fraction of these dissolved proteins appear to be resistant to normal degradation processes and accumulate in seawater. Previous work by Tanoue suggests there are a very few number of these refractory proteins present at detectable concentrations, indicative of selective enrichment. The mechanisms of survival for these refractory proteins are unknown and greatly debated, yet fall into two main categories: selective preservation and physical protection mechanisms. The combination of tangential flow ultrafiltration and methanol/chloroform/water precipitation allows recovery of dissolved proteins from seawater. Our analysis of the protein pellets by SDS-PAGE has revealed over 25 distinct protein bands spanning a broad range of molecular weights. Subsequently, we have used tandem mass spectrometry to analyze in-gel and solution tryptic digests of these recovered seawater proteins. Analysis of the CID spectra using database searching algorithms has not yielded any definitive matches, largely due to limitations of sequence databases. However, denovo sequencing has produced many short sequence tags which yield a trend of membrane protein sequence homologues.

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IRON SPECIATION DURING THE NORTHEAST PACIFIC IRON ENRICHMENT EXPERIMENT

Previous work during mesoscale Fe fertilization experiments has shown a large production of Fe complexing ligands almost immediately after injections of Fe in an equatorial system (Rue and Bruland, 1997) or almost 2 weeks after in the Southern Ocean (Bowie et al., 2001). In order to contrast these two systems, we collected samples immediately prior to and for 25 days after the injection of Fe in the Northeast Pacific HNLC as part of the Canadian SOLAS mesoscale Fe enrichment experiment. Concurrent with the 3 nM increase in total dissolved Fe, we observed an almost immediate increase in Fe complexing ligand concentration. Therefore, the concentration of inorganic Fe increased only slightly. The concentration of Fe complexing ligands rapidly (within 1 week) returned to baseline concentrations. Therefore, the dissolved Fe concentration also rapidly returned to pre-injection levels (~0.05 nM). This system does not seem to be able to sustain elevated F concentrations for more than 2 weeks due to removal of ligands and a lack of ligand production.

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ABSOLUTE DEPENDENCY OF MARINE PRIMARY PRODUCTION ON ATMOSPHERIC OZONE CONCENTRATION : UV-B RADIATION AMPLIFICATION FACTORS IN CALIFORNIA COASTAL WATERS

A field study during four seasons of 1998 collected the required information to model the full spectral distribution of the underwater ultraviolet radiation (UVR, 290-400 nm in nature) (Swan/Prezelin this conference) at the same time that experimental spectral drifters, with eight UVR light treatments, were deployed to determine the in situ biological weighting functions (BWFs) for ozone-dependent UV-B (290-320 nm in nature) inhibition of primary production. A set of modeling tools were developed which enabled BWFs to be determined by extensive Monte Carlo modeling and error assessment for mean spectral algorithms to be determined (McKagan/Prezelin this conference). An ozone-weighted variant of the BWF modeling was derived to more accurately determine the UV-B inhibition of carbon fixation as atmospheric ozone changes. From these BWFs, the Radiation Amplification Factor (RAF) can be derived to predict the percent change in carbon fixation rates that will occur within a phytoplankton community for each percent change in atmospheric ozone. RAFs for more than 80 drifter experiments have now been derived and analyses of their relationship to season, community composition, light field conditions and other hydrographic variables are in progress.

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ON THE RELATIONSHIP BETWEEN CARBON FIXATION EFFICIENCY AND BIO-OPTICAL CHARACTERISTICS OF PHYTOPLANKTON

Bio-optical characteristics of phytoplankton and carbon assimilation were measured in the NW Atlantic Ocean near the continental shelf break South of New England (40ºN/70ºW) in August 2002. Discrete samples included: chlorophyll a, phytoplankton absorption (aph), the photosynthetic vs. irradiance (P vs. E) response, the maximum quantum yield for charge separation at Photosystem II (fv/fm) and its recovery kinetics, and the functional absorption cross-section (sigma PSII). Covariations between the initial slope of the photosynthesis-irradiance curve and fluorescence and photoadaptation absorption parameters of phytoplankton suggest a new pathway to estimate primary production in the marine environment, including the effect of the recent light history. Recovery kinetics in laboratory culture confirmed the effects of light history in the derived parameter from the dark incubations from natural populations. A similar exercise was performed but using only instantaneous parameters, and which produced promising results.

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COMPARISON OF N CYCLING GUILDS IN MICROBIAL BIOFILM COMMUNITIES FROM VEGETATED AND NONVEGETATED ESTUARINE ENVIRONMENTS.

As a part of a larger project to develop biofilms as indicator communities for estuarine status, we characterized microbial biofilms from vegetated and nonvegetated habitats in Pensacola Bay. This study assessed whether the observed macroscale habitat differences were reflected in differences in microbial community composition, with particular attention to N cycling guilds. Biofilms colonized slides over a 10-14 day period; nirS, nirK (denitrifier) and nifH (nitrogen fixer) genes was amplified from the DNA. FAM-labeled PCR products were analyzed by TRFLP. Clone libraries were constructed; trees of nitrogen fixer and denitrifier community composition were built. qPCR estimated the abundances of nitrogen fixers and denitrifiers. Differences in community composition, diversity, evenness and relative abundances were observed between the different habitats. In general, the biofilms in the vegetated habitats developed into more even and more diverse communities compared to the nonvegetated habitats. Nearly half of the denitrifiers were distantly related to other environmental clones while most of the nitrogen fixers appeared to be related to other environmental clones. Denitrifiers comprised a larger percentage of the vegetated biofilms while nitrogen fixers comprised a similar proportion, regardless of habitat. Biofilm microbial composition did reflect macroscale differences in habitat and shows promise as indicator communities for assessing estuaries.

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POPULATION GENETIC STRUCTURE OF THE SNOW CRAB (CHIONOECETES OPILIO) AT THE NORTHWEST ATLANTIC SCALE: A CASE OF HIGH MARINE CONNECTIVITY

Population genetic structure of the snow crab (Chionoecetes opilio) is investigated at the Northwest Atlantic scale in an attempt to assess the degree of connectivity between populations, an important parameter for conservation purposes and the understanding of marine ecosystem dynamics. Eight microsatellite markers were analysed on 449 snow crabs sampled at one site off Greenland (GRE) and 10 sites distributed among Southern Labrador Shelf, St. Lawrence Gulf and Lower Estuary, Eastern Newfoundland Shelf and Eastern Scotian Shelf (“St. Lawrence-Atlantic” sites, SLA). GRE is highly significantly differentiated from all SLA samples and there are no significant differences among SLA samples (global Fst estimate including GRE = 0.0066, P < 0.0001). These results are consistent with geographical position of samples and C. opilio distribution in the Northwest Atlantic. They are nevertheless not trivial given the geographical scale considered (150-4500 km) and C. opilio’s 3-5 months pelagic larval stage. Genetic data and oceanic circulation patterns in the Northwest Atlantic support the hypothesis that C. opilio “upstream” populations (e.g. Labrador) constitute a source of larvae for “downstream” populations (e.g. Eastern Scotian Shelf).

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SAVANNAH, GEORGIA (USA) ESTUARINE, MARSH AND RIVERINE SEDIMENT RADIOGEOCHEMISTRY CHARACTERISTICS

The Savannah River drainage basin spans parts of North Carolina, South Carolina and Georgia (USA). For those radionuclides that are not permanently sequestered at their introduction sites, the aquatic system often becomes the major mechanism by which the radionuclides are transported. Sediments were examined in order to identify processes affecting the distribution of radionuclides and metals in Savannah area Riverine, marsh and estuarine environments. Radiogeochemistry patterns suggest that in the marsh, steady-state particle mixing and burial processes primarily controls downcore particulate Cs-137 distribution, whereas in the local riverine and estuarine environments, non-steady state processes govern post-depositional Cs-137 distribution. In addition, Fe, Cs and Mn data for the marsh and estuarine environments suggest the presence of oxic conditions throughout the cores. Cs and Mn profiles determined for the riverine environment, suggest the likely presence of suboxic or anoxic conditions, which may have resulted in Cs-137 remobilization from non-selective particle binding sites via biologically mediated processes. In addition to physical and biogeochemical-related processes, clay mineralogy and grain-size differences may also influence the Cs-137 retention ability of the Savannah area aquatic sediments.

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MINORITIES STRIVING AND PURSUING HIGHER DEGREES OF SUCCESS (MS PHD’S) IN EARTH SYSTEM SCIENCE INITIATIVE

The Minorities Striving and Pursuing Higher Degrees of Success (MS PHD’S) in Earth System Science initiative was developed by and for underrepresented minorities, with the overall purpose of facilitating our increased participation in Earth system science (oceanography, meteorology, environmental science, geology/geophysics, and astronomy. The initiative was established with a goal of providing professional development experiences and mentoring opportunities that facilitate the advancement of minorities committed to achieving outstanding Earth system science careers. The MS PHD’S initiative sponsors programs that provide minorities with increased exposure to Earth system science community, via participation in scientific conferences, mentoring relationships and virtual community activities. The 2003 MS PHD’S in Ocean Sciences Program facilitated activities that supported meaningful engagement of 25 underrepresented minority students at the final Joint Global Ocean Flux Study (JGOFS) Open Science Meeting, entitled A Sea of Change: JGOFS Accomplishments and the Future of Ocean Biogeochemistry. Future MS PHD’S sponsored activities will facilitate the engagement of program participants at AGU and other professional society meetings.

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CHARACTERIZATION OF HIGH MOLECULAR WEIGHT DISSOLVED ORGANIC CARBON USING PERIODATE OVER-OXIDATION

Nuclear magnetic resonance (NMR) spectra of high molecular weight dissolved organic matter (HMWDOM) from fresh and marine waters indicate that most of the carbon is in the form of polysaccharides. However, this observation has not been confirmed at the molecular level. Molecular level analyses of neutral, amino and acidic sugars yield only a 10-20% recovery of carbon as carbohydrate. To identify additional molecular components, HMWDOM was analyzed using periodate over-oxidation. Periodate rapidly oxidizes sugars, but reacts only slowly with lipids and proteins. Evaluation of this reaction by UV-Vis and proton NMR spectroscopy shows approximately 80% of the organic carbon in HMWDOM is oxidized by periodate, in general agreement with NMR assignments. However, we find no significant quantities of lipid present in the samples. Carbon previously assigned as lipid in NMR spectra is rapidly oxidized by periodate, suggesting a large fraction of this carbon is in the form of previously unidentified 6-deoxysugars. The stoichiometric ratio of periodate to sugar suggests the polysaccharide is highly cross-linked, and this may explain why conventional hydrolyses techniques result in such low yields of monosaccharides.

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ASPECTS OF WIDESPREAD EUTROPHICATION IN THE NORTHERN GULF OF MEXICO

The northern Gulf of Mexico receives the freshwater and constituent flux from the Mississippi River, which integrates 40% of the conterminous United States. In the last half of the 20th century, the flux of nitrogen tripled, phosphorus concentration appears to have increased, and silicate concentration decreased. These changes result from landscape alterations over two centuries with an intensification of human activities that increased the flux of nitrogen and phosphorus particularly in the 1960s to 1980s. Evidence for eutrophication in the coastal ecosystem includes an increase in algal biomass, carbon accumulation from nutrient-enhanced production, worsening oxygen deficiency in the lower water column, and shifts in food web structure. The extent of the oxygen deficiency reaches 20,000 km^2 of the inner continental shelf over long periods in summer with the potential for affecting commercially important fisheries in the Gulf. The change in nutrient loads and responses of the northern Gulf coastal ecosystem parallels similar evidence of eutrophication on a global scale.

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BEACH CLOSURES: A NO-WIN SITUATION AT FRESH WATER AND MARINE BEACHES?

Beach monitoring programs utilize fecal indicator bacteria (FIB) as a proxy for human health risk. Implicit in the policies driving monitoring programs is the assumption of a strong relationship between FIB measurements taken one day and public health risk on a following day. Policy effectiveness relies strongly on the accuracy of this assumption, which in turn is contingent upon the temporal variability of the FIB signal. In this work, we quantify and compare the effectiveness of beach closure policies at fresh-water and marine beaches in Lake Michigan and Southern California using an economic benefit transfer analysis. Beach closures present losses to would-be beach goers and gains to swimmers who avoid illness. The contrasting environments of a fresh-water and marine beach provide opportunities to evaluate the importance of physical and biological processes (i.e. dilution and inactivation of FIB) on policy performance.

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NEW APPLICATIONS OF AIRBORNE SENSORS DURING THE AUTONOMOUS OCEAN SENSING NETWORK (AOSN-II) PROGRAM IN THE MONTEREY BAY

The sea surface temperature, surface roughness, and water leaving radiance are being mapped over the Monterey Bay using a time series of flights at an altitude of 33 m. The new instruments include a pair of computer-controlled six-megapixel digital cameras looking 35 degrees down from the horizon on either side or the aircraft, and a HOBILabs HydroRad-3 hyperspectral radiometer. The Chlorophyll-a content of the water is computed from the HydroRad using the standard SeaWiFS algorithms. The patterns observed during a series of upwelling and relaxation events during August 2003 correlated well with the appearance and spread of cold water at the upwelling centers, with magnitudes in good agreement with SeaWiFS imagery and ground truth. The cameras are surprisingly revealing and show surface slicks, kelp beds, and upwelling fronts in addition to whitecaps, low clouds and other factors which might degrade the radiometer data. The sensors are small, light, and inexpensive enough to be flown on autonomous air vehicles. The data facilitated improved ocean forecasts when assimilated into the Caltech ROMS and Harvard HOPS numerical models.

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GELATINOUS ZOOPLANKTON OF THE ARCTIC OCEAN: IN SITU ROV OBSERVATIONS UNDER THE ICE

Gelatinous zooplankton were known to be numerous in Arctic waters, but the biodiversity of this group has been poorly documented. To address this paucity of knowledge, a NOAA OE cruise surveyed the Canada Basin from the surface down to 2900 m using a remotely operated vehicle (ROV) to assess the taxonomic composition, abundance, and vertical distribution of soft-bodied zooplankton. Three ctenophore species (Bolinopsis vitrea, Mertensia ovum, and Beroe cucumis) and two scyphomedusae (Chrysaora melanaster and Cyanea) were observed in the upper 20-50 m throughout the cruise track. Physonect siphonophores (Nanomia sp.) were observed at depths corresponding to the intrusion of Atlantic waters at 350-400 m. The scyphomedusa Atolla tenella was extremely numerous at 1100-1500 m. Larvaceans were distributed down to 1400 m then appeared again below 2200 m. Hydromedusae were the most numerous taxa, especially below 1000 m. Trachymedusae were the most common, accounting for 4 of the 5 species observed (Sminthea arctic, Botrynema ellinorae, Aglantha digitale, and Crossota sp.). Many of the vertical distribution patterns correlated with the depths of the Atlantic, Pacific, and Fram Strait Branch water intrusions.

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GULF STREAM INFLUENCE ON COASTAL BIOGEOCHEMICAL TRANSPORT IN THE MID-ATLANTIC BIGHT

High resolution hydrographic and geochemical observations of the Mid-Atlantic Bight shelfbreak region show a strong influence of slope and Gulf Stream water on transport and exchange. The structure of the shelfbreak front and alongshelf jet are significantly affected by the presence of these high salinity intrusions. During the observations this resulted in an alongshelf volume transport that was up to three times larger than previous estimates. Simultaneous measurements of radium isotopes indicate that exchange across the shelfbreak is minimal. The observations suggest that alongshelf recirculation pathways may be a more important route for transport of geochemical and biological matter than direct cross-shelf exchange. The observed circulation may be especially important for biological exchange between the shelf/slope regions of the Middle and South Atlantic Bights which have been traditionally viewed as divided by the Gulf Stream separation at Cape Hatteras.

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USING GC/C/IRMS ANALYSES OF PLFAS TO IDENTIFY BACTERIAL OM SOURCES IN GULF OF MEXICO SEDIMENTS

The past five years have experienced increasing use of gas chromatography/combustion/isotope ratio mass spectrometry (GC/c/IRMS) analyses of phospholipid fatty acids (PLFAs) to link organic matter (OM) sources with sedimentary bacteria. We have applied this technique across diverse estuarine and coastal sediments, including lower Laguna Madre, TX, an oligotrophic, coastal lagoon dominated by a single OM source, seagrasses; the Mississippi River Plume (MRP), an eutrophic coastal region receiving multiple sources of OM and deep slope and abyssal plain sediments of the Gulf of Mexico (GOM). We have reported previously, using the Laguna Madre data as examples, on comparisons of PLFA 16:0 and PLFA 15:0 isotope ratios and PLFA 16:0 and total organic carbon isotope ratios. Deviations from the 1:1 line in the former indicate living or recently senescent sources of organic matter are not predominantly bacterial. Deviations from the 1:1 line in the latter indicate living or recently senescent sources of organic matter differ isotopically from detrital or older OM in sediments. We report on how these relationships compare amongst GOM environments and discuss how they relate to bacterial composition.

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UNDERSTANDING THE ROLE OF BACTERIA IN AQUATIC ENVIRONMENTS USING LIPID BIOMARKERS AND PHYLOGENETIC ANALYSIS

Bacteria play important roles in biogeochemical cycles, especially in the transformation of organic matter. Yet quantification and identification of the active bacterial community remains difficult, as few bacteria can be cultured successfully. We performed control and enrichment experiments involving regrowth of natural bacterial assemblages. We monitored changes in the bacterial community structure to the addition of several sources of dissolved organic matter (DOM), including protein, glucose and >1KDa ultrafiltered DOM. Experiments were conducted during different seasons at lower bay, marsh and anoxic sites. To ascertain shifts in bacterial community structure and to link lipid biomarkers with changes in bacterial communities, analysis included lipid abundance and distribution (GC and GC-MS), phylogenetic composition (fluorescence in situ hybridization-FISH), denaturing gradient gel electrophoresis and stable isotopes of individual fatty acids (GC-IRMS). A shift in lipid distribution towards branched fatty acids (15:0 iso and 15:1) could be attributed to Cytophaga-Flavobacteria in the protein-amended incubations. Carbon isotopic analysis of individual fatty acids shifted by as much as -9‰ and confirms those acids synthesized by a subset of growing bacteria relied on protein as a major substrate.

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EVALUATING LONG-TERM ENVIRONMENTAL QUALITY OF THE BAY OF ST. LOUIS, MISSISSIPPI

The Bay of St. Louis is a shallow, vertically-mixed estuary along the Mississippi Gulf of Mexico coastline. Freshwater enters via two rivers, Jourdan River and Wolf River, from numerous bayous, and from runoff. Nutrients enter from three sewage treatment plants, from septic systems and from agricultural or commercial activities in the watershed. We conducted studies in 1995/1996 and 1997/1998, with a 1-year program beginning in summer 2003. We compare our results with a 1977/1978 study. Data sets span three decadal climate regimes based on the Southern Oscillation Index (SOI): 1977/1978 – 1989, 1989 – 1998/1999, and after 1999. Measured parameters include dissolved inorganic nutrients, pigments, POM, O2, temperature and salinity at up to 25 stations. The bay acts as a single system with environmental quality varying at all stations as a result of storm events. Several parameters varied in relation to the SOI. Bay-wide average N:P ratios (moles) were highly correlated with SOI. N:P was significantly greater than the Redfield ratio during La Nina events, significantly below the Redfield ratio during El Nino events and only approached Redfield proportions during normal years.

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BEHAVIOR OF SHORT-LIVED AND SHORT-TRANSIENT TRACERS IN A LATTICE-AUTOMATON MODEL OF BIOTURBATION

The lattice-automaton bioturbation simulator (LABS) is a computer program that allows researchers to model benthic organisms, their behavior in sediments, and their effects on sediment properties. While this program is a work-in-progress, we have employed it to study the effects of small deposit feeders on short-lived tracers (e.g., Th-234 versus Pb-210) and short-transient tracers (i.e., early evolution of time-dependent inputs). The model suggests two unappreciated effects of mixing on such tracers. Firstly, the calculated bio-diffusion coefficients for short-lived tracers are systematically greater than those of long-lived tracers, subject to the very same intensity and mode of mixing (no selectivity). This effect is similar to that of age-dependent mixing, but the latter is a selectivity-based phenomenon. These effects are thus confounded. Secondly, transient tracers exhibit time-dependent biodiffusion coefficients over periods as long as 40 days. Contrary to the classical (Taylor) theory of diffusion, this dependence creates concave-down curves (sub-diffusion) on a time-versus-mean squared displacement plot. This result has implications to transient tracers experiments.

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SOURCES, MANAGEMENT, AND SCALING OF FECAL INDICATOR BACTERIA IN RUNOFF FROM A COASTAL URBAN WATERSHED IN SOUTHERN CALIFORNIA

This paper describes a series of field studies aimed at identifying the sources and environmental forcing of fecal indicator bacteria in dry and wet weather runoff from the Talbert watershed, a highly urbanized coastal watershed in southern California. On a year round basis, the vast majority of fecal indicator bacteria loading occurs during storm events when runoff diversions are not operating. During storms, the load of fecal indicator bacteria in runoff follows a power law of the form $L \sim Q^n$, where Q is the volumetric flow rate and the exponent n ranges from 1 to 1.5. This power-law, and observed range of exponent values, are consistent with a mathematical model that assumes fecal indicator bacteria in storm runoff originate from the erosion of contaminated sediments. The theoretical analysis, which is based on a conventional model for the shear-induced erosion of particles from land and channel-bed surfaces, predicts that the magnitude of the exponent reflects the geometry of the storm water conveyance system from which the pollution derives. This raises the possibility that the scaling properties of pollutants in storm water runoff (i.e., the value of n) may harbor information about the origin of non-point source pollution.

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EXPERIMENTS AND RAPID DISTORTION THEORY FOR DIFFERENTIAL DIFFUSION

Differential diffusion, or the preferential transport of temperature in a fluid with stable profiles of both temperature and salinity, affects the interpretation of oceanic vertical mixing and ocean modeling. We measured eddy diffusivities of salt and heat in a diffusively stable flow stirred by oscillating rods and computed an average dissipation of turbulent kinetic energy by measuring the work done by the rods on the water. The diffusivity ratio varied between 0.5 and 1.1 and decreased with increasing stratification strength. Calculations with rapid distortion theory reproduce the laboratory measurements, resemble results from numerical simulations, and provide insight on the mechanisms responsible for differential diffusion. In particular, rapid distortion theory predicts countergradient fluxes, which are thought to be important for differential diffusion. Rapid distortion theory also allows effects of mean shear on differential diffusion to be examined. In the experiments differential diffusion also affected the mixing efficiency when the stratification was strong: For experiments with the same Richardson and Reynolds numbers, the mixing efficiency was higher for larger density ratio, the ratio of the contributions of temperature and salinity to the density profile. This result suggests that layer formation in the ocean will depend on the density ratio, and preliminary experiments show that fewer layers form when the density ratio is larger.

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BENTHIC ORGANISMS AND CONTAMINANT FLUX, AVAILABILITY AND UPTAKE

In many sediment environments, bioturbation controls the migration and fate of hydrophobic chemical contaminants. The benthic community influences the stability, porosity and permeability of the sediments, and encourages migration of particles, porewater, and associated contaminants to the sediment surface. Benthic organisms also accumulate contaminants and may influence their bioavailability to themselves and other organisms. Models of each of these processes have been developed and tested using laboratory and field data. The developed models range from fairly simplistic and conceptual to more sophisticated stochastic and deterministic numerical models. A summary of the results to-date will be presented. The presentation will focus on a Levy flight model of burrowing and particle reworking and a model of biphasic desorption, availability and uptake.

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THE EFFECT OF CORAL MORPHOLOGY AND FLOW ON MASS TRANSFER IN CORAL COMMUNITIES

Mass transfer in coral reefs is governed both by the physical flow environment as well as the morphology of the coral. Mass transfer rates were estimated in unidirectional and wave dominated flows by measuring the rate of dissolution of gypsum cylinders placed within the branching structure of three morphologically distinct coral species. As expected, mass transfer rates increase with increasing flow rate and decreasing compactness of the skeletal branching structure. Results also reveal that wave dominated flows have mass transfer rates up to 3 times the rate of equivalent unidirectional currents. This ratio increases with increasing wave frequency, likely due to the corresponding decrease in diffusive boundary layer thickness. We used Planar Laser Induced Fluorescence imaging to study the instantaneous structure of mass advection through the coral. Observations reveal that wave action acts as a dominant forcing mechanism able to drive flow within the coral structure at rates not attainable with comparable unidirectional currents. Thus, wave action has been found to be an important mechanism in providing high rates of mass transfer in coral reef communities.

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ON THE ROLE OF MESOZOOPLANKTON GRAZING FOR VERTICAL FLUX REGULATION IN THE NORTHERN BARENTS SEA

Previous investigations from the Barents Sea marginal ice zone (MIZ) have revealed a strong decline in the vertical carbon flux related to the base of the upper mixed layer (UML) (70% from 30-50 m depth). We hypothesised that high grazing activity from zooplankton optimising food intake with lower predation risk just below the UML could result in the strong C-retention observed. The grazing impact from the dominant mesozooplankton species Calanus glacialis was tested during an expedition to the MIZ in the northern Barents Sea in July 2003. Here sediment trap deployments with high vertical resolution were combined with grazing experiments to obtain mesozooplankton grazing rates in three vertical layers in the upper 100 m. The role of mesozooplankton as consumers in the Arctic shelf food web and their impact on the vertical carbon flux attenuation will be discussed based on results from the grazing experiments and the vertical carbon export.

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PROKARYOTIC PRODUCTION AND GROWTH YIELD IN THE NORTH ATLANTIC DEEP WATER

Estimates of the prokaryotic growth yield (PGY) are generally scarce, particularly for the prokaryotic plankton of the ocean's interior. During a cruise with R/V Pelagia we followed the western branch of the North Atlantic Deep Water (NADW) from its origin in the Greenland-Island Norwegian Sea to Bermuda comprising roughly about the first 50 years of the NADW in the oceanic conveyor belt system. We compare the prokaryotic production measured via leucine incorporation and bacterial growth rates derived from oxygen consumption estimates between the surface layers and the NADW usually found in a depth of 2000-2800m. Generally, prokaryotic production decreased from the surface layers to the NADW by 94% whereas respiration decreased only by about 11%. Depending on the factor used to convert leucine incorporation into carbon production, the PGY ranged from 13 up to 29% in the surface waters and between 1 - 2% in the NADW. Our data confirm previous estimates that the PGY of deep water prokaryotes is generally low, however, they also indicate that the PGY in the ocean's interior might be higher than commonly assumed.

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MEASUREMENT OF GROWTH AND RESPIRATION IN THE DARK OCEAN

Measurements of bacterial production, bacterial oxygen consumption and ETS activity were made over the depth range 200-3500m metres along the course of the N. Atlantic deep water. Over the depth range 1000-3500m, the rates varied from 0.0001 to 0.4 milimoles/m3 day with average rates 0.022 (ETS), 0.146 (O2 respiration) and 0.001 (bacterial respiration). ETS rates and bacterial production were closely correlated (R2=0.5) whereas the measures rates of bacterial oxygen production showed a low correlation with both the ETS (0.16) and the bacterial production rates (0.15). When analysed together, the ETS rates and production rates imply a bacterial growth yield of approximately 5%, whereas the bacterial oxygen production rates would imply yields an order of magnitude lower. The basis of the large discrepancy between the ETS and oxygen determined respiration rates is not understood.

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PREDICTING BIVALVE BEDS QUALITY IN RIA FORMOSA (PORTUGAL) BY MODELLING COLIFORM DISPERSION IN WATER AND ACCUMULATION/DEPURATION IN CLAMS (RUDITAPES DECUSSATUS)

Ria Formosa is an estuarine lagoon (80 Km2) on the southern coast of Portugal, responsible for 80% of the clam production of the country. The objective of this work was to develop a tool to predict the quality of shellfish beds in Ria Formosa, through a modelling approach that simulates sewage dispersion in the water and the accumulation of faecal coliforms in clams cultured in Ria Formosa. 18 months monitoring data, both at high and low tide, of physical, chemical and microbiological variables, along transects established for each of the outlets of the 5 main Sewage Treatment Plants, was used to fit a model (MOHID) that computes the hydrodynamics of Ria Formosa and coliform concentration in the water column. Another model simulates the accumulation/depuration processes in the clams, based on data obtained from laboratory and field experiments exposing clams to E. coli contaminated waters, and measuring periodically the faecal coliform concentration in sub-samples of clams and water. The prediction of interdiction and quality zones for clam harvesting in function of sewage discharge takes also in account the results of experiments held in a depuration plant.

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UNDERSTANDING OPC SAMPLING PERFORMANCE USING AN IN-SITU IMAGING SYSTEM

Using the HRS sampling platform, we have investigated mesozooplankton spatial distributions with the OPC and a concurrently operating multiple-net system in both neritic and oceanic waters of the Gulf of Mexico. While the OPC has been capable of describing gross trends in zooplankton abundance and size distributions, there have been many instances where it has both significantly under- and overestimated the abundance and size distribution of zooplankton observed in the nets. Consequently we have developed and deployed an in-situ zooplankton imaging system, SIPPER, on the HRS capable of resolving the fine-scale distribution of zooplankton and other seston in the water column that may be limiting the effectiveness of the OPC. The sampling performance of the OPC is examined using examples and analysis from concurrent SIPPER imagery.

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BIOGEOCHEMICAL CONVERSION OF NITROGEN IN PELAGIC COASTAL ECOSYSTEMS OF THE GERMAN BIGHT, NORTH SEA: MESOCOSM EXPERIMENT AND MODELING STUDIES

Mesocosm (2.5 m^3) experiments were carried out in the German Bight, North Sea in spring/summer 1999 to study nutrient and phytoplankton dynamics in shallow, turbid waters affected by nutrient-enriched river plumes. Phytoplankton assemblage showed significant patterns of N nutrient utilization (NH4>NO3>NO2). DON remained at steady state concentration between utilization and regeneration processes. However, total nitrogen pool (DIN+PN+DON) decreased over the course of the experiments probably due to denitrification by particle-attached bacteria. Primary production, phytoplankton biomass and nutrient uptake were all enhanced by nutrient additions. A box model simulated successfully the development of the main N compartments in control bags and the experimental systems and provided the means to calculate N fluxes. Limitations of the model were likely due to the ability of phytoplankton cells to store P and modifications of nutrient utilization due to the different nutrient status within the cells, which could not be covered by the Michaelis-Menten-Monod equation. Thus, the Droop equation was also applied and compared with the M-M equation for nutrient uptake. The model results were compared with calculations from the European Regional Sea Ecosystem Model.

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THE USE OF STABLE ISOTOPES TO DESCRIBE FOOD WEB DYNAMICS AND CARBON CYCLING AT MULTIPLE SITES IN THE ARCTIC: WHAT HAVE WE LEARNED?

Climate models predicting significant warming in the Arctic Ocean and its marginal seas have led to an increased effort to identify potential consequences of warmer air and water temperatures and decreased ice extent and thickness. Understanding current food web dynamics and carbon pathways is a critical step in predicting the effects of altered productivity regimes and water column structure. Stable isotope analysis has for several decades been an important tool in delineating food web structure, sources of carbon to the food web, and intensity of benthic-pelagic coupling throughout the world's oceans. We use data from published and more recent studies at five locations across the Arctic: Barents Sea, northeast Greenland shelf, west coast of Greenland, central Canadian archipelago, and Chukchi Sea, to identify panarctic patterns in trophic structure. Isotopic signatures provide insight into processes at multiple levels: from spatial variability in primary food source and trophic level of individual species, to regional differences in numbers of trophic levels within a food web and intensity of links among ice, pelagic, and benthic environments.

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MAPPING PATCHY HABITATS WITH AUTONOMOUS OBSERVERS

The pervasiveness of patchiness in nature has been widely recognized, and several analytical and computer models for their emergence and dynamical evolution have been proposed, see [1] and references therein. For terrestrial applications, aerial photography is generally able to provide the raw data necessary for identification of model parameters as well as for incremental tracking of habitat's evolution over time. For underwater ecosystems no such permanent and extensive observation means exist except for the sea surface. We present work on the definition of strategies for autonomous mapping of patchy habitats by underwater platforms. These strategies integrate sensor-driven behaviors able to map the contours of individual patches as well as delineating regions of similar spatial organisation of the individual patches (addressing thus the issue of multi-scale organisation of ecological systems). The definition of these observation behaviors is formally based on stochastic models of the spatial organisation of the observed ecosystem, whose parameters are fit, on-line, to the acquired data. Examples using simulated environments, considering realistic patch distributions identified for the scattering of maerl in Wyre Sound, Scotland, will be shown.

[1] Wu, J. and Loucks,, O.L., 1195. From balance of nature to hierarchical patch dynamics: a paradign shift in ecology. Quart. Rev. Biol. 70, 439-466.

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PREDICTING EARLY JUVENILE BLUE CRAB SECONDARY DISPERSAL IN A WIND-DRIVEN ESTUARY

Recent research highlights the importance of pelagic dispersal by newly-settled (< 1cm carapace width), juvenile blue crabs (Callinectes sapidus) in determining recruitment patterns in Pamlico Sound, NC; however, the mechanisms mediating such transport remain unclear. In part, this is because Pamlico Sound is a predominately wind-driven estuary that has limited tidal exchange near inlet regions, and therefore lacks the predictable tidal cues commonly used by larval fishes and crustaceans to move up-estuary. To determine how early juvenile blue crabs disperse across Pamlico Sound, we conducted a coupled bio-physical study over multiple 24-hr periods relating the vertical distribution of early juvenile blue crabs in the water column (plankton tows) with circulation patterns within Pamlico Sound (S4 current meters). In addition, a circulation model of the region was used to assess potential blue crab secondary dispersal pathways that link near-inlet and across-sound nursery habitats. We evaluate model predictions against actual blue crab distribution and abundance patterns and discuss how the model may be refined by incorporating early juvenile blue crab behavior.

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THE USE OF THERMOCOUPLE ARRAYS TO INVESTIGATE THE MICROBIAL COLONIZATION WITHIN ACTIVELY FORMING CHIMNEY DEPOSITS IN GUAYMAS BASIN

Numerous studies have identified a vast diversity of Archaea and Bacteria associated with actively forming hydrothermal mineral deposits at deep-sea vents, yet few have addressed the successional changes that may occur in the microbial composition as the active chimneys grow. In order to trace the evolution of environments within newly formed chimneys walls, Ti-thermocouple arrays were deployed using the ROV Tiburon on 3 vent structures at Guaymas Basin in March, 2003. On recovery (after 4 and 72 days) the solid material on outer and inner portions of the chimneys, and adjacent to each thermocouple, was sub-sampled for chemical, isotopic, and molecular microbial analyses. The final measured temperatures ranged from 110 to 303 C. DNA was successfully extracted from some of the samples collected within mm of the thermocouples. Archaeal and bacterial 16S rRNA genes were amplified from DNA extracted from material obtained from both the long-term and short-term deployments. Diffusive and advective transport models will be developed to determine the chemical environment within chimney walls thereby placing the microbial diversity in a chemical, thermal, and temporal context.

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THE IMPACT OF PATCHINESS ON THE DYNAMICS OF THE MARINE ECOSYSTEM

Spatial heterogeneity of populations is a well-known characteristic of the marine ecosystem. But does this heterogeneity, or 'patchiness', impact on the overall dynamics of the system? And what characteristics of the spatial variability do we need to build into models? Here we apply an ecosystem model to investigate the combined effects of diffusion, fluid stirring and zooplankton behavior in producing spatial structure and on the overall rates of primary and secondary production of the system. The main conclusion is that patchiness does matter. The areal means of both phytoplankton and zooplankton can be very different for cases with and without spatial structure. In particular large-scale blooms can be initiated under conditions of spatial heterogeneity whilst the homogeneous counterpart is stable. Our results have strong implications for the interpretation of observations. The apparent rate of biological processes of the population as a whole maybe very different from that of individual organisms. This suggests extreme caution needs to be exercised in simply 'tuning' 1D ecosystem models to fit observations without taking into account the effects of patchiness.

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PLANKTONIC FOOD WEBS OF THE EQUATORIAL PACIFIC AT 140W: A SYNTHESIS OF EQPAC TIME SERIES CARBON FLUX DATA

We used inverse and network analysis approaches to examine food web interactions during EqPac time series cruises in the eastern equatorial Pacific in March-April and October 1992. Our goal was to characterize carbon flows and trophic transfers while synthesizing the available information into a complete picture of ecosystem dynamics. Key findings were: 1) primary production of the larger phytoplankton size classes was most often dominated by the prymnesiophytes and pelagophytes and not by the diatoms, 2) picoplankton primary production was not always balanced by microzooplankton grazing, despite conventional views of balanced microbial producter/grazer interactions in this system, 3) the picoplankton played an important direct + indirect role in the export of carbon from the euphotic zone through a pathway involving production of detritus from picoplankton carbon and subsequent grazing of this picoplankton-derived detritus by the mesozooplankton, 4) estimates of carbon export as DOC ranged between 9 and 25 mmolC/m2/d, and 5) export of carbon through consumption of meszooplankton by higher trohic levels was of the same magnitude as DOC export yet this pathway is rarely considered in equatorial carbon balances.

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ROMBUS: A MODEL OF DOM MOBILIZATION AND REACTION

Large rivers receive and transform inputs from heterogeneous landscapes, resulting in highly aggregated and complex signals in the composition of the dissolved organic matter in transport We hypothesize that these signals can be decomposed into their constituent dynamics by representing bulk carbon as a sum of carbon fractions divided by molecular weight (to account for the observed increase in degradation state as the molecular size decreases, and to facilitate the parameterization of organo-mineral associations), mobilized by hydrologic flow paths. We are exploring this hypothesis for the Amazon River system within the construct of a "River Basin Organic Matter and Biogeochemistry Synthesis" (ROMBUS) model. Within ROMBUS each of the organic and inorganic carbon pools are represented by state variables that characterize the nitrogen-to-carbon ratio (for the OM pools), δ13C signature and age (via Δ14C). The model is implemented as pixels within a geospatial model of the landscape, and flow paths are computed via a hydrology model.

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FACTORS AFFECTING SURVIVAL, RESILIENCE AND RECOVERY OF ESTUARINE CORAL REEFS

Estuarine coral reefs within the high islands of the central and Indo-West Pacific often experience a higher degree of environmental variability than reefs situated along open coastal expanses. The effects of salinity and temperature changes as well as high rates of sedimentation and nutrient loading can be severe, depending upon receiving water characteristics of residence time, depth and mixing. Changes in water and substratum quality from watershed discharges can interfere with critical life history stages of corals and associated organisms, including spawning success, fertilization rates, embryological development, and larval recruitment. A 15% drop in salinity from 34 ppt to 29 ppt can cause a 90% drop in fertilization rates among spawning corals in the genus Acropora. Layers of sediment, cyanobacteria and fleshy algae can block chemical cues from appropriate substrata resulting in recruitment failure of coral planula larvae. While individual species of corals may still be represented in populations, there is concern that genetic diversity is declining along with coral abundance and reef resilience. Integrated watershed management efforts can help restore those conditions that allow natural reef recovery to occur.

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LAYER 2A AT THE SOUTHEAST INDIAN RIDGE, CLUES TO ABYSSAL HILL FORMATION

Faults that bound abyssal hills enable seawater to travel down into the crust. As a result faulting is an important means of exchanging heat and minerals between the ocean and the mantle, yet the formation of abyssal hills is not well understood. The Southeast Indian Ridge (SEIR) south of Australia is an excellent place to study morphology and mantle variations. The 2A layer is a boundary between low-density extrusive rocks and the higher-density dikes. Extrusive layers of a portion of the SEIR (segment P1 and P2) show that Abyssal hills seem to form by the horst/graben method. The East Pacific Rise-like axial (segment P1) high gets thicker away from the axis whereas layer 2A reaches close to its full thickness at the axis of the rifted axial high (segment P2). The crustal thickness is approximately 6500 m for both segments, and the magma supply for the ridges seem to be pretty similar. However, as the axis begins transforming to a shallowly rifted valley, the abyssal hills seem to be forming from a combination of the horst/graben and split volcano methods.

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OPERATIONAL AUV OBSERVATIONS IN MONTEREY BAY

MBARI is routinely deploying an AUV with a multi disciplinary senor suite and configurable payload midbody in the Monterey Bay study region. Included in this effort are periodic AUV surveys conducted in parallel with mooring and shipboard time series observations. Relative to ship board surveys, the enhanced spatial resolution from the AUV is revealing significant ecosystem processes related to primary productivity, sediment transport, frontal processes, and carbon fluxes. For specific missions, the AUV has been equipped with a configurable midbody section allowing different payloads to be added to the core instrumentation suite. This midbody has successfully obtained bioluminescence measurements and particle size distributions. Bioluminescence measurements obtained during these missions show clear relationships between the spatial distribution of phytoplankton and bioluminescent organisms. Particle size spectrum measurements reveal clear patterns of particle size distribution in regions of strong sediment resuspension and phytoplankton blooms. Early AUV operations have allowed new discoveries about physical and biological processes. Future operations show promise for new and expanded understandings in this research area.

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EFFECTS OF PERSISTENT SMALL-SCALE TURBULENCE ON THE GROWTH, SIZE, MORPHOLOGY, AND INHERENT OPTICAL PROPERTIES OF THREE DIATOMS FROM THE FAMILY CHAETOCEROTACEAE

The effects of persistent, small-scale turbulence on the marine planktonic diatoms Bacteriastrum hyalinum, Chaetoceros debilis and Chaetoceros affinis were studied in replicated laboratory experiments. All three bear siliceous setae (spines), however they form very different 3-dimensional colonies. Each taxon was grown under 5 levels of quantified turbulence, plus an unstirred control. Both morphological (cell/colony size and shape) and physiological (growth rate, inherent optical properties) responses were quantified. The taxa differed in their sensitivity to turbulence. Particle size and growth rate showed clear, species-specific responses. Turbulence was necessary for formation of normal helical colony morphology in C. debilis. Spectral absorption and attenuation of dissolved and particulate material were measured with a WET Labs ac-9 for each turbulence level at the end of each experiment. Although turbulence had no effect on spectral absorption by dissolved material, we observed strong spectral effects on absorption and attenuation by total particulate material, biogenic detritus, and phytoplankton alone. These results not only demonstrate that persistent turbulence can affect particle size, shape and growth rate of spiny diatoms, but that turbulence can also affect inherent optical properties.

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BASEFLOW AND STORM-RUNOFF IMPACTS ON AN URBANIZED SUBTROPICAL ESTUARY

Fluvial impacts on water quality and ecosystem structure were evaluated in southern Kaneohe Bay, Oahu, Hawaii. Fluvial inputs occured as small, steady baseflows interrupted by intense pulses of storm runoff. Baseflows impacted only restricted areas around stream mouths, but storm events produced transient 'plumes' of much greater areal extent. Water-column productivity normally is nitrogen-limited, but inorganic N:P ratios in both baseflows and storm runoff exceeded the 'Redfield' ratio, and post-storm phytoplankton blooms ultimately were phosphorus limited. Gross primary productivity increased during blooms, and photopigment analyses showed that phytoplankton community structure also was affected. High flushing rates resulted in rapid recovery following storm events, but terrigenous sediments delivered by storms probably continued to provide nutrients to the water column over much longer timescales. Storm inputs thus can have significant impacts on water column ecosystems and biogeochemistry, both on event timescales and on longer timescales via nutrient remobilization from sediments. Effective management of human impacts due to changes in fluvial nutrient loading will require consideration of the timing and form of dissolved and particulate nutrient delivery, and of nutrient recycling from sediments.

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BACTERIAL RESPONSE TO MESOSCALE IRON ENRICHMENTS: SYNTHESIS OF FIELD STUDIES

Iron supply controls the growth of phytoplankton in the euphotic zone of High Nitrate Low Chlorophyll (HNLC) waters. Changes in upper ocean biogeochemistry and the dynamics of phytoplankton have been the primary focus of all the mesoscale Fe-enrichment studies. Less is known about the response of bacteria and other microheterotrophs. It has been suggested that an increase in the Fe-supply rate would enhance the downward export of biogenic carbon. For significant export to occur however, the biogenic carbon produced in the surface layer must escape microbially-mediated solubilisation and remineralization, suggesting that microbial activity is crucial in regulating Fe-stimulated biogenic carbon export in HNLC regions. Here, we characterised the dynamics of bacterial growth and loss during mesoscale Fe enrichments in the Equatorial Pacific, the Southern Ocean, and the Subarctic North Pacific. Depending on the region, bacterial growth rates ranged from 0.08-0.80/d, with higher rates typically occurring when phytoplankton biomass was high. Bacterial dynamics are generally grazer, rather than resource controlled, which leads to the retention and/or remineralisation of biogenic carbon in the surface layer.

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GLUTAMINE SYNTHETASE ISOENZYME EXPRESSION IN THE MARINE DIATOM SKELETONEMA COSTATUM

Glutamine synthetase (GS) catalyzes the ATP dependent formation of glutamine from glutamate and ammonium. In Skeletonema costatum, two GS isoenzymes are expressed and are members of evolutionarily distinct gene families (GSII and GSIII). Our working model predicts that GSII is localized to the plastid where it plays a critical role in the assimilation of ammonium produced from nitrate reduction, while GSIII is targeted to the cytosol and assimilates ammonium from sources external to the cell. In order to test this model, we have produced GSIII (previous work) and GSII antisera (this study). A portion of the S. costatum GSII gene was cloned and expressed in bacteria. The expressed protein was purified and used to produce antisera. Experiments comparing the GSII and GSIII antisera confirmed that the sera recognize distinct polypeptides. The antisera will be used to examine the expression of the isoenzymes in response to nitrate and ammonium availability. These experiments will evaluate whether GS expression patterns can be used as molecular indicators of nitrogen assimilation and provide insight into the cellular regulation of these pathways.

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THE EFFECT OF DISINFECTION OF AN OFFSHORE OCEAN OUTFALL EFFLUENT AND SURFZONE BACTERIA LEVELS

The Orange County Sanitation District (District) discharges treated wastewater effluent about 7.5 km offshore in 60 m of water on the southern portion of the San Pedro Shelf, California. Before August 2002 this effluent was not disinfected. Discrete water samples were collected for analysis of three fecal indicator bacteria at a series of offshore and shoreline stations. Comparisons of pre- and post-disinfection bacteria data from stations located at the outfall, between the outfall and the shoreline, and at the shoreline were made. Bacteria densities seen at the outfall have changed significantly at all depths since disinfection began, with the great majority of post-disinfection samples being below the method detection limit of 10 MPN/ 100 mL. Results from intermediate stations were variable, dependent on the location of the stations and the depth of the sample. This finding was consistent with previous plume tracking studies and reflects predominant ocean currents, shelf bathymetry, and water column stratification. Overall temporal and spatial patterns for surfzone bacteria measurements did not reflect improved offshore subsurface bacterial water quality.

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TEMPERATURE TOLERANCE OF THE UNCULTURED SYMBIOTIC COMMUNITY OF THE VENT POLYCHAETE, ALVINELLA POMPEJANA, AS INFERRED FROM STABILITIES OF MALATE DEHYDROGENASES

In order to approximate the thermal activity range of the uncultured microbial community of Alvinella pompejana epibionts, the community's metagenome was investigated to find malate dehydrogenases for overexpression and functional analyses. Of 106,622 ORFs analyzed, 15 malate dehydrogenase genes were found. As none of these genes supplied a full ORF sequence, alignments were performed with the intention of finding the end sequences for overexpression of the full recombinant genes. The result of alignments was a wide diversity of MDH genes, with few overlapping sequences, and therefore no full genes. The two dominant types of the MDH gene were found at both 9N and 13N, and accounted for 5 of the 15 genes analyzed. These were chosen for further study. Panhandle PCR was used to access the full length ORFs, and sequence analyses were performed. These malate dehydrogenase genes were overexpressed to learn about their relative stabilities with respect to temperature, and this data is presented here.

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AOSN IN MONTEREY BAY: MODELING AND PREDICTING MULTIPLE SCALES FOR ADAPTIVE SAMPLING

Throughout August 2003, two regional ocean models, the Harvard Ocean Prediction System (HOPS) and the Regional Ocean Modeling System (ROMS) made 2 day predictions of the Monterey Bay/California Current circulation. Atmospheric forcing was obtained from forecasts using NRL's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) (resolution of 3 km). The ocean models assimilated data from ships, gliders, AUVs, aircraft and satellites. HOPS is interdisciplinary generic, stand-alone and relocatable. The JPL/UCLA ROMS configuration has nested multiple domains for the US west coast. Guidance for adaptive sampling by WHOI gliders and ships was provided by identifying important dynamical events and observations to reduce forecast errors. Coordinated glider tracks were, on an hour-to-hour basis, designed for adaptive sampling using feedback control theory methods by scientists from Princeton. CalTech scientists computed Lagrangian Coherent Structures from forecast flows. Dynamics include: onset, maintenance and relaxation upwelling; interaction of the Undercurrent variabilities, and exchanges across the mouth of Monterey Bay. These dynamical events were successfully represented in the models and model-data and model-model inter-comparisons with quantitative skill metrics are underway.

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DEFINING THE PARAMETERS REGULATING ANTARCTIC PHYTOPLANKTON SPECIES DISTRIBUTION: PHOTOPHYSIOLOGY

In the Ross Sea, Antarctica, the pattern of distribution of the two major phytoplankton groups has been correlated to specific hydrologic conditions. Diatoms bloom in shallow and strongly stratified waters, where irradiance is high, whereas Phaeocystis antarctica blooms in deeply mixed and weakly stratified waters, where irradiance is more variable. This pattern has been attributed to differences in the ability of each taxon to photoacclimate to either high light or variable light conditions. To understand the extent to which photophysiology influences phytoplankton species distribution in the Ross Sea, we undertook a laboratory study of three diatom species (Fragilariopsis cylindrus, Nitzschia subcurvata, F. curta) and P. antarctica. One set of cultures was grown under static light conditions that ranged from light-limiting to photoinhibiting. A second set was grown under transient light conditions designed to simulate shallow (100-250 micromol photons m-2 s-1) and deep (0-250 micromol photons m-2 s-1) mixing. Measurements of fluorescence (PAM fluorometry), P-E parameters, specific absorption and pigment composition were made on cultures to assess photoacclimation, photoprotection, and sensitivity to photoinhibition.

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EXPLORING THE GULF OF CALIFORNIA: THE INFLUENCE OF THE OXYGEN MINIMUM LAYER ON MIDWATER ECOLOGY

In the Spring of 2003 MBARI's R/V Western Flyer made the first extensive, ROV-based exploration of the Gulf of California. We used the ROV Tiburon to examine the faunal composition and vertical structure of the Gulf's midwater community in four of its deep basins. We compared the results of these surveys with our reference community in Monterey Bay, in order to find similarities that reveal basic patterns of ecological structure, and differences that are linked to specific hydrographic characteristics. Our results show that several species occurred much closer to the surface in the Gulf than is the case for their counterparts in Monterey Bay; and that these differences appear to be correlated with the greater vertical extent of the Gulf's oxygen minimum layer (OML). Biological stratification was pronounced in the relatively narrow region above the OML. Within the OML, species diversity was low but the number of animals was higher than anticipated, largely due to the daytime presence of vertical migrators. Diversity and abundance increased below the OML and several inter-basin faunal differences occurred at these depths.

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GENETIC DIVERSITY IN FIELD POPULATIONS OF PROCHLOROCOCCUS AND SYNECHOCOCCUS

The marine unicellular cyanobacteria Prochlorococcus and Synechococcus are responsible for a significant portion of primary production in oligotrophic waters. Within each genera, cultured isolates exhibit significant physiological diversity in their photosynthetic properties and capacity to utilize different forms of nitrogen. We have used the 16S-23S ribosomal RNA internal transcribed spacer region (ITS), which is highly variable in both length and nucleotide sequence, as a molecular marker to discriminate the ecotypes of Prochlorococcus and Synechococcus. Cyanobacterial communities in the Sargasso Sea, the Equatorial Pacific and the Red Sea have been characterized using fragment analysis and sequences of cloned amplicons. ITS fingerprinting reveals that between four to six ecotypes of each genera coexist in a typical water column, suggesting that niche partitioning is quite complex. This is consistent with extensive genome wide variation observed among strains of Prochlorococcus. Finally, we recovered several groups of sequences of both Prochlorococcus and Synechococcus that do not have cultured representatives.

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SPATIAL INHOMOGENEITY OF ALEUTIAN ISLANDS CLIMATE VARIABILITY

The Aleutian low is the primary driving forcing of climate variability in the Aleutian Islands. The regional manifestations of its influence are substantially different for the eastern and western Aleutians; the transition between the regions in terms of the climate occurs at about 170W. Unlike the eastern Aleutians, which experienced a regime shift toward a warmer climate in 1977, the western Aleutians showed a declining trend in winter temperature (particularly in January), accompanied by an increase in its intra- and inter-annual variability. At the same time, the temperature variability in southeast Alaska significantly declined. Much of the increase in the intra-annual variability for the western Aleutians is associated with the warming trend in November and cooling trend in January. As a result, the rate of seasonal cooling from November to January is doubled since the late 1950s. We hypothesize that this trend in SAT variability may have increased the environmental stress on the western stock of Steller sea lions and contributed to its decline.

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COMBINING SUBSURFACE FLOAT AND HISTORIC HYDROGRAPHIC DATA TO OBTAIN ABSOLUTE TRANSPORT POTENTIAL FOR THE BRAZIL AND SOUTH ATLANTIC CURRENTS

Mean absolute transport potential for the top 1000db is estimated for the regions of the Brazil Current (BC) at 25-40S and the South Atlantic Current (SAC) along 40-45S. These transports are obtained by combining Gravest Empirical Mode (GEM) fields calculated from historical hydrography with data from isobaric RAFOS floats deployed in the area. A GEM field is a projection of the hydrographic data in geostrophic streamfunction space; it captures most of the vertical structure associated with frontal regions. The performance of the float-GEM method is tested using the WOCE transect A17. Baroclinic transport of volume across the section is accurately reproduced by the GEM fields. The absolute transport potential reveals several interesting features such as an increase of 20Sv in the BC from 30S to 38S; a narrow SAC around 50W transporting 60Sv (only 40Sv continues to flow eastward at 40W with the remaining 20Sv turning southward to eventually join the ACC); and two SAC branches at 2E, a narrow eastward flow along 37S and a broader flow along 45S. Calculations of heat and mass transports are under development.

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A KNOWLEDGE-BASED REACTIVE TRANSPORT APPROACH TO REDOX, PH AND SI DYNAMICS IN SEDIMENTS

The knowledge about biogeochemical transformation processes in natural environments is expanding rapidly, creating a need for efficient transfer of this knowledge into biogeochemical models. It is essential that reactive transport models cope with such rapidly increasing observational knowledge base on the mechanisms and rates of biogeochemical processes. In this framework, a Biogeochemical Reaction Network Simulator (BRNS), based on the novel concept of an evolving 'Knowledge Base' (KB) has been developed (Regnier at al., 2002). With this approach it is no longer the model itself, but an easily accessible, open resource element, the KB, which contains the conceptual and quantitative understanding of biogeochemical pathways and their interactions. The current focus of the KB implementation and of the resulting model applications is on redox, pH and Si dynamics in sediments. Our results demonstrate that the BRNS allows to incorporate easily reaction networks of increasing complexity, to evaluate alternative process formulations – including microbial activity -, and to develop diagnostic indicators of biogeochemical pathways that can be measured in the field or in experimental set-ups. Regnier P., Vanderborght J.P., Steefel C.I., and O'Kane J.P. (2002). Modeling complex multi-component reactive-transport systems: Towards a simulation environment based on the concept of a Knowledge Base. Applied Mathematical Modelling, 26, 913-927.

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GAINS AND SACRIFICES OF USING DIFFERENT SCALES OF DATA IN FISHERIES OCEANOGRAPHIC ANALYSES

Understanding how fish stocks change in response to their environment and to the effects of fishing is critical for improving fisheries management decisions and improving the efficiency of fishing operations. The importance of evaluating physical, chemical and biological relationships from different time and space scales will be compared with regard to understanding changes in fish distribution and catchability (availability and vulnerability). These comparisons, using different information gained from different data collection platforms and modeling output will provide fisheries oceanographers and policy makers insight needed for the integration of the data derived from the next generation of observational platforms and coupled bio-physical models. Focus will be on the utility (gains and losses) of using data derived for use in real-time, short-term and climate scale fisheries oceanographic work. A consideration of what research, data products, and tools are needed to improve the accuracy and reliability of forecasting and diagnostic fisheries models and data products.

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THE UNSEEN IRON POOL: IS THERE A BIOGEOCHEMICAL IRON CYCLE IN THE OCEAN CRUST?

The biogeochemical cycling of iron (Fe) within the oceanic crust, where Fe constitutes ca. 10 wt.%, may be an important and unrecognized electron donor that supports the growth of a potentially extensive microbial biomass. Various studies have indirectly suggested the presence of microorganisms in the crust using a variety of microscopic and molecular techniques, however the metabolic functions of these proposed microorganisms were completely unknown. Recent studies have isolated phylogentically diverse guild of bacteria capable of oxidizing iron from crustal rocks such as basalt glass. Laboratory studies indicate that these organisms may be important in controlling chemical exchange between the ocean and the lithosphere through the mobilization and oxidation of iron. The potential importance of this guild is estimated based on the physiology of cultures and by examining the chemical composition of the ocean crust over time. These methods estimate that autotrophic oxidation of iron within the young (<10My) ocean crust could support a significant amount of biomass (~10^11 mol C / year), a flux of carbon greater than occurs from open ocean sediments, which may serve as an important food chain base in young ocean crust.

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ZOOPLANKTON DYNAMICS IN THE LOWER SAN FRANCISCO ESTUARY: ROLE OF MICROZOOPLANKTON

We sampled microzooplankton in South San Francisco Bay (SSFB) with two objectives: assess inter-annual/seasonal variability of microzooplankton abundance, and compare vertical distributions of microzooplankton and predators/prey vs. stratification. Ciliate biomass dominated in SSFB, and showed peaks during the spring bloom. Microzooplankton biomass was significantly higher in 1998 (El Nino) vs. 1999 (La Nina). During periods of high abundance, microzooplankton vertical distributions were more correlated with their copepod predators than their prey, and vice versa when in low abundance, and were never significantly correlated with stratification index. Previous results demonstrated copepods in SSFB preferred microzooplankton over diatoms during non-bloom periods and comprised at least 15-20% of copepod diet during the bloom. Tintinnid ciliates were also found to be a substantial component of larval herring diets. We conclude that, as with phytoplankton biomass, strong El Nino events lead to increased microzooplankton biomass, that biological factors play a larger role in determining microzooplankton vertical distributions than stratification, and that bloom periods of windows of opportunity for planktonic consumers and, by extension, higher trophic levels.

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OPTICAL, ACOUSTIC AND NET ESIMATES OF ZOOPLANKTON BIOMASS IN THE GULF OF MEXICO: PATTERNS OF ZOOPLANKTON BIOMASS AND ITS RELATION TO HYDROGRAPHIC VARIABLES

A sampling survey was conducted in the Gulf of Mexico during the summer of 2003 using a towed sensor package (Scanfish) that included hydrographic sensors and an Optical Plankton Counter (OPC). Hydrographic variables (i.e. temperature, salinity, oxygen, suspended sediments, fluorescence) and zooplankton biomass were measured simultaneously throughout the water column. A set of transects was sampled along and across the shore of the continental shelf west of the Mississippi River delta. In addition to OPC measurements, the vertical distribution of zooplankton biomass was estimated at select stations with a six frequency, Tracor Acoustic Profiling System (TAPS) and pump collections. Comparisons of the OPC, TAPS and pump estimates of zooplankton biomass were performed under a range of water types that ranged from turbid waters of the Mississippi River plume to clear, oligotrophic waters of the outer shelf of the Gulf of Mexico. The preliminary results showed that variability in spatial patterns of zooplankton biomass and hydrographic variables was coherent on a various spatial scales. Zooplankton biomass was strongly influenced by the Mississippi River plume and was higher inshore than offshore.

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DISTRIBUTION OF JUVENILE ROCKFISH OF THE ALEUTIAN ARCHIPELAGO IN RELATION TO BENTHIC HABITAT AND OCEANOGRAPHIC FEATURES

Little is known of the relationship of juvenile rockfish to oceanographic and biological habitat features in the Aleutian archipelago. The objective of this project was to identify juvenile Pacific Ocean Perch (Sebastes alutus) habitat, using data from trawl surveys conducted by the National Marine Fisheries Service and non-linear modeling techniques. The results indicate that juvenile POP were distributed at depths from 100 to 250-m, and juvenile catches decreased as temperature increased from 3 to 5.5 0C. Juvenile rockfish were found in highest numbers in areas of steep bathymetry at the shelf break edge. They were also most abundant at sites in the western Aleutians (beyond 1700 W longitude), on large underwater banks (Stalemate and Petral banks), and in passes between islands where currents are strong and production may be higher than surrounding areas. Juvenile rockfish were also linked to invertebrate organisms such as deep-sea corals and sponges. Over 60% of the tows capturing juvenile rockfish also caught significant volumes of sponge and coral, possibly indicating a strong role of these invertebrates in the life history of juvenile POP.

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PATHOGEN IMPACTS ON COASTAL WATERS USING QUANTITATIVE MICROBIAL RISK ASSESSMENT

Quantitative microbial risk assessment can be used to examine types of pathogens, their sources and reservoirs, survival, transport and impact on public health associated with contaminated beaches. The CDC reported an increase in recreational waterborne disease outbreaks associated in freshwaters in the last few years. However, very few studies have focused on freshwater systems and most epidemiological studies have examined marine waters but without adequate pathogen assessment. Wastewater sources, including untreated and combined sewer overflows, septic tanks are all significant contributors of pathogens with enteric viruses and protozoa being discharged at levels as high as 100 million per day. Temperature is one of the key factors influencing pathogen survival and in marine systems salinity may play a key role, yet few studies have actually addressed this. Rainfall, currents, winds and tides affect transport. In the Great Lakes, 60% of the 52 areas of concern are listed as impaired for recreational use. Potential polices on combined sewer overflows show that probability of infection for pathogens is as much as 1000 times greater if untreated sewage is discharged to recreational waters.

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THE EUTROPHICATION OF WAQUOIT BAY, MASSACHUSETTS: FROM PRE-AGRICULTURE THROUGH URBANIZATION

Waquoit Bay is a small, shallow and groundwater-dominated estuary on Vineyard Sound that lies on the south-facing coast of Cape Cod. This region experienced some of the earliest permanent European settlements in North America, being within the original Plymouth Colony (1620). Land-use within the watershed has varied greatly since colonization. Recent environmental concerns, stemming from coastal zone urbanization have been centered on the eutrophication of Waquoit Bay since 1950. This eutrophication has been caused by the increased nitrogen loading from within the watershed derived from residential wastewater, and its effects have noticeably altered the bay's ecosystem. Sediment cores acquired from the bay were radiocarbon-dated and analyzed for their organic (carbon and nitrogen) content. The results indicate that the most rapid and largest increase in the organic concentration in the bay's sediments began during the early period of agriculture (1700s) and since has maintained a high and constant level, even during the past 50 years of exponential population growth. The disappearance of agriculture and reforestation since 1900 may be partly mitigating the effect of urbanization on organic input to the bay.

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FECAL INDICATOR BACTERIA PATTERNS IN THE HUNTINGTON BEACH SURF ZONE

Fecal indicator bacteria concentrations were measured in the surf zone between July 1998 and December 2001, and analyzed with respect to their temporal and spatial variability. Single sample bacteria concentrations were compared to state recreational water quality standards. Higher bacteria concentrations were associated with spring tides, consistent with previous findings. Distinct spatial patterns for coliform and enterococci bacteria were classified into different types of events. During the June to October 2001 timeframe, little correspondence was found between bacterial events and coastal ocean transport processes. Hourly sampling during six 48-hour periods near spring tides, were examined to elucidate relationships between surf zone bacterial concentration and either time of day or tidal phase. Enterococci show a much more pronounced diel cycle than the coliform bacteria. Coliform levels appeared to be controlled more by the phase of the tide. The results suggest that flow from the Santa Ana River and/or a constructed wetland, Talbert Marsh, may be a source of high bacteria concentrations, particularly for total coliform, while there appear to be multiple sources for high concentrations of enterococci.

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ALGAL MOTILITY IN VARIABLE TURBULENCE

Motile phytoplankton species are suspected to use their motility for adjusting their vertical position in the water column in order to optimise the availability of both light and nutrients as their primary resources for growth. We investigate the use of motility in various turbulent regimes through a coupled 1D physical-biological Lagrangian model in space- and time-varying diffusivity. This individual-based approach allows us to investigate possible migratory strategies and their effect on the individual light histories (photoacclimation) of the cells as well as the effect of turbulent intensity on swimming success. We studied two particular environments: (1) a partially mixed estuary where the tides produce periods of strong but intermittent vertical mixing; and (2) a stratified but tidally energetic shelf sea, where observations often show the predominance of motile species in the base of the thermocline. Our results indicate under which circumstances motility can provide the phytoplankton with a competitive advantage over non-motile species.

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DEGRADATION AND MODIFICATIONS OF DISSOLVED PROTEIN BY NATURAL MICROBIAL ASSEMBLAGES

Organic nitrogen is important to the oceanic nitrogen cycle in both particulate and dissolved forms. Despite the widespread presence of the amide functionality, chemical forms and origins remain uncertain. We examined protein as a contributor to DON and the potential for microbial mediated structural modifications. A model protein, Bovine Serum Albumin (BSA), was incubated in waters from the Arctic Ocean, Delaware Bay and Patuxent River to examine its degradation and potential for alteration by microbes. Size exclusion chromatography was used to follow modifications of BSA and isolate proteins based on molecular size with rapid loss of intact protein and production of modified products observed in all systems. Liquid chromatography-mass spectrometry (LC/MS) with peptide mapping has been applied to collected fractions together with analysis of individual amino acids (THAA) to structurally evaluate lower molecular weight products seen and their relation to the original protein.

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MODULATION OF OCEAN PRODUCTIVITY BY SMALL-SCALE TURBULENT FLOW

Direct numerical simulation (DNS) of small-scale turbulent flow induces patch structure or "patchiness" among randomly distributed particles. The aggregation or apparent contagion of the particles increases as a function of the turbulent kinetic energy dissipation rate (and the Reynolds number of the flow). This demonstrates the counterintuitive proposition that the small-scale flow field is both aggregative and dispersive. The aggregation-dispersion phenomenon further characterizes the causal chain linking climate-scale changes in wind velocity, the turbulent kinetic energy dissipation rate, and the influence of the flow field on smaller plankton. The aggregation-dispersion provides a new explanation of how multiscale changes in wind velocity can induce major changes in observed plankton biomass and possible long-term changes in the flux of carbon dioxide across the sea surface.

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REGIONAL OCEAN DATA ASSIMILATION AND FORECAST MODELING USING NCODA.

The analysis component of the operational ocean nowcast/forecast system at the Naval Oceanographic Office is being upgraded with the NRL Coupled Ocean Data Assimilation (NCODA) system developed for the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS). NCODA is a fully 3D multivariate optimum interpolation system that produces simultaneous analyses of temperature, salinity, geopotential, and vector velocity. The ocean data types assimilated include remotely-sensed sea surface temperature, sea surface height, and sea ice concentration, plus in situ surface and sub-surface observations of temperature, salinity and currents from a variety of sources including ships, buoys, XBTs, CTDs and profiling floats. An ocean data quality control (QC) component that is fully integrated with the NCODA analysis is also being implemented, and includes feedback of forecast fields and prediction errors in the QC of new data. We will describe the system and present results of model/analysis assimilation cycles and evaluations of forecast skill for two contrasting ocean domains: the western North Pacific and northern Indian Ocean.

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SIZES AND SETTLING SPEEDS OF SUSPENDED PARTICLES IN THE CHESAPEAKE BAY ESTUARINE TURBIDITY MAXIMUM

Fine sediments suspended in estuarine waters usually exist, not as individual particles, but as flocs (large, porous aggregates). Little data exists on estuarine floc characteristics, especially their settling speeds. Studies indicate that floc structure tends to follow fractal scaling. This study deployed a Video In-situ Settling Tube Apparatus (VISTA) repeatedly at three depths

through the water column of the Chesapeake Bay Estuarine Turbidity Maximum region in October 2002. Water was pumped through VIMS's clear tube, which was then closed, permitting macro-videography of trapped settling flocs. Video clips were analyzed to calculate sizes and settling speeds of flocs. Relationships between size and settling speed were used to calculate fractal dimension, D3, and reference particle diameter, dr. Results indicate that settling speeds increased with size and depth, ranging between 0.5 - 4.5 mm/s. Sizes ranged between 71 - 549 microns, increasing with depth. Fractal dimensions decreased with depth from 2.2 - 1.8. Reference particle diameter values increased from 4 - 16 microns. The observed values of settling speeds, sizes and fractal characteristics are similar to those in other coastal environments.

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DIFFERENTIAL MIXING OF HEAT AND SALT BY BREAKING INTERNAL WAVES

A laboratory experiment has demonstrated differential mixing of heat and salt due to breaking internal waves. Following McEwan's classic experiment, a paddle was pivoted at resonant frequency to excite the gravest internal wave mode. Energy was transferred to higher modes via a cascade of resonant triad interactions, leading to quasi-random overturn/mixing events. Fluxes of heat and salt were deduced from profiles measured before and after mixing periods, after correction for thermal heat exchange through the tank walls. The ratio of salt to heat eddy diffusivites was found to be approximately 0.6 when the waves were strongly pumped (thermal eddy diffusivity approximately 2 x 10-6 m2/s) , decreasing to less than 0.2 at weaker pumping rates. Corrections for molecular diffusion, estimates of viscous dissipation of turbulent kinetic energy, and the possibility of heat flux via sidewall Stokes boundary layer effects, will be discussed.

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A LIFE HISTORY MODEL FOR THE CALIFORNIA POPULATION OF THE CHINESE MITTEN CRAB, ERIOCHEIR SINENSIS

First discovered in San Francisco Bay in 1992, the Chinese mitten crab has become firmly established over hundreds of km2 of the San Francisco Estuary. This crab's potential to negatively impact native species and habitats motivated our efforts to understand the life history of this catadromous species in California. Data for this life history model comes from the authors' research and scientific literature. Juvenile crabs migrate into fresh water where they develop into adults over one or more years. Environmental signals appear to stimulate gonad development, followed by downstream migration at the end of summer. Mating occurs in saline water, where females ovoposit and fertilize eggs that are carried until hatching. Our model projects rates of larval development at various temperatures and predicts that juvenile crabs migrate into fresh water during their second year. We suggest a minimum of 2 years, and for most crabs 3 years, in fresh water to reach adult size. We are currently exploring the role of environmental factors, including temperature and salinity, in shaping the life history and population dynamics of this important invasive species.

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OCEAN EXPLORATION OF GAS HYDRATE-RELATED ECOSYSTEMS ON THE BLAKE RIDGE: PHYSICAL PREDICTORS FOR BIOLOGICAL SYSTEMS

A NOAA Ocean Exploration program visited gas hydrate related ecosystems and potential seep sites on the Blake Ridge and Carolina Rise in the summer of 2003. The goal of this program was to identify and quantify links among physical, chemical, and biological processes associated with known chemosynthetic communities and to assess the capacity of geophysical data to identify new seeps. On the Blake Ridge Diapir, where clam and mussel communities occur near an area of methane venting, we conducted 3 DSV Alvin dives to acquire push cores and biological and geological samples in an area we first visited in 2001. These new data provide precise spatial control on the loci and geochemical characteristics of the seeps. Coincident geophysical imaging of the diapir using Seabeam and 3.5 kHz surveys conducted along transects spaced at ~20 m revealed surface and subsurface features, respectively. The pseudo three-dimensional imaging by the 3.5 kHz data reveals fluid conduits beneath the chemosynthetic communities. Exploratory dives on the flank of the Blake Ridge Depression and on the Cape Fear Diapir did not discover classic chemosynthetic communities, but did find a number of new and previously undescribed features, at least one of which was spatially associated with living organisms. This multi-disciplinary effort has led to the development of specific criteria to be used in evaluating seismic data for the identification of probable seafloor seep communities in gas hydrate zones.

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REGULATION AND UTILIZATION OF DISSOLVED ORGANIC PHOSPHORUS IN THE COASTAL OCEAN

A seasonal study of upwelling-driven nutrient cycling and utilization in an Oregon coastal system reveals significant spatial and temporal variability in dissolved inorganic and organic phosphorus (DIP, DOP) that is directly linked to upwelling and relaxation events. DIP and DOP vary inversely with one another, and are variable on time-scales of days. DIP anti-correlates, while DOP correlates with temperature and chlorophyll-a. These patterns reflect the different pathways for DIP and DOP cycling in the coastal ocean, and strongly imply a phytoplanktonic source of DOP. The absence of DOP in deep waters implies efficient DOP recycling in surface waters. Alkaline phosphatase (APase) activity was spatially and temporally variable in the field, both at the community level (bulk activity) and within phytoplankton genera (cell-specific ELF activity). APase activity (bulk and ELF) is stimulated under P-depleted conditions in incubation experiments, indicating that enzyme expression is regulated by phosphate concentrations. These coupled field and experimental results indicate that some portion of the phytoplankton in the field are phosphate stressed, and that DOP is likely an important component of phytoplankton nutrition in this coastal system.

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SPRINGTIME SUCCESSION OF PLANKTONIC DIATOM BLOOMS: SAME SPECIES, DIFFERENT POPULATIONS?

The spring bloom in temperate regions is often comprised of multiple bloom events that occur over several months. Here, we examine whether successive springtime blooms of a single species are genetically differentiated. To investigate how environmental conditions affect the genetic composition of successive blooms, population structure in the diatom Ditylum brightwellii was determined in two hydrographically distinct estuaries in Puget Sound, WA. Over the course of five months, we isolated 1200 individual D. brightwellii cells from the Main Basin (residence time, 2 wk.) and Hood Canal (residence time, 9 mo). DNA fingerprints from each isolate were obtained using highly sensitive molecular markers. In early spring, a single population was identified repeatedly in both basins. In late spring, this population was replaced in the Main Basin by a second, genetically distinct population. At the same time, cell numbers decreased below detection in Hood Canal. These populations may have different growth optima, thriving under different seasonal light conditions. The patterns of succession within and between basins indicate that environmental conditions may select for populations with significantly different genetic, and likely physiological, compositions.

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LONG-TERM CHANGES IN THE SUMMER REGIME OVER THE MEDITERRANEAN BASIN

A warming trend has been found for the summer season, June-August, over the entire Mediterranean Basin, for ‎the last 56 years. We study the impact ‎of synoptic-scale dynamic features, i.e., ‎horizontal advection and vertical motion, on this trend. The results indicate that ‎the observed warming can be explained, at least ‎partly, by dynamic factors. For instance, the intense warming ‎trend over the Western Mediterranean is imparted by an increase in the southerly wind component there. ‎In the Levant region the warming trend is explained by ‎the decrease found in the north westerly Etesian ‎Winds. A cooling trend found over the Balkans, in spite of the increase in subsidence there, ‎seems to result from the increasing trend in the ‎northerlies there. ‎

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BIODIVERSITY AND ECOLOGY OF HALOALKALIPHILIC BACTERIOPHAGE: ESTABLISHMENT OF A GENOMIC LIBRARY OF UNCULTURED PHAGE FROM MONO LAKE

Bacteria and the viruses that infect them are the most abundant organisms on the planet, yet little is known about the relationship between bacteriophage and their hosts, especially in an extreme environment. The literature suggests that mesophilic phage are important factors in shaping bacterial genomes through transduction as well as contributing in a symbiotic manner by expressing host photosynthesis and metabolism genes. Studies on haloalkaliphilic bacteria have demonstrated the necessity of proteins to function in high salinity as an adaptation to their environment. It is therefore feasible to speculate that haloalkaliphilic bacteriophage have also evolved their protein structure to withstand the harsher aquatic environment as well as have possibly incorporated critical host genes within their genome for potential symbiosis. In order to better understand the biodiversity and ecology of haloalkaliphilic bacteriophage and their evolutionary adaptations in a hypersaline alkaline environment, we have cloned uncultured viral genomes from Mono Lake utilizing the bacterial artificial chromosome (BAC) technique. Analysis of genomic as well as open reading frame sequences of several clones isolated from the surface waters is underway.

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OPTICAL MEASUREMENTS COLLECTED WITH AN AUTONOMOUS UNDERWATER GLIDER OFF THE WASHINGTON COAST IN SPRING 2002 AND THEIR RELATIONSHIP TO SATELLITE OCEAN COLOR.

Seaglider, a long-range autonomous glider, was deployed off the coast of Washington, USA, for 28 days in April-May 2002. Measurements of chlorophyll fluorescence (proxy for phytoplankton concentration) and optical backscatter (proxy for particle concentration) were collected along a transect that extended 200 km from the continental shelf into deep oceanic waters. Satellite-derived measurements of spectral remote sensing reflectance, chlorophyll a concentration, suspended solids concentration and fluorescence line height were obtained from MODIS and SeaWiFS and compared with in-water optical data collected by Seaglider. Despite qualitative agreement between Seaglider and satellite-derived estimates of surface phytoplankton biomass, mid-day quenching of Seaglider fluorescence made more quantitative comparisons difficult. An algorithm that used nighttime ratios of fluorescence to optical backscatter was developed to adjust the daytime estimates of surface biomass from Seaglider. Over the continental slope, a sub-surface chlorophyll maximum layer developed at approximately 20-30 meters depth and surface integrated biomass showed little relationship with satellite-derived phytoplankton concentrations at the surface. By combining satellite ocean color measurements with optical measurements from Seaglider, a more comprehensive understanding of the local phytoplankton distribution was achieved.

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AN UPDATED ESTIMATE OF PRIMARY PRODUCTION IN THE MEDITERRANEAN SEA FROM REMOTE SENSING DATA

Satellite derived primary production rates are generally based on few key assumptions on the relationship between the vertical profile of biomass and the satellite chlorophyll, the spatial and temporal patterns of algal physiology and the vertical temperature profile. The three terms may vary at regional scale and therefore, regional algorithms also for primary production may better describe local variability. We used a significant set of in situ data collected over the years in the Mediterranean Sea to test the performance of different algorithms in estimating primary production. We also introduced a few changes in the parametrization, to better fit the in situ data. Our results suggest that current algorithms may overestimate primary production in the Mediterranean. A comparison between satellite based estimates and the numbers derived by indirect methods (e.g., nutrient budgets) will be also discussed.

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RESPONSES OF MICROGRAZERS TO THE MESOSCALE IRON FERTILIZATION IN THE WESTERN SUBARCTIC PACIFIC (SEEDS)

Responses of ecosystem structure and food-web processes were investigated focused on micrograzers during the mesoscale iron fertilization (IF) experiment in the western subarctic Pacific (SEEDS). Total chlorophyll a concentration increased from 1 mg/m3 to >15 mg/m3 after 9 days after IF (D9), and the floristic shift form pico/nano-phytoplankton to diatoms, dominated by Chaetoceros debilis, was observed. Although eukaryotic ultraphytoplankton and Synechococcus increased their gross growth rates on 2-4 days after IF, the grazing rates on them increased at the later part of the experiment and the grazing rates and gross growth rates balanced well at the end of the experiment (D13). Grazing mortality of total phytoplankton decreased from 0.29/d (D0) to 0.17/d (D9), but on D11 it jumped up to 0.70/d. Heterotrophic dinoflagellates increased during the diatom bloom and their abundance on D13 was 4 times of the initial. This study showed the important role of micrograzer for the food-web dynamics and the fate of carbon during manipulated or natural perturbation events in the HNLC regions.

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IRON AND COBALT CO-LIMITATION IN THE CENTRAL NORTH PACIFIC AND THE BERING SEA

Cobalt and iron bottle incubation enrichment experiments were conducted in the central N. Pacific and Bering Sea in July 2003. At the Central N. Pacific Station, a cobalt chloride addition of 500pM enhanced chlorophyll significantly relative to controls after 4 days. At both the central N. Pacific and Bering Sea stations, 2nM iron and 500pM cobalt added together enhanced chlorophyll concentrations significantly relative to the iron additions alone. Electrochemical cobalt speciation measurements on the surface waters used in these incubation experiments showed all cobalt present as strongly complexed cobalt, despite the relatively high concentrations of total dissolved cobalt. This cobalt appeared to be unavailable in this complexed form to the blooming phytoplankton. On a transect across the N. Pacific and into the Bering Sea, cobalt correlated with phosphate in surface waters with total dissolved cobalt increasing to ~100pM entering the HNLC waters. Surprisingly, a large peak of labile cobalt is present immediately below the central N. Pacific station where cobalt and iron co-limitation were observed, suggestive of active recycling processes. From these results it is apparent that the strongly complexed cobalt in the N. Pacific and Bering Sea HNLC region result in low bioavailability of the high total dissolved cobalt present, resulting in cobalt limitation and/or co-limitation of iron and cobalt in certain environments.

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BIO-OPTICAL RELATIONSHIPS AND OCEAN COLOR ALGORITHMS FOR SUB-ARCTIC NORTH PACIFIC

Sub-arctic North Pacific is one of the highest biological productivity regions in the world. The quantitative assessment of phytoplankton production in this region is very important to estimate global primary production. The objective of this study is to validate recent ocean color algorithms and develop the regional algorithms in this sub-arctic region. We examined the bio-optical properties of northern North Pacific, including the sub-arctic marginal seas of the Okhotsk Sea and the Bering Sea, as part of ADEOS/OCTS and ADEOS-II/GLI validation programs from 1996 to 2003. Vertical profiles of the downward spectral irradiance and the upward spectral radiance was measured with an underwater spectroradiometer, PRR-600 or MER-2040 (Biospherical Instruments Inc.). Chlorophyll a concentrations (Chl-a) and the absorption coefficients of particulate matter, phytoplankton, detritus and CDOM were also measured in seawater samples. Our measurements show that the current NASA global algorithms, OC2 and OC4, tend to overestimate Chl-a in the Bering Sea and underestimate Chl-a in the northwestern North Pacific. There is relatively high accuracy in the northeastern North Pacific and the Okhotsk Sea.

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AUTONOMOUS NITRATE AND PHOSPHATE MEASUREMENTS IN A COASTAL EMBAYMENT (ELKHORN SLOUGH, CA): BRINGING CLARITY TO MURKY WATERS

Nutrient variability in estuarine and coastal waters is enhanced both spatially and temporally as tidal effects, internal waves, sporadic inputs from terrestrial systems, and human alteration of natural cycles amplify inputs in shallow coastal embayments. Development of new sensor technologies that enable sustained and automated observations in these waters is necessary to fully understand the functioning of these ecosystems. We have developed and tested two nutrient sensors for use in coastal moorings. The In Situ Ultraviolet Spectrophotometer (ISUS) measures nitrate and the Digital Submersible Chemical Analyzer (DigiSCAN) measures either nitrate or phosphate. These instruments were tested for several months in Moss Landing Harbor in the fall and early winter of 2002 and measured remarkable injections of nitrate and phosphate that coincided with rain events and agricultural runoff associated with flow through tidal gates during low tides. These instruments will be incorporated into a biogeochemical mooring that can operate continuously with near real-time data assimilation to address scientific and management issues.

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IMPORTANCE OF BIO-OPTICAL VARIATION AND THE SPECTRAL QUALITY OF LIGHT IN NORTHERN WATERS FOR ESTIMATING PRIMARY PRODUCTIVITY

Bio-optical variation of Phaeocystis-dominated communities was studied in 1993-1995 in Case I (Greenland, Norwegian Sea) and Case II water (Trondheimsfjord, Norway). Chla concentration ranged from 0.25-7 mg m–3. Linear regression of Chla vs POC in

combination with mathematically derived estimates for detrital absorption yielded average algal Chla:C ratios (w w–1) of 0.018 (Case I) and 0.036 (Case II). Algal carbon averaged 88 % of POC in Case I water and 63 % in Case II water. The Diadinoxanthin:Chla ratio (w w–1) was high in ocean water (0.047-0.061) and low in fjord water (0.019). Chla-specific absorption at 436 nm reached 0.048 m2 (mg Chla–1) in oceanic water and 0.027 m2 (mg Chla–1) in fjord water. The differences can be interpreted as an acclimation response of the phytoplankton to the different optical quality (PUR) of Case I and Case II waters. Chla-normalised absorption at 675 nm varied little, averaging 0.020 m2 (mg Chla–1) and indicating the same extent of packaging. Neglecting the spectral composition of irradiance in estimates of primary production can cause errors as large as of 68 % in Case I water.

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COASTAL RIVER PLUMES OF THE GULF OF MAINE: LINKING SALINITY VS. ABSORPTION RELATIONSHIPS TO TERRESTRIAL DOC FLUXES

We examine the relationship between salinity and the concentration of colored dissolved organic matter (CDOM) as indexed by its absorption coefficient at 443 nm (ag443, m-1) from individual rivers discharging into the Gulf of Maine. We document that variability associated with dissolved organic carbon (DOC) in the drainage basin is related to the slope of the ag443 vs. salinity regressions in the offshore river plume. For each drainage basin under consideration, DOC fluxes are estimated using a modified version of the model of Aitkenhead and McDowell (2000). These fluxes are then normalized by local annual runoff to derive a DOC index (g m-3) which is analogous to average concentration. Measurements of salinity and ag443 were taken during several cruises to river mouths and estuaries in the Gulf of Maine. We show evidence that the slope of the ag443 vs. salinity relationship within individual plumes covaries with the DOC index of the contributing drainage basin. Our results suggest that one or more drainage basin attributes - most likely related to the DOC flux - are responsible for distinct ag443 vs. salinity relationships within coastal plumes discharged by individual basins. The documentation of phenomena relating drainage basin attributes to satellite-retrievable optical signals is of considerable importance in aiding remote studies of the origin, persistence and fate of riverine constituents in coastal waters.

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DEVELOPING SANCTUARY STEWARDS THROUGH HIGH SCHOOL MONITORING PROGRAMS

High school students in the San Francisco Bay Area monitor local coastal habitats to help the Gulf of the Farallones National Marine Sanctuary protect the resources of the marine environment. Since 1999, students and teachers from 16 high schools monitor 12 sites. The Sandy Beach Monitoring Project raises the awareness of high school students about their local coastal area through monitoring the sand crab population. Students set up transects, collect samples, and measure and sex the crabs. Trends examined include differences in the gender ratio, size frequency, and distribution along the beach at the online database (http://www.sandcrab.org).

Student volunteers from The Branson School monitor the rocky intertidal habitat at Duxbury Reef. Three times per year, they conduct baseline surveys to count key invertebrates and algae. Students compare their results with other sites along the west coast National Marine Sanctuaries (http://limpets.noaa.gov). Students helped install an information kiosk at the reef and lead annual intertidal walks for the public. Implementation of monitoring projects is invaluable to broaden students' understanding of the natural sciences and the role of monitoring habitats for coastal management.

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INORGANIC AND ORGANIC NITROGEN UPTAKE IN NUTRIENT ADDITION MESOCOSM EXPERIMENTS IN A NORWEGIAN FJORD

Mesocosm experiments were conducted at the Marine Biological Field Station in Bergen, Norway. Inorganic nutrients (16 uM nitrate, 1uM phosphate) were added to two 11 cubic meter mesocosms, with 10% of those concentrations added daily thereafter. A third unamended mesocosm was used as a control. Inorganic (ammonium and nitrate) and organic (urea and amino acids) nitrogen uptake rates as well as nutrient and chlorophyll concentrations were monitored for 31 days. By Day12, chlorophyll in all enclosures had increased (0.5-5ug/l), followed by a predominately Phaeocystis megabloom (5–30ug/l) in the amended mesocosms. Ammonium concentrations dropped rapidly between Day1 and 5 and then leveled off in all treatments while nitrate and nitrite concentrations slowly declined to below detection limits by Day20. Dissolved organic nitrogen remained constant in all mesocosms until Day20 when concentrations increased; a greater increase occurred in amended mesocosms. At the peak of the bloom, net uptake rates of nitrate were greater than ammonium in the greater than 8um fraction but there was little difference in the 0.2 – 0.8um size class.

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ABILITY OF PHAGE TO PERSIST IN NEW ENVIRONMENTS

Phage, viruses that infect bacteria, are ubiquitous and abundant in all known ecosystems. Here we tested the possibility that phage from one environment can successfully propagate in another environment. Phage concentrates were prepared from different near-shore marine sites, lake water, and marine sediments using tangential flow filtration. The concentrates from each location were added to microcosms that contained dissolved organic matter as a food source (0.02micron filtrate) and a 3% bacterial inoculum (from a marine water sample)(0.45micron filtrate). Bacterial and phage abundances were then monitored for ~ 1 week using SYBR Gold direct counts. Phage populations from all different environments underwent repeated replication and degradation when incubated with the marine bacteria, showing that phage can successfully move between different ecosystems and persist in the new environment.

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BIOGEOCHEMISTRY MID-WATER SUSPENDED PARTICLE LAYERS, MONTEREY BAY, CALIFORNIA

ROV Ventana was used to investigate suspended layers of fine particles over depths of 400-1300 m. The layers ranged from broad bands several hundred meters thick to thin layers <20 m thick. Water samples were collected both within and adjacent to these layers to examine the effect of the particles on the bulk water chemistry. Optical measurements were also made using a structured light source and high definition video, as well as with a nephelometer and a transmissometer. Particle concentration was positively correlated with alkalinity and nutrients (indicating the presence of active organic matter oxidation within the layers) and negatively correlated with delta-13C-methane (indicating active biogenic methane production within the particle layers and biogenic oxidation of methane diffusing out of the layers). However, different correlations exist above and below 800 m (the depth of the oxygen minimum); the cause is currently under investigation. Methane concentrations, although generally elevated, were not correlated with the other parameters. Elevated N2O was found throughout the water column, reflecting the importance of active suboxic processing.

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DOC DYNAMICS IN THE EASTERN MEDITERRANEAN. IMPLICATIONS FOR ITS BUDGET IN THE SUBBASIN AND IN THE WHOLE MEDITERRANEAN SEA

The DOC pool of the Mediterranean, a marginal sea, depends on the exchange at Gibraltar, the internal production and transformation and the fluxes at the boundaries (atmosphere and land). Recent analyses also evidenced that a change in the source water feeding the deep layers through convection significantly altered the amount and the reactivity of the DOC there present. Transformation of organic compounds in the water column is coupled with oxygen utilization and nutrient remineralization, whose ratios display anomalous values in the basin. Using a significant set of biogeochemical data collected in the two last decades, an analysis of transformation processes in different regions of the basin is currently carried out. The main results of the analysis will be discussed with the aim of discriminating the role of the different sources and water masses in determining the DOC budget of the Eastern and Western Mediterranean seas, and their role in the trapping of carbon. Due to its reduced site and its faster responses the Mediterranean is, in fact, a very suited test site to monitor the coupling between carbon sequestration in the sea and climate variability.

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PLANKTON NET COMMUNITY PRODUCTION (NCP) IN THE ARABIAN SEA USING OXYGEN BUDGETS

Data collected under different international programs such as JGOFS, WOCE, LOICZ are applied to an oxygen model for the euphotic zone in an attempt to estimate the net community production in the Arabian Sea. Horizontal and vertical exchanges of oxygen were computed using modular ocean model. In general, the NCP over annual basis would appear to be equivalent to new production. The plankton NCP in the Arabian Sea was estimated to ~220 Tg/y which is close to the export production evaluated using measured f-ratios in the photic zone in different seasons. Based on observations, it was found that eastern and western Arabian Sea regions are significantly different in terms of plankton production and carbon demand. For instance, production exceeds demand while demand exceeds production in the western and eastern Arabian Sea respectively. It was found that carbon demand by the zooplanktons, includes bacteria, micro and meso zooplankton (1097+/-165 TgC/y), is higher than the primary production (987+/-44 TgC/y) in the euphotic zone by 104+/- TgC/y. The model estimated net respiration amounts to 302 TgC/y. The inconsistency in these two estimates can be explained using surface nitrate and oxygen saturation distribution over the basin.

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DISTRIBUTION, SPECIES COMPOSITION AND PRODUCTION OF APPENDICULARIANS IN THE NORTHERN GULF OF MEXICO

Appendicularian assemblages in the Mississippi River plume and adjacent waters were examined in March, April and June 2002. In March and April, appendicularians were concentrated in the upper 20 - 30 m at almost all stations. Eleven species in 5 genera were identified but Oikopleura longicauda and O. dioica accounted for 66 - 100% of all individuals. Mean production of these two species was very high in April: 275 mgC/m2/d for somatic production, 488 mgC/m2/d for new house production, 1676 mgC/m2/d for discarded house production and 1115 mgC/m2/d for fecal pellet production. Values were much lower in March. June data are being analyzed. For March/April, the mean daily somatic + new house P/B ratio was 1.6, higher than the reported highest value for copepods (1.25), indicating the importance of appendicularians as secondary producers. Furthermore, the mean daily discarded house + pellet P/B was 6.0, indicating the large contribution made by appendicularians to production of detrital organic matter in the water column.

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A NEW RESPIRATION MODEL FOR DIAPAUSING CALANUS FINMARCHICUS: IMPLICATIONS FOR SURVIVAL IN THE GULF OF MAINE

A new nitrogen specific respiration model has been developed for the resting stage of the calanoid copepod Calanus finmarchicus. Stage C5 C. finmarchicus were collected during July and September 2003 from Wilkinson and Georges Basins in the Gulf of Maine using both a MOCNESS and the suction sampler of the Johnson Sea Link II submersible. Metabolic rates were measured using a Micro-Oxymax gas analyzer and Winkler incubation techniques. Rates measured in the field in July and September were not significantly different with means of 22 umol O2/gC/hr or 225 umol O2/gN/hr at 0ºC using a Q10 of 3.1. In order to predict potential survival time, the nitrogen specific rate was applied to individual C. finmarchicus from the Gulf of Maine that were caught and measured during the summer and fall of 2001. Results suggest that diapausing animals caught in June have a survival window of two to four months and that significant starvation mortality will accrue by August. Strong changes in the size distribution of C. finmarchicus between June and August and August and November support these predictions.

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EXTERNAL VS. INTERNAL DRIVERS OF THE BALTIC SEA EUTROPHICATION

The Baltic Sea is considered a classic example of anthropogenic eutrophication caused by excessive external nutrient inputs, which could be counteracted by expensive nutrient load reductions. However, sporadic saltwater inflows from the North Sea result in redox alterations in the bottom layers: hypoxic waters are stripped of nitrate due to denitrification and enriched with ammonium and phosphate released from anoxic sediments. Nitrogen fixation enhanced by stoichiometric excess of phosphorus is an important natural driver of primary production. Internal nutrient fluxes evolving due to these processes are today often larger than external inputs. Long debates on the legacy of the Baltic Sea eutrophication have been fuelled by perturbations occurring in the Baltic over the 90s. The analysis of massive data from the past 40 years, combined with empirical budgeting and simulation modeling confirms two conclusions important for management decisions: a) the naturally driven variations of nutrient pools are emphasized by the long-term nutrient accumulation in the Baltic, ultimately caused by anthropogenic inputs; b) the effects of nitrogen or phosphorus load reductions depend on the scales and sites of management.

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THE RESPONSE OF DMS(P) PRODUCTION RATES TO IRON ENRICHMENT IN THE NE PACIFIC: A SHIPBOARD MICROCOSM EXPERIMENT

Production rates of DMS and DMSP were determined in shipboard micocosm incubations during the SERIES iron-enrichment experiment. Eight 20-L microcosms were incubated under natural light using four (duplicated) treatments: 1) Control (unenriched seawater), 2) iron-enriched (4 microM), 3) iron (4 microM) and germanium (80 microM) enriched, 4) Seawater from the enriched patch (approx. 4 microM iron). DMS, DMSP, Chl a, nutrients, phytoplankton abundance, bacterial abundance and bacterial production were measured every 2 d. In all treatments chlorophyll increased (0.5 - 1 microg/L/d) for 8 d before declining. Germanium-enriched treatments produced relatively more chlorophyll in smaller size fractions, indicating diatom growth inhibition. DMS production was elevated in the iron-enriched treatments (2 nmol/L/d) compared to controls (no change). Particulate and dissolved DMSP increased until Day 8 and then declined in all reatments except germanium-enrichment, where DMSPp production was 2-fold higher. DMS and dissolved DMSP production in germanium-enriched treatments increased rapidly toward the end of the experiment. Bacterial abundance and production increased in all treatments except germanium-enrichment, suggesting that enhanced DMS production under Fe-enrichment is related to the phytoplankton species assemblage.

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KARENIA BREVIS LIPID PATTERNS DURING DIEL VERTICAL MIGRATION IN NITRATE DEPLETE AND REPLETE MESOCOSMS

Laboratory studies have identified the internal biochemical status of the cell as a determinant for the growth, reproduction, and possibly migratory behavior of Karenia brevis. The experiment reported here expanded previous experiments that focused on nitrogen replete mesocosms with low light by considering nitrate depletion and increased light conditions. Cultures were simultaneously grown in duplicate 225L mesocosms, one nitrate deplete and the other nitrate replete, to allow diel vertical migration for three days during 12 hour light/dark cycles. Surface light intensities attained 1000 umol quanta m^-2 s^-1. Prior to lights on (day 1) and in mid-afternoon (day 3), samples were removed from the surface and mid-mesocosm depths and incubated in a radial photosynthetron that ranged from 0 to 2000 umol quanta m^-2 s^-1 in 10 steps. Aliquots from the mesocosm and the photosynthetron were subsequently collected to determine cell number, toxins, pulsed amplitude modulate fluorometer (PAM-FL) electron transport, yield, chlorophyll, and lipid content for populations with (mesocosm) and without (photosynthetron) behavior. Results will compare the pattern of the measured quantities under the different nutrient states both with and without behavior.

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LONG TERM OBSERVATIONS OF FISH POPULATIONS IN SOUTH SAN FRANCISCO BAY

We report on a study comparing the changes in fish populations in South San Francisco Bay over a thirty-year period. The analyses are based on 2,561 otter trawls completed between February 1973 and June 1982 and an additional 3,999 trawls completed between October 1992 and December of 2001. Striking differences in fish abundances were seen between the two time periods, although there was no general trend across all species. All of the nine observed species of surfperches (Family Embiotocidae) have declined dramatically during the period of this study, and several species have not been collected for more than ten years. English sole (Parophrys vetulus) populations have also shown a significant decline between the two time periods. At the same time, populations of species with similar habitat preferences, including speckled sanddabs (Citharichthys sordidus) and Pacific sanddabs (Citharichthys stigmaeus), have increased or remained stable during the same time period. California halibut (Paralichthys californicus) populations have increased, and seem to be heavily influenced by offshore sea surface temperatures.

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TWO APPROACHES TO MAKING A LARGE INSTITUTIONAL EARTH SCIENCE DATA SYSTEM ACCESSIBLE TO EDUCATORS AND STUDENTS

Education and outreach are primary missions of The Center of Excellence in Coastal Ocean Observation and Analysis (COOA) at the University of New Hampshire. COOA maintains a WEB-Based Coastal Ocean Analysis SysTem, WebCOAST, as a first step towards ensuring that coastal ocean observing data are fully used to generate new information and understanding for a wide variety of issues. WebCOAST distributes up-to-date MODIS images of sea surface temperature and chlorophyll for the Gulf of Maine, an important region that has seen recent declines in fishery populations and increases in algal blooms. Challenges in getting imagery used in the classroom include making educators aware of available resources, and providing them with enough in-depth knowledge of those resources to facilitate their use in the classroom. This presentation will discuss two approaches we are exploring through collaborative projects to address these challenges: (1) integrating image acquisition and analysis into existing curricula, specifically the Global Systems Science course for high school, and (2) developing step-by-step instructions for educators that facilitate inquiry into Earth system science datasets via the Web-based Earth Exploration Toolbook (EET).

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DIAGENETIC MODELLING BY AN OBJECT ORIENTED PROGRAMMING APPROACH CONSIDERING FLUID FLOW, BIOLOGICAL MEDIATED TRANSPORT AND BIOGEOCHEMICAL PROCESSES

Complex interaction of biogeochemical reactions, physico-chemical transport and biological activities control the remineralisation and dissolution of organic and inorganic particles and the flux of dissolved and gaseous components through the sediment-water-interface. Especially in dynamic systems as coastal sediments or pockmarks this results in vertical as well as horizontal gradients. These gradients are due to spatial vicinity of “reaction zones” as well as to the distribution of benthic fauna. In such cases diagenetic modelling requires a 2D/ 3D approach, considering several transport-reaction mechanisms and regional entities. For consideration of complex systems object oriented programming, applied in

software engineering, provide efficient techniques for software development. These techniques, including encapsulation, inheritance, polymorphism and late binding, were applied for the development of a diagenetic model. The model region is considered by a set of domains each with specific properties and methods. The class structure and interaction is presented and case studies of this modelling approach are given. The later include consideration of fluid flow and CH4 inventories and fluxes at sites affected by fluid flow.

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FORMATION AND RAPID EXPANSION OF THE DOUBLE DIFFUSIVE LAYERING IN LAKE NYOS (KILLER LAKE, CAMEROON)

No signs of double-diffusive convection have been reported from Lake Nyos since the catastrophic CO2 eruption in 1986. In December 2002, however, 26 well mixed layers with thicknesses of 0.2 to 2.1 m and sharp interfaces were discovered at 53 to 74 m depth. Such pronounced steps are characteristic of double-diffusive convection of the diffusive regime. It was most probably triggered by cooling during the dry season in February 2002. The heat fluxes calculated by heat budgeting agree within the uncertainties with values expected from double-diffusive flux-laws. The heat fluxes increased by an order of magnitude since the establishment of double-diffusive convection and reached values of the heat input by a sublacustrine source of warm and CO2-enriched water at maximum lake depth. Because the double-diffusive heat fluxes were higher in the upper part of the double-diffusive zone, the temperature gradient doubled from March to November 2002, whereas the TDS gradient remained almost constant. This process reduced the staircase stability and led to a rapid expansion of the double-diffusive zone. In the talk the most recent development will be reported.

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TROPHIC DYNAMICS AND CARBON FLUX IN THE LAPTEV SEA

Pathways and processes of the coupling between sea-ice, water-column and seabed biota have been studied by a German-Russian research project since 1993. In general, high Chl a concentrations in the sediments indicated a tight coupling between sympagic and pelagic primary production and nutrient supply to the benthos throughout the entire Laptev Sea. Autochthonous primary production is not sufficient to fuel both pelagic and benthic secondary production, hence, input of allochthonous organic carbon is required to balance the overall carbon budget. There were pronounced regional differences in magnitude of primary production and trophic dynamics, indicating that a higher proportion of primary production is channelled through the benthic trophic web in the eastern part of the Laptev Sea. Two scenarios (abundant ice vs. limited ice) will be discussed to demonstrate how climate might alter–through the leverage of its impact on sea-ice dynamics– the general kryo-pelago-benthic fluxes in Arctic seas and shift the relative importance of sea-ice, pelagic and benthic biota in the overall carbon flux from a 'sea-ice algae–benthos' to a 'phytoplankton–zooplankton' dominance.

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THE CONSEQUENCES OF SCALE: ASSESSING THE DISTRIBUTION OF BENTHIC POPULATIONS IN A COMPLEX ESTUARINE FJORD

Evidence suggests that patterns of benthic community structure are linked to hydrographic processes and physical characteristics of the benthos. However, there is a lack of information that would allow rigorous assessments of these linkages for sediment shorelines. We used a spatially nested sampling design to quantify patterns of distribution and abundance of both macroinfauna and macroepibiota as they vary among beach segments within a site (~ 1km), among sites within areas of relatively uniform salinity and temperature (~10km), and among areas (~100km) in the two major basins of Puget Sound, Washington. As expected, species richness decreased from north to south along gradients of wave energy, temperature and salinity. Nested ANOVAs showed that most of the variability in population abundance was captured at the smaller spatial scales. Non-metric ordinations indicated that communities became more different from north to south as species intolerant of estuarine conditions dropped out. Because there are strong linkages between the biota and physical patterns and processes in estuaries, a replicated sampling design like ours provides a powerful means to detect environmental change at multiple spatial scales.

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SINGLE CELL GENOMICS OF HYPERTHERMOPHILES

"Single Cell Genomics" is a new initiative to develop methods to sequence the genome of a single cell without the intermediate step of culturing, providing a powerful means to analyze and express the genetic information within cultivation-resistant microbial communities. The ability to analyze all the genes in a single culture-resistant microbe will elucidate metabolic strategies, evolution, and gene transfer events of life forms that are not currently amenable to study. In recent years, sequence analysis of 16S rRNA sequences has revealed remarkable diversity among the microbial populations of very high temperature thermal pools, but provided no insight into their biology. To extend this work, we have begun in-depth genomic analysis of the microbes in a superheated thermal pool. Improved sampling methods and our NanoClone and CloneSmart technologies have allowed construction of highly complex community genomic libraries from very limited samples of directly isolated microbial DNA (< 1 ng). Limited 16S rRNA sequencing of NanoClone libraries made from this pool has revealed at least 20 distinct Bacteria and Archaea, many without significant similarity to cultivated microbes. To further study the diversity, we have developed methods to construct representative libraries from single microbial cells. Using these methods, we have begun whole genome sequencing of single cells of the uncultivated microbial community.

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MAPPING RED TIDE USING AUTONOMOUS UNDERWATER WEBB GLIDERS

Rapid development in Glider technology now offers the potential for collecting weekly to monthly data on temperature, salinity, depth-averaged currents, hyperspectral absorption, backscatter, attenuation and chlorophyll/dissolved organic fluorescence. Glider communication is facilitated through Iridium satellites or line of sight radio modems. Operation Gulfcast has focused on optimizing the Gliders to monitor red tide abundance and hydrographic properties on the west coast of Florida. Glider deployments in 2003, demonstrated optically-based similarity indexes calculated from hyperspectral absorption, measured with a miniaturized spectrometer system, can discriminate the presence of the toxic dinoflagellate Karenia brevis. The mesoscale sampling capabilities make the Glider make it an ideal platform to provide subsurface spatial data to complement the time series mooring stations throughout the Gulf of Mexico. Coordinated activity of multiple Gliders is being based on Agent Oriented programming that has been used to construct self-operated, self-aware, and self-controlled robots, exploring rovers and intelligent machines. Software agents will interpret data obtained from the Glider's sensors, and usinge its growing knowledge base, to decide what region of the water column to sample.

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THE UTILITY OF CABLED SYSTEMS FOR IN SITU AND REMOTELY SENSED HYPERSPECTRAL OPTICS

An existing set of cabled coastal ocean observatories will be augmented in the near future with an expanding network from newly deployed electro-optic and converted retired telecommunication cables. The cables will provide the researcher several large advantages. The cabled systems will effectively provide unlimited band and power and time series ranging from turbid coastal waters to the deep sea providing researchers time series data spanning a wide optical gradient. The high bandwidth will allow for hyperspectral data to be collected and delivered back to shore in real-time which is not capable with satellite communications where data needs to be degraded spectrally and temporally to allow for delivery back to shore. Real-time data will allow for algorithm tuning based on real-time in-water measurements of the inherent and apparent optical properties allowing the vicarious calibration of ocean color imagery. Examples taken from the cable at the Long term Ecosystem Observatory of optical closure studies, inversion techniques, diver visibility algorithms, and bioluminescence light propagation will be used to illustrate the potential of cables for the optical oceanography community.

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THE ENVIRONMENTAL SAMPLE PROCESSOR (ESP): A NOVEL DEVICE FOR DETECTING MICROORGANISMS REMOTELY, SUBSURFACE, IN NEAR REAL TIME

The ESP was designed to collect discrete water samples remotely, subsurface, concentrate microorganisms and automate application of DNA (or other) molecular probes to enable identification and quantification of particular species captured. The instrument transmits results of DNA probe array assays in real-time via radio modem to a shore based location for processing, interpretation and dissemination. In addition, the ESP archives discrete samples for nucleic acid, microscopic and toxin analyses for validating real-time data from the probe arrays as well as facilitating other analyses in the laboratory (such as construction of gene libraries). Development of a "second generation" (2G) ESP has begun. The overall goals in designing the 2G ESP are to make it much more robust and user friendly than the original prototype, to reduce the size, complexity and power consumption of the instrument, and to take advantage of microfluidic-scale detection technologies. The first 2G ESP is scheduled to begin operation mid-2004. This presentation focuses on progress made to date designing and developing the 2G hardware, and emphasizes development of DNA probe array technology used onboard the instrument.

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RETRIEVAL OF WATER CONSTITUENTS IN CASE-2 WATERS FROM MERIS MEASUREMENTS: A COMPARISON OF DIRECT AND INDIRECT INVERSION SCHEMES

In this work we present a direct and an indirect inversion algorithm to retrieve water constituents from MERIS measurements above case-2 waters. Both algorithms are based on inverse modeling of radiative transfer calculations with the help of artificial neural networks. All inverse models consist of Multi-Layer-Perceptrons (MLPs) with one hidden layer trained by the backpropagation algorithm. The indirect inversion scheme consists of two steps. First a MLP derives the remote sensing reflectance and the spectral aerosol optical thickness (AOT) at mean sea level from the measured Top-Of-Atmosphere (TOA) radiances for each MERIS pixel. In a second step a further MLP will use the spectral reflectances as input to retrieve the concentrations of chlorophyll-a, sediment and the gelbstoff absorption. In contrast to the indirect method no explicit atmospheric correction is performed for the direct inversion scheme where a single MLP relates the TOA spectra directly to the concentrations of the water constituents and to the spectral AOTs. To evaluate the accuracy the results of both algorithms are compared with concurrent in situ measurements of oceanic and atmospheric parameters.

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FREE-CHOICE LEARNING AND THE OCEAN: RAISING PUBLIC AWARENESS AND DEEPENING UNDERSTANDING

The Ocean Project, Census of Marine Life, Pew Oceans Commission, and U.S. Ocean Policy Commission all have pointed out that much of the American public is unaware of the importance of the oceans in their lives and of the how their lives affect the oceans. All call for major new public education initiatives. The NSF Centers of Ocean Science Excellence in Education was created in part to address this issue. The impoverished state of public awareness and understanding is not restricted to the central part of the country. It is pervasive. One of the best opportunities we have to reach the public is the nation's network of aquariums and science museums which attract more than 100 million visitors each year. In these free-choice learning institutions, learning is driven by curiosity and love of learning. By the time I present this paper I will be able to describe the program we have developed with aquarium, COSEE, and Coastal America partners to bring the findings and recommendations of the Pew Oceans Commission and the U. S. Ocean Policy Commission to the public.

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COPEPOD FEEDING IN A DIATOM BLOOM - INSIGHTS FROM AN IRON FERTILIZATION EXPERIMENT IN THE SOUTHERN OCEAN

Mesozooplankton grazing activity during an iron-stimulated diatom bloom in the Antarctic Polar Frontal Zone (PFZ) was evaluated in 13-43h dark incubations of dominant copepods feeding on natural plankton communities from inside and outside the fertilized patch. Diatoms and microzooplankton were counted in grazing and control bottles. Clearance rates for the same copepod species on different diatom genera vary over one order of magnitude and increase with the size of the diatom. Calanus simillimus exhibited constant clearance rates over the 3 weeks hence ingestion increased linearly with the developing diatom bloom. Initially, Rhincalanus gigas and the size fraction of copepods < 2mm ingested only low numbers of diatoms, but substantially increased their overall clearance of diatoms with time. All tested copepods preyed on ciliates and dinoflagellates, copepods < 2mm additionally ingested nanoflagellates. The relative contribution of siliceous and non-siliceous organisms to the copepod diet over the course of the bloom, the existence of trophic cascades and evidence for highly selective feeding are presented and interpreted in consideration of the marine silica cycle.

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129I/127I OF DISSOLVED ORGANIC IODINE: A NOVEL TOOL FOR TRACING TERRESTRIAL ORGANIC MATTER IN ESTUARINE SURFACE WATERS OF GALVESTON BAY, TEXAS

129I/127I ratios in terrestrial organic matter are greatly elevated over those from marine systems due to atmospheric delivery from nuclear fuel reprocessing plants in Europe (Moran et al., 2002, Wat. Res. Res., 38, 1149). The biophilic nature of iodine is exemplified by the fact that ~ 40 to 75% of total iodine in fresh and coastal marine waters is found as organo-iodine (Schwehr et al., 2003, ACA, 482, 59). This provides an opportunity to trace terrestrial organic matter across an estuary. Analytical techniques of 129I/127I ratio determination in dissolved organic iodine, DOI, and the other iodine species, utilizing dehydrohalogenation, anion chromatography, HPLC and Accelerator Mass Spectrometric techniques, had to be first developed. These novel techniques were then applied to samples from a salinity transect across Galveston Bay, Texas. Results indicate that elevated 129I/127I ratios in DOI from terrestrial sources are elevated in the upper estuary up to salinity of about 15, similar to a behavior previously described for stable isotope signals of DOM in this estuary (Guo et al., 2003, MEPS, 252, 51). 129I/127I ratios in the other iodine species, e.g., iodide and iodate, did not show this feature, indicating fast isotopic and chemical equilibration between the two isotopes among the different inorganic species in the estuary. These results thus provide proof of concept that 129I/127I-DOI can serve as a tracer for terrestrial organic matter in the coastal zone.

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MOLECULAR ANALYSES OF COPEPOD SPECIES FROM THE WESTERN ARCTIC

Copepods dominate the pelagic plankton community in the Chukchi and Beaufort Seas where they are key components of the food web. Taxonomic identification of copepod species is essential to define their distribution, which is determined by the physical processes occurring in the region. The purpose of this study is to generate a molecular-based copepod species identification database that will allow rapid and precise identification of all life history stages. Copepods were collected from the USCGC Healy during the summer Shelf-Basin Interactions cruise in 2002, preserved in ethyl alcohol and identified from morphological characteristics. Sequences from the D1/D2 domains of the large subunit rDNA (circa 700 bp) were determined for 22 species belonging to the genera Augaptilus, Calanus, Centropages, Eucalanus, Metridia, Microcalanus, Neocalanus, Oithona, Oncaea, Paraeuchaeta, Pseudocalanus, Scaphocalanus and Spinocalanus. The rD1/D2 domains discriminated among most copepod species, with important exceptions such as the morphologically distinct species Calanus marshallae and C. glacialis which were identical in the mitochondrial 16S RNA (circa 400 bp) and in the rD1/D2 domains. Molecular analyses are ongoing in an attempt to differentiate between these two species.

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LOW LEVEL NUTRIENT ANALYSIS IN SEA AND ESTUARINE WATERS USING FLUOROMETRIC METHODS VIA A CONTINUOUS FLOW ANALYZER

It is well known that accurate determination of nutrients in sea and estuarine waters is essential in understanding aquatic ecosystems. Automated continuous flow analysis (CFA) is an effective analytical technique for determining nutrient levels. Traditional colorimetric CFA methods are susceptible to numerous interferences when measuring at the submicromolar level. Fluorescence methods offer a better selectivity and sensitivity than spectrophotometric methods. Fluorescence also significantly reduces the refractive index observed with samples of varying salinity. The work presented shows a combination of new and revisited fluorescence methods to determine ammonia and nitrate at submicromolar levels in sea and estuarine waters. Ammonia determination is carried out by reaction with o-phthalaldehyde and sodium sulfite in a buffered solution which has been previously reported. Nitrate is determined by first reducing nitrate to nitrite then measuring the fluorescence quenching of Rhodamine 110 dye. These fluorescence methods provide a rapid, automated method for measuring low level ammonia and nitrate with negligible effect in varying salinities.

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BUILDING BRIDGES BETWEEN RESEARCH AND EDUCATION

The Office of Marine Programs (OMP) at the University of Rhode Island Graduate School of Oceanography (GSO) is a national leader in ocean science education and outreach. Current and planned efforts target grades K-16 and a variety of public audiences. Funding from a host of federal agencies, foundations, and industry has allowed OMP to serve as a bridge between its audiences and GSO scientists and graduate students for over 25 years. From museum exhibits to scientist /educator partnerships and interactive educational Internet sites, OMP projects cover a wide range of activities. Successes and lessons learned will be discussed, in particular with regard to engaging the scientific community in education and outreach. Implications for the impact on K-16 science education will be highlighted.

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DENITRIFICATION AND OTHER PROCESSES IN THE SUBOXIC ZONE OF THE CARIACO BASIN

The CARIACO Time Series program has monitored the Cariaco Basin water column at monthly intervals since 1995. In 1997 the suboxic zone (defined as the zone where both oxygen and sulfide concentrations are less than 10 micromolar) increased dramatically from a relatively thin layer to a layer of up to 200 meters in thickness. Since 1997 the suboxic zone has ranged in thickness from a few tens of meters to more than 100 m. The presence of small oxygen, nitrate or nitrite maxima and/or sulfide minima in this zone indicate the importance of intrusions of oxygenated water from the Caribbean in the creation of this feature and its detailed characteristics. CARIACO time series data can be used to estimate the extent of denitrification and phosphate cycling within the suboxic zone over time. We also examine the hypothesis (made initially by those studying the paleo-oceanographic record) that denitrification in the suboxic zone is a major control on supply of nitrogen supply and on the N:P ratio in waters upwelled to the mixed layer. , The CARIACO Time Series program has monitored the Cariaco Basin water column at monthly intervals since 1995. In 1997 the suboxic zone (defined as the zone where both oxygen and sulfide concentrations are less than 10 micromolar) increased dramatically from a relatively thin layer to a layer of up to 200 meters in thickness. Since 1997 the suboxic zone has ranged in thickness from a few tens of meters to more than 100 m. The presence of small oxygen, nitrate or nitrite maxima and/or sulfide minima in this zone indicate

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ENVIRONMENTAL CONTROLS ON TISSUE AND SKELETAL GROWTH IN REEF CORALS

Scleractinian corals use a variety of resources to grow and calcify. In shallow habitats with high irradiance, zooxanthellae produce more than enough photosynthate for growth and maintenance, but nutrients needed for tissue growth can be scarce. In deep and shaded habitats, photosynthesis cannot meet energy needs and particulate material may be utilized for both nutrients and energy. Dissolved inorganic and organic compounds can also be important sources of limiting nutrients in all habitat types. Experiments show that zooplankton ingestion and assimilation can control calcification and tissue growth in several coral species, and that this response varies among species. The effect of feeding on calcification can be much higher than that of changes in dissolved carbon, water flow, temperature or calcium saturation. Measurement of respiration and photosynthesis, along with chorophyll and zooxanthellae densities, show that this symbiosis undergoes significant change when heterotrophy increases. Energy budgets are also strongly affected by short term temperature fluctuations, well below those needed to cause bleaching. Differential allocation of carbon, nitrogen and other resources to tissue versus skeletal growth determines how corals fare under altered conditions. Comparisons among species are needed to explain patterns of diversity, zonation and abundance on reefs and to interpret changes in growth rate with current and future modifications of environmental conditions.

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LAND-TO-OCEAN TRANSPORT OF MICROBES AND IRON IN SOIL DUST: THE AIRBORNE FUNGAL SIDEROPHORE HYPOTHESIS

Airborne soil dust is a major source of iron to the surface ocean, and a potentially important vector for land-to-ocean transport of microorganisms. Recent work by Prospero and colleagues has shown significant concentrations of viable bacteria and fungi in marine aerosols collected at Barbados, in association with Saharan dust. From May-September 2003, we examined microbes in marine aerosols collected at Bermuda. Light microscopy and molecular techniques were used to identify biogenic particles on our aerosol filters, which were also incubated in culture media suited to bacteria and fungi. Biogenic (DAPI-fluorescent) particle concentrations were as high as 1.5 million per cubic meter, with maxima following arrival of Saharan dust in mid summer. Less than 15% of these particles reacted with a bacteria-specific probe, and fungi were the dominant culturable organisms, suggesting that many of the biogenic particles in our samples were fungal spores. Since most fungi are known to produce siderophores to acquire and store iron, we hypothesize that airborne fungi could play an important role in solubilizing iron in mineral aerosol, and in supplying iron-binding ligands to the surface ocean.

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DIRECT UTILIZATION OF HUMIC NITROGEN BY COASTAL PHYTOPLANKTON

Humic substances are a collection of colored organic acids characterized by high molecular weight (HMW) and low nitrogen (N) content. These compounds, which comprise a large percentage of the dissolved organic matter (DOM) in riverine and estuarine environments, have historically been thought to be biologically recalcitrant, and utilization of humic-N was only possible following breakdown of the molecule by bacterial enzymes or photooxidation. Recent studies, however, suggest that phytoplankton may have the ability to take up these HMW organic compounds. In this study, 17 phytoplankton isolates, obtained off the coast of South Carolina, were examined to determine if they were capable of taking up humic-N directly. 15N-labeled humic substances were formed in the laboratory and offered to the coastal isolates as the sole N source. All coastal isolates examined were capable of taking up humic-N under nutrient deplete conditions. An open ocean isolate did not utilize the humics. The results suggest that phytoplankton utilization of humic-N could be an important sink for terrestrial DOM as it approaches the coastal ocean and that humics should be considered in N loading budgets.

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ENVIRONMENTAL CONSTRAINTS ON VERTICAL MIGRATION IN THE JUMBO SQUID, DOSIDICUS GIGAS

The jumbo squid, Dosidicus gigas, is a large (2 m), active squid that is believed to migrate from near surface waters at night to depths of over 300 meters during the day across a substantial temperature and oxygen gradient in the Eastern Pacific. However, its precise vertical distribution and behaviors are poorly known due to the oceanic habitat of this squid. Using a remotely operated vehicle and laboratory analyses, we investigated the vertical distribution, behavior and physiology of D. gigas in relation to temperature and oxygen in the Gulf of California. D. gigas' high metabolic rate, estimated from measurements of metabolic enzymatic activities, is difficult to support at either shallow or deep depths due to high surface temperatures (25 C) and a severely hypoxic water column (0.1 ml/l) in the Gulf of California. Preliminary analysis suggests an optimal physiological depth of 50 meters. Energy expenditure during vertical excursions above or below this depth must be either suppressed or supplemented by anaerobic ATP production. The consequences of such metabolic strategies for estimates of vertical carbon flux are discussed.

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AN OVERVIEW OF SEA-COOS AND THE DEVELOPMENT OF A REGION-WIDE WIND FIELD

The Southeast Atlantic Coastal Ocean Observing System (SEA-COOS) is developing a regional scale system and discovering the challenges involved in the process. The organization and initial challenges faced will be discussed. One theme that has emerged is the value of a specific product to focus group activities, identify needed areas of development, and to foster cross-cutting interactions. A region-wide wind product has been chosen for initial observation merger and display. This requires development of standards for data exchange and drove consideration of standardization issues well beyond this simple wind field. The merged observed winds provide a unique view of the transition of the wind field across the coastline in the southeast. We are also developing an optimally-interpolated wind field product by combining the merged observed winds with ETA reanalysis products. Results of this ongoing development and analysis will be presented.

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MOLECULAR LEVEL CHEMICAL CHARACTERIZATION AND BIOAVAILABILITY OF DISSOLVED ORGANIC MATTER IN AQUATIC SYSTEMS USING ESI MASS SPECTROMETRY

Electrospray-ionization mass spectrometry (ESI-MS) was used to chemically characterize, at the compound level, the majority of DOM in two streams. There was considerable consistency in the composition of the DOM between the two streams; >70% of the compounds detected occurred in both streams. About 50% of the bulk DOC in the stream water was bioavailable during a 12-day microbial decomposition experiment. ESI-MS compound level analysis identified which compounds were used, which were not, and their patterns of utilization. In both streams, about 40% of the compounds decreased in concentration, approximately 55% did not change, and less than 5% increased. Despite the complex system (>1500 DOM compounds and a natural consortia of bacteria), there was a high degree of similarity in which compounds were used and the amount of each compound used between replicate flasks for a stream, as well as between the two streams. This suggests that the selection of organic compounds in the complex and heretofore largely uncharacterized DOM pool by the microbial consortia is repeatable and therefore ultimately predictable. These results provide insights into factors affecting the composition of the suite of compounds in the DOM pool in aquatic ecosystems, and a new approach to develop ecological theories of resource utilization by microbial communities.

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HARMFUL ALGAL BLOOM TECHNOLOGIES IN OCEAN OBSERVING SYSTEMS

The increasing frequencies, duration, and impacts of many harmful algal blooms (HABs) in coastal waters have fostered community interest in deploying innovative new sensor technologies throughout inshore areas of the world. There are a suite of cell detection capabilities based on molecular tools as well as cell imaging capacities developed over the last decade that now permit almost routine detection of individual species, some in real time. Other technologies permit detection of optical characteristics associated with specific taxa, in situ and remotely. Detection of specific HAB toxins and toxicities are possible in routine lab-based assays and kits and in water field sensors are not far off. Chromatographic technologies are possible for in water deployment but detection spectra remain to be inclusive of all molecular weights of the diverse toxic compounds. An integrated observing system combining in water technologies and aerial/satellite remote sensing offer great promise for early warning systems for increasingly problematic HABs that impact living resources, public health, and coastal economies throughout the world's coastal oceans and estuaries.

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DEVELOPMENT OF A SELF-CRUISING OCEAN OBSERVATION PLATFORM

A self-cruising unmanned boat for observing surface ocean air and water was developed. The boat named SCOOP was made of FRP and had a length of 8.0 m, a maximum width of 2.8 m, and a maximum displacement of 3.5 tons. It equipped a diesel engine, which drove DC and AC dynamos to supply electric powers. A computer controlled a rudder and an engine speed by monitoring a GPS and a compass. A 5m-high mast was equipped for sampling air. Sample air was introduced into analytical and sampling instruments for aerosols and gases, NH3 and SO2. Temperature, salinity, chlorophyll fluorescence and turbidity of the surface water were measured every minute by sensors attached on the bottom. Vertical profiles of these parameters up to 100m depths are also measured by a yoyo system equipped inside the keel. A satellite communication system enabled a real time monitoring of observed data and an emergency control of the cruising. SCOOP was operated 13 times, reached 4,860km total travels from 2001 in the southeast coastal area of Japan.

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EFFECT OF TIDES AND FRONTAL SCALE PROCESSES ON ICHTYOPLANKTON ASSEMBLAGES AND PHYTOPLANKTON DYNAMICS IN THE EASTERN ENGLISH CHANNEL: OBSERVATIONS AND MODELING

Concentrations of fish larvae observed in spring 1995 show an accumulation of larvae in the vicinity of the French coast and an alongshore migration. We apply the Princeton Ocean Model coupled with the particle tracking model to study larvae migration under different forcing conditions. Results from the modeling are validated against observed concentrations of Flounder larvae. The hydrodynamic model accurately reproduces tidal circulation and dynamics of the region of fresh water influence (ROFI). Numerical Lagrangian tracking experiments with active and passive particles provided an explanation for larvae accumulation and indicated the location of accumulation zones. Passive particles were neutrally buoyant whereas active were able to exercise light dependent vertical migrations. The experiments revealed that the strongest accumulation of particles occurs along the French coast and is mostly associated with the ROFI. It arises from the interaction between the turbulence, the stratification, and the tidal dynamics, which produces particle trapping and spreading vertically within the frontal convergence zone. We apply the modeling approach to analyze the phytoplankton dynamics in the Channel.

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USING REMOTELY SENSED DATA TO DESCRIBE SPATIAL AND TEMPORAL HABITAT DISTRIBUTIONS OF GIANT KELP, MACROCYSTIS PYRIFERA

Giant kelp, Macrocystis pyrifera, is an important habitat-forming species of California's shallow rocky marine environment. We examine the role of time in giant kelp habitat distributions by developing a biophysical model that utilizes remotely sensed data, along with other variables, to describe optimal habitat for giant kelp. The model is based on habitat preferences of giant kelp ("optimal habitat descriptors") and consists of a set of rules generated from observable environmental parameters (such as sea surface temperature, wave exposure, bathymetry, and bottom type). Monthly time-series of optimal giant kelp habitat is used to quantify persistence. A seasonal cycle of optimal habitat area is marked by large fluctuations in area between summer and winter for most of the study area. Optimal habitat area in coastal waters south of Point Conception appears to be more stable than north of Point Conception and around the Channel Islands. Discrepancies between matchups of optimal habitat and aerial kelp cover indicate that optimal habitat is a function of the previous month's conditions and is defined by synergistic effects between the optimal habitat descriptors.

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SAMPLING THE SAMPLING UNIT: A WORLD IN A BOTTLE

Conventional sampling implicitly assumes steady state, especially at the microscale. The most common sampling procedure draws a sub-sample from a Niskin bottle for each parameter to be measured. However, the establishment of centimetre-scale patchiness of nutrients, bacteria and phytoplankton in the ocean, raises the question of whether there is patchiness in a standard Niskin bottle sample? We show, with exhaustive sub-sampling, that intra-Niskin bottle variability for nutrients, viruses, bacteria and phytoplankton is spatially organized and that it can be greater than the seasonal variability. We finally compare this variability with in situ patchiness sampled with one-, two and three-dimensional sampling devices, and discuss the consequences for sampling techniques.

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MICROSCALE DISTRIBUTIONS OF BACTERIOPLANKTON AND VIRUS-LIKE PARTICLES ASSESSED USING FLOW CYTOMETRY

Microscale sampling techniques and flow cytometric analysis were used to investigate the distributions of several sub-populations of heterotrophic bacteria and virus-like particles (VLP) at centimetre scales. Bacterial sub-populations were discriminated according to variations in DNA content and cell size, and in accordance with recent evidence illustrating strong links between these parameters and single cell activity, these groups are predicted to represent populations of varying metabolic activity. These sub-populations often exhibited up to 14-fold changes in abundance over distances of centimetres, with distributional features including 'hotspots', 'coldspots' and gradients in abundance frequently observed. Furthermore, dissimilar distribution patterns displayed by these populations may imply a fundamental change in the average activity state of the bacterial community at the microscale. Significant shifts in the abundance of VLP were also observed across centimetres, with distribution patterns generally correlated ($p < 0.05$) to heterotrophic bacteria. Microscale variability in the distributions and activity of bacterioplankton communities, and shifts in the abundance of virus populations, are likely to have considerable consequences for ecological interactions amongst aquatic microbial communities, and organic matter cycling through the microbial loop.

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MERCURY METHYLATION ALONG A GRADIENT OF INDUSTRIAL POLLUTION NEAR GARY, INDIANA

Wetlands can be a strong sink for atmospherically-deposited or hydrologically-transported mercury; however, they are also active sites of biotic formation of monomethylmercury, MMHg, from inorganic mercrury, Hg(II). While much work has been done on methylation in wetlands of various natural settings, particularly in pristine settings, little work has been done in highly contaminated wetland sediments. While one would naturally expect higher MMHg production with higher total Hg concentrations, issues of HgS(s) solubility, Hg(II) bioavailability, and expression of Hg detoxification genes all have the potential to alter expected net methylation rates. We will present results from a survey MMHg concentrations in individual wetlands along a gradient of industrial pollution from the low-impact Indiana Dunes National Lakeshore on Lake Michigan to highly impacted sites along the Grand Calumet River near Gary, Indiana. These sites have similar soils and vegetation, but vary greatly in total Hg loads and loads of other metals and organic contaminants. Preliminary data show lower MMHg concentrations in the highly Hg-impacted Roxanna Marsh than in the wetlands of the relatively unimpacted recreational Marquette lagoons. Also presented will be isotopic rate studies of methylation and demethylation rates at several of these sites.

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HOW DO DIATOMS ACQUIRE IRON? NEW OBSERVATIONS AND A UNIFYING MODEL

Current findings of iron organic complexation in the ocean challenge our understanding of iron acquisition by eukaryotic phytoplankton. Laboratory data show a dependency of iron uptake rate on the concentrations of free ions or dissolved inorganic species (Fe'). However, Fe' concentrations are too low in the ocean to support growth. Iron reduction by diatoms has been proposed to explain this quandary, but analytical limitations inhibited this research. We developed a new method to assess the role of bio-reduction in iron uptake by phytoplankton, based on additions of the specific Fe(II) ligand–ferrozine. Competition between the cells and the ferrozine for Fe(II) results in inhibition of iron uptake rate. Simultaneously, an estimate for the bio-reduction rate is obtained from the Fe(II)-ferrozine retained on C18 columns. We applied this method to Thalassiosira weissflogii cultures and to field populations in the Bering Sea using EDTA as a model ligand, and found that ferrozine addition significantly decreased the rates of iron uptake. We therefore propose a new model of iron acquisition in marine diatoms that reconciles these results with previous studies.

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EMPIRICAL FUNCTION REDEFINING OF MODIS SEMIANALYTIC ALGORITHM FOR THE PEARL RIVER ESTUARY BASED ON ABSORPTION MEASUREMENTS

Absorption coefficients of particles (both phytoplankton and de-pigmented particles) as well as color dissolved organic matter (CDOM) were measured for the Pearl River Estuary in November, 2002. The empirical functions of MODIS semianalytic algorithm was then redefined based on this dataset. The hyperbolic tangent function to model the relationship between phytoplankton a(numda) and a(675) was likely not matching the optical characters of this highly polluted estuarine domain. A simple polynomial function to model phytoplankton a(numda) versus a(443) was thus proposed. Detritus a(numda) was found much higher than CDOM a(numda) in general. Therefore it would be impractical to derive CDOM a(numda) if not separating detritus a from CDOM a. In addition, the value of parameter S was probably better to be kept as ca.0.012, rather than 0.022. Further tuning and optimization would be necessary in order to derive a practical MODIS semianalytic algorithm for the Peral River Estuary.

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VARIATIONS IN THE SPECTRAL PROPERTIES OF ESTUARINE WATER CAUSED BY CDOM PARTITIONING ONTO RIVER AND ESTUARINE SEDIMENTS

We investigated the impact of chromophoric dissolved organic matter (CDOM) partitioning onto natural and model sediments on the UV and visible spectral properties of two southeastern U.S. estuaries (Satilla and Cape Fear). Addition of model sediments to filtered (0.2 um) Satilla water induced a small (0.0001 to 0.0025 m-1) but rapid (<10 minutes) increase in the spectral slope coefficient (S), likely because of selective sorption of the CDOM's high molecular weight fraction. Our data indicate sorption can decrease CDOM concentrations and increase S in sedimentary pore waters, but that only a small percentage (<1%) of the CDOM would partition to sediments in the water column. We are currently evaluating CDOM sorption to organic-rich (5-10% C) Cape Fear estuarine sediments. Preliminary evidence indicates an increase in S similar in magnitude to that observed in the Satilla River experiments. This abstract of a proposed presentation has been approved by the US EPA.

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EMERGING GEOBIOLOGICAL PATTERNS OF FAUNAL EVOLUTION AND MICROBIAL DIVERSITY IN DEEP-SEA CHEMOSYNTHETIC ECOSYSTEMS: WHERE TO NEXT?

The first hydrothermal vent sites located on the global mid-ocean ridge were discovered approximately 25 years ago on the Galápagos Spreading Center. Although seafloor hydrothermal circulation has subsequently been demonstrated to be of fundamental importance to the cooling of the Earth, and the regulation of the oceans' geochemical composition, perhaps the most striking discoveries associated with hydrothermal vents remain the unique chemosynthetic biota they host. The tight coupling between geological processes and biology at hydrothermal vents provides a singular opportunity to study how fundamental planetary processes shape the evolution of chemosynthetic life. Emerging patterns of microbial diversity and invertebrate evolution point to the importance of exploring spatial and temporal studies within this network, and exploration for specific chemosynthetic ecosystems (including vents, seeps, whalefalls, and woodfalls) that are geographically, hydrographically and/or topographically isolated and more likely to have developed distinctive endemic ecosystems (e.g., South Atlantic, Lau Basin, and Southern Ocean). Future studies aimed at understanding evolution and inter-related biological and oceanographic processes in deep-water systems will continue to provide significant advances in understanding the full spectrum of marine biodiversity.

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SUMMIT-TO-SEA MAPPING AND CHANGE DETECTION USING SATELLITE IMAGERY: TOOLS FOR CONSERVATION AND MANAGEMENT OF CORAL REEFS

Accurate maps and spatial data are essential to effectively manage coral reef resources at an ecosystem level. This analysis, using moderate (30-meter) resolution satellite imagery covering Puerto Rico and the U.S. Virgin Islands from four time periods between 1986 and 2003 demonstrates that satellite-derived data is an efficient tool for coastal zone management, monitoring, planning and assessment. Maps depicting terrestrial elevation and estimated water depth provide the basis for terrain models and characterization of water flow over land, which were used to identify specific reefs vulnerable to land based sources of pollution. Land use and land cover data layers were merged with satellite-derived benthic habitat characterizations to create products for coastal land use planning and designing marine protected areas. Analysis of the time series imagery identified areas of significant change in coral systems; notably, seagrass colonization, and sedimentation. These observed changes in the marine environment were linked with land use and anthropogenic change in watersheds (deforestation, urbanization), to identify terrestrial areas that particularly affect coral reefs, and thus provide a guide for land use planning for reef conservation.

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THE APPLIED SCIENCE OF FISHERIES OCEANOGRAPHY, WHERE AWAY?

Operational Fisheries Oceanography has an unusual history. As societies evolved, the goals of advisories also changed, to include far more information, useful in making many decisions. The least understood ecosystems on earth are home to the huge variety of ocean resources. Fish are complicated. They have evolved innumerable adaptations to various physical and ecological challenges that they face during early life stages, maturation and reproduction. In studies of these interactions, Fisheries Oceanographers have uncovered a vast array of measures and features needing routine monitoring in order to maintain safety; provide direction for fishermen into most likely productive locations; and to provide insights into long and short-term variations in CPUE. Ultimately, these efforts lead to general understanding of not only daily and seasonal ocean weather patterns, but also help track the longer scale decadal, centennial and longer time scale forces that fish life history complexities assure us are there. 'Mean expectation', and 'average behavior' is not adequate for managing human impacts on fisheries. Turning fisheries management around to face forward, by providing insightful forecasts, is the next phase, now in development.

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UNIFORM ABILITY TO MEASURE DISSOLVED ORGANIC NITROGEN IN WATER

I am coordinating an effort of the international marine science community to establish more reliable community ability for accurate and precise measurement of dissolved organic nitrogen (DON) in seawater. The effort includes some estuarine and freshwater components. For almost two decades, it has been obvious that a variety of wet chemical and high temperature combustion methods can be used to get roughly the same numbers. However, since the majority of analyses measure total dissolved nitrogen followed by subtraction of dissolved inorganic nitrogen (DIN) to derive DON, the ability of the marine community to accurately measure DON has not been very good. The drinking water and wastewater research and monitoring community is also addressing the measurement of DON with similar conclusions; I serve on an advisory committee for that study. Important progress has been made in the past year. I will discuss recent intercalibration results and the proposed next steps that also include more emphasis on detailed protocols and accurate adjustment for DIN.

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SRING-NEAP PULSES OF PRODUCTION AND EXPORT IN THE SUBSURFACE CHLOROPHYLL MAXIMUM (SCM).

Tidal mixing at the base of the thermocline both erodes the SCM, and fuels the SCM by injecting nutrients from the bottom water. A 1-D model of the SCM shows that the spring-neap cycle introduces fortnightly variability in the growth and erosion of the biomass. As the tidal currents increase towards springs, the base of the SCM and thermocline are eroded into the bottom layer. As the currents decrease after springs, stratification reaches deeper into the water column and traps nutrients in the base of the deepening thermocline. The model predicts tidally-driven fortnightly pulses of primary production within and biomass export from the SCM. Observations of the SCM in the Celtic Sea are used to investigate the validity of this model result.

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MOULTING AND GROWTH RATES OF TWO SPECIES OF EUPHAUSIIDS OFF THE OREGON COAST: SEASONAL, SPATIAL AND LIFE STAGE DIFFERENCES

Euphausia pacifica and Thysanoessa spinifera are the two dominant species of euphausiids in coastal North America. Moulting rate experiments on these two species were conducted using animals collected off the coasts of Oregon and Northern California throughout 2001-2002. These experiments determined change in length and intermoult period (IMP) to calculate growth in mm per day. Positive growth ranged from 0 to 0.9 mm per day. Individual growth tended to decrease as animals got larger but was highly variable. Negative growth occurred during all seasons, usually in larger animals of both species. IMP was fairly constant over all size classes for both species, but varied seasonally. IMP tended to be shorter in summer months and longer during the winter, averaging approximately 6.9 d and 10.6 d respectively.

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AUTONOMOUS MEASUREMENTS OF TEMPERATURE, SALINITY AND CURRENTS OVER THE INNER-SHELF AT THE MARTHA'S VINEYARD COASTAL OBSERVATORY

Several rapid, high-resolution cross-shelf sections of temperature, salinity, currents and optical backscatter were collected over the New England inner-shelf at the Martha's Vineyard Coastal Observatory (MVCO), using the REMUS (Remote Environmental Monitoring Units) autonomous underwater vehicle (AUV), as part of a pilot study designed to demonstrate the scientific usefulness of autonomous sampling in this setting. These surveys provide an exceptionally detailed view of the cross-shelf structure of the density and current fields; as a result a previously-unknown, narrow (4 km wide), weakly buoyant plume was found near to shore with strong (25 cm/s) along-shelf currents in approximate thermal wind balance. Using surface meteorological observations from the MVCO, the affects of wind-forcing and surface heating on the cross-shelf structure and temporal variability of the density and current fields are also explored. In a fully operational setting with multiple vehicles conducting surveys each day, our view and understanding of physical processes in the coastal ocean will be greatly expanded.

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A SOUTH SAN FRANCISCO BAY SEDIMENT BUDGET: WETLAND RESTORATION AND POTENTIAL EFFECTS ON PHYTOPLANKTON BLOOMS

Evaporative salt pond restoration has the potential to alter the sediment budget and phytoplankton dynamics of South San Francisco Bay (SSFB). The USGS used a bay-wide, calibrated, 2-dimensional sediment box model to develop a sediment budget specific to SSFB. The sediment input in the model comes from tributary inflows, sediment removal is from wetland deposition, and suspended sediment exchanges with the bed and the rest of San Francisco Bay. The model results indicate that the addition of 9.4 km2 of Alviso salt evaporation ponds A9-A16 as a 50 percent efficient sediment sink decreases SSFB suspended-sediment concentrations (SSC) an average of 7 percent for water years 1995-2001. The additional pond area increases the vertical and horizontal SSC clearing rates described in the conceptual framework for phytoplankton growth response to water column clearing developed by Christine May and colleagues in 2003. Thus, restoring salt ponds to wetlands can affect phytoplankton population dynamics, although inter-annual variability of benthic grazing rates on the shoals can have a greater influence on controlling phytoplankton populations than the increase in SSC clearing rates.

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COMPARING EMERGENCE BEHAVIORS OF TWO SEPARATE POPULATIONS OF NEOMYSIS SPP.

Using a bottom-mounted, upward-looking, sonar device (TAPS-6) nightly migrations were recorded from September through November of 2001 off of Friday Harbor Lab's main pier, San Juan Island, Washington, USA, in approximately 20 m of water. TAPS-6 is a high-frequency (265 kHz – 3 MHz) sonar that has the ability to resolve 12.5 cm bins through the water column. Samples were collected every min. Like series in the Damarisotta River, Maine, USA, emergence showed seasonal onset in spring. Tidal effects at Friday Harbor were more subdued than in the Damariscotta River, but still evident. In both systems emergence traps suggested that the emerging populations were dominated by Neomysis spp. Duration of emergence events appeared to be similar in both systems with greater densities occurring in the San Juans.

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A TIDAL INTERNAL WAVE MODEL FOR SIMULATING SHELF-BREAK ACOUSTIC ENVIRONMENTS

Coastal internal waves/tides that affect acoustic signal propagation often originate from the continental shelf-break where barotropic tides interact with the shelf-break topography. The generation/propagation of internal waves/tides involves nonhydrostatic processes. We describe a free-surface hydrodynamic model developed based on the vorticity and free-surface momentum formulation. This approach provides a consistent frame work for treating weakly nonhydrostatic motions using the Boussinesq long-wave approximation and strongly nonhydrostatic motions using a full elliptic equation in terms of vertical velocity. In many situations, the computationally more efficient long-wave approximation suffices. The model has been validated with exact nonlinear solutions from the Dubriel-Jacotin-Long equation. The simulated generation of internal solitary waves at the shelf-break by tides will be presented, and the link of the hydrodynamic and acoustic models will be discussed. Work supported by the Office of Naval Research.

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MODIS AND SEAWIFS DATA AT DIAGNOSTIC DATA SET SITES FROM GES DAAC

The diagnostic data set (DDS) sites for spaceborne ocean color sensors were selected at the 4th SIMBIOS meeting to aid in data comparison and algorithm development. The size of the sites varies from 50km x 100km to 400km x 400km. MODIS and SeaWiFS Cutouts were created as data inputs to the DDS, which are subsets of MODIS (Level 1B and Level 2) and SeaWiFS (Level 1A and Level 2) data products that cover each DDS site. Six Cutouts of 39 DDS sites are currently archived at the GES DAAC. MODIS and SeaWiFS Cutouts have the same spatial resolution of 1km at nadir and the same data format (HDF). The subset formats differ geographically. MODIS Cutouts were created from the original 5-minute granules and the subset boundaries are aligned with longitude and latitude lines. SeaWiFS Cutouts were created from the Local Area Coverage (LAC) products acquired from a HRPT station or the on-board data recorder, and the subset boundaries are aligned with the satellite scanning direction and orbital inclination. In this presentation we will demonstrate how to order and work with these data, relevant tools, as well as example images. The data files can be directly downloaded one by one from the Diagnostic Data Set Browser at the SeaWiFS Project Web site: http://seawifs.gsfc.nasa.gov/cgi/seawifs_region_extracts.pl?TYP=ocean
Or can be ordered from the search and order engine at the GES DAAC: http://daac.gsfc.nasa.gov/data or the EDG: http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/

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FREE SWIMMING AND PREGNANT: THE FATE OF THE GIANT LARVACEAN?

The giant larvacean, Bathochordaeus sp. constitutes an important component of the zooplankton in many of the world's oceans. They build large, complex houses of mucopolysaccharides that serve as feeding filters. Previous studies have focused on these structures as microhabitats for bacteria and copepods and on discarded houses as a significant source of carbon flux to the seafloor, yet much remains to be learned about the basic ecology and life history of these animals.

In the Monterey Bay off central California, giant larvaceans occur throughout the year, the majority between 200 and 400 meters. However, striking exceptions to this distribution exist. Free-swimming Bathochordaeus sp. have been found at depths in excess of 1000 m. These deep individuals are generally large and most are fecund. All have been free-swimming, an indication that they were not feeding. Two animals collected below 750 m in August 2003 spawned en route to the surface, enabling us to make some developmental observations. Most of the Bathochordaeus sp. we see between 200 and 400 m are similar to each other in size, suggesting that their young may be spawned in deeper waters.

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MICROZOOPLANKTON AS A FOOD RESOURCE FOR MESOZOOPLANKTON

An important ecosystem-level function of phagotrophic protists is to channel the production of microbes at the base of food webs to higher trophic levels. Pelagic food web models now explicitly include microzooplankton both as consumers of phytoplankton, and as food for mesozooplankton. In regions of the ocean where most phytoplankton are less than 5 microns in size, microzooplanktonic protists are likely to be a primary source of food for copepods and other zooplankters. Even in mesotrophic systems characterized by diatom blooms, phagotrophic protists can serve as an important trophic link between phytoplankton and mesozooplankton. Ciliates and heterotrophic dinoflagellates, which are rich in fatty acids and sterols, represent a high quality food for copepods that appears to enhance egg production. However, direct evidence for the protist-zooplankton trophic link in marine systems remains sketchy. We will summarize available data on this topic, including preliminary results from our projects in the Oregon upwelling ecosystem and in the Arctic Ocean.

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SBI - MICROZOOPLANKTON AS HERBIVORES AND AS FOOD FOR MESOZOOPLANKTON IN ARCTIC OCEAN FOOD WEBS

During the 2002 field year of the Shelf-Basin Interactions (SBI) project, we carried out both dilution assay experiments to evaluate microzooplankton grazing rates, and mesozooplankton grazing experiments to determine relative grazing of copepods on phytoplankton and on heterotrophic protists. Based on changes in chlorophyll-a concentration as a proxy for change in phytoplankton biomass, 2 out of 6 dilution experiments in spring, and 6 of 12 experiments in summer, showed significant rates of microzooplankton herbivory, primarily at slope and basin stations. We independently analyzed change in phytoplankton stocks in the dilution

experiments via flow cytometric (FCM) enumeration of small (less than 5 micron) and large (greater than 5 micron) phytoplankton size classes. In some experiments, FCM data indicated differential grazing losses for smaller-sized versus larger-sized cells. FCM and inverted microscopy analyses made for the mesozooplankton grazing experiments showed that, in general, copepods appeared to be consuming large phytoplankton cells and heterotrophic protists, but not small phytoplankton cells. Microzooplankton accounted for up to 100% (average of 29%) of total carbon biomass ingested by copepods.

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THE PHOTOCHEMICAL TRANSFORMATION OF DISSOLVED ORGANIC CARBON TO DISSOLVED INORGANIC CARBON IN THE ESTUARINE ENVIRONMENT

Photochemical reactions transform considerable quantities of terrestrial dissolved organic matter (DOM) to dissolved inorganic carbon (DIC) in the coastal ocean. To characterize the oceanic carbon cycle, the transformation rate of chromophoric DOM (CDOM) to DIC must be quantified. Thus, we determined apparent quantum yield spectra (i.e. spectral efficiencies) for DIC photoproduction within the Delaware River and Cape Fear River estuaries (USA). For Delaware Estuary stations (3 – 23 salinity), DIC photoproduction efficiency did not vary with CDOM absorbance indicating that a single spectral efficiency controls DIC photoproduction. Surface DIC photoproduction rates in the Delaware Estuary ranged from 1.38 - 0.17 umol C/ L/hr suggesting DIC photoproduction is both an important sink for terrestrial DOM and an in situ source of DIC within the estuary. In the highly colored Cape Fear River estuary, quantum yield spectra varied considerably. The highest spectral efficiencies were for the 0 salinity end-member, with a steady decrease in the photochemical efficiency as CDOM absorption decreased. A number of chemical or physical processes effecting CDOM in the Cape Fear estuary may be responsible for the variations in photochemical efficiency.

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PHYTOPLANKTON RESPONSE TO A MESOSCALE IRON ADDITION IN THE SUBARCTIC NE PACIFIC OCEAN: PRIMARY PRODUCTIVITY

On 9 July 2002, the Canadian SOLAS program added dissolved iron to a 64 km2 patch of the subarctic NE Pacific, and followed the evolution of the subsequent phytoplankton bloom for 26 days. Primary productivity inside the patch began to increase relative to outside the patch within 48 h. As the bloom progressed, diatoms became responsible for the vast majority of both primary productivity and chlorophyll. As diatoms became increasingly dominant over flagellates, the proportion of primary production released as dissolved organic carbon decreased substantially. Primary productivity peaked on day 15 (~3 g C m-2 d-1, 24 July) associated with a sharp decrease in silicic acid toward limiting levels. Chlorophyll concentrations were maximal (>10× background, 4-6 mg m-3) on days 16 – 18 during which time diatom primary productivity dropped off and primary productivity by the smaller size fraction continued to increase. The early drop in diatom primary productivity suggests that bloom termination began with diatoms being increasingly limited by the availability of silicic acid, and that the bloom finally declined following iron limitation of the whole community from day 19 onward.

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DISCREPANCY OF BACTERIAL COUNTS MADE WITH SYBR GREEN I AND DAPI MEHTODS

Bacterial biomass has been mostly estimated based on the assumed carbon content of one bacterial cell and bacterial counts under epifluorescent microscopy. In the past decade, a fluorescent dye, 4'6-diamidino-2-phenylindole (DAPI), has been used for the staining of bacteria retained on 0.2-µm-pore-size Nuclepore filters. Noble and Fuhrman (1998) showed the available counting method using a newly developed fluorescent dye, SYBR Green I (SYBR I), for staining bacteria retained on 0.02-µm-pore-size Anodisc filters. However, the comparison of bacterial counts between the DAPI and SYBR I methods has not been made in detail. We made such comparison with seawater samples. Bacterial counts with the SYBR I method generally exceeded those with the DAPI method. The discrepancy of bacterial counts suggests that bacterial biomass may have been underestimated with the DAPI method. We recommend the use of the SYBR I method for bacterial counts in aquatic samples. Furthermore, the use of another recent developed fluorescent dye, SYBR Gold, for the staining of bacteria potentially allows for more reliable counts than the use of SYBR I, due to its intense and stable fluorescence.

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PARAMETERIZING TURBULENT DIFFUSIVITY USING HOMOGENEOUS SHEAR FLOW SIMULATIONS AND LABORATORY DATA

Quantifying the vertical transport of mass and momentum in stratified turbulence is fundamental to understanding the global heat budget of the oceans and atmosphere. Results from direct numerical simulations (DNS) of stratified homogeneous shear flow, with Prandtl number (Pr) between 0.5 and 2 (heated air), are used to assess the Osborn (1980) model for turbulent diffusivity. Modifying the Osborn model to allow the flux Richardson number to vary with epsilon/(nu N^2) yields a better fit to the data in more energetic flow regimes. Furthermore, a relationship is found for turbulent diffusivity as a function of turbulent Froude number for high Reynolds number. These results are compared to data from laboratory experiments of stratified grid turbulence by Barry et al. (2001), Rehmann and Koseff (2003), and Jackson and Rehmann (2003), which were performed in fluids with Pr = 7 (heated water), 700 (salt water), and 3200 (water-glycerol solution). The normalized turbulent diffusivity from all the data sets are found to collapse when multiplied by a factor of Pr to the 1/5 power.

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EFFECTS OF FE, P, SI AND DUST ADDITIONS ON PHYTOPLANKTON PRODUCTIVITY IN THE WESTERN TROPICAL ATLANTIC OCEAN

The effects of Fe, P, Si and dust additions on phytoplankton productivity were studied during cruises to the western tropical Atlantic Ocean between 3º – 14ºN and 42º - 57ºW. Experimental and control units contained 3L (winter, 2001) and 20L (summer, 2001) of trace metal clean seawater and the natural plankton assemblage. Incubations were terminal and primary (PP) and biogenic silica production (SiP) rates were measured initially and after two and four days. Two experiments were conducted each season; different results were observed each time (all expressed relative to controls). In the winter (lower riverine influence) SiP rates were consistently elevated in the +Si and +Si/+Fe treatments. In one experiment, the +Fe treatment increased PP rate variability. Dust was the only treatment with a consistent effect on SiP in the first summer experiment (greater riverine influence). During the second summer experiment, all nutrient additions resulted in elevated SiP rates at day 2, with no significant differences at day 4. These results indicate the varying effects that aeolian and riverine nutrient inputs can have on phytoplankton dynamics in this region.

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LIGHT AND TIME-SENSITIVE REGULATION OF BIOLUMINESCENCE IN THE DINOFLAGELLATE LINGULODINIUM POLYEDRUM.

Dinoflagellate bioluminescence occurs in response to mechanical stimulation to deter predator grazing. Bioluminescence is also regulated both directly and indirectly by light. Light inhibits mechanical stimulation of bioluminescence, and entrains and resets a circadian rhythm in bioluminescence. This study examined how light sensitive pathways interact with the mechanically sensitive pathway regulating bioluminescence. KCl, believed to act proximal to the initial mechanotransduction step, strongly stimulated bioluminescence even in samples that were mechanically insensitive due to light exposure. Therefore, the photoinhibitory pathway regulates bioluminescence at a very early step in the mechanotransduction pathway. 6-DMAP, a kinase inhibitor known to inhibit the phase-resetting of the endogenous circadian rhythm by light, partially inhibited stimulation of bioluminescence both by mechanical stimuli and KCl. 6-DMAP did not inhibit stimulation of bioluminescence by a Ca2+ ionophore or acidification nor did it affect the inhibitory effect of light on bioluminescence. These results suggest that light affects bioluminescence through two separate pathways: Photoinhibition of bioluminescence acts at a very early step in mechanotransduction, while the phase-resetting effect of light acts via a time-sensitive pathway downstream in the mechanotransduction pathway.

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GEOCHEMICAL PROCESSES DRIVEN BY GROUNDWATER-SEAWATER INTERACTION IN A COASTAL AQUIFER: IMPLICATIONS FOR THE OCEANIC CYCLES OF BA, RA AND U

A comprehensive geochemical study of the subterranean estuary underlying Waquoit Bay (Cape Cod, MA) has been undertaken. Sediment and pore water samples across the groundwater-seawater mixing zone show that the porous sediments support an active biogeochemistry. The redox cycles of iron and manganese are well developed with the oxidation of dissolved ferrous iron forming extensive deposits of iron-oxide coated sands. The strong relationship between the sediment concentrations of Fe and P reflects the sorption of phosphate from seawater and/or groundwater. Though two orders of magnitude less abundant than iron oxides, manganese oxides also precipitate in the subterranean estuary. Recirculation of seawater past the iron-rich sediments under reducing conditions makes this subterranean estuary a net sink for U from coastal seawater. Our evidence of this removal is twofold: (1) near zero uranium concentrations in the low to intermediate salinity groundwater beneath the bay and (2) a measurable deficit of uranium (relative to the predicted U-Salinity relationship) in the water column of Waquoit Bay. In contrast, large scale release of Ba and Ra occurs in the mid to high salinity zone of the subterranean estuary, leading to a net input of Ba and Ra to the coastal ocean. In addition to salt-induced desorption of Ba/Ra from aquifer sediments, reductive dissolution of Mn oxides and weathering processes may explain the distribution of these elements in coastal groundwater. These results provide insight into the processes controlling Ra cycling during groundwater-seawater interaction and, therefore, its use as a tracer of submarine groundwater discharge to the oceans.

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TEMPORAL VARIABILITY IN NITROGENASE GENE (NIFH) EXPRESSION IN THE SUPTROPICAL NORTH PACIFIC OCEAN

Small unicellular cyanobacteria (<10 um) in the subtropical North Pacific Ocean are capable of expressing nitrogenase genes. To further characterize their role in N dynamics, the timing of nitrogenase gene expression of organisms in the 0.2 - 10 um size fraction was determined in incubation experiments using Kaneohe Bay and station ALOHA water in summer 2001 and winter 2002. Organisms expressing the nitrogenase gene nifH were identified by cloning and sequencing RT-PCR amplified nifH gene fragments and quantitative RT-PCR was used to assess nifH gene expression from Group A cyanobacteria and a gamma proteobacterium. Although very few Group A nitrogen fixing unicellular cyanobacteria transcripts were detected in the RT-PCR clone libraries (0-19%), QRT-PCR indicated that in some samples they outnumbered the proteobacteria transcripts by several orders of magnitude. In Kaneohe Bay, RT-PCR showed that nifH gene expression was highest at night and lowest in the afternoon, while QRT-PCR of station ALOHA water showed that Group A cyanobacteria gene expression was highest in the morning. This suggests that unicellular cyanobacteria may play an important ecological role in oligotrophic oceans where fixed nitrogen often limits growth.

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NITROGENASE GENE EXPRESSION IN THE CHESAPEAKE BAY

Recent experiments demonstrated that the Chesapeake Bay is home to a diverse consortium of bacteria encoding the nifH subunit of nitrogenase, the enzyme responsible for nitrogen fixation. Further study revealed that different diazotrophs were spatially and temporally variable within the estuary indicating that they occupied different niches. To gain insight into the function of diazotroph communities and determine if nifH is expressed in the Chesapeake, reverse transcriptase PCR was performed on RNA extracted from Chesapeake microbial communities. Amplification from several samples demonstrated that nifH was expressed at certain times and locations. To identify the organisms expressing nifH, the amplified gene fragments were then cloned and sequenced. Contrary to the results from screening clone libraries of nifH amplified from genomic DNA, there was low diversity of nifH amplified from RNA. However, the organisms expressing nifH in the Chesapeake differed depending on the location, i.e. the head vs. the mouth. These results suggest that nitrogen fixation is an important metabolic activity of some resident microbes, even if it is not a major source of nitrogen relative to nitrate, ammonium and urea in the Chesapeake Bay.

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PATTERNS OF BIOTURBATION, BURROW IRRIGATION AND MERCURY METHYLATION IN MARINE SEDIMENTS

By changing the geometry of the redox potential discontinuity (RPD), bioirrigation can influence the concentrations and profiles of chemical species that form at the RPD, such as methyl mercury. We investigated the effects of bioirrigation, which affects the RPD, and particle bioturbation, which affects the supply of inorganic mercury associated with particulate organic matter to the RPD, on mercury methylation in the sediments of Boston Harbor. Bioturbation, bioirrigation, porewater oxygen, porewater sulfide and methyl mercury concentrations were measured at several sites in Boston Harbor, encompassing a range of burrow densities. Porewater-exchange models simulating the rates and geometries of bioirrigation at each station were developed using data from CT-scan images of burrows, Rn-222 and oxygen profiles. Our results indicate that patterns of burrow irrigation influence distributions of methyl mercury in marine sediments, perhaps by changing the concentrations of porewater oxygen and sulfide.

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MODELED CIRCULATION PATTERNS AND BIOLUMINESCENCE DISTRIBUTION PREDICTIONS DURING UPWELLING AND RELAXATION EVENTS IN THE MONTEREY BAY AREA .

This study uses the model originally configured as part of the Innovative Coastal-Ocean Observing Network (ICON) program to characterize dominant velocity patterns under upwelling- and downwelling-favorable wind regimes in the Monterey Bay area. In order to also include dominant flow effects from the broader California Current system, the ICON model is nested within the regional-scale NRL Pacific West Coast (PWC) model. This paper overviews ICON modeling results with the focus on: 1) multiyear analysis of the ICON and PWC model predictions that compare current structures during upwelling and relaxation events and 2) model interpretations and predictions of observed, short-term changes in bioluminescence intensity. The latter focus exploits unique observations of bioluminescence intensity made from ships and autonomous vehicles during three intensive summer field campaigns in 2000, 2002, and 2003.

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LAGRANGIAN DESCRIPTIONS OF MARINE LARVAL DISPERSION

Many marine organisms are sedentary as adults and are redistributed between generations by oceanic transport of planktonic larvae. We introduce a Lagrangian description of larval transport to assess larval dispersal kernels (settlement probability distributions) for a range of ocean flows and larval settlement pre-competency/competency periods. Paths of individual planktonic larval releases are modeled statistically and, by averaging over many individuals, estimates of the larval dispersal kernel can be determined. Typical dispersal scales vary from a few km to > 400 km. Modeled dispersal kernels are well explained using only a few readily available biological and oceanographic parameters and derived scales agree well with population genetic estimates. Importantly, settlement patterns resulting from larval releases made over short times (days to months) should be comprised of a small number of discrete samples taken from the long-term averaged dispersal kernel. The resulting larval dispersal patterns will be quasi-random in both space and time, which will have important implications for the interpretation of settlement time series and the prediction of recruitment of sessile organisms.

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DISTRIBUTIONS OF AEROBIC, ANOXYGENIC PHOTOHETEROTROPHIC BACTERIA CELLS AND BIOMASS IN THE NORTHWEST ATLANTIC OCEAN

Bacteria with an aerobic, anoxygenic, photoheterotrophic metabolism (AAPs) are now known to be widespread in the ocean. These diverse bacteria can use either dissolved organic matter or light as an energy source, but their photosynthesis does not produce oxygen. This unusual metabolism complicates our concepts of the ocean carbon cycle. Reports to date have suggested that the AAP metabolism may be an adaptation to low nutrient open ocean conditions. We used infrared epifluorescence imaging to measure cell counts and sizes along an onshore-offshore trophic gradient from two cruises in the NW Atlantic. Surface (15m) cell concentrations ranged from 7,000 to 98,000 cells per milliliter. AAP cells were higher in numbers, biomass, and proportion of total bacteria in productive coastal and shelf waters of the Gulf of Maine, than in the oligotrophic Sargasso Sea. Distributions of AAPs indicate possible control by temperature and overall organic and inorganic nutrients. Our results do not support the hypothesis that these cells are specifically adapted to oligotrophic waters.

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BIO-OPTICAL PROPERTIES OF THE SOUTH ATLANTIC SUBTROPICAL GYRE

Bio-optical properties of the South Atlantic subtropical gyre are investigated using SeaWiFS ocean color data and in situ measurements of pigments, nutrients, and light penetration. The in situ data originate from the Atlantic Meridional Transect (AMT) cruises. The gyre domain is classified in terms of its dynamic boundaries (hydrography), biological signature (biomass), and optical properties. Phytoplankton functional groups are identified based on biomarker classification of accessory pigments. Relationships of physical and bio-optical parameters that apply to remote sensing, such as SST, mixed-layer depth, biomass, deep chlorophyll maximum, and light attenuation coefficients are analyzed and the data are used to test existing algorithms. The in situ measurements of the diffusion attenuation coefficient and reflectance ratios are tested against the chlorophyll-dependent empirical relationships for Case 1 waters of Morel and Maritorena (2001).

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TRACING FOOD WEB CONNECTIONS WITH A PHYCOTOXIN: THE CASE OF DOMOIC ACID

The diatom toxin, domoic acid (DA), was first recognized on the US west coast in 1991, after a mortality event involving seabirds in Monterey Bay, California. Starting in 1999, our group has been measuring cell abundance and particulate toxin concentration in local DA-producers, species of the diatom Pseudo-nitzschia, in Monterey Bay. We also have measured DA levels in various pelagic animals, including krill, planktivorous fish (anchovy, sardine) and recorded DA-related strandings of California Sea Lions in the region. Here we review the food web connections indicated by the occurrence of DA in pelagic organisms in this coastal upwelling system. Similarly, we discuss the idiosyncrasies of using DA as a natural tracer, given its apparent short-lived residence in consumers, and the reasons for the event-scale match and mismatch of DA in populations that normally show strong trophic linkages.

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BRINGING REAL-TIME OCEAN SCIENCE DATA INTO THE CLASSROOM THROUGH COASTAL OCEAN OBSERVATORIES AND THE MID-ATLANTIC CENTER FOR OCEAN SCIENCES EDUCATION EXCELLENCE

The recent advent of coastal ocean observatories, and their ability to provide real-time oceanographic data, has created a unique opportunity to bring the ocean into classrooms around the world in a meaningful and effective way. The Mid-Atlantic Center for Ocean Sciences Education Excellence (MA-COSEE) is committed to delivering relevant ocean science education to diverse audiences, with an emphasis on translating data and information from coastal ocean observatories into instructional materials and products for classroom educators and the public. To date, the MA-COSEE features two educational projects that incorporate real-time oceanographic data. The C.O.O.L. Classroom, an online collection of interactive and interdisciplinary lessons based on the Rutgers University Coastal Ocean Observation Lab (C.O.O.L.) and the New Jersey Shelf Observing System (NJSOS), was developed to bring cutting-edge oceanographic research, data, and technology directly to the classroom. The Gulf Stream Voyage, developed by the Center for Improved Engineering and Science Education (CIESE), guides students in discovering the science and history of the Gulf Stream current through a collaborative online project. The content and recent comparative evaluation efforts of both projects will be presented.

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KINETIC PROPERTIES AND THERMAL STABILITIES OF A4_LACTATE DEHYDROGENASES OF MESOPELAGIC FISHES EVOLVED TO DIFFERENT THERMAL GRADIENTS

Kinetic properties of the muscle-type intermediary metabolic enzyme lactate dehydrogenase (A4-LDH, EC 1.1.1.27, NAD+:lactate oxidoreductase)were positively correlated with the upper environmental temperature that mesopelagic fishes experience and negatively correlated with species' depth of occurrence. Reduced A4-LDH activity and catalytic rate constants (kcat) in deep-living species are patterns consistent with the greater thermal stability exhibited by their enzymes. Indices of binding affinity between enzyme and ligand, rates of enzyme performance and thermal stability all suggest that strong vertical migrators are more thermotolerant than asynchronous and non-migrating species. Turnover rates of the A4-LDH from mesopelagic fishes were approximately one-third the rate of those reported for shallow-living fishes experiencing similar habitat temperatures. The inefficient enzymes of mesopelagic fishes may be one factor of importance in establishing the upper limits of their distribution.

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MAKING PHYSICS FUN: APPLIED OCEANOGRPAHY IN A MIDDLE SCHOOL SETTING

The Oceans GK-12 program is a National Science Foundation funded program at the University of South Florida College of Marine Science. Created to bridge the gap between scientists and GK-12 educators in Pinellas County, Florida, novel approaches to integrating marine science into elementary, middle school and high school curricula are being explored. Presented here is the evolution of a series of activities designed to use current physical oceanographic methods to teach about motion, speed, acceleration, velocity and waves. Three major educational strands and benchmarks are addressed in the activities: The Nature of Motion, The Nature of Matter, and Scientific Thinking. Pooling the experiences and resources of three diverse Oceans GK-12 Fellows-a graduate fellow, an undergraduate science fellow, and an 8th grade Pinellas County teacher, we are combining classroom and field activities to provide real-world applications of ocean science research using fun, hands-on activities.

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REFINING SHARK STOCK ASSESSMENTS USING TELEMETRY DATA

Direct estimates of the levels of natural and fishing mortality experienced by newborn blacktip sharks were made using data from an acoustic monitoring experiment. Acoustic data produced estimates of natural mortality of 0.32 to 0.70, and fishing mortality of 0.41 to 0.60. These telemetry-based mortality estimates are approximately double those used in previous stock assessments. The monitoring experiment also revealed that both natural and fishing mortality occurs primarily in the first 15 weeks after birth. These mortality data were used to construct new prior distributions of intrinsic population increase rate or Beverton-Holt steepness for use in Bayesian population models. The impact of the new estimates of mortality rates on the priors, and also the overall stock assessment, will be described. The potential of acoustic and satellite telemetry to provide additional improvements to the stock assessment are also explored.

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ABUNDANT SLOW GROWING OLIGOTROPHIC BACTERIOPLANKTON SHOW LOW VIABILITY IN DILUTION CULTURES

Diverse behavior by bacteria, include different life strategies for bacterioplankton. Using serial dilution the same marine bacteria that are dominant in clone libraries appear in seawater cultures. Recently the SAR11 clade member, Pelagibacter ubique was isolated and its abundant presence in the global ocean has been demonstrated. These oligotrophic so-called "uncultured" bacteria do not form biofilms or colonies instead thrive dispersed in the water. In this presentation we show estimates of culturability in dilution cultures detected by 1) microscopy, 2) CFU on marine agar plates, 3) amplification of extracted DNA using universal and SAR11 specific probes using real time quantitative PCR, 4) 3H-thymidine and 14C-leucine uptake. DAPI agars slides were also inoculated from each dilution to study micro-colony formation. Micro-colonies were detected on DAPI agar-slides from all dilution tubes positive for CFU. In tubes with no CFU but where growth was observed in the microscope and through PCR amplification no micro-colonies were found, instead dispersed single cells were abundant. The viability of opportunistic bacterioplankton (CFU) showed an expected low value of 0.1% of the total count, but surprisingly only 6 % of the oligotrophic bacteria were able to multiply. Positive SAR11 signal was observed in a majority of the tubes showing growth. The implications of these results, for the interpretation of FISH and micro-autoradiography data are discussed.

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OLIGOTROPHIC BACTERIOPLANKTON WITH A NOVEL SINGLE-CELL LIFE STRATEGY.

A large fraction of the marine bacterioplankton community is unable to form colonies on agar surfaces, which so far no experimental evidence can explain. Here we demonstrate a unique life strategy of non-colony forming oligotrophic bacterioplankton including two SAR11 cluster representatives, the worlds most abundant organism. We have demonstrated that these bacteria exhibit a behavior that promotes dispersal instead of colony formation and thus optimizes the individual cell access to the substrate. Although these bacteria do not form colonies on agar it was possible to monitor growth on seawater agar with fluorescent stain. Prompt dispersal of newly divided cells explained the inability to form colonies since immobilized cells (cells immersed in agar) formed micro-colonies. We suggest that the inability to form colonies/biofilms is part of the K life strategy that oligotrophic bacteria have adopted to explore the dissolved organic matter continuum as single cells.

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PHYSICAL MECHANISMS INFLUENCING REGIONAL DISTRIBUTION AND ABUNDANCE OF APEX PREDATORS: RELEVANCE TO ECOSYSTEM MANAGEMENT

Diet and decline patterns between rookeries of Steller sea lions (Eumetopias jubatus) indicate four metapopulations extending across the Aleutian Island chain. Zonal breaks in east-west distribution of cetaceans during the Passes cruises align with Steller sea lion metapopulation boundaries. Generalized Additive Models (GAMS) used to examine these patterns as a function of the oceanography of the Aleutian passes, corroborated field observations and refined linkages between physical variables influencing interspecies patterns of distribution. Two variables were modeled as functions of the physical characteristics of each pass: 1) population trend on Steller sea lion rookeries; and 2) presence/absence of the five observed cetacean species: humpback (Megaptera novaeangliae), minke (Balaena acutorostrata), sperm (Physeter macrocephalus), and killer (Orcinus orca) whales, and Dall's porpoise (Phocoenoides dalli). Fluorescence in the top 50 meters of the nearest pass was significant for all five species of cetaceans. Direction or distance to the nearest pass was significant for all five cetaceans and for Steller sea lions. GAMS used in this study will be further explored as tools for ecosystem management.

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THE SEABED AUV AND ITS USE IN HABITAT CHARACTERIZATION

The Seabed AUV is a small, inexpensive autonomous underwater vehicle (AUV) designed to conduct high resolution optical and acoustic imaging in rugged terrain. Over the last two years it has been deployed off of Bermuda, Puerto Rico, Massachusetts and the US Virgin Islands for habitat characterization. In this talk we explore the systems level issues associated with control, navigation and imaging from AUVs that make it possible to obtain high quality optical and acoustic data within the constraints of power, cost and size that are unique to small, scientific AUVs. Specifically we focus on the requirements for closed loop control, color imaging from an AUV, and the ability to work close to the bottom in rugged terrain.

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EFFECTS OF IRRADIANCE AND FE-LIMITED GROWTH ON NITROGEN RELEASE BY VERTICALLY MIGRATING RHIZOSOLENIA MATS

Rhizosolenia mats undergoing vertical migrations to exploit deep nitrate pools in the oligotrophic central North Pacific (CNP) gyre are likely to encounter light and/or Fe-limited growth. It was hypothesized that Rhizosolenia mats release nitrogen as a response to light and/or Fe-stress. Field samples were examined during the 2002 (Hawaii to California transect) and 2003 (Hawaii to Midway transect) summer periods to assess whether Rhizosolenia mats release nitrogen in situ. Onboard incubations ranging from 6-7 hrs were set-up under varying light (15%, 30% and 0% of surface irradiance) and/or induced Fe-limitation conditions. Analyses for NO3-, NO2- and NH4+ were done immediately after collections and end of incubations. Nitrogen release occurred for NO3- (2002 period) and NH4+ (both periods). Nitrite release in the 2002 summer period did not occur in situ but only when Fe-limitation was induced. Fluorescence-based maximal quantum yield was consistently high (~0.61) for summer 2002 period but was lower during summer 2003 (~0.51). The results provide no evidence of Fe stress in Rhizosolenia mats. Nitrogen acquired at depth is actively released in the surface layers.

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SUNLIGHT INACTIVATION OF ENTERIC BACTERIA AND BACTERIOPHAGES IN SEAWATER

In shallow, reasonably clear, coastal waters, sunlight is the principal mechanism inactivating enteric microorganisms. The inactivation rate depends on the penetration of different sunlight wavelengths into seawater, and the intrinsic susceptibility of the microorganism to those wavelengths. This presentation summarises a series of studies in which the inactivation of enteric bacteria and bacteriophages in seawater was determined as a function of cumulative global solar radiation ("insolation"). Over one day of sunlight exposure, fecal coliforms from raw sewage were inactivated more rapidly than enterococci, but showed evidence of photorepair in the late afternoon, and improved survival rates (similar to enterococci) on the second day. Fecal coliforms also seemed to repair some of the sunlight damage sustained in a waste stabilization pond (WSP), and became more sunlight resistant than WSP enterococci. Enterococci appeared unable to repair sunlight damage sustained in either WSPs or seawater. Indicator bacteriophages were more sunlight resistant than bacteria in seawater, with somatic coliphages significantly more resistant than F-RNA phages. Implications for the monitoring of raw sewage and WSP effluent discharges to coastal waters are discussed.

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THE HYDRODYNAMICS OF A CORAL BLEACHING EVENT

Coral Bleaching events are weather events. Mass bleaching occurs when there is an extended summer period (eg two weeks) of calm, sunny conditions that coincide with small tides. Over 98% of solar radiation energy is absorbed in the top 4 metres of the water column. This heat will stay at the top of the water column unless there is a mechanical mechanism to mix it into the cooler water below.
Hydrodynamic models provide us with a tool for predicting SST patterns during a future severe mass coral bleaching event. They also provide tools for understanding the many other hydrodynamic related issues within a reef system (eg connectivity).
This talk will demonstrate how the hydrodynamics of a coral bleaching event are predictable. A case study for the GBR will be used for examples, and a comprehensive hydrodynamic modeling effort for Palau will be described, including how this will be used to evolve the idea of coral bleaching prediction.

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DENSE-WATER PRODUCTION AND OVERFLOW FROM AN ARCTIC COASTAL POLYNYA IN STORFJORDEN (SVALBARD ARCHIPELAGO)

Storfjorden, in winter, is a site of active brine formation due to its recurrent polynya. The dense, brine-enriched waters fill the depressions of the fjord to its sill level and subsequently descend like a bottom gravity current following the topography towards the shelf break. An existing polynya and ice production model when applied to winter 2002 predicts large brine rejection in agreement with observations. The resulting strong overflow in 2002 is observed at densely spaced hydrographic stations occupied across its path. Estimates of mixing of the dense overflow plume inferred from Thorpe-scale analysis, suggest enhanced mixing within the plume, with vertical diffusivities in excess of 10^(-3) m^2s^(-1). The model results combined with the field data provide a picture of the link between forcing, generation of the source conditions in the basin and the corresponding overflow. The results are contrasted to the earlier winters 1998 to 2001.

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THE EFFECT OF PHASE TRANSFER ON THE CHEMICAL COMPOSITION OF DISSOLVED AND PARTICULATE ORGANIC MATERIAL

Sheer, caused by waves or currents, can cause formation of particulate material from colloidal and dissolved precursors. This phase transfer influences the fate of organic material and is therefore important for the global carbon cycle. We collected surface-water samples from two salinity regimes (~6 PSU and ~25 PSU) in a near-coastal environment and induced shear by rolling the water samples in glass bottles for 48 hours. Before and after rolling the samples, we determined concentrations of dissolved and particulate components of organic carbon and nitrogen, amino acids, and neutral sugars. There were significantly higher concentrations of particulate material after rolling, but we found no significant differences between the two salinity regimes. Formation of particulate organic matter by shear appears to be large enough to have a profound effect on dissolved organic carbon cycling in near-coastal environments.

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DISSOLVED COPPER IN ORGANIC-RICH ESTUARINE WATERS: INTERACTIONS OF LIGHT AND SUSPENDED SEDIMENTS IN ALTERING SPECIATION

The behavior of dissolved Cu(I) and Cu(II) and Cu-complexing ligands was examined in a series of light and dark experiments using filtered and unfiltered estuarine waters and sediments. Variable results were obtained for light-induced release of total dissolved Cu in waters and sediment suspensions from the organic-rich, relatively uncontaminated Cape Fear estuary (CFE) in southeastern North Carolina, although significant release did occur in suspensions from the more impacted San Diego Bay. Strong Cu-complexing ligands (log K' > 13) degraded appreciably in CFE waters in full spectrum sunlight, but only modestly in photosynthetically active radiation (PAR). In some experiments, suspended sediments from the CFE exposed to light generated strong Cu-complexing ligands as a small fraction of the dissolved organic carbon which is also photo-produced. Sunlight-exposed CFE waters typically generated significant concentrations of Cu(I) in the presence and absence of sediments; PAR alone also induced Cu(I) formation. Ambient Cu(I) in the CFE was a relatively large fraction of the total dissolved Cu concentration, leading to the possibility that Cu(I) is stabilized by organic complexation.

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DEVELOPMENT AND GROWTH RATES OF THE COPEPOD CENTROPAGES ABDOMINALIS IN THE SUBARCTIC PACIFIC

Copepods play a critical role in food web dynamics and thus energy resources available to higher trophic levels. We determined the growth and development rates of the neritic copepod Centropages abdominalis from the Gulf of Alaska under excess food conditions in the laboratory. Development rates were determined by following daily changes in stage distribution, and growth rates were measured by examining the daily change in size frequency. At 5 C, the development time was unexpectedly slow: time from eggs to 50 % of the population at copepodite stage V (CV) was 51 days. We had difficulty reaching 50 % adults at this temperature. At 7 oC, the total development time was much faster: 42 days from eggs to 50 % adults. Based on this total development time, the average growth rate at 7 oC was ~ 14 % per day. Copepodite stage durations at 5 oC were 5.5, 8.0, and 8.1 days for stages CII, CIII, and CIV respectively. At 7 oC, stage durations were 1.4, 3.2, 4.1, 4.6, and 6.1 days for stages CI, CII, CIII, CIV, and CV respectively.

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A NEAR REAL-TIME 1/12 DEGREE ATLANTIC HYCOM NOWCAST/FORECAST SYSTEM

A 1/12 degree HYbrid Coordinate Ocean Model (HYCOM) of the Atlantic Ocean north of 27S is used in a near real-time nowcast/forecast system. The Modular Ocean Data Assimilation System (MODAS) sea surface height analysis of available satellite altimeter data is assimilated into the model. The surface information is projected in the vertical using the Cooper and Haines (1996, JGR) technique. The model is currently run once a week to produce the nowcast and a forecast. A web page has been developed showing the near real-time results, http://hycom.rsmas.miami.edu. The results are compared to frontal locations determined from independent MCSST observations. The frontal analysis is performed at the Naval Oceanographic Office. Independent SeaWIFS images are also used to verify the results. This system is the first step toward a global 1/12 degree nowcast/forecast system based on HYCOM that is planned for transition to the Naval Oceanographic Office in 2006. More advanced assimilation techniques will be included in the system as soon as they show increased model nowcast/forecast skill and the system can run within the operational time limits.343 -

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DEAD WHALES, ROTTING WOOD AND PUTRID KELP: BIOGENIC CHEMOSYNTHETIC HABITATS AT THE DEEP-SEA FLOOR

Deep-sea chemosynthetic habitats result from both geological and biological processes. Biota of geological (vents/seep) and biogenic (large-organic-fall) habitats must be compared for biogeographic and evolutionary syntheses. We use natural whale falls, and wood and kelp emplacements, to investigate sulfide levels, persistence, and community structure of organic-fall habitats off California (1000-2000m). Fresh whales produce high sediment sulfides (~10 mM) after 4.5 yr. Whale skeletons continue to support chemosynthetic communities after 50-80 yr, but only on sulfide-rich, decomposing bones. Kelp parcels (100-kg) after 3-6 mo support intermediate sulfides (<1.3 mM). Wood parcels (200-kg) yield low sulfides (<50 microM). Each habitat fosters a characteristic fauna and different patterns of succession. Whale falls are species-rich (~185 spp./carcass), dominated by mussels and limpets, and harbor 27 potential specialists. Kelp falls contain moderate diversity with abundant limpets, ampharetids, and mites; Wood islands are species-poor and dominated by “infaunal,” boring bivalves and ampharetids (Baco et al., in prep). Whale falls share 11 species with vents, 20 with seeps, and may be ecological/evolutionary stepping-stones. Structural and functional contrasts among whale, wood, kelp, and vent/seep habitats will be discussed.

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INVASIVE MACROALGAE ON HAWAII'S CORAL REEFS: INFLUENCE OF BIODIVERSITY ON INVASION SUCCESS AND ULTIMATE CONSEQUENCES TO ECOSYSTEM FUNCTION

Despite the number of fish, invertebrate and algal species that have been introduced both intentionally and accidentally to coral reef regions around the world invasive species are generally not considered among the primary threats to these ecosystems. In general invaders in tropical ecosystems tend to be restricted to protected or highly disturbed environments such as harbors and bays and when they have escaped to open coastlines they have usually remained benign. It is unclear why invasive species have not become more problematic in the tropics but perhaps these systems are more resistant to invasion than other ecosystems. Hawaii's reefs are an exception to the above statement where a number of nonindigenous macroalgal species have successfully established in a variety of reef habitats. The goals of this study were to examine relationships between invader success and biodiversity, to examine interactions between invaders and other benthic reef species, to identify other physical and/or biological factors that may enhance (or covary with) invasion success and to quantify the long term consequences of such invasion events to the structure and function of Hawaii's reefs.

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GEOCHEMICAL EVIDENCE FOR SEASONAL-SCALE VARIATIONS IN SEDIMENT ACCUMULATION IN ABANDONED HARBOR SLIPS OF THE LOWER HUDSON RIVER ESTUARY

Our past studies have shown that a large portion of the particulate load in estuaries tends to bypass areas that have reached “dynamic equilibrium” with the hydraulic regime and (through a series of deposition and resuspension events) tends to rapidly accumulate in low-energy areas that are temporally out of equilibrium as a result of natural processes and/or human activity. Measured I-131, Th-234, Be-7, Pb-210 and Cs-137 inventories and activities in sediment cores taken on October 12, 2001 from two abandoned harbor slips in the lower Hudson River estuary (suspected to be non-equilibrium areas) were used to provide evidence of sediment focusing and rapid, non-steady state sediment accumulation (over months to years) at the two sites. Radionuclide-derived geochronologies reveal a pattern of seasonal-scale variability in sediment sources possibly linked to changes in freshwater flow. These sites, and possibly other non-equilibrium areas, may act as sinks for fine-grained sediments and may also act to record local sediment dynamics over seasonal to yearly time scales, therefore providing insight to the physical processes driving sedimentation in estuarine systems.

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BIOGEOGRAPHIC DIFFERENCES IN CLAW SIZE AND PERFORMANCE IN AN INTRODUCED CRAB PREDATOR: EVIDENCE OF AN EMERGING ARMS RACE?

Biological invasions provide outstanding opportunities to study nascent arms races. Key unanswered questions are: to what extent can an invading predator respond to resident prey and how rapid is the response? We have tested for latitudinal differences in claw size and crushing performance in the introduced green crab Carcinus maenas on both Atlantic and Pacific coasts of the United States. On the Atlantic coast, morphometric analyses indicate that southern (Massachusetts) populations of green crabs have larger crusher claws than northern (Maine) populations. In laboratory performance tests, southern crabs were also able to crush larger snail prey than their northern counterparts. These patterns correlate positively with geographic differences in shell thickness of at least one species of snail prey and suggest that an arms race has developed within the last century. Latitudinal differences in claw size were also detected in the more recent Pacific coast green crab invasion, but only for the cutter claw. The different results may relate to differences in the duration of the two invasions, substratum (and thus prey) type, or temperature regimes between coasts.

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TOWARDS AUTONOMOUS IN SITU MICROBIAL MONITORING – THE AUTONOMOUS MICROBIAL GENOSENSOR (AMG).

Monitoring of the marine environment for organisms of public heath, economic or ecological significance normally requires a spatial and temporal separation between sample collection, analysis and data reporting. Our goal is to overcome this division by developing and deploying an autonomous microbial genosensor (AMG) that detects target organisms based upon mRNA amplification/detection and transmits the information to land based data centers in real time. The challenging aspect of AMG design is to automate protocols normally performed by laboratory personnel in a remotely deployed instrument. Instrumentation designed for sample collection and RNA extraction/purification is being developed in a modular fashion. Real-time amplification of target RNA using the Nucleic Acid Sequence Based Amplification (NASBA) coupled with molecular beacons has been incorporated into a novel reaction detection chamber fed by a unique microfluidic system. Real-time NASBA assays to detect a range of marine organisms including Synechococcus, Karenia brevis and Enteroviruses have been developed to incorporate into the AMG. The AMG will thereby provide in situ rapid, real-time and inexpensive identification of target microorganisms that have ecological or public health significance.

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DISTRIBUTION AND BIOMASS OF MESOZOOPLANKTON IN THE BEAUFORT AND CHUKCHI SEAS DURING SUMMER, 2002

Polar regions may be significantly impacted by ecological perturbations resulting from climate change. Alterations in temperature, circulation and ice cover in Arctic seas may result in altered food chain dynamics, beginning with planktonic processes. The present study was conducted within the Shelf-Basin Interactions program with the objective of determining whether large-bodied copepods, associated with deep waters of the Bering Sea or the Canada Basin, were present in sufficient numbers over the Chukchi and Beaufort shelves to modify the food web in this region where small-bodied copepods often numerically dominate the zooplankton community. We conducted zooplankton surveys during summer 2002 to assess the distribution and abundance of copepods over the Chukchi and Beaufort shelves, slope regions and the adjacent Canada Basin. The mesozooplankton community was numerically dominated by copepod nauplii and small-bodied juveniles, including Pseudocalanus spp. and Oithona similis. While few large-bodied copepods from the Bering Sea were collected, juveniles of large-bodied Calanus species were common suggesting reproduction by species advected from the Canada Basin. These larger bodied species could significantly impact the food web of the Chukchi and Beaufort shelves.

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SIMULATIONS OF THE LOWER TROPHIC LEVEL MARINE ECOSYSTEM AND SILICON AND NITROGEN CYCLES IN INCUBATION EXPERIMENTS

We have developed a new multi-element marine ecosystem model and used it to simulate a new set of bottle incubation experiments recently conducted by our experimental team at Shizuoka University (led by B. Casareto).Water from three depts in Suruga Bay, near Shizuoka, Japan, was incubated in 20 L bottles on land. Measurements included nutrients, particulate and dissolved organic matter, particulate silica, and organisms. Using a Markov Chain Monte Carlo method to assimilate this data into the model, we examine differences in the Si:N ratios of smaller versus larger diatoms. We also examine in detail a problem encountered in the first set of experiments, in which the total concentrations of both silicon and nitrogen measured (inorganic plus organic) varied with time. The problem was worse for silicon. We examine the silicon to nitrogen ratio of particulate matter in relation to measurements of particulate matter. We also use simulations and data assimilation to examine possible effects of biogenic silica on organic matter degradation.

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ESTUARINE TYPOLOGY: PERTURBATIONS AND EUTROPHICATION RESPONSES

NOAA and US estuarine science and management communities have recognized that the 1999 National Estuarine Eutrophication Assessment (NEEA), while useful, needs modification and updating. This would best be accomplished by a progression from (1) classification of estuaries into functional types that respond differently to perturbation, through (2) characterization of the nature and degree of perturbation, to (3) identification and prediction of responses. Each step requires objective assessments based on quantitative data, and depends on comparisons among many estuaries. We describe a physically based approach to classification of coastal waters. This includes development of classification tools (e.g. geospatial clustering such as DISCO) and supporting infrastructure (web-based access to tools, databases, and outcomes). This will enable community input to and participation in the development of a typology that will provide a rigorous yet flexible basis for the NEEA update and for management actions at the estuary level.

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DIFFERENTIAL MIXING IN SHEAR-DRIVEN OVERTURNS

We investigate mixing due to shear instability in a doubly diffusive fluid via linear stability analysis and direct numerical simulation. Breaking Kelvin-Helmholtz billows are studied in three stratification regimes: (1) diffusively stable, (2) unstable to salt fingers and (3) unstable to diffusive convection. The resulting flows combine turbulence, gravity waves and double diffusive phenomena. Analyses focus on property fluxes, turbulent diffusivities and mixing efficiencies. Variance and covariance budgets, including codissipation terms, are computed. Results are compared with the balances proposed by DeSzoeke (1998, J. Phys. Oc. 28, 2064) for stationary turbulence and with ocean observations.

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TEMPORAL AND SPATIAL PERSISTENCE OF ICHTHYOPLANKTON ASSEMBLAGES: THE ROLES OF ADVECTION, DIFFUSION AND BEHAVIOR

To determine whether ichthyoplankton occur as persistent communities over scales of days to weeks, we repeated detailed bongo grid surveys three times in Trinity Bay Newfoundland over a 10-day period during June of 2001. We hypothesized that circulation would largely dissipate spatial patterns that were observed during the first survey, and that changes would reflect a combination of advection and diffusion that could be modeled reasonably well with a coastal circulation model and without invoking active behavior. Preliminary analysis of ichthyoplankton data indicates that patterns were variable over time periods of days, and that particular assemblages were not maintained in consistent areas of the bay. This result suggests that ichthyoplankton occur as poorly defined assemblages rather than persistent communities in specific water masses, and that their spatial patterns are more influenced by physical transport and dispersal than by behaviour. Observed patterns in ichthyoplankton will be used to seed the circulation model and determine whether the model output is consistent with the observed changes in distribution and community assemblages.

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REMOTE SENSING REFLECTANCE AND THE OPTICAL PROPERTIES OF THE COASTAL AND ESTUARINE WATERS OF LEO-15 DURING JULY 2001

The near-shore waters of LEO-15, and adjacent estuarine environments of Great Bay and Barnegat Bay, New Jersey, were remotely surveyed at 1-2 meter spatial resolution with the PHILLS-1 optical-nir hyperspectral sensor between 23 July and 2 August, 2001. Within this period, a series of ground truth measurements were made by our group and we report here on 15 stations for which a complete set of in-water data is available for cross-check and comparison. Measurements include at surface Remote Sensing Reflectance (Rrs), HPLC pigment, total suspend sediment (organic and inorganic fraction), particle size, and depth profiles of water absorption (both filtered and unfiltered), attenuation and backscatter coefficients. These measurements are used to quantify the water properties of LEO-15 during this time period and to note how the estuarine environment compares to that off-shore. Near-simultaneous PHILLS-1 measurements are available for 5 of the stations. A comparison of PHILLS-1, above water surface measured and HYDROLIGHT modeled Rrs shows generally good agreement with comparable variations noted between any two sets of measurements.

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PHOSPHORUS ACQUISITION IN TRICHODESMIUM AND OTHER NITROGEN FIXERS IN THE SUBTROPICAL NORTH ATLANTIC AND PACIFIC

The oligotrophic open oceans are generally considered to be nitrogen limited. However, nitrogen fixing organisms such as the filamentous cyanobacterium Trichodesmium and cyanobacterial symbionts of diatoms, which can be important contributors to the nitrogen cycle in these areas, are inherently not nitrogen limited. Phosphorus acquisition therefore is an important process to these organisms, as P may be their limiting nutrient. Phosphate uptake rates by diazotrophs were measured using P-33 in April and May 2003 in the tropical Atlantic and August 2003 in the Pacific. Trichodesmium phosphate uptake was found to be independent of light, but did exhibit a diel pattern, increasing before the middle of the day and then decreasing. Vmax in Trichodesmium ranged from 0.8-12.2 pmol per colony per hr, while Ks ranged from 0.024-0.287 micromolar PO4. On four days in the Pacific when alkaline phosphatase activity in Trichodesmium was measured, the rate of PO4 cleavage from a fluorescent substrate was always higher than ambient PO4 uptake rates and sometimes higher than Vmax.

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STOCK IDENTIFICATION OF CHUM SALMON (ONCORHYNCHUS KETA) USING MICROCHEMISTRY OF OTOLITH

The chemical analysis of trace elements was conducted to reveal the depository relationship between otolith and ambient water and to develop the ways to distinguish fish stocks. The ambient water and otoliths of hatchery-reared chum salmon fry were collected from three major hatcheries (Yangyang, Samchuk and Uljin of Korea) each spring from 2001 to 2003. Trace elements in the otoliths and water were analyzed using inductively coupled plasma mass spectrometry (ICP-MS). Composition of trace elements of the ambient water did not significantly vary during the three years and some trace elements/Ca ratios such as Sr/Ca and Ba/Ca in the ambient water seemed to be well reflected in the otoliths of salmon fry. These two elements might be indicators in distinguishing hatcheries which have different chemical environments. Discriminant analysis with 8 element/Ca ratios (Na/Ca, Mg/Ca, Al/Ca, Cu/Ca, Sr/Ca, Ba/Ca, Mn/Ca, and Zn/Ca) represented a distinct separation in accordance with the natality of stocks.

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DYNAMICS OF BIOACTIVE TRACE METALS DURING THE SUBARCTIC PACIFIC IRON EXPERIMENT FOR ECOSYSTEM DYNAMICS STUDY (SEEDS2001)

During the first Fe-enrichment experiment in the northwest subarctic Pacific (SEEDS2001), the dynamics of dissolved and acid dissolvable trace metals were studied. Immediately after sampling, seawater for dissolved species was filtered and acidified to pH 2.2. Seawater for acid dissolvable species was acidified to pH 2.2 without filtration and stored for 20 months at an ambient temperature until the chelating column extraction and determination by ICP-MS. Before the Fe enrichment, the dissolved Fe in the surface mixed layer was <0.13 nM and the acid dissolvable Fe was 4.7 nM. The difference was a labile particulate fraction, which was not easily available to phytoplankton, since the photochemical quantum efficiency of photosystem II was low. After the Fe enrichment, acid dissolvable Fe in the patch decreased exponentially from 9.6 nM on day 2 to 4.6 nM on day 13, which was still ~3 nM higher than the outside concentration. Dissolved Fe decreased from 1.4 nM to <0.13 nM. Although the acid dissolvable concentrations for Mn, Co, Ni, Cu, Zn and Cd did not change significantly, the dissolved concentrations decreased exponentially.

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THE BALTIC ENVIRONMENTAL DATABASE AND TOOLS FOR DATA ANALYSIS

The Baltic Environmental Database is a database comprising hydrographic and chemical observations from the Baltic Sea since 1900 (243412 stations); gridded bathymetry, inputs from the drainage basin, weather data, atmospheric nitrogen inputs and sea level variations. The database is under frequent updating thanks to the contributions of over 100 laboratories and institutions from all countries around the Baltic Sea. Several of computer programs were developed to analyze data from the database in different ways. DAS (Data Assimilation System) requests data from the database to construct 3D gridded data and allows the users to analyze spatial distribution of variables (horizontal surfaces, vertical transects) and perform different calculations. NetStations is used to analyze temporal variation of the parameters for a selected region of the Baltic. The database is also used in the program NEST — an information environment of a decision support system for developing and testing cost-effective

strategies to reduce eutrophication in the Baltic Sea. The database is accessible on-line and its tools can be found on http://data.ecology.su.se/Models/BEDonWeb

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MOLECULAR “FINGERPRINTS” USED TO IDENTIFY AND DIFFERENTIATE DINOFLAGELLATE SPECIES IN THE GULF OF MEXICO

Karenia brevis is a toxic dinoflagellate that blooms regularly in coastal waters of the Gulf of Mexico. Anonymous single copy nuclear (scn) DNA markers were developed, optimized, and tested against clonal cultures of K. brevis, K. mikimotoi and other dinoflagellate species. When DNA isolated from these cultures was amplified using polymerase chain reaction (PCR) primers for three scnDNA loci, distinct banding patterns occurred that clearly differentiated between genera and species. Internal transcribed spacer (ITS) and large subunit (LSU) rRNA sequences of the clonal isolates confirmed these results. Observations of morphology via light microscopy can easily distinguish among genera; however, under certain growth conditions, K. mikimotoi can be difficult to distinguish from K. brevis. Positive identification of phytoplankton species can be important in determining which organism is responsible for an algal bloom. Such knowledge has implications on fishery management during bloom events.

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LOW NITROGEN STABLE ISOTOPE SIGNALS OF SUMMER ZOOPLANKTON IN THE BALTIC SEA: AMMONIA RECYCLING OR TRANSFER OF DIAZOTROPHIC NITROGEN?

In the Baltic Sea, nitrogen stable isotope signals of zooplankton have been observed to drop significantly during summer blooms of the diazotrophic cyanobacterium Nodularia spumigena. Hence, this decrease may result from the transfer of diazotrophically fixed, 'light' nitrogen to zooplankton. Yet, alternatively, this decrease may be due to regenerated production fuelled by isotopically depleted, recycled ammonia during summer stratification. We tested these two hypotheses in a mesocosm study using a density gradient of the natural zooplankton assemblage. For the recycling hypothesis, zooplankton nitrogen isotope signals were expected to decrease strongest at high zooplankon densities, since ammonia recycling is proportional to zooplankton biomass. The contrary was expected for the transfer hypothesis, because the exchange of nitrogen in zooplankton is faster at low zooplankton biomass. Final zooplankton isotope signals and the negative correlation of POM isotope signals with N. spumigena cell concentrations supported the tranfer hypothesis. Cell counts and frequency distributions of N. spumigena trichome lengths yet indicated that – in contrast to recent findings – the transfer to zooplankton was not through direct grazing, but through an indirect pathway via a microbial link.

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ARCHAEAL PHYLOTYPES IN A METAL-RICH, LOW-ACTIVITY DEEP SUBSURFACE SEDIMENT OF THE PERU BASIN (ODP LEG 201, SITE 1231)

Site 1231 of the Ocean Drilling Project (ODP) is located in the Peru Basin at a depth of 4827 m. This site is characterized by low organic carbon content, near-zero sulfate reduction rates, and unusual metal gradients over the upper 50 m of the sediment column. As a preliminary study of the microbial communities in deep subsurface sediments, samples were taken from drill cores of various depths during ODP leg 201, and the microbial community was studied using 16S rRNA surveys. Due to a combination of low bacterial numbers, DNA adsorption to clay particles, and the presence of PCR inhibitors, it has proven extremely difficult to obtain genomic material suitable for phylogenetic analysis from these samples. However, by optimizing the DNA extraction and purification protocols, a number of clone libraries were constructed and analyzed, demonstrating distinct differences in the microbial communities inhabiting various depths. The results show that specialized prokaryotic communities inhabit the deep, organic poor sediments of site 1231, and identify specific phylogenetic groups of organisms likely to constitute a deep subsurface biosphere in the world's oceans.

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NEW INSIGHTS INTO PHYTOPLANKTON DYNAMICS FROM OPTICAL OBSERVATIONS

Our understanding of the dynamics of phytoplankton communities has often been limited by the space and time scales of traditional monitoring approaches. Submersible optical sensors such as beam transmissometers and fluorometers have helped to overcome some of these limitations but, until recently, focus has been almost exclusively on estimating biomass. New optical approaches, however, can characterize natural phytoplankton assemblages in ways that extend beyond biomass. These approaches include spectrally resolved measurements of attenuation and absorption, assessment of microsecond-scale fluorescence kinetics, coincident determination of multiple optical properties, and assessment of single particle optical properties. With careful interpretation, the results have the potential to provide information about ecological and physiological characteristics as varied as community structure and size distribution, pigmentation, photosynthetic efficiency, and growth rate.

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PHYTOPLANKTON DYNAMICS ON THE NEW ENGLAND INNER SHELF: TIME SERIES OBSERVATIONS AT THE MARTHA'S VINEYARD COASTAL OBSERVATORY

To better understand what regulates phytoplankton dynamics on the inner continental shelf of the northeastern US, we have begun time series observations at the Martha's Vineyard Coastal Observatory (MVCO), a new cabled research facility. We deployed a custom-built submersible automated flow cytometer in late spring 2003 for extended near continuous measurements of pico/nanophytoplankton abundance, cell size, and cell fluorescence characteristics. Our observations show a classic late spring bloom of Synechococcus, which was also accompanied by an increase in abundance of picoeukaryotes. Subsequently, there were changes in cell abundance and in size structure of the community over a range of time scales throughout the summer. Application of a matrix population model that represents diel changes in size distribution of Synechococcus suggests that there are substantial variations in cell specific growth rate at MVCO, presumably in response to changing growth conditions in the region.

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HYDRODYNAMICS OF PLANKTONIC MICROCRUSTACEAN LOCOMOTION: TURNING WAKE VORTICES INTO COMMUNICATION SIGNALS

It has long been hypothesized that aquatic microcrustaceans, such as planktonic copepods, are able to distinguish an attractive mate from a lunging predator by sensing their respective hydrodynamic signatures in the form of coherent vortical structures. We develop a hybrid Cartesian/Immersed-Boundary numerical method for simulating the flow around a swimming copepod. A realistic copepod-like body is constructed, which includes most important parts of the animals anatomy: the antenulles, legs, and tail. The kinematics of the individual body parts are prescribed using laboratory observations and measurements. We will report numerical simulations for a copepod advancing at steady velocity over a range of Reynolds numbers, 10<Re<300. The computed flowfields will be analyzed to elucidate the structure and dynamics of the coherent vortices shed by the copepod, quantify the persistence of these vortices in the wake, and explore hypotheses about the possible role of coherent hydrodynamic structures as communication signals.

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DESCRIBING SPACE-TIME MULTISCALE PATTERNS IN AQUATIC ECOLOGY USING STOCHASTIC APPROACHES AND IBMS

A new simulation platform, ‘Mobidyc’, dedicated to non-computer expert end-users, is used to illustrate the advantages of individual based modeling for simulating population dynamics. The platform ‘Mobidyc’ is specifically dedicated to the field of population dynamics with 2D-discrete spatial representation. We show first how to build easily population dynamics models with increasing levels of complexity. This process is illustrated on the basis of an experimental parameterization of the population dynamic of the copepod Eurytemora affinis, the dominant species in most estuaries of the Northern hemisphere. We subsequently focused on the role of spatial representation and the possible sources of heterogeneity in copepod populations. The simulated spatio-temporal developmental stages abundances data are analyzed statistically. Spatial and temporal patterns are investigated using models and data analysis techniques initially developed in the fields of turbulence and nonlinear physics (e.g. scaling and multiscaling approaches for data analysis and stochastic simulation). The ecological relevance of our approach is finally tested comparing the stochastic nature and the parameters of the simulations to space-time patterns observed in the field in a wide range of ecological situations.

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MACROALGAL AND NUTRIENT DYNAMICS ACROSS A DEPTH GRADIENT IN A CORAL REEF COMMUNITY IN WEST MAUI, HAWAII

Sporadic macroalgal blooms in west Maui have long eluded explanation, prompting a multi-disciplinary investigation to determine possible interactions between the geochemical environment and macroalgal abundance. Baseline data at 3, 10, 20, and 30 m depths were collected at a persistent macroalgal bloom site (Kahekili, west Maui). At each water depth, nutrients (nitrate, ammonium, phosphate, and silicate) and salinity measurements were collected from 6 discrete depths within the sediment, and at 5 cm and 1 m above the sediment-water interface. The percent cover of coral and macroalgae was recorded at 2 sites within each depth along permanent and random transects. The 3 m and 10 m sites were characterized by coral and the invasive alga Acanthophora spicifera. In contrast, the 20 m and 30 m depths were dominated by the psammophytic (sand-dwelling) macroalga Halimeda incrassata. This interdisciplinary approach across a wide depth range will enable a thorough characterization of the west Maui coastal environment and its algal dynamics. Evaluation of current and future algal blooms in west Maui will be possible with the baseline data provided by this on-going investigation.

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EFFECTS OF ENVIRONMENTAL CONDITIONS ON RNA:DNA RATIO ANALYSIS OF ZOOPLANKTON

Copepods are the dominant zooplankton taxa and form a critical trophic link between phytoplankton and fish. RNA:DNA ratios have been shown to correlate to egg production and serve as an index of nutritional condition and secondary production for several fish species and a few copepod species. Until recently it was nearly impossible to measure nucleic acid of small individual zooplankton, such as Acartia tonsa. A new highly sensitive fluorescent dye in combination with an automated microplate reader can measure nucleic acids of individual adult female A. tonsa. Egg production experiments followed by RNA:DNA analysis were conducted under several different environmental conditions. A. tonsa was cultured at three different temperatures and salinities to determine how these environmental factors may affect RNA:DNA ratios. Preliminary findings from RNA:DNA analysis and egg production data suggest there are significant interactions of temperature x salinity and temperature x food. This study should help determine what factors may be altering nucleic acid values in nature and ultimately this technique may be applied to wild populations with minimal manipulation to use as a proxy of secondary production.

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STRATEGIES FOR CONNECTING OCEAN SCIENTISTS TO EDUCATORS

Of the many federal and state efforts to increase the connections between scientists and educators, the National Science Foundation's Centers for Ocean Sciences Education Excellence are testing diverse models to provide sustained pathways for interaction. SouthEast COSEE, regionally targeting GA, SC and NC, is applying four strategies: (1) providing the summer workshop settings in which a selected group of science teachers hear presentations from ocean scientists and experience some of the research techniques on site in a marine laboratory over a week's time; (2) building a setting with different types of nonformal institutional facilities, such as aquariums and museums, where teachers and scientists meet for a day; (3) initiating dialogue with the ocean science research community to assist with NSF proposals in regard to Criterion Two; and, (4) developing an electronic newsletter where research topics are highlighted and also lead educators to Sea Grant publications.

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EFFECT OF SUSPENDED PARTICLES ON WATER OPTICAL PROPERTIES IN THE MISSISSIPPI RIVER PLUME

Water samples were collected approximately 1 m below the surface along with measurement of water optical properties near the mouth of the Mississippi River in the Gulf of Mexico. Water samples were filtered to obtain total suspended sediment (TSS). Filters were dried, weighed, ashed and re-weighed to obtain fractions (%OM) of organic (POM) and inorganic matter (PIM). Profiles of spectral absorption (a), attenuation (c), backscattering (bb), upwelling radiance (Lu), downwelling irradiance (Ed), and particle size distribution (PSD) were collected in the same vicinity as the water samples. Near-surface measurements of a, c, b, bb and R= Lu/Ed showed some correlation in all wavelengths versus TSS, PIM, POM, and %OM ($0.03 < r^2 < 0.52$, n=15). Highest correlations were found with unfiltered measurements of a, b, and c ($0.3 < r^2 < 0.52$). R and bb were less well correlated ($0.03 < r^2 < 0.47$). All optical parameters, except a, showed strongest correlations with %OM, TSS and PIM, suggesting that even in waters containing high percentages of OM, the inorganic fraction has a strong influence on optical properties.

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IMPACT OF SURFACE CHLOROPHYLL-A FROM SATELLITE REMOTE-SENSED OBSERVATIONS ON IMPROVING ECOSYSTEM MODELS

The goal of this study is to use a reduced state space Kalman filter to improve a basin scale three-dimensional coupled physical/ecosystem model. We are testing this concept at several stations in the North Pacific (e.g., HOT, OSP, EqPac, KNOT). The Spitz et al. (2001) ecosystem model with parameters estimated from data assimilation at HOT is coupled to a coarse circulation model (POP). SeaWiFS chl-a observations between 1998 and 2002 are used. Based upon a one-dimensional study, we found the use of the reduced state space Kalman filter to be promising. At HOT, the first two EOFs explain 77% of the variance and mimic the weak coupling of the surface chl-a and the deep maximum chl-a (DCM). In addition, significant correlation between the ecosystem components exists. Surface information as provided by satellite can provide significant correction to the modeled surface and deep ecosystem components. At OSP, the coupling between surface chl-a and DCM is weaker. More EOFs than at HOT are required to explain the variance in the ecosystem. The impact of surface observations is weaker than at HOT. We will extend this study to the North Pacific basin.

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TROPHIC STRUCTURE, BIODIVERSITY, AND CARBON CYCLING: EVIDENCE OF CASCADING EFFECTS IN AN EXPERIMENTAL EELGRASS SYSTEM

Coastal regions lie at the interface between land and ocean, providing habitat for economically and ecologically important organisms, transforming nutrients through biogeochemical processes, and buffering allochthonous substances. Natural and anthropogenic influences contribute to ongoing biodiversity loss and subsequent changes in community structure. Such alterations have substantial consequences for ecosystem dynamics and function. Using an experimental eelgrass system we tested effects of changing grazer diversity and trophic structure (number of levels) on sediment organic carbon accumulation. Increasing grazer diversity significantly reduced algal biomass and primary production; while cascading influence of predators (blue crabs) eliminated this effect. Food-web manipulations had little influence on bulk sediment organic matter (SOM) quantity, however, SOM quality was strongly affected. Lipid biomarkers of OM sources indicated that grazer identity, crab presence, and their interaction all affected total fatty acid concentration. Both grazer identity and predator presence influenced SOM lability (polyunsaturated fatty acid content), and bacterial biomass (branched fatty acid concentration). These data demonstrate that biodiversity within trophic levels, the number of trophic levels, and their interaction significantly influence carbon dynamics and geochemical processes in marine sedimentary ecosystems.

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OBIS-SEAMAP: MAPPING THE GLOBAL DISTRIBUTION OF MARINE MAMMALS, BIRDS AND TURTLES

The Spatial Ecological Analysis of Marine Megavertebrate Populations (SEAMAP) initiative, a node of the Ocean Biogeographic Information System (OBIS), is developing and populating a digital database of global marine mammal, seabird and sea turtle distribution and abundance data. This publicly-available system, designed to facilitate the analysis of megavertebrate distributions in conjunction with environmental data, is intended for a broad audience of educators, students, resource managers and researchers. Additionally, supporting web-based mapping tools, educational materials and metadata have been designed to enhance the potential research and educational application of this database.
We showcase the OBIS-SEAMAP system and highlight some biogeographic and resource management applications of this dataset. In particular, we illustrate how novel spatial ecology techniques can be used to integrate the necessary disparate perspectives (e.g., movement data, vessel-based surveys, remote sensing information) required to understand the ecology and biogeography of marine megavertebrates.

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EFFECTS OF SPATIAL DISTRIBUTIONS ON TROPHIC EFFICIENCIES: AN APPROACH USING AN OPTICAL PLANKTON COUNTER

Spatial patterns in the horizontal and vertical distributions of organisms are known to exist in most natural communities. However the relevance of actual spatial structure to trophic interactions in aquatic food webs remains poorly known. This is at least partly because there are relatively few simultaneous observations of the multi-scale spatial structure of predators and their prey in nature, and insufficient consideration of how such structure may affect ecological processes such as net growth efficiency. In this study I use an Optical Plankton counter (OPC) and a fluorometer to record patterns in the spatial coherence of zooplankton and algae throughout the water column in Lakes Ontario and Erie. These data are used in simple simulations of trophic interactions to test the hypothesis that the net growth efficiency of zooplankton feeding on algae is higher under observed spatial structures than under uniform distributions of the same mean concentration. Results indicate that the growth efficiency of zooplankton can be up to two times higher in spatially explicit simulations than in those with no spatial pattern.

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BIOAVAILABLE DOM IN RAINWATER: LINKING COMPOUND-LEVEL INFORMATION TO ECOSYSTEM EFFECTS

In a time-series experiment, a natural assemblage of bacteria was three times more productive in rainwater from an undisturbed site than from an urban site. Bacteria consumed similar amounts of DOM in both samples and were not limited by inorganic nutrients. Bulk chemical information could not account for these different ecosystem effects. We obtained molecular-level information on the bioavailable DOM pool of each site using APESI-MS, a non-fragmenting, soft-ionization mass spectrometry technique. Approximately 19 and 25% of compounds were taken up in the urban and undisturbed site, respectively. A slightly higher proportion of compounds with positive functional groups (e.g., carbohydrates, amines) was taken up in the undisturbed site. Of the pool of organic compounds that was bioavailable, only 23% were consumed at both urban and undisturbed sites. Many (33%) were only present in one site. The chemical characterization of compounds that were present in only one site may help explain the different bacterial response observed. This molecular level approach provides new insight into resource utilization dynamics of microbial populations.

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INTERNATIONAL OCEANOGRAPHIC AND METEOROLOGICAL MONITORING NETWORK EXPANSION AND NEW APPLICATIONS

The international scientific community has recognized a need for a Global Ocean Observing System (GOOS) to study climate change and monitor oceanographic conditions. In response to this need, the International SeaKeepers Society has implemented a system of autonomous oceanographic and meteorological data collection modules on volunteer ships of opportunity, cruise and cargo vessels and fixed platforms. Over the past 5 years, data has been successfully collected from this network of modular low-power and low-maintenance SeaKeepers modules. This system is currently being expanded to remote regions that include coastal zones of developing nations where there is a paucity of real-time environmental observations. Here we present a summary of data collected, validation techniques and sensors types, including those under development, to increase awareness of the range and value of this worldwide network. The application of this data to global climate models, oceanographic weather monitoring, monitoring anthropogenic influence and its expansion to educational programs based on real-time data will be discussed.

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TRANSPORT THROUGH THE ALEUTIAN PASSES

The Aleutian Island Arc separates the Bering Sea from the rest of the North Pacific. This is a porous boundary through which relatively warm, saline water flows northward into the Bering Sea. Historically, the baroclinic transport through the passes has been measured from hydrographic sections. During the last two years (2001-2003), moorings. which measured currents, temperature and salinity. were deployed in five of the passes. The two eastern passes (Unimak and Akutan Passes) are shallow (depth <120m), with relatively small transport (<0.3 x 106 m3 s-1) that appears related to along shore winds. The three western passes (Amukta, Seguam and Tanaga Passes) are deeper (>200m) and transports are larger. The greatest transports are through Amukta Pass, where they can exceed 5 x 106 m3 s-1 and are much higher than the baroclinic transport (<1.0 x 106 m3 s-1), since the predominant flow is barotropic. Transport in the western passes does not appear to be related to the local winds, but to the position and strength of the Alaskan Stream, which is the source water for the northward flow through the passes. The high current velocities in the passes result in strong vertical mixing. Thus, high-salinity, nutrient-rich water is mixed into the upper 100m of the water column. These nutrients are an important source for the high primary production that occurs in the Bering Sea.

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BIODIVERSITY ENHANCES THE TEMPORAL CONSISTENCY AND INVASION RESISTANCE OF SESSILE MARINE INVERTEBRATE COMMUNITIES

Despite growing evidence that increasing diversity of an ecosystem can enhance its functioning (productivity, stability), our understanding of the mechanism underlying this effect is often poor. An oft-cited possibility is that species are complementary in the ecosystem functions they perform. Alternatively, species may function similarly but be complementary in their temporal pattern of abundance such that greater diversity results in greater consistency over time. Field experiments with sessile marine invertebrate communities demonstrate that limiting resources (space) are more completely utilized at higher diversity. This is because each species fluctuates in abundance (boom and bust), but the timing of these fluctuations differs among species. Thus adding species to a community increases the consistency of space occupation over time. We also show that lower resource availability in more diverse systems enhances their resistance to invasion by non-indigenous species. On larger spatial scales, seasonal differences in the timing of recruitment among these species appear to determine temporal fluctuations within species. Because similar seasonal fluctuations occur in phytoplankton, macroalgae, and annual plant communities, this mechanism may operate in a variety of systems.

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AEROSOL RETRIEVALS OVER CASE 2 WATERS USING HYPERSPECTRAL DATA

A method for simultaneous retrieval of aerosol properties and marine constituents in Case 2 waters is being developed. This method is an extension of previous work where a similar method was developed for simultaneous retrieval of aerosol properties and chlorophyll concentrations in Case 1 waters. The emphasis in this presentation will be placed on the use of near-infrared (NIR) channels not available on the SeaWiFS and MERIS platforms to help characterize the aerosol parameters over Case 2 waters. In particular we explore the usefulness of radiances measured at longer wavelengths, such as the 1240, 1640, and 2130 nm channels that are available on MODIS, for the purpose of atmospheric correction.Both forward and inverse modeling strategies will be discussed. Synthetic data, as well as hyperspectral images of real data obtained over Case 1 as well as Case 2 waters, will be used to test the validity of the new retrieval approach. We will describe the status of our work, and outline future research directions.

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TEMPORAL VARIATION IN JUVENILE REEF FISH POPULATIONS AT THE WAI OPAE TIDEPOOLS IN KAPOHO HAWAII. CAN THIS AREA BE CONSIDERED A NURSERY?

The Wai Opae tidepool area in Kapoho, Hawaii is a popular destination for tourists and locals. The many large tidepools provide a sheltered area to snorkel and observe the numerous fish, corals, and other sea life. A portion of this area has recently been designated a Marine Life Conservation District (MLCD) by the state of Hawaii. This prohibits any collection of marine life from the area. The sheltered nature of this shallow reef area with its network of tidepools provides an excellent habitat for juvenile fish. There is a strong possibility that it is a nursery for reef fish of the island of Hawaii. Ongoing research has shown that juvenile fish as a whole were found to prefer shallow and/or closed tidepools. Additionally, data are being collected to study the temporal variation in the juvenile populations to observe recruitment into and movement out of the tidepools, in order to demonstrate the nursery function of Wai Opae. This study is important because it is the first attempt at documenting a reef fish nursery area on the island of Hawaii.

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BIOGEO-OPTICS: OPTICAL SCATTERING CROSS SECTIONS FOR SUSPENDED MINERAL AND ORGANIC MATTER OF COASTAL AND NEAR-COASTAL WATERS

The Naval Research Laboratory and NASA are sponsoring new initiatives in the study of in-water optical properties of suspended matter for coastal and near-coastal ocean waters. Improved remote sensing algorithms for suspended matter in coastal ocean water will not be forthcoming until the mass of suspended particulates is properly partitioned into inorganic and organic fractions. Such has not been the case heretofore where the occurrence of Total Suspended Solids (TSS) has been used to explain in-water scattering. We have been measuring TSS and then ashing the sample after the drying step. With this information on mass concentration of mineral and organic matter and the particulate spectral scattering coefficient from the WET labs AC-9 instrument we determine the scattering cross section of mineral and organic matter by multiple linear regression. This accurate partitioning into suspended mineral and organic components allows meaningful models and calculations using the known average refractive indices of mineral and organic matter. We are at the stage now of assessing the composition of the suspended particulate matter and assigning meaningful optical scattering cross sections for further modeling and research. The data for this effort come from cruises in Mobile Bay, AL, the Southwest pass of the Mississippi River, and Monterey Bay, CA. We will compare regional patterns of the optical scattering cross section for suspended mineral and organic matter.

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SURFACE CURRENTS OFF THE OUTER BANKS OF NORTH CAROLINA

Beginning in early summer 2003 two HF Radar units were deployed on the Outer Banks of North Carolina: at the Army Corps of Engineers Field Research Facility in Duck; and at the Cape Hatteras Coast Guard Facility in Buxton. Both were Long Range SeaSonde units, manufactured by Codar Ocean Sensors. This component of the regional observing system SEACOOS relies on ocean waves to scatter HF radio waves, then uses Doppler shift and theoretical wave speed to compute surface currents. Combining output from two sites results in a map of surface currents that are an average over a 6 by 6 km square of ocean up to 120 km from the shore. These measurements are a temporal average, outputting a three hour average every hour in near real time. Our analysis focuses on long term mean currents and tidal harmonic analyses for all points of consistent coverage in the region. Tidal ellipse parameters are compared to model results. Since the region of data coverage often includes part of the Gulf Stream, characteristics of its flow are compared with thermal imagery.

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TRACING THE PRODUCTION AND DEGRADATION OF AUTOCHTHONOUS FRACTIONS OF DISSOLVED ORGANIC MATTER

The marine dissolved organic matter pool consists of a complex mixture of compounds. Its composition, and therefore characteristics, vary with changes in supply and exposure to degradation processes. For many years, fluorescence spectroscopy has been used as both a quantitative and qualitative descriptor of DOM. Recently refined techniques combining fluorescence Excitation-Emission Matrix (EEM) spectroscopy and PARAFAC data analysis have proven to be valuable tools for characterising DOM and tracing its many different fractions in natural waters. In this work we present the results of a mesocosm experiment investigating the production and utilisation of DOM by the planktonic community under different inorganic nutrient regimes. The experiment was carried out in 10, 11 m3 polyethylene bags and followed with daily measurements for a period of 22 days. From our results we are able to identify a range of autochthonous components that differ in their rate of production and consumption. Additional bacterial and photochemical degradation experiments on the DOM produced, help us identify the importance of these processes as a sink for the respective DOM fractions. The results from this experimental approach provide a valuable insight to the temporal and compositional dynamics of phytoplankton derived DOM in the marine environment.

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EFFECTS OF INORGANIC IRON, PHOSPHORUS, AND DUST ADDITION ON PROKARYOTE COMMUNITY DYNAMICS IN THE NORTH PACIFIC SUBTROPICAL GYRE

Effects of inorganic Fe, P, and dust upon surface prokaryotic communities were investigated in the North Pacific Subtropical Gyre in July and September 2002, and July 2003. Fe, P, and local Aeolian dust were added to duplicate 20L incubations. Separate incubations were sacrificially sampled at 0, 48, and 96 hours. Heterotrophic bacterioplankton production was measured with tritiated thymidine uptake. In 70% of additions production was not significantly different from controls, in 12% production significantly decreased, and in 18% production significantly increased. Bacterial diversity in 0.2-1.2 micron fraction was determined by automated rRNA intergenic spacer analysis (ARISA). Clustering analysis demonstrated that communities in Fe, Fe+P, and dust additions showed greater similarity than communities in P additions and controls. Dust and Fe additions, however, diverged significantly from each other. Community change observed in ARISA did not correspond to production measurements. The divergence in community composition of the iron and dust cluster from phosphorus suggests a possible effect by iron, and presumably iron in dust, on the bacterioplankton community mesocosms.

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MEDFLUX: 210PO AND 210PB CONCENTRATIONS, FLUXES, AND PARTICLE SETTLING VELOCITIES AT THE DYFAMED SITE, NORTHWESTERN MEDITERRANEAN

As part of the MEDFLUX project, vertical profiles of the natural radionuclides 210Po, 210Pb, and 234Th were collected during March, May, and July 2003 at the DYFAMED site (Ligurian Sea). Novel settling velocity sediment traps and an elutriator were employed along with the traditional IRS sediment traps, Niskin bottles, and in situ pumps to explore the physical and temporal characteristics of sinking and suspended material. This is the first time that these radionuclides have been examined in samples separated by sinking velocity and may further elucidate the magnitude and composition of particulate flux. Preliminary elutriator results suggest that the specific activity of polonium may differ among particles sinking at different rates, with the highest activity in particles sinking 29 - 57 m/day. In addition, 50 - 60% of the total particulate polonium was found in particles sinking faster than 160 m/day in both elutriator and sinking velocity trap samples. These measurements will allow us to compare the efficiency of 210Po and 234Th as flux tracers, with an emphasis on the potential usefulness of 210Po as an organic carbon flux tracer.

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USING REAL-TIME DATA IN OCEANOGRAPHY COURSES AT THE COLLEGE LEVEL

I will describe how I use real-time data in four different types of university courses ranging from general introductory courses to specialized graduate courses, usefulness of using data, limitations, and student reactions.

In teaching my students, I am limited in the types of data, and types of work by classrooms and software. Few classrooms are equiped with multiple computers, and few computers have analysis software. Thus, I prefer to use data in the form of gif images which everyone can download and use. For advanced courses, which have fewer students, I can require students to learn specialized software such as OceanAtlas or Ocean Data View.

The biggest limitations from my perspective are: 1) the difficulty of doing quantitative work with gif images, although, in practice, it should be possible to write software to extract numbers behind the image. 2) Data sites keep changing their locations, URLs, and layout so I must check sites before class, and often revise class web pages. As a result, I tend to use long-lived sites, not short term project and principal investigator sites.

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TOWARDS AN INTERNATIONAL RESEARCH PROGRAM ON SEAMOUNT ECOLOGY AND BIOGEOGRAPHY

In August, 2003, the Census of Marine Life hosted an international workshop to review what is known about seamount ecology and define priorities for future research. The workshop resulted in a strong call for international coordination; progress towards such coordination through a devoted CoML field program on seamounts is presented, along with current opportunities for collaboration. The workshop focused on seamount biogeography, biodiversity, productivity, and evolution. It identified the following priority research questions: 1) how can seamounts be categorized with respect to community structure and what “proxy” variables may predict community structure; 2) how do seamount communities vary, within and between seamounts, with respect to ecological function; and 3) what ecological roles do seamounts play in the oceans as a whole? Priority activities for addressing these questions included: fostering new field research; coordinating and supporting existing and planned research; analyzing existing global seamount data to find emergent patterns and to efficiently guide future sampling; expanding SeamountsOnline (seamounts.sdsc.edu) as an open data resource; and creating mechanisms to effectively communicate scientific results to management and policy groups.

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EXOPOLYMERIC SUBSTANCES OVER THE WESTERN ARCTIC SHELF: A PRELIMINARY ASSESSMENT OF WATER COLUMN AND PACK ICE DISTRIBUTIONS

Exopolymeric substances (EPS) commonly produced by marine microbes constitute an important component of organic matter within marine habitats. EPS concentrations were measured during the spring Western Arctic Shelf-Basin Interactions (SBI) process cruise of 2002 and the relatively ice-free summer 2003 SBI survey cruise. Alcian blue staining of both water column and melted ice samples yielded EPS concentrations in excess of 6 mg xanthan gum equivalents (XGEQV)/liter. Preliminary estimates of EPS distributions reveal high concentrations of EPS throughout the study area. Ice concentrations and water column distributions are compared. High concentrations of EPS may potentially contribute significantly to carbon cycling over both the Chukchi and the Beaufort shelves and ultimately the Arctic basin. EPS distributions are examined with concurrent chlorophyll distributions made throughout the study area. This data set further adds to the evidence of the importance of EPS to the arctic carbon cycle.

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LIGHT ABSORPTION AND SCATTERING BY ASIAN MINERAL DUST AND EFFECTS ON OCEAN OPTICAL PROPERTIES

Our laboratory measurements show that the optical properties of Asian mineral dust suspended in seawater exhibit significant variability associated with the origin (hence the chemical and mineralogical composition) as well as the size distribution of particulate samples. The mass-specific absorption coefficient of mineral particles, a*, at a light wavelength 440 nm, varies from 0.028 m2 g-1 for relatively weakly absorbing sample from Chinese desert near Dunhuang to 0.15 m2 g-1 for the volcanic soil from Cheju Island (Korea). The sample collected during a massive dust storm over the Sea of Japan shows a* > 0.1 m2 g-1 for wavelengths shorter than 425 nm. The absorption decreases with wavelength to small or undetectable level in the far red/near infrared spectral region. The mass-specific scattering coefficient for different particulate assemblages ranges from approximately 0.8 to 1.5 m2 g-1 at blue and green wavelengths. These determinations of particle optical properties combined with atmospheric deposition rates of Asian dust onto the North Pacific Ocean provide estimates of potential contribution of mineral dust to ocean optical properties.

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TRACE ELEMENT COMPOSITION OF LARVAL BIVALVE SHELLS REFLECTS NATAL ENVIRONMENT

We are investigating the use of environmentally-occurring trace elements retained in the larval shells of bivalves as tags of their natal habitat. We have three objectives: 1) to determine geographically unique trace element signatures for Mya arenaria shell material from sites in New England; 2) to accurately measure the trace element composition of larval shell material retained on a juvenile; 3) to compare larval shell composition from recruits in a site to geographic patterns in shell signatures, to determine whether the recruits originated in the site

or from elsewhere. Laser-ablation and solution-based ICPMS analyses demonstrate that shell material formed at an urban site (Neponset River) has elevated levels of Pb, Mn, and Ba relative to shells formed at more rural Barnstable Harbor. The geographic difference has been consistent over three years (1999-2002) for Pb, suggesting temporal variability in this element is low relative to geographic variation. We are currently quantifying intra-seasonal variation in a suite of elements and are developing a laser-based protocol that reliably ablates only the thin larval shell material retained on shells of recently recruited individuals.

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GRAVITY AND PLANKTONIC COPEPODS: TO BE NEUTRALLY BUOYANT IS THE WORST

To be neutrally buoyant demands fine physiological controls. Most planktonic copepods are negatively buoyant necessitating constant swimming. However, since they combine swimming with creating a feeding current they gain from being heavier than water. A conflict situation exists when the suspended food is of lesser nutritional value or very sparse. I will examine the parameters governing the swimming/feeding behaviors of different calanoid copepods as observed in fresh-water, the Great Barrier Reef lagunes, and the East and West coasts of the US. Videos will be shown, and cookies provided.

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CORALS AND CLIMATE - BEYOND NATURAL VARIABILITY?

Coral reefs ecosystems are rapidly becoming ecosystem sentinels for our rapidly changing climate. Coral reefs are second only to rainforests in diversity of species, but they are dying off at an alarming rate. Not only does the loss of reefs represent a tragedy of epic proportions in itself, it may be a warning sign of dangerous trends to come. Using satellite sensors at NOAA, we are currently tracking ongoing Pacific Decadal Oscillations (PDO) as well as El Niño Southern Oscillation (ENSO) occurrences and linking them to coral responses. Coral Reef Watch (CRW), led by NOAA's Satellite and Information Service, and consisting of components from NOAA Research and NOAA Fisheries Service, continuously monitors and posts (Internet) coral reef areas world-wide for changes in sea surface temperature, as well as other key parameters linked to the onset of bleaching events. These environmental products are geared towards managers and stakeholders of coral reef areas and include tools to help them determine what areas are more susceptible to coral bleaching enabling them to focus manpower efforts more efficiently.

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EFFECTS OF TURBULENCE AND BEHAVIOR ON LARVAL SETTLEMENT IN WAVE-DRIVEN FLOW

The larvae of many benthic marine invertebrates settle and undergo metamorphosis in response to waterborne chemical cues, but it is debated whether behavioral responses to dissolved cues can affect larval transport to the substratum in the turbulent, wave-driven flow characteristic of many coastal habitats. We addressed this question using larvae of the sea slug, Phestilla sibogae, which stop swimming and sink in response to a waterborne species-specific metabolite of their prey, Porites compressa. We used a numerical model of larvae and dissolved cue carried in the wave-driven flow above a coral reef to explore the effects of turbulence and of specific aspects of larval behavior on the rate of transport of larvae to the substratum. Our model showed that even at high levels of turbulence, larval behavioral responses to enounters with cue can increase their rate of delivery into the reef.

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ZOOPLANKTON DISTRIBUTION IN COASTAL AND OCEANIC WATERS IN THE INDIAN OCEAN OFF SOUTH WEST OF AUSTRALIA.

The sea off Western Australia (WA) is influenced by a unique eastern boundary current, the Leeuwin current. Unlike the Benguela and Humboldt currents, which flow towards the equator, the Leeuwin current flows from the tropics towards higher latitudes, so there is little upwelling off Western Australia. The Leeuwin current is responsible for the dispersal and recruitment of tropical organisms to temperate areas of Western Australia. However, little is known about the interaction of this unique physical oceanography with zooplankton dynamics and variability in space and time. The mesozooplankton was sampled approximately monthly at 5 stations extending from near-shore to offshore environments using nets with 100 µm and 355µm mesh. Temporal and spatial variability within and among the stations is examined and correlated with the physical environment (e.g. currents and water masses), phytoplankton and microzooplankton abundance and community structure. The abundance and composition of zooplankton assemblages off WA is compared with those from other eastern boundary currents and related to biological productivity.

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UPTAKE OF IRON FROM ORGANIC COMPLEXES BY PLANKTON IN THE SOUTHERN OCEAN

The vast majority of dissolved Fe(III) in the ocean is bound to strong organic ligands. Although these ligands increase the solubility of Fe in seawater, Fe-ligand complexes are not directly available for uptake by eukaryotic phytoplankton. Biological and photochemical reduction of organically bound Fe(III) may enhance the dissociation of inorganic Fe from the organic complexes, and increase Fe uptake rates by phytoplankton. To elucidate the importance of these two mechanisms in Fe acquisition by indigenous plankton communities in the Southern Ocean, we determined short-term, non-saturating Fe uptake rates by plankton in three size-fractions (> 20, 2-20, and 0.2-2 micrometers) in the presence and absence of light. We used naturally occurring ligands in seawater, as well as six model organic Fe chelators, each differing in its Fe-binding functional groups, formation and dissociation rate constants for Fe, and photolability. Our results demonstrate that non-photolabile organic Fe complexes were a preferred source of Fe for all size-fractions. We shall discuss the relative importance of ligand kinetics and photolability in determining the availability of various organic Fe complexes to phytoplankton.

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A MOORED PROFILER TIME SERIES FROM THE SALT FINGER TRACER RELEASE EXPERIMENT

A moored vertical profiler was deployed in the thermohaline staircase of the western tropical Atlantic in February 2001 and recovered in April 2002. The instrument cycled between 100 m and 700 m depth, obtaining temperature, salinity, and horizontal velocity profiles six times per day for 4.3 months. The data reveal a staircase of ten persistent mixed layers in the main thermocline. The temperature and salinity of each layer display a unique linear relationship. The T-S trend lines for each layer cross isopycnals in a manner consistent with salt finger buoyancy flux divergence. The average ratio of thermal to haline density changes within the ten central layers is 0.86+-0.03, consistent with earlier spatial surveys. This ratio has a systematic variation such that layers in the middle of the staircase have a higher flux divergence ratio than those above or below. The vertical density ratio has an inverse variation, with lowest values in mid-staircase. The apparent flux divergence ratio decreases with increasing density ratio, consistent with salt finger theory, experimental and numerical simulations, and the Radko (2003) layer formation model.

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INVESTIGATION OF THE DIVERSITY AND FUNCTION OF PROTISTS IN BENTHIC MICROBIAL FOOD WEBS

This study concentrates on the seasonal composition and trophic dynamics of the benthic microbial community in freshwater and marine systems and on the effect of macrozoobenthos grazing on these communities. Laboratory experiments with and without added macrograzers were carried out with sediments from the North Sea, temperate lakes of Northern Germany and arctic lakes of North East Greenland. Incubation time varied between 30min and 5d. In further experiments, fluorescently labeled bacteria (FLBs) were added as food tracers in order to estimate bacterivory. The abundancec of bacteria, cyanobacteria, protists and meiofauna were determined at the beginning and in the end of all experiments. First results indicate no effect of the macrograzers Hydrobia ulvae (Gastropoda), Corophium volutator (Crustacea), Potamopyrgus antipodarum (Gastropoda), mixed polychaets (Annelida) and chironomid larvae (Insecta) on the abundance of bacteria and flagellates. However, FLB experiments revealed a removal of 40 to 60% of the standing bacterial stock per day, with no differences between the treatments with and without macrograzers. These results point a minor effect of macrograzers as bacterivores. Implications on the structure of the food web will be discussed.

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EFFECTS OF THE AMAZON RIVER PLUME ON PHYTOPLANKTON SPECIES COMPOSITION IN THE WESTERN TROPICAL ATLANTIC OCEAN (WEQAT)

The Amazon River flow is five times that of the world's second largest river and accounts for 15% of all freshwater input to the sea. We studied the major chemical and physical forcings that affect phytoplankton populations of the WEQAT with particular reference to keystone N2 fixing phytoplankton in the winter (Jan/Feb) during a period of low runoff, in the spring (Apr/May) during a period when the runoff just began and in the summer (Jul/Aug) during a period when the runoff was "mature". We found that the river transports vast quantities of chromophoric dissolved organic matter (CDOM) and that the absorption due to CDOM at the surface changes the underwater light field very significantly. The results of our analyses show a clear change in near surface phytoplankton species composition as we tracked the plume water from relatively fresh (~25 PSS) to the oceanic end member (>36 PSS). We also found that the dominant organism in the deep chlorophyll max changed from Prochlorococcus to Synechoccocus as the underwater light field changed due to the presence of the plume.

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DISTRIBUTION OF LARGE MEDUSAE OFF THE COASTS OF WASHINGTON AND OREGON, USA: SEASONAL AND INTERANNUAL VARIABILITY IN RELATION TO ENVIRONMENTAL CONDITIONS

Although they can exert substantial predation pressure on zooplankton and ichthyoplankton, gelatinous zooplankton remain relatively understudied in coastal upwelling areas. We analyzed a multi-year, regional-scale data set to determine habitat, seasonal appearance, and interannual variability of large medusae in the northern California Current. The scyphomedusa Chrysaora fuscescens and the hydromedusa Aequorea sp. were among the most common taxa caught in trawls deployed in surface waters across the Oregon and Washington shelf during 1) 10-day cruises in May, June, and September, and 2) bi-weekly 2-day cruises from April through August of 2000 to 2003. Density of C. fuscescens increased dramatically from late spring through summer months each year, with maximum abundance approximately 1/m3 and biomass comparable to that of net zooplankton. C. fuscescens were retained close to shore, and within fronts associated with the Columbia River plume, whereas Aequorea sp. were more widely distributed across the shelf. We report where and when aggregations occurred, how distributions varied with environmental parameters, and how timing of population growth coincided with initiation and magnitude of seasonal upwelling.

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BIOPHYSICAL AND OPTICAL DETERMINATIONS OF LIGHT ABSORPTION BY PHYTOPLANKTON IN VIVO AND IN SITU

Active fluorescence techniques, such as fast repetition rate (FRR) fluorescence, enable rapid determinations of light absorption by photosystem II (PSII) and can thus improve the resolution of bio-optical phytoplankton productivity models. Laboratory experiments compared biophysical (FRR) and optical determinations of the chlorophyll a-specific absorption cross-section from phytoplankton taxa with different pigment compliments and light harvesting arrangements. The rate of light absorption by functional PSII reaction centres from FRR fluorescence was highly variable between taxa and growth irradiance but was highest (1000-1400 A2/quanta) in small-celled eukaryotes and lowest (150-350 A2/quanta) in cyanobacteria. Both approaches yielded a high range of chlorophyll a-specific light absorption (~ 0.0025 to 0.015 m2/mg chlorophyll a) but values were similar for the majority of species tested (biophysical = 0.973*optical, r2 = 0.852, n = 22). Optical and biophysical estimations of chlorophyll a-specific light absorption were subsequently determined in the Celtic Sea at stations characterised by distinct water column and phytoplankton community structure and relatively high concentrations of chlorophyll a (~ 0.5 to 5 mg/m3) in an attempt to confirm the relationship in situ.

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FIELD AND LABORATORY CHARATERIZATION OF A NEW HYPER-SPECTRAL AC METER (THE AC-S)

A new, in-situ hyper-spectral absorption and attenuation meter (the AC-S) has recently been developed by WET-Labs (Philomath, OR - http://www.wetlabs.com). A complete mechanical description of this sensor is provided separately. The AC-S employs the same path-length and absorption and attenuation optical configuration for measurement, as a WET-Labs ac-9 (9 wavelength ac meter), allowing the established calibration and correction protocols of an ac-9 to be used on the AC-S. However, the AC-S has hyper-spectral resolution with approximately 100 wavelength bands between 390-740 nm (~ 4 nm bandwidth). The performance of the AC-S was tested in a series of comparative laboratory studies and field measurements with a WET-Labs ac-9. The calibration stability and precision of the AC-S measurements were comparable to that of an ac-9. Laboratory measurements in tank water with pure scattering (Maalox added to DI) and pure absorption (CDOM added to DI) yielded very similar absorption and attenuation values between the two instruments (within the calibration precision of each sensor), additionally AC-S field measurements from Narragansett Bay and Narrow River, RI compared well with those of an ac-9.

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STABLE CARBON ISOTOPIC ALTERATIONS OF ALGAL LIPIDS DURING DECOMPOSITION IN CARIACO STRATIFIED OXIC AND ANOXIC SEAWATERS

To examine the effects of diagensis on the molecular isotopic signals of algal lipids, cultured Emiliania huxleyi cells were incubated in seawater collected from 30 m and 930 m in the Cariaco Basin. In oxic seawater, three classes of algal lipids (alkenones, fatty acids, and sterols) degraded almost completely in 2-3 months (the only exception was 16:0 fatty acid) but in anoxic seawater 10-40% of initial algal lipids remained after three months. During degradation, alkenones became more isotopically depleted (-4 to -6‰) in 13-C, fatty acids became enriched (+2 to +7‰) and sterols showed little change. It appears that anoxic degradation resulted in more fractionation (either positive or negative) than oxic degradation. Isotopic fractionation, which depends on the lipid compounds, is likely caused by specific chemical reactions at specific function groups, where the carbon atoms may have dissimilar isotopic ratios from other carbons in the molecules. Significant molecular isotopic shifts found in this laboratory study provided a direct evidence of diagenetic effects on the molecular isotopic signal in preserved organic matter.

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FEEDBACK INTERACTIONS BETWEEN NUTRIENTS, DIMETHYLSULFIDE, AND CLIMATE

Dimethylsulfide (DMS), a volatile compound derived from the algal osmolyte dimethylsulfoniopropionate (DMSP), influences climate by providing a source of sulfate condensation nuclei in clouds. DMS occurs at similar concentrations in oceanic and coastal surface waters despite much higher neritic Chl a levels. Consequently, ratios of DMSP and DMS to Chl are 20-100 times higher in the open ocean. The results of enrichment bottle experiments suggest that nutrient availability may play an important role in coastal/oceanic patterns in DMS and DMSP, and in their regulation in surface ocean waters. In oligotrophic surface water from the Sargasso Sea, the addition of nutrients (N and P) decreased the DMSP:Chl ratio by 6-fold and the DMS:Chl ratio by 15-fold after two days relative to the no-addition control. Likewise, in productive water from coastal North Carolina, a sample amended with nutrients had a 12-fold lower DMSP:Chl ratio and a 21-fold lower DMS:Chl ratio after 24 h relative to the control. Similar effects of nutrients were observed with algal cultures. The low nutrient concentrations in surface ocean waters are largely caused by solar thermal stratification, which limits nutrient supply from colder, deeper waters. Consequently, large-scale feed-backs may exist among thermal stratification of ocean water, nutrient supply to phytoplankton, and DMSP and DMS dynamics, which influence climate.

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SEQUENCE ANALYSIS INDICATES MOST VIRUSES IN THE SEA BELONG TO UNKNOWN GROUPS

We have complete sequence from ssRNA and dsDNA viruses that are associated with lysis of the toxic microalga, Heterosigma akashiwo, and from a phage that infects Vibrio parahaemolyticus. As well, we have partial sequence from a dsDNA virus infecting a heterotrophic flagellate (Cafeteria sp.), and many sequences from viral genes PCR amplified from aquatic communities. Many of these are only distantly related to sequences from known viruses. For example, for the gene encoding the major capsid protein of cyanomyoviruses, many sequences fall into unknown groups. However, very similar sequences occur in a wide range of environments from Arctic ice-melt lakes to the Gulf of Mexico. DNA polymerase gene sequences of podoviruses were also striking; the most commonly occurring sequences were not closely related to those from known phage. The most startling results came from viral isolates. For example, the ssRNA virus infecting H. akashiwo, appears to belong to a new family of picorna-like viruses, the virus infecting Cafeteria sp. has homology with African Swine Fever Virus and Iridoviruses, while a dsDNA virus associated with lysis of H. akashiwo appears phage-like but has little homology with other viral sequences. The virus infecting V. parahaemolyticus has the greatest homology with extant sequence, but nonetheless, appears to be an ancestor to a T7-like supergroup. Such data suggest that marine viruses may represent the greatest unknown biological diversity discovered to date.

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TROPHIC ECOLOGY OF THE DEEP-SEA FISH MALACOSTEUS NIGER: AN ENIGMATIC FEEDING STRATEGY SUPPLIES CHLOROPHYLL FOR VISION?

The 'dragonfishes' and their relatives (family Stomiidae) are among the top predators of the mesopelagic zone of the open ocean. Based on feeding morphology (e.g., large gape, long fangs, and no gill-rakers or ethmoid membrane), the meso/bathypelagic fish Malacosteus niger would also be expected to be a large-item predator, as are the other members of its family. However, analysis of specimens from different ocean basins revealed that the most common prey items are calanoid copepods, despite an apparent inability to handle such small prey. Malacosteus niger is considered advanced within the Stomiidae, so this feeding mode represents a secondary reversion to planktivory. Feeding mechanics are unknown, but the integration of trophic, visual and distributional ecology may explain this finding. Malacosteus niger is unique in the possession of a chlorophyll-derived photosensitizer (bacterial pheophorbide), which it uses to see its own far-red bioluminescence. This pigment, whose synthesis by vertebrates is unlikely, may be incorporated through an anaerobic phototrophic bacteria-(protist?)-copepod-fish trophic linkage. In essence, the atypical diet of Malacosteus niger may be driven by the need for this pigment rather than by energetics per se.

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ROLE OF DECOMPOSITION, AGGREGATION AND DISSOLUTION OF DIATOMS IN THE SINKING FLUX OF ORGANIC MATTER TO THE MESOPELAGIC LAYER

Diatoms play on important role in the biological pump of CO2. The contribution of diatoms to the biological pump depends on the fate of diatoms via their production, decomposition, aggregation and dissolution in the pelagic layer. We have tried to clarify coupling of organic matter decomposition and biogenic silica dissolution with laboratory experiment. We also compared observations in the field and model calculation using parameters obtained from laboratory experiments. Two different incubation experiments were conducted in the dark, at constant temperature: 1) decomposition and aggregation experiments using Skeletonema costatum which is cultivated phytoplankton, 2) decomposition and dissolution experiments using natural seawater collected at depths of 20m, 100m, 800m. We found that there are strong co-relationship among rates of decomposition, aggregation and dissolution, these three processes depend on temperature and initial size of fresh pytoplnakton , not concentration of organic matters.An increase of 10 degree C in water temperature doubled the rate constant of decomposition, aggregation and dissolution . Our results suggest that the structure of the ecosystem and mineral and organic matter content of organisms controls the sinking flux of organic matter.

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UVA PHOTOECOLOGY OF SUBSURFACE CHLOROPHYLL-A MAXIMA OF THE SANTA BARBARA CHANNEL

Our findings suggest UVA radiation (320-400nm) may be a significant control on the vertical distribution of subsurface Chl-a maxima within the Santa Barbara Channel. Data presented comprise 25 days spanning all four seasons of 1998, and include coverage of water masses with diverse hydrographic characteristics and phytoplankton community composition. Values are based upon in situ GUV-PUV determinations of the UV-PAR underwater light field, and upon coincident CTD-fluorescence profiles. 92% of Chl-a maxima studied were located at depths characterized only by UVA-PAR light fields [i.e., where no UVB (280-320nm) was present]. Chl-a maxima were never localized in PAR-only light environments. Our dataset is further supported by in situ drifter determinations of UV effects on phytoplankton pigmentation and primary production. Certain UVA wavelengths affect PAR-based primary production by inhibiting carbon fixation as much as 10%, and/or enhancing PAR-based production by up to 30% (Mengelt and Prezelin, this conference). We continue to assess whether subsurface Chl-a maxima are associated with a definable range of UVA:PAR, and whether this ratio is a tool for estimating UVA controls on marine primary production and bio-optical properties.

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FIRST HYDROGRAPHIC RESULTS FROM THE 2003 SBI SURVEY CRUISE

The primary scientific goal of the Arctic Shelf-Basin Interactions (SBI) 2003 Survey cruise, 05 July - 20 August on RVIB Nathaniel B. Palmer, was to carry out a CTD/lADCP/O2/nutrient/chl-a survey of the outer shelf and slope of Chukchi and Beaufort seas. The survey included high-resolution sections (5 km station spacing) across key regions, covered the entire SBI study area more comprehensively than feasible during other SBI cruises, and repeated two of the intensely-sampled sections during the cruise.
The 329 stations provided a finely detailed, coherent view of the variations across the shelf and continental slope. A potpourri of early results includes: identifying and tracing two shelf water masses from their regions of origin, through Barrow Canyon, and into the slope regime; clear identification of shelf-influenced intermediate waters over the slope, and the transition to basin interior characteristics; observations across several eddies; and a surprise finding of a strong broad westward flow of upper layer water 75 km off the Beaufort slope with nearly identical properties to those over the slope itself.

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SPATIAL AND TEMPORAL DYNAMICS OF PHYTOPLANKTON IN MISSION BAY OVER A COMPLETE ANNUAL CYCLE

Mission Bay is a shallow estuary flushed primarily by tidal circulation. The eastern region of the bay receives little or no tidal flushing, compared to areas closer to the mouth. From November 2002 through November 2003, biweekly sampling was conducted at six sites within Mission Bay. Hydrographic, nutrient, and phytoplankton abundance data were gathered at each site. Spatial variation in sea surface temperatures was observed, with temperature differences up to 8.1 degrees Celsius between sites located near the mouth and back bay during the summer. Nutrient levels also varied spatially, with highest concentrations in the back regions of the bay, decreasing with proximity to the ocean. Areas with higher nutrient concentrations generally had lower phytoplankton diversity, while the regions with lower nutrient concentrations had higher phytoplankton diversity. Distinct fluctuations were observed between communities dominated by either diatoms or dinoflagellates, with pronounced seasonal shifts in the east bay. Phytoplankton densities generally were highest when diatoms dominated the community. Densities fluctuated throughout the year, with peaks in abundance observed during the spring and summer months.

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THE QUESTION OF UNIQUENESS IN REMOTE SENSING OF THE INHERENT OPTICAL PROPERTIES OF OCEAN WATER

We examine the problem of uniqueness in the relationship between the Remote Sensing Reflectance (Rrs) and the Inherent Optical Properties of ocean water (IOPs). The results point to the fact that diffuse reflectance of plane irradiance is inherently ambiguous. Furthermore, in the 400 to 750 nm region of the spectrum, Rrs also suffers from ambiguity caused by the similarity in the wavelength dependence of the absorption coefficients due to particulate and Color Dissolved Organic Matter (CDOM). The two absorption coefficients have overlapping exponential response leading to the fact that more than one combination of IOPs can produce nearly same Rrs spectrum. This ambiguity in absorption parameters demands that we identify the regions of Rrs spectrum where we can isolate the effects that can be attributed only to the scattering by particulate and the absorption by pure water. Our results indicate that the spectral shape of the absorption coefficient by phytoplankton, aph, cannot be derived from multi-parameter fit to Rrs. However, its magnitude and its spectral dependence can be estimated from the difference between measured Rrs and the best fit to Rrs in terms of IOPs that exclude aph. We answer two questions: Why are algorithms for IOPs not global especially in presence of CDOM? Why do we need hyperspectral measurements of Rrs rather than measuring Rrs at few well-placed wavelengths in order to retrieve IOPs from Rrs data?

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ASSESSMENT OF RADIOACTIVITY IN SOIL, SEDIMENT AND GRASS ON KUTUBDIA ISLAND IN BANGLADESH USING HIGH RESOLUTION GAMMA-RAY SPECTROMETRY

A series of measurements have been conducted to study the concentration of natural radionuclides (U-series, Th-series and K-40) and artificial radionuclides (Cs-137) in the soil, sediment and grass on Kutubdia island in the Chittagong region of Bangladesh. A total of 33 soil samples, 30 grass samples and 10 sediment samples were collected and then the measurements were carried out using gamma-ray spectrometry with a high purity germanium detector, coupled with Personal Computer Analyzer Sierra-2008. The exact isotopes used were Th-232, Th-228, Ra-226, K-40 and Cs-137. The ranges and average values of activity concentration were calculated in Bq/kg for each isotope in soil, sediment and grass. The results revealed that the activity of K-40 in soil samples has been found to be relatively higher than that of other places in the Chittagong region. The activity of Cs-137 in soil samples varies. The maximum activity of Cs-137 was found to be 8.66±0.50 Bq/kg in the sediment samples and in almost all the grass samples the activity was below detection level.

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THE IMPORTANCE OF IRON CYCLE COMPLEXITY WHEN PREDICTING C-CYCLE RESPONSE TO FE FERTILIZATION

Ecosystem models currently use iron (Fe) cycles of varying detail and complexity, from simple, one species models to more mechanistic parameterizations including a variety of chemical and biological processes. How sensitive are model predictions of carbon cycling to the detail of the Fe cycle when simulating Fe fertilization? In this study we present a new version of the CIAO model of the Ross Sea (Antarctica), parameterized to include phosphate, the carbonate system, and an Fe cycle of varying complexity. We examine the overall impact of Fe fertilization and shifts in the taxonomic composition of the phytoplankton on the Ross Sea carbon cycle. Model results were found to exhibit a high degree of spatial heterogeneity; dependent on both existing degree of Fe supply and biological pump efficiency, and variability in taxon-specific Fe demands. The impact of including a more mechanistic Fe cycle, including Fe2+ and Fe3+, photoproduction, scavenging, and redox reactions is assessed. Model predictions are compared and contrasted and the necessary detail required of the modeled Fe cycle will be discussed.

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APPLICATION OF REAL-TIME PCR TO STUDY THE ENVIRONMENTAL REGULATION OF GENE EXPRESSION OF NITROGEN ASSIMILATION IN DIATOMS

Diatoms are the most numerous primary producers in coastal upwelling regions. They dominate the biological pump and the carbon biogeochemical cycling. It is, however, difficult to identify diatom contributions to carbon and nitrogen assimilation, unless molecular genetic approaches are used. Emerging real-time PCR technology offers a quantitative means to measure when and to what extent, genes for particular enzymes are 'turned on' in taxa of interest in given environments. In the nitrogen assimilation pathway of diatoms, NH4 is incorporated into organic nitrogenous compounds via the action of glutamine synthetase (GS). The source of NH4 may be external or the internal product of NO3 reduction or photorespiration. We measured transcription levels of three GS isoforms in cultures of a ubiquitous diatom, Thalassiosira pseudonana, grown in different nitrogen regimes. Transcription of GSII was induced as a rapid response to externally available nitrogen whereas GSIII was constitutively expressed. Transcription of GSI was often below the level of detection. How GS expression may vary with changing environmental conditions and how different taxa may exhibit different physiological or genetic capabilities regarding GS will be discussed.

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SEASONAL VARIATION OF IN SITU GRAZING RATE OF THE COPEPOD COMMUNITY IN THE OYASHIO RIGION OF THE SUBARCTIC PACIFIC OCEAN

The role of copepod grazing on the ecosystem dynamics in the Oyashio region, western subarctic Pacific was investigated during 6 cruises from June 2001 to June 2002. In situ grazing rates of copepods community (CGR) were measured by gut fluorescence method. Eucalanus bungii, Neocalanus cristatus, N. flemingeri, N. plumchrus, Metridia okhotensis, and M. pacifica were important as a grazer through the year. The CGR was lowest, 8-15 mg C m-2 d-1, during autumn to winter (November2001, January2002) and increased to 200 mg C m-2 d-1 during the spring bloom period (April 2002). The highest CGR was observed in June 2002 (400 mg C m-2 d-1) and much higher than one in June 2001 (65 mg C m-2 d-1) due to higher copepods biomass. CGR in June 2002 contributed 87 % of the primary production, while CGRs in other periods did 2-20 % of the primary production. The annual CGR was 37g C m-2, accounting for 13 % of annual primary production. These showed that copepods play an important role for phytoplankton dynamics in the Oyashio region, especially after the spring bloom.

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INTERMEDIATE GROWTH RATES OF IRON-STRESSED DIATOMS INDUCE SILICATE DEPLETION RELATIVE TO NITRATE IN THE SUBARCTIC PACIFIC WATERS

In the Subarctic Ecosystem Response to Iron Enrichment Study (SERIES), increases in the Si:NO3 uptake ratios by diatoms were observed upon iron-stress during the transition to post-bloom conditions. The elevated Si:NO3 uptake ratios were due primarily to increases in silicate consumption relative to nitrate. Numerical experiments are conducted to examine the reasons for the observed changes in silicate and nitrate consumption upon iron stress. Phytoplankton suffering from an insufficiency of iron can continue to grow at a reduced rate for some time by using intracellularly-stored iron. Under the growth rates of 0.1-0.2 d-1, only nitrate consumption decreases and silicate consumption is nearly constant, as previously reported in the bottle incubation experiments in HNLC waters. While the growth at intermediate levels of 0.2-0.3 d-1, which are equivalent to the observed rates during the SERIES, lead to a slight increase in nitrate consumption, but a large increase in silicate consumption. Thus continued growth of iron-stressed diatom at intermediate levels seem to induce depletion of silicate relative to nitrate and lead to simultaneous limitation of growth by both iron and silicate.

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SEASONAL AND INTERANNUAL VARIATION OF SEAWIFS CHLOROPHYLL A IN MALACCA STRAITS

The oceanographic conditions in Malacca Straits are strongly influence by the monsoon system, as well as the influence from river inflow at the coastal area. Five years of SeaWiFS monthly mean chlorophyll a data (January 1998 until December 2002) had been applied in this study. Results showed that mean chlorophyll a concentration in Malacca Straits highest during the northeast monsoon season (November-February), while lowest during the southwest monsoon season (May-August). The northern and southern parts of Malacca Straits exhibit difference in seasonal chlorophyll a variation. Southern Malacca Straits showed higher chlorophyll a concentration, and SeaWiFS algorithm might over-estimating the chlorophyll a concentration in this area due to turbid water. Seasonal chlorophyll a variation shows similar trend with the Equatorial Southern Oscillation Index (EQSOI) during the La Nina event from September 1998 until August 2001. The Dipole Mode Index (DMI) also exhibits certain time lag relationship with the seasonal variation of chlorophyll a. This study will be continued to further examine the interannual chlorophyll a variation that related to global climate changes.

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COUPLED PHYSICAL-BIOLOGICAL PROCESSES AND RECRUITMENT OF CAPELIN LARVAE IN COASTAL WATERS OF NORWAY

The strategic program BASECOEX (Capelin and Herring in the Barents Sea-coexistence or exclusion) is a multidisciplinary research project for understanding capelin-herring interactions in the Barents Sea. The project has undertaken field surveys to resolve the 3-dimensional advection, migration and in situ population dynamic rates of capelin larvae and zooplankton in the core spawning area of capelin. The spawning sites of capelin are often found in fjords and adjacent areas on the shelf of northern Norway, where tidal currents, wind driven currents, density driven currents and coastal up- or downwelling events interact. The Scanfish package (including OPC and Seabird CTDF) provides high-resolution data that can be used to understand variations of mesoscale physical fields and the phytoplankton-zooplankton-ichthyoplankton linkage. Eddies were revealed from the mesoscale temperature and salinity structure. Translation speed of these mesoscale eddies was approximately 7 km day-1. OPC measurements also revealed mesoscale patterns in phytoplankton and zooplankton fields that can be explained by the physical forcing, such as advection of jets and entrapment of eddies, and behavior of zooplankton and capelin larvae.

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BIOCOMPLEXITY: SPATIAL VARIABILITY IN THE REPRODUCTIVE OUTPUT OF INTERTIDAL BARNACLES IN SOUTHERN AND BAJA CALIFORNIA – EFFECTS ON DISTRIBUTION AND DYNAMICS

We have monitored the size structure, reproductive activity and fecundity at size of the intertidal barnacle Balanus glandula in Southern and Baja California. Monthly samples were taken from seven sites located between Dana Point (Orange County, CA) and Punta Baja (Baja California). Data on the annual cycle of brooding activity and the size structure of adult barnacles were used along with fecundity-at-size and density estimates to compute the reproductive output (i.e. number of larvae produced per unit length of coastline) of B. glandula at each site. These estimates were in turn used to parameterize a coupled benthic-oceanic model of the population, which describes the adult and larval dynamics in terms of their abundance and distribution along a one-dimensional shoreline and on a two-dimensional ocean, respectively. The model was used to test different scenarios in terms of spatial gradients in reproductive output, as well as to generate testable hypotheses regarding the proximate cause for a southern boundary in the distribution of B. glandula south of Punta Baja.

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INDUCTION OF STRESS PROTEINS IN THE COPEPOD ACARTIA TONSA

Cells from all organisms respond to many stressful stimuli by the rapid synthesis of a family of highly conserved polypeptides known as stress or heat shock proteins (HSP). One physiological role of these proteins is to protect organisms from damage caused by solar ultraviolet radiation (UVR, 290-400 nm). Here, we present data of HSP induction experiments conducted with the copepod Acartia tonsa. The animals were collected from Tampa Bay, Florida, and exposed to in situ levels of solar radiation or kept in the dark for 1-4 h. Simultaneously, UVR, PAR (400-700 nm), and temperature were monitored. After exposure, the animals were radiolabeled (sulfur-35); protein electrophoresis (12% polyacrylamide gels in a SDS-buffer system) and fluorography were used to measure the amount of newly synthesized proteins. Stress proteins were induced in both treatments, suggesting that other factors in addition to UVR (e.g., increased temperature) were responsible for HSP synthesis. Interestingly, high UV doses caused suppression in the protein synthesis of the copepods. Our data indicate that several abiotic stressors are responsible for the induction of stress proteins in marine copepods.

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ENERGY CRISIS IN THE CARIACO BASIN'S REDOXCLINE: DOES MICROBIAL DEMAND EXCEED SUPPLY?

Carbon fluxes, through primary production, sedimentation, microheterotrophic production, acetate turnover and chemoautotrophy, have been measured in the Cariaco Basin at intervals varying from biweekly to semiannually since 1995 by the CARIACO Time Series program. We have focused on carbon biogeochemistry of the redoxcline, that depth interval where O2 disappears and the H2S concentration gradient is steepest, usually between 250 and 450 m. Decreases in particulate organic carbon (POC) flux between sediment traps at 250 and 450 m

seldom exceed microheterotrophic carbon consumption estimated from 3H-leucine productivity. Energy demand in the form of reduced carbon consumption by microheterotrophs in the redoxcline apparently exceeds vertical transport of POC from surface waters. We previously demonstrated that midwater production by chemoautotrophs provides fresh organic matter to this zone. Mass balances suggest this production exceeds the microheterotroph's unmet energy needs. However, estimates of inorganic reductant (H2S, NH4) fluxes to the chemoautotrophic zone account for < 5% of autotrophic energy demand. Our analysis underscores shortcomings of 1-D vertical models for this ecosystem. We will explore alternative explanations for the energy imbalance and evidence for proposed processes.

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SPATIAL COHERENCE OF ESTUARINE EMERGENCE PATTERNS

Previous studies using one TAPS instrument (a 6-frequency, moored, upward-looking sonar) in the Damariscotta River estuary showed nocturnal increases in backscatter caused largely by the nightly emergence from the benthos into the water column of Neomysis americana and Crangon septemspinosa. There appear to be multiple events in a night with the greatest emergence rates occurring during the first decelerating tide after dark. Various clues suggested an offshore-onshore component of migration as well as the vertical one. Two TAPS instruments were deployed in the summer of 2003, 50 m apart from one another alongshore. At this distance, the backscatter signal was coherent between the two instruments, with the greatest cross-correlation occurring at zero lag. This result suggests that emergence and re-entry by organisms in a wide area is relatively synchronous. Examination of small changes in the initiation time and pattern of emergence events in locations separated alongshore and cross shore can help us to refine hypotheses both about the cues controlling emergence and the dispersal consequences of these behaviors.

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THYLAKOID MEMBRANE LIPID COMPOSITION IS THE MECHANISTIC BASIS FOR UNDERSTANDING AND DIAGNOSING CORAL BLEACHING PATTERNS.

Coral bleaching is induced by positive anomalous temperatures in surface waters is a growing concern worldwide. The susceptibility to elevated temperature stress (ETS) varies strikingly between species and even within the same species. We report that thylakoid membrane lipid composition in the algal symbiont is critical in determining the susceptibility to thermal stress. Parallel, 28 S rDNA sequence analysis, demonstrates there is no correlation between phylogenetic assignment of the symbiotic algal type and their thylakoid membrane lipid composition. The thylakoid membrane lipid composition affects the structural integrity of PSII. This finding provides a mechanistic basis for understanding and diagnosing coral bleaching patterns. Measurements of photosynthetic energy conversion efficiency indicate that in heat sensitive clones, the inability to change lipid composition at elevated temperatures leads to the loss of photosynthetic competence and the simultaneous production of reactive oxygen species. Ultrastructural and histological analyses suggest the latter are agents of cell destruction in vivo.

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UPTAKE OF D- VS. L- AMINO ACIDS BY THE MAIN PROKARYOTES IN THE MESO- AND BATHYPELAGIC WATERS OF THE NORTH ATLANTIC

Only recently, fluorescence in situ hybridization (FISH) became sufficiently sensitive to allow the enumeration of prokaryotes even in oligotrophic and deep waters by using catalyzed reporter deposition (CARD-FISH). Using this method in combination with microautoradiography, we determined the uptake of D- vs. L-aspartic acid (asp) by the major prokaryotic groups (Bacteria, Eury- and Crenarchaeota) in samples collected in the North Atlantic between 100m and 4,500m depth. Recently, it has been reported that the prokaryotic D-/L-asp uptake ratio for the bulk community increases by 2-3 orders of magnitude from the surface to bathypelagic waters. Thus our overall goal was to identify the prokaryotic group responsible for this shift in the D-/L- asp uptake ratio with depth. Our data indicate that Archaea are both more abundant (about 40% of DAPI stained cells) than Bacteria (30% of DAPI) and more active (60% vs 40% of active cells) in meso- and bathypelagic waters. The previously reported increase of the D-/L-asp uptake ratio with depth is mainly due to an increase in the ratio of D-/L-asp uptake by Crenarchaeota towards the ocean's interior.

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THE ALLIANCE FOR COASTAL TECHNOLOGIES (ACT): DEVELOPING, IMPROVING, AND SHARING INFORMATION ON SENSORS AND SENSOR PLATFORMS

The Alliance for Coastal Technologies is a NOAA-funded partnership of research institutions, state/regional resource managers, and private sector companies interested in sensor technologies for studying and monitoring coastal environments. ACT was established on the belief that instrument validation and open communication is necessary so that effective existing sensor/senor platform technologies are recognized and promising new technologies become available to support both basic research and resource management and the long-term development of a U.S. Integrated Ocean Observing System. The specific functions of ACT are to serve as: (1) an unbiased, third-party testbed for evaluating existing, new, and developing coastal sensors and sensor platforms; (2) a comprehensive data and information clearinghouse on coastal technologies; and (3) a forum for capacity building through workshops and seminars on specific technology topics. We will describe how ACT is aiding resource managers, coastal scientists, and private sector companies by facilitating interactions between the groups and by providing critical information on the latest, best, innovative, and most efficient technologies for monitoring, studying, and predicting the state of coastal waters.

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VALIDATION OF GEOLOCATION ESTIMATES BASED ON LIGHT LEVEL AND SEA SURFACE TEMPERATURE FROM ELECTRONIC TAGS

Geolocation estimates based on light levels and sea surface temperatures (SSTs) from electronic tags have enhanced our understanding of the movements of pelagic animals but the validation of these estimates is difficult. We report double tagging experiments on free-swimming salmon sharks and blue sharks, comparing Argos positions with light and SST geolocations. The pop-up tag endpoints and recapture locations of Atlantic bluefin tunas are also compared with light and SST geolocations. In the double tagging experiments, light level longitudes had root mean square (rms) errors of 0.55 to 0.89 while SST latitude estimates had rms errors of 1.06 to 1.54 . Atlantic bluefin tunas with archival datasets had rms errors of 0.76 and 0.93 for light level longitudes and SST latitudes, respectively. Using data transmitted by pop-up tags from Atlantic bluefin tunas, light level longitudes had a rms error of 1.30 and SST latitudes had a rms error of 1.89 . These results demonstrate that SST can be used with light levels to significantly improve geolocation estimates from electronic tags.

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NATURAL EUTROPHICATION OF THE EASTERN CARIBBEAN SEA

Douglas Cay of the Pelican Cay group and the Lair at Twin Cays (Atlantic Coral Reef off Belize, Central America) were the sites for a comparative study of natural enrichment effects on oligotrophic waters. Douglas Cay is remote and without major human perturbations, but is characterized by a population of brown pelicans that feed on large schools of fish associated with the mangrove fringe. The comparison site, the Lair does not have a substantial pelican population. Examination of 8 days of continuous environmental measurements (PAR, pH, dissolved oxygen, fluorescence, temperature, salinity and wind speed) at Douglas Cay indicated a cyclic increase in dissolved oxygen in the water column during the night that was four fold greater than the peak DO concentration in the water column during the day. Close inspection of the records suggest the basin at Douglas Cay experienced a nightly turnover of the water column and the oxygen was likely due to benthic production. Chlorophyll biomass and nutrient addition studies suggest Douglas Cay was not nutrient limited while the Lair was oligotrophic.

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ISOLATING NEW SILICIC ACID TRANSPORTERS FROM DIATOMS FOR COMPARATIVE SEQUENCE ANALYSIS

Diatoms have long been admired for the intricate microstructure of their silica frustules. Uptake experiments have provided critical information about silicon metabolism, but molecular mechanisms regulating transport remain unknown. Silicic acid transporters (SITs), first identified in the marine pennate diatom, Cylindrotheca fusiformis, represent a novel family of transporters and were the first proteins shown to directly interact with silicon. The predicted transmembrane domains of the SITs are likely to contain amino acid residues directly involved in silicon transport. The purpose of this project is to compare SITs from evolutionarily distant diatoms to identify conserved amino acids essential for recognition, binding, and transport of silicic acid. Primers designed based on conserved residues with low degeneracy in C. fusiformis SITs were used to amplify products from both pennate and centric diatoms, from marine and freshwater environments. Comparison of partial sequences reveals less than 30% amino acid identity, providing a starting point to identify residues important for transport. Genomic libraries were constructed to obtain full-length clones, which will be analyzed to determine if domain motifs identified in the C. fusiformis SITs are conserved.

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INTEGRATING OUTREACH AND EDUCATION INTO A REGIONAL OBSERVING SYSTEM: THE SEA-COOS EXAMPLE

The South East Atlantic Coastal Ocean Observing System (SEA-COOS) is organized into four working groups: 1)observing, 2) data management, 3) modeling, and 4) outreach and education. The goal of the outreach and education workgroup is to identify non-scientific users of ocean observation information, the specific information needed and the preferred delivery methods. To accomplish this, the four workgroups collaborate to design useful information delivery systems . Two primary concepts guide the efforts. One concept is to provide multiple situation-dependent educational products. These are 1) information, 2) products , 3) training , 4) informal networks, and 5) formal networks. The second concept is that the team must prioritize opportunities and focus on what we can deliver. This is accomplished by a "phased approach" to user engagement and assistance in which groups are categorized as Phase I: users we can help now with information currently available; Phase II: users we can help in 2-3 years ; and Phase III: users groups we can help in 3-5 years. These two concepts form a matrix that provides a structural dimension for identifying and prioritizing outreach and education opportunities.

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A MACROALGAE TO SEAGRASS SHIFT IN A BENTHIC CANOPY: EFFECTS ON TURBULENCE, NUTRIENT EXCHANGE, AND INVERTEBRATE POPULATIONS

Sites within Tampa Bay Florida have recently been found to have an extensive cover of a rhizophytic green alga, Caulerpa prolifera in regions that have historically been vegetated predominantly by seagrass. The presence of C. prolifera in these habitats has implications for both the biological and physical attributes of the ecosystem. The morphology of the canopy can affect turbulence within and above the canopy which in turn affects nutrient exchange rates. Thus, the change in vegetation may have significant impacts on the benthic/pelagic exchange of nutrients. Further, the characteristics of the canopy influences the types of invertebrates using the habitat. In this paper, we assess the implications of the shift in canopy type to invertebrate and epiphyte abundance, hydrodynamic regime (e.g turbulent energy dissipation), and nutrient exchange between the benthos and the water column. We measure the hydrodynamic regime within and above canopies of C. prolifera and Thallasia testudinum, measure nutrient uptake rates by the canopy, identify the importance of uptake by epiphytes in both types of canopies and quantify the invertebrates present. Results indicate that the change from seagrass to macroalgae significantly impacts invertebrate populations and the hydrodynamic regime of the benthos. Further, turbulent energy dissipation differs between the two canopy types. This difference is reflected in rates of nutrient uptake.

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REDEFINING THE ROLE OF OPERATIONAL FISHERIES OCEANOGRAPHY IN MARINE ECOSYSTEM OBSERVING PROGRAMS

Many of the major marine ecosystem programs throughout recent history have been justified by major fisheries issues and usually after a population collapse. Ironically, the science that followed often was only indirectly and sometimes not at all related to the fisheries problem. Today, there has been a proliferation of ocean observing programs, which use similar fisheries justifications to generate funding. However, little has been done to define the criteria necessary to qualify a program as responsive of fisheries problems. We provide examples of what fisheries information need to be part of an marine observing program if it is to use fisheries as justification for its funding.

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PREDICTING BIODIVERSITY PATTERNS IN DEEP WATER CORAL ECOSYSTEMS: LESSONS FROM PHYLOGENETIC STUDIES OF SHALLOW WATER CORAL REEF CRUSTACEA

Comprehensive studies of coral reef biodiversity suggest that diversity patterns may be more congruent with geotectonic events than with the reigning paradigms of dispersal, center of origin, and vicariance. Geotectonic processes slowly accumulate taxa in areas exemplified by the presence of composite or lineage-based evolutionary diversity. This process-pattern model can suggest additional areas where similar patterns are likely to occur. Information on types and levels of diversity should be a primary concern in emerging conservation efforts for deep-water coral ecosystems. Current marine conservation efforts in shallow reef systems rely primarily on identifying “hotspots” that reflect measures of species richness and endemicity rather than intrinsic evolutionary relationships. Recent phylogenetic and molecular research from shallow reef systems questions the validity of the hotspot approach. Biodiversity assembly rules for both deep-sea and shallow coral assemblages are likely congruent and thus should exhibit similar diversity patterns. Given logistic and expense concerns in studying deep coral systems, a predictive and testable biodiversity model that suggests areas where composite, lineage-based diversity may be located would help focus and allocate scarce resources.

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MODELING AND FIELD OBSERVATIONS OF ALGAL BLOOMS IN SOUTH SAN FRANCISCO BAY, 4: INTEGRATION OF NUMERICAL MODELS AND FIELD OBSERVATIONS

Aquatic ecologists have long recognized that numerical models are useful in developing hypotheses and examining processes that include parameters with varying spatial and temporal scales. However, integration of such parameters is challenging because field data are rarely available at the scales used in models. Ecologists can use models to inform their decisions about relevant sampling scales and processes, but for the models to be accurate, the modelers need appropriate data during model development. In answer to this conundrum we have developed an iterative process between modeling and field sampling in South San Francisco Bay (SSFB) that has allowed us to better understand the critical processes in algal bloom development. We will show how our field program "dynamically" changed in response to results from 1-D, Pseudo-2D, and 2-D models and how these changes resulted in models that accurately characterize field observations and helped us understand the relevant ecological processes. This integrative approach has highlighted new directions for model development (eg. small scale variations in light availability (May et al. this session), possible nutrient limitation) and for future field programs.

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DIVERSITY AND DYNAMICS OF A NORTH ATLANTIC COASTAL VIBRIO COMMUNITY

Vibrios are ubiquitous marine bacteria harboring many ecologically significant and some facultatively pathogenic strains. We hypothesized that seasonal changes in coastal waters lead to distinct Vibrio communities and sought to characterize their level of differentiation. A novel technique was employed to quantify shifts in 16S rRNA gene abundance in samples from Barnegat Bay, NJ, collected over 15 months. Quantitative PCR (QPCR) using highly Vibrio-specific primers was combined with separation and quantification of amplicons by constant denaturant capillary electrophoresis (CDCE). Vibrio populations identified by CDCE-QPCR showed little overlap between summer and winter samples suggesting distinct "warm-water" and "cold-water" populations. Cloning and sequencing of 16S rRNA genes from two summer and two winter samples confirmed this distinction, showing that CDCE populations corresponded in most cases to ~98% rRNA similarity-groups. Phylogenetic comparison yielded closely related cultured and often pathogenic representatives for most sequences and temperature ranges for these isolates confirmed the trends seen in the environmental samples. This suggests that temperature is a good predictor for the occurrence of closely related vibrios but that considerable microdiversity of unknown significance co-exists within this trend.

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MODELING THE FORMATION OF TRANSPARENT EXOPOLYMER PARTICLES DURING A BLOOM OF THE COCCOLITHOPHORID EMILIANIA HUXLEYI

A simple two-size-class aggregation model is developed to describe the time-dependent carbon content of dissolved polysaccharides (PCHO) and of transparent exopolymer particles (TEP) during the bloom. A conservative estimate for the effective collision kernel is obtained from the Smoluchowski equation under the assumption that the growth of aggregates is controlled by a Brownian process near the scaling regime. In the model, PCHO are assumed to represent a fraction of the photosynthetic carbon, which is not used for net algal growth. Time dependence of chlorophyll a and of cellular carbon during the bloom is modelled in terms of algal growth and sinking of single and aggregated algal cells. The aggregation of exopolysaccharides into TEP may have important implications for the organic carbon cycle in the ocean, as TEP promote the aggregation of algae during a bloom.

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INFLUENCE OF COPEPOD ABSORPTION EFFICIENCY ON PELAGIC ORGANIC MATTER FLUX

Marine copepods often exhibit high grazing pressure on primary producers. The efficiency with which organic matter is absorbed (AE) in copepods therefore constitutes a key determinator of organic matter flux in the pelagic ecosystem. It controls the amount of matter directed to higher trophic levels within the epipelagic. On the other hand it also controls the amount of matter that either sinks to the ocean floor or alternatively becomes remineralized. In a series of studies we demonstrated that AE depends not only on food quantity or ingestion rate but also on diet quality and copepod species. AE's ranged from 30% to 70%. They decreased linearly

from 45% to 30% with increasing food concentration and varied between copepod species, 30% for Acartia clausi, 40% for A. tonsa and 60% for Temora longicornis on average. Algal quality and toxicity had strong effects on AE (from 30% to 60%) and we observed supplemental effects of multiple diets. Thus, transformation and flux of organic matter through marine copepods vary strongly with seasonal changes in the food setting or during irregular algal blooms.

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INTERRELATIONSHIPS BETWEEN PACIFIC HERRING IN PRINCE WILLIAM SOUND AND THE ABUNDANCE AND FORAGING BEHAVIOR OF SELECTED MARINE MAMMALS AND BIRDS

We have used acoustic techniques to monitor the biomass of Pacific herring in Prince William Sound (PWS) since 1993. Estimates over the past 10 years correlate well with an aerial survey index of cumulative miles of spawn that the Alaska Department of Fish and Game has conducted since 1974. We used the relationship to hindcast the population abundance, and show that it reached a peak of slightly over 100,000 t in 1988, then declined over a 5-year period to only 13,000 t before eventually declining to under 10,000 t in 2002. We examined reasons for the decline and the impacts on marine mammals and birds. Several species, including Steller sea lions, showed parallel declines. We examined several foraging behaviors in detail, including estimates of the impact of predation on the herring population. We conclude that the decline of Steller sea lions numbers in PWS is the result of an adaptive behavior of a larger population of sea lions in response to decreasing wintertime forage.

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ONLINE STRATEGIES FOR DELIVERING SCIENCE TO MANAGERS: RECENT EXPERIENCES WITH THE COASTAL SCIENCES JOURNAL ESTUARIES

The Estuarine Research Federation has recently sought to more effectively deliver the results of scientific investigations published in its journal Estuaries to coastal managers. We recently announced our Open Archives Policy, in which all online journal content is made available to the public free of charge 5 yrs after its publication. In order to improve accessibility to these and more recent articles, we have implemented an ArcIMS application which facilitates geographic-based searching of all articles published in Estuaries based on either the study location or the location of the institutions where the work was completed. The online search engine uses recent satellite imagery made available from NASA, thus helping individuals searching for relevant articles to better visualize the locations to which the articles might apply. We have also begun to deliver an online digest of articles published in ESTUARIES that have management implications under the title Coastal and Estuarine Science News. These diverse policies and efforts are intended to make a broader array of science published in the journal Estuaries available, and more readily accessible, to the management community.

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PHYSIOLOGICAL, BEHAVIORAL AND MOLECULAR RESPONSES OF GELATINOUS ZOOPLANKTON TO HYPOXIA

Gelatinous zooplankton can form rapid population blooms in hypoxic estuarine waters, and tolerance to low oxygen has been previously shown to affect estuarine community structure. We have investigated physiological, behavioral and molecular mechanisms that allow gelatinous zooplankton to thrive in low oxygen. Our study organisms have included 17 species of ctenophores, scyphomedusae, hydromedusae, and siphonophores. We have found that several species can oxyregulate to less than 10% oxygen saturation and survive at 0% oxygen for over several hours. Intra-gel oxygen profile measurements on ctenophores and medusae demonstrate that facilitated diffusion is the mechanism allowing these animals to oxyregulate at low oxygen partial pressures. Temperature appears to affect their oxyregulatory abilities more so than salinity. Laboratory experiments demonstrated species-specific behavioral responses to extreme hypoxia. Molecular investigations of the stress response demonstrated that low oxygen elicits production of hsp70. Our results show that gelatinous organisms can thrive in low oxygen waters through a combination of physiological, behavioural and molecular mechanisms.

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ON THE UTILITY OF HETEROGENOUS RESOURCES

Resources in marine environments exhibit heterogeneity both in space and time. When foragers are able to track the resource, the exposure to the resource has larger mean and variance than in a homogeneous environment. The size of the effect depends on the temporal and spatial scales of the environment and of the individual behaviour. Recently, Danny Grünbaum demonstrated how the mean exposure is governed by a dimensionless quantity, the Frost number. Here, considering small-amplitude harmonic resources, we determine the mean and mean-square exposure as functions of the relevant characteristic scales. This establishes a relation between the spectral properties of the exposure and those of a more general resource field. Employing both simulation and qualitative analysis, we also consider non-linear responses and ambient turbulence.

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FE(III) SPECIATION IN SURFACE TRANSSECTS AND DEPTH PROFILES ACROSS A FRONTAL ZONE: THE CHATHAM RISE, NEW ZEALAND

Variations in the speciation of dissolved iron (<0.2 micron) were investigated for samples collected along three surface transects and two vertical profiles across a frontal zone, east of New Zealand, covering at least two different water masses. Dissolved iron concentrations were low (ca. 0.1 nM) in subantarctic waters. The highest Fe concentration (1.2 nM) was observed at the mixing boundary north of the STC and then decreased relatively quickly both southward and northward. The dissolved Fe (III) was fully complexed (>99.9%) by natural organic ligands which were found to occur in excess of the dissolved iron concentration at 1.2 +/- 0.22 nM (equivalent to an excess of 0.8 nM), and with a complex stability of Log K'(FeL)=22.76 +/- 0.17 (K' with respect to Fe3+). The relative constancy of the conditional stability suggests that there was no systematic change in the ligands (could be of siderophore type) across the different water masses. Although the exact mechanisms of primary production over the front are uncertain, our Fe speciation data imply that the regional currents may be an important vehicle for carrying micro-and macro-nutrients across the front in determining the total biological production.

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CHLOROPLAST ULTRASTRUCTURE OF PHAEOCYSTIS ANTARCTICA KARSTEN USING ELECTRON TOMOGRAPHY

Understanding the light-harvesting properties of algae and higher plants are a fundamental topic in photosynthesis research. Using thick sections obtained from fixed and embedded cultures of colonial Phaeocystis antarctica, we calculate tomographic reconstructions of individual chloroplasts under light-limiting and saturating conditions for net photosynthesis. Our goal is to gain an understanding of the continuity of thylakoid membranes and understand the spatial relationship between the pyrenoid, the starch containing organelle, and thylakoid membranes. We found that Phaeocystis showed considerable morphological and physiological flexibility in response to environmental light levels. We found that the thylakoids generally run parallel to the chloroplast membrane with many junctures and bifurcations, many of which are in contact with the chloroplast membrane itself. The considerable flexibility in the thylakoid membranes allows for the accommodation of the pyrenoid structure. The arrangement of the thylakoids within these structures resemble those found in new structures of mitochondria cristae. We present a model for algal chloroplasts which revises current concepts of thylakoid membrane structure in relation to photoacclimation.

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EFFECTS OF BIOTURBATION BY THE CONVEYOR BELT FEEDING POLYCHAETE ARENICOLA MARINA ON THE FATE OF PYRENE -INSIGHTS THROUGH MODELLING

We developed a radial diagenetic model to describe the effects of bioturbation by Arenicola marina on the fate of pyrene, a toxic polycyclic aromatic hydrocarbon. Contrary to other radial models the symmetry axis was placed in the center of the feeding funnel and not in the burrow allowing focusing on the rapid advective transport of particles and water characteristic for A.marina bioturbation. The model consists of 3 coupled PDEs describing the concentrations of oxygen, dissolved pyrene and pyrene adsorbed to particles. Comparisons between numerical model solutions and experimental data showed that the model could predict the total pyrene inventory with a maximum uncertainty of 22% and describe the spatial distribution of pyrene. Model results indicated that the main route of pyrene removal in bioturbated sediment was due to flushing to overlying water caused by A.marina irrigation. Model results also indicated that although the presence of lugworms increased the aerobic zone in the sediment, and thus the potential of microbial pyrene degradation, overall pyrene degradation was surprisingly low probably because molecular oxygen and dissolved pyrene were almost completely spatially separated.

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MEASURING DISSOLVED TRACE ELEMENTS IN SUBTROPICAL FRESHWATER AND ESTUARINE ENVIRONMENTS WITH DGTS

Dissolved trace element concentrations were measured in a subtropical estuary of Oahu and in the upper and lower watershed of this estuary with passive samplers using diffusive gradients in thin films (DGTs). This study was unique being the longest study to date employing DGTs in extensively characterized fresh and estuarine waters. DGT results were compared with discrete water samples collected manually and with automated samplers. For most trace elements, comparison of mean concentrations from discrete samples compared favorably with DGTs provided there were sufficient discrete samples collected over a wide range of conditions. Mean concentrations of estuarine Cu, Zn and Pb measured with DGTs were generally higher than concentrations of discrete samples collected during weekly retrievals of DGTs; conversely DGT Ni and Co concentrations were lower than discrete samples. DGT limitations include 1) pH must remain between 5 and 10, 2) ionic strength must be greater than 0.001, and 3) after 1-2 weeks, biofouling can be problematic in subtropical estuarine waters. Nonetheless, DGTs provide a viable method for augmenting dissolved trace element data obtained from discrete samples.

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ESTIMATION OF PICO-PHYTOPLANKTON DISTRIBUTION IN WESTERN PACIFIC OCEAN FROM OCEAN COLOR AND SST IMAGES

Through three long cruises in the western Pacific Ocean carried out on 1999, 2000 and 2002, six kinds of major photosynthetic pigments in the surface water were analyzed by a high-performance liquid chromatography (HPLC). The spatial distribution of chlorophyll-a showed peaks at the equatorial region and near Japan. In contrast, zeaxanthin, a specific pigment of pico-phytoplankton such as Synechococcus and Prochlorococcus showed a broad low peak around equatorial region. From these results, we found inverse relationship between the ratio of zeaxanthin to chlorophyll-a concentration (ZCR) and chlorophyll-a concentration, and also positive relationship between ZCR and sea surface temperature (SST). A multiple regression equation to estimate ZCR from chlorophyll-a concentration and SST was obtained. The equation was applied to estimate spatial distribution of ZCR in the Pacific Ocean using a chlorophyll-a image by SeaWiFS and a SST image by AVHRR. Pico-phytoplankton has an important role in export flax of carbon. The result will contribute to estimate a global carbon cycle.

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FEEDING OF CARNIVOROUS ZOOPLANKTON IN THE SKAGERRAK DURING TWO SEASONS

Carnivorous zooplankton feeding and their importance as a structuring force on zooplankton communities were studied during two cruises, March 20 – 28, 1999 and August 25 - September 3, 2000. Zooplankton was dominated by copepods, both in number and biomass, with the highest numbers in August-September. We assessed feeding by measuring egestion of fecal pellets from captured Pareuchaeta norvegica and estimated their production rate and predation impact. P. norvegica caught at night egested higher number of pellets (5 pellets per female) compared to day-caught animals (2 pellets per female). Average pellet production from juveniles (C4-C5) was twice the pellet production from females. Chaetognaths (mainly Sagitta elegans) were collected in March and their gut contents analysed for ingested prey. Number of prey per chateognath (NPC) ranged from 0.1 to 0.9 with significantly higher values at night. The copepods Calanus sp. and Pseudocalanus sp. dominated gut contents with addition of nauplii, Oikoplura diocia and Temora sp. Cannibalism was low. The predation impact of various carnivorous zooplankton in different seasons is discussed.

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LIGHT-DRIVEN CYCLING OF DIMETHYLSULFIDE (DMS) IN THE SARGASSO SEA – THE STRESS-FORCED REGIME

The open-ocean dimethylsulfide (DMS) time-series sampled twice monthly in the upper water column at Hydrostation S in the Sargasso Sea (1992 – 1994) is an example of the DMS summer paradox. DMS concentrations peak in the summer, concurrent to seasonal minima in phytoplankton biomass, productivity, and its precursor compound dimethylsulfoniopropionate (DMSP). Mechanistic studies indicate that the seasonal distribution of DMS is inconsistent with phytoplankton community structure or succession. DMS concentrations and estimated net biological community production are most highly correlated with physical and optical, seasonally varying factors with mean mixed layer irradiance accounting for a striking 78% of the variability in surface concentrations. These relationships indicate that DMS cycling in open ocean regions is fundamentally different than in coastal regions where the variability is a function of bloom dynamics. In the Sargasso Sea, sulfur cycling ultimately is forced by physical factors that determine biological stress, specifically irradiance exposure mediated by mixing depth. This response is consistent with the proposed phytoplankton-climate feedback mechanism and suggests that the subtropics may become an even larger source of atmospheric sulfur.

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INTRODUCED SPECIES AND THEIR MISSING PARASITES: WHAT'S GAINED BY THEIR LOSS?

Damage caused by introduced species results from the high population densities and large body sizes they attain in their new location. Escape from the effects of natural enemies is a major hypothesis given for the success of introduced species. Because some parasites can reduce host density and decrease body size, an invader that leaves parasites behind and encounters few new parasites could experience a demographic release and become a pest. To test whether introduced species are less parasitized, we compared the parasites of exotic species in their native and introduced ranges, using 26 host species of molluscs, crustaceans, fishes, birds, mammals, amphibians and reptiles. Compared to the number of parasite species found in native populations, only half as many parasitized exotic populations. Furthermore, introduced populations were less heavily parasitized (% infected) than were native populations. Reduced parasitization of introduced species has multiple causes. These include reduced probability of introduction of parasites with exotic species (or early extinction following host establishment), absence of other required hosts in the new location, and the host-specific limitations of native parasites adapting to novel hosts. To examine the consequences of this release from parasites on marine species, we conducted a global assessment of the effect of parasitism on the demographic performance of the European green craband the Japanese mud snail.

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REAL-TIME MEASUREMENT OF TRACE GAS CONCENTRATIONS IN THE EASTERN BERING SEA VIA MEMBRANE INLET MASS SPECTROMETRY

Marine microorganisms influence global climate through the production and consumption of various trace gases in the upper ocean. In highly dynamic marine ecosystems such as the Bering Sea, trace gases exhibit large spatial and temporal concentration gradients across multiple biological and chemical fronts. High frequency sampling is therefore necessary to fully capture the gas dynamics in these waters, yet such intensive monitoring is often difficult using current methods based on discrete sample collection. Here I describe a new mass spectrometer-based method for underway, real-time measurements of CO2, O2, and dimethylsulfide (DMS), and present results from a series of cross-shelf transects in the Eastern Bering Sea. Trace gas concentrations exhibited a high degree of spatial variability across the sampling transects. The most significant changes occurred across the slope/shelf transition where enhanced biological productivity resulted in a sharp drop in CO2 concentrations and a significant increase O2 levels. In contrast, surface water DMS concentrations did not generally correlate with total phytoplankton biomass or productivity, but rather showed significant variations associated with physical fronts that may have affected phytoplankton community composition.

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THE SYMBIOTIC ASSOCIATION OF THE GRACEFUL CRAB (CANCER GRACILIS) AND THE FRIED EGG JELLYFISH (PHACELLOPHORA CAMTSCHATICA) IN PUGET SOUND

Large numbers of megalopae and juveniles of the crab Cancer gracilis were found riding the scyphozoan jellyfish Phacellophora camtschatica in southern Puget Sound. Densities of megalopae ranged from 0 to 326 per medusa; instar densities ranged from 0 to 7 per host (n=64). Microscopic analysis of fecal pellets indicated that the epibionts use the medusae as a source of food and also eat other planktonic organisms. In laboratory experiments, instar crabs were observed to consume P. camtschatica, their associated parasitic amphipods (Hyperia medusarum) and the scyphozoan Aurelia labiata, a staple in the diet of P. camtschatica. Stable C and N isotope analyses of these and other Puget Sound planktonic organisms support the fecal pellet data and laboratory observations. Although C gracilis megalopae and instars are not seen riding A. labiata in the field, when confined to a planktonkreisel, instar crabs clung readily to A. labiata. Crabs also rode artificial medusae. Enzyme activities and O2 consumption rates of epibiotic instars and megalopae and planktonic megalopae were measured to evaluate differences in metabolic potentials between the pelagic and epibiotic groups. In addition to providing a ready supply of food, this phoretic association may present an energy saving transportation mechanism for C. gracilis that increases larval survival within the estuary.

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THE SPRING PHYTOPLANKTON BLOOM IN THE YORK RIVER ESTUARY, VIRGINIA: CHARACTERIZATION AND INTERANNUAL VARIABILITY.

Spring blooms are characteristic features of the seasonal phytoplankton cycle in the York River, a subestuary of the lower Chesapeake Bay. As part of the laboratory section of the 2003 SMS core course, relevant physical and biogeochemical factors were measured during three cruises in March 2003. Significant blooms of the dinoflagellate Heterocapsa triquetra were observed in 2001 and 2003, consistent with temporal peaks in fresh water flow. In 2002, a record low flow spring, no dinoflagellate bloom was observed. The 2003 bloom occurred on all three dates in both stratified and well mixed conditions. Silica and DON exhibited conservative behavior, while DIN and DIP were depleted within the bloom. Although the freshwater DIN:DIP indicated potential phosphorous limitation, within-bloom nitrogen was below detection levels while phosphorous was still measurable, suggesting an additional allochthonous source of phosphorous to the mesohaline York River. Predicted zooplankton grazing impact on the bloom was minimal. In summary, the major factors favoring a dinoflagellate over a diatom spring bloom in the York River include: high river flow and nutrient loading; low temperatures; and low grazing pressure.

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RESPONSE OF PHYTOPLANKTON TO A MESOSCALE FE ENRICHMENT IN THE SUBARCTIC PACIFIC OCEAN.

Elemental composition, Fe uptake, and C production of phytoplankton were examined during the Subarctic Ecosystem Response to Iron Enrichment Study (SERIES) in July 2002. Biomass and chlorophyll-specific primary production of the small autotrophs (<20 um) increased rapidly following Fe enrichment as Fe uptake capacity declined. Although production rates remained high, the biomass of the small phytoplankton dropped after day 6, implying an increase in grazing losses. Standing stocks of C and Si and rates of primary production of the large

phytoplankton (>20 um) were initially low and increased exponentially. Saturated rates of Fe uptake decreased 5-fold and remained at low levels for the duration of the experiment. The results suggest that the delay in the large diatom bloom was caused by very low initial stocks rather than by slow physiological response. Bulk C:N and C:P ratios decreased after Fe was added. Si:N ratios of the large size fraction decreased until day 6 and then increased as the concentration of dissolved Fe fell. Overall, the elemental composition of the large diatoms differed substantially from that of the small phytoplankton.

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IRON LIMITATION AND COPPER EFFECTS IN THE JUAN DE FUCA EDDY

The Juan de Fuca eddy system, a persistent high chlorophyll region centered ~50 km offshore of Vancouver Island, Canada, and Washington State, USA, overlies a complex submarine canyon system on the continental shelf. We show here using deckboard incubations that phytoplankton growth in the offshore regions of the eddy is enhanced by iron addition during summer and fall, even though elevated concentrations of dissolved iron are present. Addition of excess concentrations of the terrestrial siderophore ferrichrome inhibits community growth while addition of protoporphyrin IX, a weaker iron-complexing ligand, does not, consistent with earlier published studies. However, growth (chl a increase and nutrient drawdown) in ferrichrome treatments is enhanced by small additions of copper. This pattern also is observed during short-term uptake experiments with 59Fe. These findings suggest that eukaryotic phytoplankton can access iron bound to the stronger of the two ligand classes in seawater provided that copper availability is adequate. We speculate that the release of copper complexing ligands by marine prokaryotics may be a competitive tool to limit the piracy of siderophore-bound iron by their eukaryotic competitors.

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THE COAST GUARD IS INCREASING ITS UNDERWATER PRESENCE IN PORTS AND HARBORS

As the Coast Guard continues to enhance its capabilities in port and harbor security, the automation of various functions becomes increasingly important. Historically known for its motto Semper Paratus (Always Ready), the Coast Guard is now taking a more proactive approach. With the purpose of prevention of an incident from ever occurring the Coast Guard is increasing its presence in the nation's ports and harbors. As the Coast Guard's only research and development entity, the Center is looking at technologies that will assist the Coast Guard in accomplishing their missions. One part of these future systems will be automated monitoring which will allow for a sustained presence. These eyes and ears need not be dedicated Coast Guard assets. The information gathered can be at the disposal of many different interest groups from universities to local regulatory agencies. The systems may not even belong to the Coast Guard but need only be smart enough to alert its users when something of interest to the Coast Guard appears. A review of current projects will follow.

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DIATOMS FROM TWO MACRO-TIDAL MUDFLATS IN CHIGNECTO BAY, UPPER BAY OF FUNDY, CANADA

Little is known about intertidal microphytobenthos, but it is an important food source of many intertidal invertebrates, ultimately cascading to migratory shorebirds. We examined two tidal flat diatom communities, one with high and one with low density of mud shrimp (Corophium volutator) in a macro-tidal (greater than 8 m) estuary in the Upper Bay of Fundy. In addition to Corophium, the two flats differed in nearly all aspects examined. The high Corophium mudflat had larger mean grain size, less water and organic carbon content. The low Corophium mudflat had a more variable depth of oxygenated sediments, often with anoxic inclusions, much higher diatom density (particularly epipelon) and higher chl. a. The lack of diatoms as food or lack of sediment stabilising mucilage therefore cannot explain the low densities of mud shrimp. The observed differences in diatom community structure, abundance and chl. a are best explained by higher grazing pressure. It could also be that the higher water content and greater mixing of the low shrimp density mudflat sediment makes it a better diatom habitat but less suitable for Corophium.

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SOLUBLE MN(III)COMPLEXES PRESENT IN SUBOXIC REGIONS OF THE BLACK SEA AND CHESAPEAKE BAY

Soluble manganese(III)complexes were measured in suboxic waters (<3 micromolar O2; <0.1 micromolar H2S) of the Black Sea and Chesapeake Bay. Mn(III) is stabilized in both environments by available organic ligands, likely produced by organisms. Samples were drawn by gastight syringe from a Niskin bottle, filtered through a 0.2 micrometer polycarbonate filter in an argon-filled glove bag and injected into an argon-purged cell of a Hanging Mercury Drop Electrode (HMDE). Deferoxamine mesylate was added up to a concentration of 20 micromolar to react with Mn(III) and out compete the weak binding organic ligands to form the strong complex, Mn(III)deferoxamine. The Mn(III)deferoxamine complex was measured by cyclic voltammetry at a potential of –1.18V (conditioning at –0.1V for 3 seconds, scan range –0.1V to –1.8V, scanrate of 500 mV/s). Leucoberbelin blue and a pyoverdine ligand obtained from Mn(II)-oxidizing bacteria also gave a positive test for dissolved Mn(III). Stable Mn(III) showed a maximum in the suboxic zone and was not observed in the oxic and sulfidic zones of the water column. Soluble Mn(III) can be a significant fraction of the total soluble Mn.

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QUANTIFYING THE IMPORTANCE OF PHYTOPLANKTON SIZE TO EXPORT USING 13C

Recent models for carbon export emphasize the role of large phytoplankton. Stable carbon isotopes offer a means to quantify this role. Southern Ocean observations found that large phytoplankton (70-200 micron size class) were enriched in 13Corg in comparison to small phytoplankton (1-5 micron size class) by ~ 8 per mil [Trull and Armand, 2001, DSRII 48 11/12 2655-2680]. This variation with size is consistent with models and laboratory experiments on carbon uptake, and is likely to be a general characteristic of phytoplankton communities. In the Southern Ocean study, comparison of phytoplankton 13Corg compositions with the seasonal mixed layer increase in 13C-DIC demonstrated that large phytoplankton dominated seasonal export, and that this export occurred without co-export of small phytoplankton. The 13C mass balance does require consideration of calcite export and air-sea gas exchange using other constraints such as seasonal alkalinity and pCO2 estimates, although these terms are often small. The application of this primary size signature to the ecosystem control of carbon export to the deep sea is currently being explored.

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AN IN-SITU IRON ENRICHMENT EXPERIMENT IN THE WESTERN SUBARCTIC PACIFIC (SEEDS): INTRODUCTION AND SUMMARY

To test the iron hypothesis, an in situ iron-enrichment experiment (SEEDS) was performed in the western subarctic Pacific in summer 2001. About 350 kg of iron and the inert chemical tracer sulfur hexafluoride were introduced into a 10-m deep surface mixed layer over an 8 X10 km area. During SEEDS there were iron-mediated increases in chlorophyll a concentrations (16 mg/m3), primary production rates and photosynthetic energy conversion efficiency relative to waters outside the iron-enriched patch. The rapid and very high accumulation of phytoplankton biomass was caused by a floristic shift from open-ocean pennate diatoms to fast-growing centric diatoms. The blooming of diatoms resulted in a marked consumption of macronutrients. The export flux between day 2 and day 13 was 12.6% of the integrated primary production in the iron-enriched patch. Major part of the carbon fixed by diatom blooming stayed in the surface mixed layer as biogenic particulate matter. Our findings support the hypothesis that iron limits phytoplankton growth and biomass in a 'bottom up' manner in this area, but the fate of algal carbon remains unknown.

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COSEE-WEST : BRIDGING THE GAP BETWEEN OCEAN SCIENCE RESEARCH AND EDUCATION USING TECHNOLOGY

COSEE-WEST is taking ocean science research to thousands of educators using web-based distance learning technologies pioneered by the College of Exploration. The goal is to engage scientists and educators in conversations about ocean science research and ocean science education online, in web-based collaborative learning environments.
A number of design principles have evolved from over 9 years of experience working with teachers and scientists and other professions in online and web-based format. COSEE-WEST is reaching out to educators mainly in California but also across the USA.
Lessons learned from the Classroom Exploration of the Oceans also contributes to the evolving design principles. This series of nine online sessions was sponsored by NOAA's Office of Ocean Exploration, NOAA's Marine Sanctuaries and The National Geographic Society. The broader impact of ocean research and study was extended to the world of geography and links to K-12 Geography standards.

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EXPERIENCE USING THE BERMUDA ATLANTIC TIMES SERIES IN EDUCATION

Bermuda Biological Station for Research, Florida International University and the College of Exploration completed a three-year NSF funded program to use ocean data from the Bermuda Atlantic Times Series (BATS) for education. Although not a live data stream it is one of the oldest continuous ocean data sets available for use in education. The program took the data sets used by scientists and provded them in an educator friendly format in an Excel spreadsheet. (http://www.coexploration.org/bbsr/classroombats) Lessons learned along with insights and suggestions that may be of use in the consideration when using real-time environmental data will be shared.

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COPEPOD EGG PRODUCTION AND EGG HATCHING SUCCESS IS REDUCED BY MATERNAL DIETS OF A NON-TOXIC STRAIN OF THE DINOFLAGELLATE ALEXANDRIUM TAMARENSE

Maternal diets of a non-toxic strain of the dinoflagellate Alexandrium tamarense reduced egg production and hatching success in the copepod Temora stylifera, even though grazing rates and copepod survival were high. Reduction of hatching success was dramatic, dropping in some cases to zero after 24 h of feeding. Effects were dosage-dependent with lower hatching success at higher dinoflagellate cell concentrations. Dinoflagellates contained no saxitoxins, neosaxitoxins, or aldehydes such as those found in the diatom Skeletonema costatum. Extracts of A. tamarense did not show antimitotic properties in that extracts did not block first-cell cleavage in sea urchin oocytes, compared to S. costatum extracts. A. tamarense extracts did block fertilization success when sea urchin oocytes were first incubated in extracts and then fertilized, as opposed to S. costatum extracts which showed normal fertilization. Although antipredation effects of some toxic dinoflagellates on copepods, and antimitotic effects of diatom aldehydes on copepod eggs are known, this is the first report that non-toxic dinoflagellates may produce antiproliferative compounds, other than aldehydes, which can potentially reduce copepod egg production and hatching success.

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EXAMPLES OF EFFECTS OF KILOMETER-SCALE SEAFLOOR TOPOGRAPHY ON DEEP-OCEAN AND SEDIMENT (BIO)GEOCHEMISTRY

Kilometer-scale topographic seafloor elevations of comparable breadth and width like abyssal hills, knolls and seamounts are ubiquitous and abundant features of the oceanic seafloor. Physical oceanographic studies have indicated that there are complex and asymmetric flow fields surrounding such seafloor elevations. We present a water-column and a sediment example of how such flow-field patterns could translate into (bio)geochemical patterns. (1) Dynamics of particle cycling differ on opposite sides of a seamount as deduced from radioactive thorium-234/uranium-238 disequilibria. (2) There is evidence of the water-column asymmetry to be qualitatively and quantitatively reflected in the sedimentary record: Increasing current strength is related to a growing discrepancy between water column-derived and sediment-derived lead-210 fluxes, and to increasing contents of larger and heavier particles (as deduced from grain-size distribution, and Si/Al and Zr/Al proxies). We conclude that studies similar to the ones above could provide further information on paleo-changes of the orientation and intensity of flow fields in the deep ocean, and on mechanisms controlling spatial patterns of food supply to the benthic community, larval dispersal and, hence, biodiversity in the deep sea.

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ACCUMULATION AND REMINERALIZATION OF IRON BY PLANKTON DURING THE SOUTHERN OCEAN IRON EXPERIMENT

The iron quotas of plankton are often represented in geochemical models by a single, static Fe:C ratio, usually obtained from Fe-limited laboratory cultures grown in buffered media. We used a synchrotron x-ray fluorescence microprobe to quantify the Fe content of individual diatom, autotrophic flagellate, and heterotrophic flagellate cells collected from the Southern Ocean during the recent Southern Ocean Iron Experiment (SOFeX). Diatoms from unfertilized waters had lower Fe quotas (5.5 micro-mol Fe/mol C) than either autotrophic (10 micro-mol/mol) or heterotrophic (18 micro-mol/mol) flagellates. Following two additions of Fe, diatom quotas increased nearly 6-fold and flagellate quotas rose 3- to 4-fold, although the diatoms still contained the least Fe, relative to C. Two-dimensional maps of Fe in the cells indicated that this increase resulted from internal accumulation of Fe by resident plankton. Such 'luxury uptake' of Fe may explain, in part, the low sequestration efficiency observed following the fertilizations. These Fe quotas were combined with microzooplankton grazing rates as measured with dilution experiments to calculate Fe remineralization rates for the natural community, and the results of these calculations will also be presented.

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RESPONSES OF PELAGIC GREAT LAKES PHYTOPLANKTON COMMUNITIES TO TRACE METAL (FE, CO, CD, ZN) ENRICHMENTS

Transient Fe limitation has been reported to occur in large lacustrine systems. A report by Nriagu et al. (1996, Environ. Sci. Technol. 30:178-187) suggests a geochemical signal of Cd replacement of Zn by plankton in Lake Erie surface waters. We examined the nutritive role of trace metals in Lake Erie. Bioassays were conducted on Lake Erie using 5-50 nM enrichments of Co, Cd, Zn, and Fe. Treatments were incubated (1-4 days) onboard. Results show that metal enrichments can lead to pronounced increases in photosynthetic efficiency over a short time period (e.g. 706% increase in C-14 uptake by picoplankton by a 10 nM Cd addition, relative to control). Metals were not always beneficial. When positive responses were detected it was predominantly due to reactions by the picoplankton (0.2-2 µm) rather than larger phytoplankton size fractions. Metal enrichments did not affect grazing rates in the microbial food web. Results show heterogeneous responses of phytoplankton to metal enrichments; these are likely due to hydrodynamic forces. Stimulation of Zn-limited phytoplankton isolates from Lakes Erie and Ontario provided Co and Cd support the field observations.

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DEVELOPING BIOPHYSICAL MODELS OF CETACEAN DISTRIBUTION IN THE CALIFORNIA CURRENT, AN UPWELLING BOUNDARY CURRENT SYSTEM

To predict the response of top-trophic predators to climate-induced changes in an upwelling boundary current system, we are developing coupled biophysical models of cetacean occurrence patterns relative to physical forcing and productivity in the northern California Current System (CCS). Associations between cetacean distributions, oceanographic features and bioacoustic backscatter were examined during two GLOBEC northern CCS process cruises during late spring and summer 2000. Occurrence patterns of 4 species (humpback whale, Pacific white-sided dolphin, Dall's porpoise, harbor porpoise) were compared with 13 hydrographic and ecological variables: sea surface salinity and temperature, thermocline and halocline depth, thermocline and halocline gradient, value and depth of chlorophyll maximum, distance to alongshore upwelling front, and acoustic backscatter at 38, 120, 200 and 420 kHz. A logistic regression model explained 25.6 to 84.2 % of the variation in occurrence patterns of cetaceans. The presence of enhanced CCS mesoscale forcing (i.e., meanders) during summer increased the amount of explained variance in some cetacean distributions. Flow-topography interactions and higher productivity associated with a submarine bank (Heceta Bank) and Cape Blanco are important predictors of cetacean occurrence patterns.

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A CLOSURE EXPERIMENT FOR IN-WATER OPTICAL PROPERTIES AND RADIATION IN THE CHESAPEAKE BAY ESTUARINE WATERS

Detailed measurements of in-water optical properties and boundary conditions in the Chesapeake Bay estuarine waters, were used as input information to perform radiative transfer model estimations of underwater radiation fields using Hydrolight code. The main objective was to study to what extent we can obtain 'closure' between measured and theoretically estimated radiation fields in this optically complex estuarine environment. The model-estimated water-leaving radiances were in very good agreement with those based on measurements of upwelling radiances. For almost all of the cases, the percentage differences were less than ±11.6% at 443nm (absolute average of 6.25%), less than ±15.2% at 555nm (absolute average of 8.3%) and less than ±11.5% at 670nm (absolute average of 6.85%). Two key changes in model input parameters improved agreement with measurements: 1) Use of measured backscattering values in place of the widely used "Petzold" average particle scattering phase function. 2) The assumption of non-zero absorption at the near-infrared wavelengths (e.g 715nm), supported by spectrophotometric absorption measurements. The assumptions made in the model simulations and the inaccuracies associated with the in-situ measurements are discussed.

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WIND-INDUCED MODULATION OF SPRING PHYTOPLANKTON BLOOMS IN THE NORTH ATLANTIC DERIVED FROM SATELLITE OBSERVATIONS

To advance our understanding of spring bloom dynamics in the North Atlantic (70N-10S, 90W-10E), chlorophyll response to wind forcing was examined on daily to interannual time scales using data collected by SeaWiFS and SSM/I from 1998 through 2002. Preliminary results support expectations that enhanced wind speed reduces bloom intensity over temperate ocean regions (30N-70N) while the opposite response of chlorophyll to enhanced wind speed occurs over subtropical regions (10N-30N). The relationship between chlorophyll concentration and wind speed remains remarkably consistent over large spatial and temporal scales. Timing of spring bloom onset increased with latitude as expected. However, bloom timing also had strong longitudinal dependency with large regions of the eastern North Atlantic exhibiting bloom onset much earlier than the western North Atlantic. Investigations of wind forcing on spring bloom magnitude and timing are expected to enhance our understanding of the long-term effects of climate variability on North Atlantic phytoplankton dynamics and ecosystem response.

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VARIOUS PHYSICAL FORCING CONTROLLING CHEMICAL COMPOSITIONS OF SUSPENDED MATTERS IN WATER COLUMN OF SEAGRASS BEDS IN A THAILAND ESTUARY

The elucidation of the mechanisms causing temporal and spatial variation of suspended matters and dissolved organic matters as well as dissolved nutrients in the vicinity of tropical seagrass beds is crucial, because both quantity and quality of these components control environmental frame of seagrass beds including the food availability of associated benthic populations. In this study, we investigated these mechanisms by combining time-series monitoring of physical parameters (turbidity, currents, wind and salinity) and multi-chemical analyses (DOM, chla, DIN and 13C, 15N and C/N ratio of POM) in water column and sediments at adjacent three seagrass beds of the Andaman coast of Thailand. Multi-regression analyses with physical parameters clearly suggested that variation of each chemical parameter in water column was caused by the synergism of wind and current-derived re-suspension and river water inputs. In addition, both temporal and spatial change in dominance of these physical forcing was observed even within this small scale seagrass beds. The observed difference in chemical characters of water column components may be important factors controlling the morphological variations of seagrass and composition of associated benthic populations.

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AUV DIVERSITY FOR UNDERWATER OBSERVATION- DEVELOPED AUVS BY UNDERWATER ROBOTICS AND APPLICATION (URA) LABORATORY -

The Autonomous Underwater Vehicle (AUV) will be one of the most sophisticated platforms for underwater observation. In other words, AUVs have vast potential to be applied to both scientific and industrial interests in various ways. To cover various applications, many kinds of AUV will be designed in conformity with their mission. Since AUVs should dive poorly supported by the operater on the surface, they should be intelligent as possible.Their intelligence can be improved only through practical operations as in the sameway as engineers have done for realization of reliable and robust machines and systems. Our laboratory has developed more than 10 AUVs in these two decades. The topics listed below which were recentely accomplished by AUVs and a new vehicle named "r2D4" which was designed for survey of mid-ocean ridge systems and showed its capability through sea trials in July 2003, are introduced as an example of steps toward establishment of intelligent AUV technology.
1. Intelligent performance of Tri-Dog 1
2. Whale following by Aqua Explorer 2000
3. Tantan's Survey in Lake Biwa
4. Exploration of Teisi Knoll by R-One Robot
4. Development of r2D4 and Survey along a Fault

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MODELING DIAGENETIC PROCESSES AS AN OPTIMIZED METABOLIC NETWORK

Current models of microbial biogeochemistry and diagenesis focus at the organismal level in that the models attempt to simulate how various microbial guilds process environmental resources based on empirical observations. Because this modeling approach is not constrained by fundamental principals, the models required extensive conditional statements that determined which guilds, hence processes, should be active for a given set of conditions. Although conditional-based models can work acceptably, they do not extrapolate well to unforeseen conditions.
An alternative approach will be presented that models biogeochemical processes directly, removing the emphasis on organisms. Based on ideas postulated in nonequilibrium thermodynamics, the model presupposes that microbial systems organize at the system level such that the resulting biogeochemistry can be modeled as a resource optimization process. In this method, a set of half reactions represent the full repertoire of metabolic reactions that microbial communities are capable of expressing. Reaction rates are determined by solving an optimization problem that maximizes a realizable objective function subject to thermodynamic, kinetic, stoichiometric and resource allocation constraints. The use of various objective functions that may describe diagenetic processes will be presented.

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DEFINING THE PARAMETERS REGULATING ANTARCTIC PHYTOPLANKTON SPECIES DISTRIBUTION: GROWTH RATES

In the Ross Sea, Antarctica, there is a distinct pattern in phytoplankton species distribution whereby two major phytoplankton groups, diatoms and Phaeocystis antarctica, each bloom in specific areas. This pattern has been attributed to photophysiological differences in phytoplankton response to light level variability. To understand the extent to which light levels may control the spatial distribution of phytoplankton in the Ross Sea, we initiated a comprehensive laboratory study to characterize their response to different light conditions. In the first phase of this study, semi-continuous cultures of three diatom species (Fragilariopsis cylindrus, Nitzschia subcurvata, F. curta) and P. antarctica were grown under static light conditions ranging from growth limiting to photoinhibiting intensities. Subsets of these same cultures were also grown under transient light conditions, so that phytoplankton were exposed to either a relatively uniform (100-200 micromole photons/m2/s) or widely varying (0-200 micromole photons/m2/s) light field. For each experimental treatment, algal growth rates at mid-exponential phase were measured for each of the four phytoplankton taxa. The different responses, and the likelihood that varying light conditions can determine species distribution, will be presented.

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EXPLORATION OF THE BLAKE RIDGE DIAPIR: RELATIONSHIPS BETWEEN VESICOMYID CLAM POPULATIONS AND SEDIMENT-POREWATER PARAMETERS

The Blake Ridge methane-hydrate seep (2155 m) hosts a bivalve-dominated (bathymodiolin mussels and vesicomyid clams), chemosynthetic community. The bivalve beds include large patches of live, dead, and mixed live/dead individuals. One objective of the 2003 Ocean Exploration-sponsored field campaign was to explore potential causes of clam mortality in this system. Clam mortality might be a consequence of a shifting locus of flux of sulfide, resulting in elevated sulfide concentrations and biological toxicity, or in decreased concentrations of sulfide and diminution or cessation of autotrophic production by endosymbionts. An alternative hypothesis is that the bivalve populations suffer from a lethal, parasitic infection. Blake Ridge mussels are known to be infected by a pathogenic virus inferred to cause death. Our analytical effort focuses on 20 push cores taken in and near clam beds to assess population density, parasite burden, reproductive condition, and overall health of the clams, and to document sediment characteristics (including grain size, organic content, microbial populations) and a suite of porewater characteristics (including sulfide, sulfate, and methane concentrations and isotopic compositions).

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THE INFLUENCE OF TURBULENT MIXING ON MUSSEL FOOD SUPPLY – IS THE ANSWER BLOWING IN THE WIND OR GOING WITH THE TIDAL FLOW?

In shallow estuaries characterised by large populations of shellfish, these cultures largely determine the ecosystem dynamics, flows of carbon and nutrients, as well as the biodiversity in plankton and benthos. The mechanisms for this control depend on the interaction between physical factors (currents, turbulence, mixing), biogeochemistry and the biology of the organisms.
In a predominantly wind-driven Danish fjord we investigated the relationship between the external forcing factors, flow velocities, large- and small-scale turbulent mixing and the food supply for the benthic filter feeders.
These shallow systems react extremely rapidly to changes in weather conditions. Wind was certainly the main driving force for water column mixing. Algal depletion occurs very rapidly over the mussels under calm conditions, severely limiting the food supply to benthic filter feeders. Soon after the wind picks up, turbulence increases and particulate material is redistributed over the water column. However, flow velocities appeared not to be directly wind-driven and the very small tidal elevations in this region may still have an effect. Ultimately, mussel feeding rates may be influenced by both driving forces.

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COMPETITIVE AND COMPLEMENTARY BIOTIC AND ABIOTIC PATHWAYS IN THE SEDIMENTARY MN-FE-S CYCLES – A MODEL APPROACH

A model is proposed to describe the dynamics of microbial manganese-, iron- and sulfate reduction in sediments. With this batch reactor model we study the redox conditions and the responsible kinetic parameters. By including secondary redox reactions, we quantify the relative contribution of chemical and microbial pathways under contrasting conditions. The model is validated by comparing the results to time series data on solid phase and pore water composition of estuarine sediments. The batch reactor model showed a sequential redox development or simultaneous redox reactions depending on whether the substrate (e-donor) is limiting or not. Manganese was increasingly reduced by Fe(II) and FeS under high substrate conditions when also the dissimilatory iron reduction rate was increased. This was only important in the very first hours of the simulation, when manganese oxides were still present. Chemical reduction of manganese and iron oxides by sulfide was less important in the high substrate simulation. With overlapping processes of manganese-, iron-, and sulfate reduction one would expect a higher probability of the chemical oxide reduction by sulfide, but FeS precipitation removed the sulfide and thereby prevented these reactions from taking place.

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ONTOGENETIC AND OCEANOGRAPHIC EFFECTS ON THE ONSET AND MAGNITUDE OF DIEL VERTICAL MIGRATION OF THE EUPHAUSIID, EUPHAUSIA PACIFICA.

In an effort to understand the factors shaping the population distributions and biology of euphausiids in the California Current System, we are studying the Diel Vertical Migration (DVM) of Euphausia pacifica. Day / Night pairs of vertically stratified MOCNESS (Multiple Opening and Closing Nets and Environmental Sensing System) tows were collected at 7 stations. Nets with 0.33 mm mesh were used. For each developmental stage we calculated the weighted mean depth (WMD) to determine variations in day / night depths in relation to ontogeny. Eggs can be found near the surface or at depth, night or day, and are normally concentrated in a single strata. Nauplii are not addressed because they are not captured by this mesh. Daytime average WMD for calyptopes was 15 m. Furcilia 1, 4, and 7 were 24, 37, and 75 m respectively. We have found that DVM can begin as early as the calyptopes stage and increases in magnitude along with development. For example, F1s migrated on average 18.3 m, whereas F4s, F7s, juveniles and adults migrated 27m, 55m, 61m and 103m.

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FACTORS AFFECTING THE PERFORMANCE OF THE OPTICAL PLANKTON COUNTER IN LARGE LAKES: INSIGHTS FROM LAKE MICHIGAN

There have been questions as to whether accurate measurements of zooplankton number and biomass concentrations in large lakes, estuaries, and oceans have been obtained using the optical plankton counter (OPC). We have gained extensive experience from comparing vertical zooplankton net tows with results from a towed OPC vertically undulated along cross-isobath transects in Lake Michigan during all seasons including the winter-spring transition, when the recurrent sediment plume consisting of suspended bottom sediments was present. OPC biomass was correlated with total suspended matter (TSM), with OPC biomass being 10 times higher than net tow biomass under high TSM conditions due to large debris suspended from the bottom and probably from formation of large clay-phytoplankton aggregates. Best correlation between net tow and OPC biomass was found in offshore waters during summer; however, colonial algae can be a problem in some systems. Our results suggest that OPC results in high TSM regions of lakes and estuaries are highly suspect and that OPC results must be “calibrated” with net tow data at all times.

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IN-SITU OBSERVATIONS ON NEKTON AND EPIBENTHIC MEGAFAUNA OF THE CHARLIE GIBBS FRACTURE ZONE, MID-ATLANTIC RIDGE.

The Charlie Gibbs Fracture Zone (CGFZ) is a transform fault area, the deepest part of the northern Mid-Atlantic Ridge. It is an area of complex topography and currents where the North Atlantic Deep Water crosses the ridge system. We used four dives of the MIR manned submersibles to examine the near-bottom fauna of the CGFZ, at depths of 2000-4500 m, including steep lava cliffs interspersed with pockets of sediment and nearby abyssal-plain type areas. There was an extremely heavy fall of “marine snow” in the water. Epibenthic megafauna included diverse holothurians, crinoids, cnidarians, sponges, and a very unusual kind of worm (possibly “lophenteropneusts”). Fishes included halosaurs, bathysaurs, a morid cod, an apparent snailfish or ophidioid, slickheads, a small orange benthic anglerfish, and three species of grenadiers, including many small individuals at about 2 m above the bottom. Additionally, we documented cirrate octopods, shrimps and a galatheid among the nekton. The contrast was remarkable between the habitat and fauna observed on the deeper dives on an abyssal-plain environment and that encountered nearby in shallower rough terrain of the ridge.

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VARIATION IN SURFACE DISTRIBUTION OF CONCHODERMA AURITUM ACROSS THE TROPICAL PACIFIC

Records indicate that the pedunculate barnacle Conchoderma auritum has a worldwide distribution. Records to date have been scattered in time and space, precluding a conclusive spatial analysis for this species. We analyzed the surface distribution of C. auritum collected annually from 1993 to 1998 from 48 mooring sites of the TAO array, an array of fixed moorings across the tropical Pacific. Each mooring is replaced annually, allowing a yearly synoptic view of C. auritum occurrence on a basin-wide scale. The sampling area was divided into 9 sectors and numbers of C. auritum recovered per mooring in each sector were compared. For each sampling period, C. auritum exhibited a clumped distribution (Standardized Morisita Coefficients from 0.597 to 1.000). Highest numbers consistently occurred in equatorial and southeastern sectors. C. auritum was found in much lower numbers in western sectors, and only in the western equatorial sector. Comparisons made among sectors indicated that the distribution of C. auritum differed among most years. Comparisons among 1994, 1997, and 1998 suggest that El Nino/La Nina events impact the distribution of C. auritum.

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MOLECULAR DIVERSITY OF SYMBIOTIC DINOFLAGELLATES (SYMBIODINIUM SPP) WITHIN ALCYCONACEA OF BERMUDA

Taxonomy of the ubiquitous algal marine endosymbiont Symbiodinium has been a topic of scientific debate for well over thirty years. However, its’ taxonomic status and phylogenetic positioning still remains ambiguous, despite the division of Symbiodinium into clades which exhibit considerable genetic variation. Furthermore, research tends to be biased toward scleractinian-algal associations. This research examines soft coral (order Alcyonacea) symbiont diversity in Bermuda. Bermudian reefs have among the lowest diversity of cnidarians and hence Alcyonacea of any well-studied reef system, although the question of whether there is a correspondingly reduced diversity in their symbiont community has not been explored. Symbionts within six species of Alcyconacea were analyzed from five sites on the Bermuda platform. Clade level identities of the symbionts were determined by restriction fragment length polymorphism (RFLP) analyses. Subsequently, partial sequences of the nuclear encoded 18S and 24S ribosomal subunit genes and their internal transcribed spacer (ITS) regions were evaluated to identify specific level genetic congruence. Using likelihood and parsimony analyses, phylogenetic relationships between symbionts were resolved and comparisons were made with host phylogenies to determine incidence of coevolution.

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MULTIFREQUENCY HF RADAR MAPPING OF FRICTION VELOCITY AND VECTOR WIND FIELD

Multifrequency HF (decameter wavelength) radar is capable of measuring radial currents at multiple depths in the top few meters of the ocean. We present initial results of two innovative multifrequency HF radar techniques: measurement of friction velocity and surface wind field vector. Friction velocity is retrieved by noting perturbations of wave phase speed measured in echo Doppler spectra. Using additional information in the radar Doppler spectra allows measurement of the surface wind vector. Since the wind measurments are inferred from 7 to 30 m ocean waves, the surface wind field estimates lag behind real time by a few 10’s of minutes. Measurement methods are described and example

measurements on Monterey Bay, California are compared to in-situ buoy measurements. Error estimates and other limitations of the techniques are illustrated. Wind estimation errors are ≈ 1.5 m/s in speed (speed < 10 m/s) and ≈ 35 deg. in direction (speed < 5 m/s) and ≈ 15 deg. (speed > 5 m/s). Friction velocity errors are small for wind speeds > 6 m/s, but larger for lower wind speeds.

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IMPACTS OF ELEVATED CO2 ON DEEP-SEA SCAVENGERS

Hydrothermal vents on the seamount Loihi which emit fluids containing CO2 at concentrations as high as 418 mol/m3 at depths below 1200 m were used to examine the effects of continuous and concentrated deep-sea injection of carbon dioxide on marine scavenger assemblages. Prior to placing trapped amphipods above the vents all animals appeared to be either actively swimming or grasping the mesh of the funnel trap or vent openings. After a 10 minute exposure to waters with pH averaging 6.3 (background pH 7.11) and temperature 5.0 C (background 3.7 C) 90-95% of the amphipods were inactive. During the experiments movement of the traps resulted in a portion of the quiescent amphipods momentarily becoming active suggesting that some were not in a full state of torpor. When the experiments were terminated after one hour all amphipods became active within 30 minutes and remained active until temperatures exceeded 10 C during ascent. These results suggest that seafloor injection of CO2 could result in an alteration of ecosystem function in the form of a reduction in biomass recycling in impacted areas of the sea floor.

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TOWARDS AN OPTIMIZATION APPROACH TO MODELLING FOOD WEB-BIOGEOCHEMICAL INTERACTIONS

Marine planktonic food webs play a major role in partitioning radiatively-active gases (CO2, DMS, etc.) between the ocean and the atmosphere and thus in regulating climate. Capturing these complex interactions in numerical models that can provide useful predictions is a daunting problem. Current PZND models, which simplify the planktonic ecosystem into a few homogeneous compartments, may be reaching their limits in terms of explanatory and predictive power. Increasing complexity can refine the representation of food-web structure, but generates other problems (many poorly known parameters, lack of stability, etc.). We review approaches proposed recently to increase the realism and generality of food web models while minimizing complexity in the context of biogeochemical and climate modelling. A promising avenue may be to base models on the premise that individual compartments can optimize their own competitive power by maximizing the overall energy and biomass flux through the food web. This optimization approach generates parameterizations which are relatively simple yet represent the response of functional groups to changes in the environment. The improved realism of such formulations could make predictions more reliable.

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EFFECTS OF LAND USE CHANGE ON ESTUARINE CORAL REEFS IN PALAU

Environmental degradation by terrigenous mud has become a major local issue for artisanal fishermen in communities living around estuarine coral reefs in Palau. Poor land-use management in watershed catchments has increased soil erosion resulting in high levels of sedimentation and changes in salinity in estuarine coral reefs leading to the die-off of corals and associated marine organisms. Artisanal fisheries have collapsed in some areas resulting in socio-economic problems. To resolve a potential conflict between farmers in the watershed catchment and fishermen in estuarine coral reefs, integrated watershed management is needed. Sedimentation has the potential to affect coral reef recovery by limiting reproductive success and recruitment of corals. Therefore, persistence of estuarine coral reef resources is not possible without simultaneously reducing erosion in the watershed catchment.

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HOW ARE OCEANOGRAPHIC CONDITIONS RELATED TO THE PRESENCE OF DOMOIC ACID, A HARMFUL ALGAL BLOOM TOXIN, IN BENTHIC FISH IN MONTEREY BAY, CA, USA?

Domoic acid (DA), produced by the diatom Pseudo-nitzschia spp., occurs along both the east and west coasts of North America and is responsible for the condition Amnesic Shellfish Poisoning (ASP). Since the original 1987 outbreak of ASP in Prince Edward Island, Canada, there have been no reported human casualties. However, DA has since been implicated as the causative factor in massive marine mammal and bird mortality events in Monterey Bay, CA. As part of a larger HAB project within Monterey Bay, CA, weekly water samples were taken from the M1 Mooring Site and the Santa Cruz Wharf and analyzed for nutrient concentration, temperature, salinity, phytoplankton biomass, phytoplankton species composition, and Pseudo-nitzschia spp. abundance and toxicity. Here we highlight the relationship between these surface water conditions to the concentration of DA in commercially important flatfish collected during the year 2003. Examining correlations between the surface water environment and contamination of higher trophic levels of the benthos will lead to a better understanding of the ecology of DA-producing blooms, including the fate of DA at the end of these blooms.

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THE USE OF TOMOGRAPHIC DATA IN NUMERIC SIMULATION OF EDDY PROPAGATION INTO THE NORTHEASTERN GULF OF MEXICO BY ASSIMILATION INTO THE NUMERIC MODEL

A tomographic system (the single source and the array of receivers) is proposed across the DeSoto Canyon to monitor the Loop Current eddies, that propagate into the Northeastern Gulf of Mexico. Mesoscale eddies may affect the environment in the coastal zones by bringing waters with different properties into the system. The speed of sound propagation depends on the physical state of the medium and is measured by travel times to the receiver(s). Inverse tomographic algorithms convert travel times into hydrodynamic characteristics of the ocean, which consequently can be used in computer oceanic models. The computational system involving acoustical part (forward and inverse tomographic models operating within vertical 2-dimensional slice), hydrodynamical part (Estuarine Coastal Oceanic Model running on 3-dimensional domain), and tomographic data assimilation link has been implemented to produce the series of numeric experiments in support of the tomographic observational systems.

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SHELF/SLOPE EXCHANGE IN THE MISSISSIPPI BIGHT: MEASUREMENTS AND MODELING

Offshore of the Mississippi-Alabama coast a sharp temperature and salinity front at the continental shelfbreak separates relatively cool and fresh shelf waters from warm and salty water of the Northern Gulf of Mexico through the whole year except during the summer. Analysis of CTD data taken during 1999 – 2000 and ECOM model simulations show intrusion of the slope waters onto the shelf. In this study we test the hypothesis that a possible source for the observed and modeled variability in the Mississippi Bight is frontal instability. To determine the role of frontal instability in the shelf/slope exchange, numerical experiments are conducted in a channel with realistic bottom topography and cyclic boundary conditions. Preliminary results of the frontal meander development in a series of model experiments with various external forcing will be presented and discussed.

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TURBULENCE AND PLANKTON IN THE MARINE PELAGIC ENVIRONMENT

Turbulence in the ocean varies over many orders of magnitude from place to place and time to time. This paper reviews the behavioral and physiological adaptations of marine planktonic organisms that allow them to take advantage of, or mitigate the effects of turbulence. Two main effects can be identified. On the one hand turbulence increases the encounter rate of planktonic predators and their prey, and increases the rate at which dissolved nutrients are exchanged by phytoplankton. However, turbulence also has a detrimental effect on the sensory ability of zooplankton – both in generating hydromechanical noise, and in disrupting chemical signals. Recent results in quantifying these effects are presented. In these cases, increased sensitivity is only of marginal benefit, and the most efficient strategy is a behavioral response, either in changing feeding mode, or through vertical migration into quiescent deeper layers of the ocean.

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MODELLING SILICON DYNAMICS AT STATION P IN THE SUBARCTIC PACIFIC

In the High Nitrate-Low-Chlorophyll (HNLC) waters of the world oceans,silicon plays an important role in determining the production and vertical export of organic matter. Surface silicate depletion was observed at station P in the subarctic Pacific (50N, 145W) several times in the 70s, and once nearby in 2000, probably following inputs of iron from dust deposition or by advective mechanisms. A similar response was observed in a recent iron fertilization experiment, SERIES. Here we present results from a 1-dimensional ecosystem-mixed layer model, to which equations for dissolved silicate and biogenic silica have been added. The ecosystem model has been developed for station P and includes two size classes of phytoplankton, the larger class representing diatoms, microzooplankton, an imposed mesozooplankton grazing based on observations, sinking particulate organic nitrogen, ammonia and nitrate. It is shown that the observed annual cycle of dissolved Si puts an additional constraint on the ecosystem model parameters and thus on the modeled community structure. A number of model solutions that are compatible with bservations of nitrogen concentrations and fluxes are not compatible with the observed silicon cycle. We also whether the slower remineralization of silica, as opposed to nitrogen could explain the elevated Si:N drawdown ratio that has been observed in the HNLC waters near station P.

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RADIOCARBON AGE OF AMINO ACIDS DISSOLVED IN THE CENTRAL PACIFIC OCEAN

We used natural abundance radiocarbon to determine the 14C-age of the amino acid fraction of higher molecular weight dissolved materials in the surface and deep waters of the central Pacific Ocean. Though proteins and amino acids are among the most readily degraded compound classes and likely a key source of fixed nitrogen in severely N-depleted upper waters, previous work has also suggested proteinaceous material to be a major component of the recalcitrant dissolved organic nitrogen (DON) which accumulates in the deep sea, persisting over multiple ocean mixing cycles according to 14C-ages of the bulk DOM. Radiocarbon dating of the isolated amino acid fraction of DON for the first time directly addresses this apparent paradox, and allows an initial look at relative cycling rates of a major component of DON vs the bulk DOM reservoir in the subsurface ocean. To isolate the required quantities of amino acids, we have built a tangential ultrafiltration system capable of processing multiple-thousands of liters of seawater.

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TITLE: WAVE-INDUCED VENTING SUSTAINS A CHEMOAUTOTROPHIC SYMBIOSIS

Symbioses involving sulfur-oxidizing bacteria and various animal groups, in its essence, require a source of sulfide, a source of oxygen, and a mechanism that exposes the bacteria to both. Here, we present evidence for a novel mechanism using the example of a chemoautotrophic ectosymbiosis recently discovered in coves of mangrove islands off the Belize coast. We show that a combination of behaviourally and physically mediated seawater transports can sustain rapid growth of the sessile ciliate Zoothamnium niveum and its chemoautotrophic ectobiotic bacteria. The stalked colonies of Z. niveum grow on peat walls around the openings of cm-scale conduits created when mangrove-rootlets decompose. Using in situ microelectrode techniques (www.unisense.com), we found that the voids in the peat left by decayed roots are charged with H2S by diffusion from the decaying tissue during periods of low boundary-layer flow speed. During these times, the feeding current of the zooids transports oxygenated seawater from out side the peat wall toward the ectobiotic bacteria. During periods of high flow speed, H2S-rich seawater from the conduits is drawn along the colonies and transported toward the bacteria. Thus, the ectosymbiont is bathed alternatively in O2-rich and H2S-rich seawater. This example raises the possibility that other systems where pockets of decay are bathed in oscillating boundary-layer flow could support similar symbioses.

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INDUCTION OF HEAT SHOCK PROTEIN 70 MRNA BY THERMAL STRESS IN CALANUS FINMARCHICUS

Zooplankton may sustain physiological stress as they experience rapid and large changes in temperature through vertical migration. Induction of heat shock proteins (hsp) is a common protective response to thermal stress and we looked for evidence for such a response in Calanus finmarchicus. We compared hsp70 expression for copepods exposed to temperature stress with that for non-stressed controls. Partial sequences of the amplified cDNA product and alignment with known hsp70 sequences established the identity of the heat shock protein. Experimental animals were subjected to temperatures of 20 C (30 min) and 18 C (48 hours). An average of 4-fold increase of hsp70 mRNA expression was measured in the 2 groups of heat shocked animals using real-time quantitative PCR. The stress temperatures are within the natural range experienced by C. finmarchicus in late summer. These findings suggest that recent history of thermal stress may be assessed in natural populations through a molecular assay. Supported by NSF (REU site grant to MDIBL and OCE99-06223 to PHL) and NIA Salisbury Cove Research Fund (CSP).

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ATMOSPHERIC DMS DURING SERIES: FLUXES AND CONCENTRATIONS

In July 2002 an iron enrichment experiment (SERIES) was carried out in the sub-arctic Pacific Ocean as part of Canadian SOLAS. One of the hypotheses to be tested was that iron enrichment would stimulate the production of DMS, resulting in enhanced surface water concentration and sea-air flux of DMS. The iron addition initially stimulated production in DMSP lyase-using phytoplankton resulting in concentrations of DMS exceeding 30 nmolar in the surface water column. Atmospheric DMS measurements were made hourly throughout the experiment. The mean atmospheric DMS concentration was 82 nmoles per cubic metre and the maximum concentration was 317 nmoles per cubic metre. Sea-air flux estimates were calculated based on the model of Liss and Merlivat (1986) using daily surface water concentrations and 24-hour average wind speeds. Estimates ranged from 2.7 to 83 micromoles per square metre per day with a mean of 34 micromoles per square metre per day. They followed the same pattern as atmospheric concentration measurements suggesting that variations in atmospheric DMS concentrations were due to variations in source strength controlled by ventilation.

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COPEPOD SENSITIVITY TO FLOW FIELDS: CAN COPEPODS DETECT FLOW-GENERATING PREDATORS?

Copepods have the mechanoreceptive abilities to detect velocity gradients generated by approaching predators and the ability to respond to these predators within milliseconds. Ctenophores produce a low-velocity feeding current to entrain slow-swimming and non-motile prey. Although adult copepods are capable of detecting solid objects and shear produced by flow fields, ctenophores often seem to remain hydromechanically cryptic to adult copepods. Since copepod species vary in their sensitivity to hydrodynamic disturbances, it is possible that species will differ in their ability to distinguish flow-generating ctenophores from the surrounding fluid. Predator-prey interactions were recorded between the ctenophore, Mnemiopsis leidyi and three copepod species, Temora turbinata, Acartia tonsa, and Paracalanus parvus. Although A. tonsa displayed greater sensitivity to shear rates generated by a siphon-generated flow field, T. turbinata was most successful in escaping the ctenophore predator. Results suggest sensitivity to shear levels may play only a minor role in determining escape success from a flow-generating predator.

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UNIQUE ANOXYGENIC PHOTOSYNTHESIS GENES AND OPERONS IN UNCULTURED BACTERIA IN THE DELAWARE ESTUARY

Marine aerobic anoxygenic photosynthetic (AAnPS) bacterial genomes contain photosynthesis genes that cluster with those from alpha-, beta-, and gamma- proteobacteria. To date, the diversity and expression of uncultured AAnPS genes in temperate freshwaters have not been examined. We surveyed the Delaware River for pufL and pufM genes, which encode AAnPS reaction center proteins, in a fosmid library of bacterial genomic DNA. Two fosmid clones containing AAnPS photosynthetic operons were completely sequenced and annotated. The operons in the two clones were organized differently than known cultured and uncultured organisms from marine and freshwaters. One clone contained genes most closely related to those of beta-proteobacteria. Preliminary data on pufM genes amplified from DNA of Delaware estuary bacteria suggest that most of those genes were most closely related to those of beta-proteobacteria. PCR-amplified and genomic-isolated pufM genes cluster separately from currently known cultured and uncultured AAnPS. These data on pufM genes in the Delaware estuary indicate an unexpected diversity of estuarine AAnPS bacteria and can be used to explore their ecological success during the transit through the estuary into coastal waters.

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SINKING FRACTIONATION OF CARBON IN A SWEDISH FJORD

We studied the growth and sedimentation of a secondary phytoplankton bloom in the Gullmar Fjord in spring 2001. Sinking fractionation, as measured by differential sinking of components with varied carbon isotope signal, was an important process in determining carbon fluxes within this complex coastal ecosystem. Large, rapidly sinking diatoms aggregated with their own carbon exudates. This exudate material was the single largest contributor to vertical carbon flux in the fjord over the study period, and according to our estimates amounted to an order of magnitude greater carbon than the live biomass in the sediment traps. . Sinking diatoms and diatom exudates represented 44% of integrated primary production, despite the fact that the surface bloom was dominated largely by high concentrations of the rogue flagellate Chattonella sp. Diatoms carried to depth a high carbon isotope signature (del13C = -19 o/oo) distinct from other POC at the surface with a low signature (-23 to -26 o/oo). This low del13C signature at the surface in coincided with a surface peak in particulate and dissolved organic carbon (POC/DOC), and Transparent Exopolymer Particles (TEP), and material carrying the low del13C signature had a negligible sinking rate. This distinctive surface signature probably contained small POC typical of the microbial loop and its products, a component of which was the very low -32 o/oo of the organic colloids (measured via colloid flocculation).

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MEDFLUX: ORGANIC MATTER COMPOSITION FROM TIME-SERIES AND SINKING-VELOCITY SEDIMENT TRAPS IN THE "TWILIGHT ZONE" IN THE MEDITERRANEAN

A bottom-moored sediment trap array was deployed at the French JGOFS DYFAMED site off Monaco during March – May, 2003, to evaluate the time-series flux of particulate matter (PM) and its sinking dynamics in the "Twilight Zone". One set of traps was operated in a time-series mode while a second was modified to collect PM as a function of its ambient settling velocity (poster by Peterson et al.). The sinking-velocity trap collected PM over the range in settling velocities from 0.7 – 1000 m/d. The collected material has been analyzed for mass, organic carbon and total nitrogen, lipids, amino acids and pigments. Here we present results of these analyses to test hypotheses related to the association of organic matter (OM) and mineral ballasts, the sinking dynamics of OM-mineral particles, and the protection against degradation that mineral matrices afford to associated OM.

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SHELF-BASIN INTERACTIONS AND CIRCULATION IN THE WESTERN ARCTIC OCEAN: 1979-2002 MODEL RESULTS

The western Arctic Ocean circulation, its spatial patterns over the shelves and in the basin, and their temporal variability are investigated using the Naval Postgraduate School pan-Arctic ice-ocean model. The primary goal of this work is to describe background physical conditions of the Shelf Basin Interaction (SBI) region, including the Chukchi and Beaufort seas, since the late 1970s through 2002. Monthly-averaged and 'snapshot' output from the model configured at 1/12 deg. and 45-level grid is analyzed with particular emphasis on regions of possible high shelf-basin exchanges. Empirical Orthogonal Function (EOF) analyses of both the prescribed atmospheric forcing fields and oceanic properties in response to them are performed to better understand air-sea linkages. Selected fields are compared to in situ observations from the SBI 2002 field experiments. Both direct measurements and model results show very high spatial and temporal variability of investigated fields, especially ocean currents, which allows general comparisons but to some degree limits direct model-data validation. We argue that time series obtained from moorings are more useful as they provide critical verification of longer-term model variability.

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EVALUATION OF JESOGAMMARUS SPECIES BIOMASS USING AUV

AUV "tantan" was launched in March 2000 to watch the environmental changes of water quality and aquatic ecosystem in Lake Biwa. Since then, we have improved the system, and succeeded in developing the image analysis technology to evaluate benthic organisms on the lake bottom with digital camera images taken by tantan. In this study, we present some results applied for the detection and evaluation of Jesogammarus species biomass, which are the major benthic organisms. As the images have less distinguishable background, we had to create a suitable filtering program to identify Jesogammarus species. The correlation coefficient between the naked eye counting and image analysis result is 0.99945 (N=7, p<0.001). Weunderstand this system can provide us the reasonable evaluation ofJesogammarus species biomass .

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ELECTRONIC TAGGING OF ADOLESCENT AND MATURE WEST ATLANTIC BLUEFIN TUNA (THUNNUS THYNNUS)

An electronic tagging program was initiated for Atlantic bluefin tuna (ABFT) in 1996. The objective was to assess large-scale movement patterns and behavior of western-tagged ABFT. We report on the results of implantable archival tags deployed in 1996, 1997 and 1999 that recorded movements from 0.5-3.8 years. To date, 24.5% of the archival tags (n= 69) were recovered indicative of high mortality on the population. ABFT displayed three different age dependent migration patterns when released from North Carolina, USA. Adolescent ABFT display western residency moving from winter aggregations in the offshore Carolina shelf and slope waters to summer aggregations in the Gulf of Maine. Mature fish moved from winter locations in the Carolinas or Blake Plateau either to waters east of the Flemish Cap and further to the eastern Atlantic (multiple crossings were observed) or directly transatlantic to the Mediterranean Sea. All fish displayed seasonal aggregations in the same regions over successive years. Archival tag records provide detailed information on diving behavior and depth and temperature profiles during the track providing an environmental context for examining the movement patterns.

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INTERNAL WAVES AND MIXING OBSERVED DURING THE SWAT EXPERIMENT

During the Fall of 2000 an intensive survey was carried out in the mid-Atlantic Bight near 72.7W, 39.3N as part of the SWAT (Shallow Water Acoustic Technology) program. Here we use moored and in-situ observations from SWAT to characterize high-frequency internal waves and associated mixing observed during the experiment. A suite of instruments including moored ADCPs, temperature/salinity chains, a yo-yo CTD, and a Scanfish allow characterization of currents, waves, thermohaline structure, as well as estimation of Froude numbers, turbulent-overturn scales, and associated mixing. Velocities are dominated by energetic internal tides with peak-to-peak velocity amplitudes of up to 40cm/s. Superimposed on this are large-amplitude internal waves with periods less than 0.5 hours and velocity amplitudes of about 20cm/s, which may have a significant effect on sound propagation in the coastal ocean. These high-frequency waves cause large deformations of the density field, and are sometimes associated with internal hydraulic jumps. Depth-averaged Froude numbers show typical values of 0.2 to 0.4, with periods in which Froude numbers close to 1 were observed, suggesting the waves may be an important contributor to local mixing.

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CULTIVATION INDEPENDENT ASSESSMENT OF METABOLIC ACTIVITY AND PERSISTENCE OF HOST-SPECIFIC BACTEROIDETES FECAL MARKERS

Fecal bacteria in fresh and marine waters cause human health risks, economic loss, and environmental impairment. Current microbial indicators fail to discriminate among fecal sources and may grow in natural systems. We have proposed molecular markers from fecal anaerobes within the class Bacteroidetes, to indicate source-specific fecal pollution. The purpose of this study was to determine persistence and survival of these markers following environmental exposure. By labeling with bromodeoxyuridine (BrdU) we measured persistence and growth of fecal bacteria in a cultivation independent manner. Preliminary experiments showed Bacteroides vulgatus incorporated BrdU. Using sewage influent, we found cells from a human-specific Bacteroidetes clade incorporated BrdU after four hours, indicating growth, under anaerobic and aerobic conditions. This work also showed the genetic marker for the human-specific clade persisted up to 24 hours under both aerobic and anaerobic conditions. Our results indicate BrdU assimilation is a robust method of measuring metabolically active fecal bacteria in situ. Ongoing research will examine survival and persistence of the entire fecal community over an extended time course, including the role of anaerobic sediments as refugia for Bacteroidetes bacteria.

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OCEAN COLOR REMOTE SENSING FOR THE CASE-2 WATERS: ATMOSPHERIC CORRECTION USING THE LONGER NIR BANDS

For the Case-2 waters, the ocean is usually not black at the near-infrared (NIR) wavelengths centered at 765 and 865 nm, which are used for the atmospheric correction for both SeaWiFS and MODIS. In these cases, the ocean contributions at the NIR are often mistakenly accounted as radiance scattering from atmosphere, thereby leading to over-correction of atmospheric radiance and underestimation of water-leaving radiance at the visible. In this presentation, I provide simulated results of the atmospheric correction using the longer NIR bands paired as 1000 and 1240 nm and 1240 and 1640 nm for retrievals of the ocean color product in the coastal waters. At the longer NIR bands, ocean is black even for the Case-2 waters. Thus, the Case-2 bio-optical model that has strongly regional dependence is not needed for the atmospheric correction. The atmospheric correction can be therefore operated routinely for the global coastal waters, and the water-leaving radiance spectrum from blue to the short NIR in the coastal regions can be derived. The scheme can also be applied to cases of the Case-1 waters with high chlorophyll concentrations. The performance of the atmospheric correction using the longer NIR bands is compared with that of the SeaWiFS and MODIS algorithm using the 765 and 865 nm bands. Some detailed discussions of the algorithm performance, error analyses for various solar-sensor geometries and atmospheric properties, as well as algorithm implementation for processing data from aircraft and satellite sensors are provided.

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A METHOD TO QUANTIFY THE UNCERTAINTIES ASSOCIATED WITH SEMI-ANALYTIC ALGORITHM FOR INVERSION OF OCEAN COLOR.

Inversion of ocean color (Rrs) into inherent optical properties (IOPs) or biogeochemical parameters come in two flavors; empirical relationship between Rrs bands and in-situ properties, and semi-analytical algorithms linking the Rrs to the absorption and scattering of biogeochemical components (e.g. phytoplankton, CDOM, etc'). Semi-analytical algorithms vary in three ways: a. relationship between Rrs and IOPs, the method of inversion (linear vs non-linear), and the assumed shape of the constituents IOPs. There is currently no method available to quantify the uncertainties associated with the inversion products. We present an algorithm to compute these uncertainties. It is based on finding all the possible solutions that are within an acceptable level of tolerance around the observed Rrs. The statistics of these solutions are calculated from the distribution of all possible parameters. We apply this algorithm to a specific inversion scheme that includes a size dependent phytoplankton absorption shape. We test it with a dataset of IOP and Rrs collected during the HyCODE field campaign and a synthetic dataset of ZP Lee.

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VARIABILITY IN SOURCES AND RADIOCARBON AGES OF MAJOR BIOCHEMICAL COMPOUND CLASSES OF HIGH MOLECULAR WEIGHT DISSOLVED ORGANIC MATTER IN ESTUARIES

High molecular weight dissolved organic matter (HMW-DOW, >1000 Dalton) represents an important component of dissolved organic carbon (DOC) in rivers, fresh water lakes and oceans, and thus plays important roles in global carbon cycling. It's sources and formation mechanisms, however, are still not well understood especially in estuarine and coastal waters where multiple inputs of organic sources coexist. In this study, we measured natural radiocarbon (D14C) abundance and stable carbon (d13C) isotopic compositions for the major biochemical compound classes (amino acids, carbohydrates, lipid) as well as the "uncharacterized" organic fractions separated from HMW-DOM samples collected from four U.S. estuaries. Our results show that distinct differences in both d13C and D14C exist among the compound classes. Both total carbohydrate (TCHO) and total hydrolysable amino acid (THAA) fractions had enriched d13C values and much younger 14C ages than those of the total lipid and uncharacterized organic fractions. These isotopic differences found among the compound classes suggest that inputs of organic matter from both terrestrial and local sources play important roles in the formation and cycling of HMW-DOM and thus regulation of its isotopic signatures in estuaries.

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OCEAN-ACOUSTIC STUDIES OF NEAR-SURFACE AND NEAR-BOTTOM SOLITON PACKETS

We have performed joint oceanographic and acoustic studies in the Strait of Messina, Gulf of Gioia, Yellow Sea, Winter Primer, and ASIAEX areas. Solitary internal waves have different characteristics in the different study areas.They propagate off shelf in the Yellow Sea and on shelf in the Winter Primer. Solitary waves of depression that peak in the pycnocline near the surface propagate away from the shore (off the shelf), and the less noticed solitary waves of elevation formed around the shelf break propagate toward shore near the shelf bottom. A fully nonhydrostatic, 2.5-dimensional oceanographic model developed by Lamb (1994) was used to perform the oceanographic simulations.The resulting solitary wave simulations are adjusted until they agree with observations and the structure of the simulated solitary wave packets compare favorably with the measured data, both in period and amplitude. Acoustical field calculations are performed using a high-fidelity ocean acoustic simulation model along the path of solitary wave packet propagation by coupling with the sound speed derived from the oceanographic simulations.The joint oceanographic and acoustic simulations indicates a complex interaction between the oceanographic and acoustic fields that can result in anomalous loses and enhancements in acoustical energy. This can occur over particular spatial and temporal bands at certain acoustic frequencies. The acoustical modes are calculated and the loss mechanisms are analyzed.

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3D SIMULATION OF THERMOHALINE PLUMES IN THE BAHAMAS

The heat budget of shallow seas is significantly affected by the optical effects of the bottom. The bottom absorbs part of the light and reflects the rest depending on its albedo. The absorbed light is reradiated as heat thus heating up the water column from below. This heating and the ensuing evaporation of the shallow seas lead to the production of hyper-saline plumes in the shallow waters. Such plumes have been known to reach salinities of 45 ppt in the shallow waters near Bahamas. In this study, a modified Princeton Ocean Model is employed during the spring to study the circulation features associated with this optical heating of the shallow seas of the Bahamas near Lee Stocking Island. It was seen that after three months the dense, saline plumes originating in the shallow waters follow the contours of the bottom and spread out into the deeper waters. After they reached a depth of about 45 m in late spring, they are buoyed by thermocline waters at that depth and spread laterally. Numerous field observations to support the model results.

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C FLUX AND PELAGIC-BENTHIC COUPLING DURING A LAGRANGIAN DRIFT STUDY CLOSE TO THE NORTH POLE

We estimated primary production, concentration of mineral nutrients, suspended chlorophyll a, POC and PON, and the vertical flux of organic particles in high Arctic during August 2001. A Lagrangian approach lasting for 4 weeks was selected. A clear density discontinuity at ~25 m separated a less saline upper mixed layer. A rough estimate of 5 - 15% ice-free surface, plus numerous melt ponds on ice sheets, supported a planktonic primary production of 50 – 150 mg C m-2 d-1 (mean 95 mg C m-2 d-1, n=6) in the nutrient replete upper 50 m. Chlorophyll a was ~ 0.25 mg m-3 in the upper 20 m and < 0.1 mg m-3 below; POC ~ 50 mg m-3 and PON ~ 7 mg m-3 with no clear vertical trend. The vertical flux of POC varied around 50 mg C m-2 d-1 without any clear decrease with depth, and was quite similar between the six deployments. We preliminarily conclude that much of the planktonic biomass and primary production was under strongly top-down controlled by local and advected, partly over-wintered calanoid copepods. We speculate that this scenario may be the typical one for most productive part of the Polar Ocean that is influenced by Atlantic inflow.

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RESOLUTION OF TAXON-SPECIFIC SPATIAL PARTITIONING IN MICROSCALE PHYTOPLANKTON DISTRIBUTIONS

We present the first quantitative evidence of taxon-specific spatial partitioning in microscale phytoplankton distributions. Sampling occurred in the Port River Estuary, South Australia. Four consecutive sample sets were collected with a two-dimensional syringe sampling array, consisting of 10 x 10 syringes (200 ul sample volume) and an intersample distance of 1.2 cm. Phytoplankton concentrations, in the size range of 0.5 to 20 um, were determined by flow cytometry. Total counts were then divided into five arbitrary taxonomic subgroups, defined from group-specific light scatter (FALS, RALS) and autofluorescence (red and orange) characteristics. The spatial organisation of taxonomic groups was compared utilising spatial correlation analysis. Pair-wise comparisons identified partial spatial separation for all comparisons. The structural organisation of taxonomic groups was further investigated using rank-size analysis. Significant, non-random organisation was identified across all taxonomic groups, including distributions of total cell counts. The taxon-specific details of rank-size analysis are used to infer dominant structuring mechanisms operating at these scales. We suggest that the results help explain the taxonomic diversity of marine plankton communities.

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INVERTEBRATE ASSOCIATES OF DEEP WATER ALCYONACEANS

Sea fans and soft corals are common members of tropical shallow water reef communities. As with their shallow water counterparts, deep-dwelling alcyonaceans are often devoid of invertebrate residents. Three groups that have been able to successfully colonize living alcyonaceans, however, are the crinoids, brittle stars, and scaled polychaete worms. The latter, usually called scale-worms, seem to be abundant on members of the family Primnoidae, where they can elicit changes in the formation of the sclerites by the host species. Crinoids have been seen on corals with robust calcareous axial skeletons, such as the Isididae and Coralliidae. Brittle stars, however, are the most ubiquitous of all invertebrates living on deep water alcyonacean corals. Brittle stars and crinoids seem to use the coral merely to get themselves higher in the benthic boundary layer, most likely for feeding, whereas it is likely that the scaleworms are either feeding on the coral, or items caught in the mucus coating the colony. The presence of deep water alcyonaceans increases biodiversity levels only slightly because the number of associated species is low.

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THE IRON SPECIATION IN THE OCEANIC MIXED LAYER: A MODELING PERSPECTIVE

Recent studies have highlighted the dynamic cycling of iron between its various physical (dissolved, colloidal, particulate) and chemical (redox state and organic complexation) forms in the mixed layer of the ocean. Previous model studies of iron biogeochemistry ignore more or less this speciation of iron. Here we present a model that describes the cycling of iron between its forms in the mixed layer at the Bermuda Atlantic Time Series Station (BATS). As the kinetics of various reactions in the model are not very well constrained experimentally, the aim of this study is to improve our understanding which of these various processes are important and which are not for the residence time and bioavailability of iron. Model results show total dissolved iron concentrations that are in accordance with observed values; however, the balance of iron fluxes depends strongly on the models parameter settings. Colloid aggregation allows the model to reproduce the rapid vanishing of iron after sudden input events that has been observed repeatedly in iron fertilization experiments, and that is unexplainable by the slow process of scavenging alone.

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A NEW LABORATORY APPARATUS TO STUDY THE INTERACTION OF TURBULENCE AND PELAGIC ZOOPLANKTON

A new experimental apparatus to simulate isotropic oceanic turbulence at low Reynolds number in the laboratory is described for the purpose of examining the effect of turbulent fluid motions on zooplankton behavior. Actuators located at each corner of a cubic Plexiglas box generate synthetic jets that interact to create turbulent flow at the center of the saltwater apparatus. Four turbulent intensity levels are established and velocity measurements are performed using Particle Image Velocimetry (PIV). The flow characteristics in the center of the apparatus are confirmed to be nearly isotropic and homogeneous. The range of the dissipation rate and the Kolmogorov microscale agree well with natural oceanic environments, and the length scales and magnitude of the velocity fluctuations are appropriate for zooplankton studies. The flow characteristics compare favorably to previous approaches for generating turbulence in the laboratory, in particular oscillating-grid apparatuses. Preliminary behavior response of copepods is quantified by swimming path analysis, including speed and trajectory, for specimen attempting to aggregate to a collimated beam of light for each of the turbulence intensity levels.

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DEVELOPMENT AND DISTRIBUTION OF PLANKTON OBSERVED WITH A FERRYBOX SYSTEM FOR MONITORING COASTAL WATERS

Ships-of-opportunity like ferries offer cheap and reliable measuring platforms to make automatic observations of coastal waters. We will present results of observations made on a route between Cuxhaven (Germany) and Harwich (UK) which is covered every night. The FerryBox system has sensors and analysers for the parameters salinity, pH, oxygen, turbidity, fluorescence, ammonium, nitrate/nitrite, o-phosphate and silicate. Strong gradients in both nutrients, and turbidity can be easily observed in the coastal vicinity on both sides of the transect. This study will focus on the distribution and development of phytoplankton. The observations in the North Sea clearly show low winter values in chlorophyll-a over most part of the transect, nearby coastal effects of riverine loadings, and patchy distribution of algal blooms along the transect in spring and summer. Data for different algae groups measured by excitation with different wavelengths are analysed and compared with pigment analysis and cell countings. The data obtained by the Ferrybox system will be compared with data from moored monitoring stations and remote sensing data measured by the instrument MERIS at the satellite ENVISAT.

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A CAPSTONE PROGRAM TO FOSTER INTERDISCIPLINARY UNDERSTANDING AND PEER NETWORKING AMONG RECENT PHD RECIPIENTS

After years of specialization, today's graduates are often transported to an environment that requires connections between distant disciplines and a network of colleagues from divergent backgrounds. The historic divide between the physical/natural and social sciences must often be bridged as well. And, work must often be placed in a context relevant to and understandable by managers and policy makers. While PhD institutions are evolving to meet the needs of interdisciplinary students, some issues transcend institutional boundaries and national borders. How can we prepare recent graduates to address these challenges? A group of established professionals and recent Ph.D. graduates met Oct. 3-6, 2003 to brainstorm about a capstone program for interdisciplinary PhDs. Participants were asked to identify the specific needs of recent Ph.D. graduates engaged in interdisciplinary work, and develop possible solutions in the context of a Capstone Program that can be disseminated via electronic resources or implemented in the context of a week-long meeting. DIALOG, the Dissertations Initiative for the Advancement of Limnology and Oceanography, was used as a model. Recommendations from this workshop will be presented along with an overview of DIALOG.

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A COASTAL OCEAN OBSERVING SYSTEM AND MODELING PROGRAM FOR THE WEST FLORIDA SHELF

The Coastal Ocean Monitoring and Prediction System (COMPS) combines observations with numerical models for the purpose of describing and predicting coastal ocean state variables for the West Florida continental shelf (WFS). COMPS observations, available in real time at http://comps.marine.usf.edu, consist of coastal and offshore stations with in-situ ocean and atmosphere measurements. COMPS is also part of the Southeast Atlantic Coastal Ocean Observing System (SEA-COOS), a regional association of observing and modeling systems extending from North Carolina to Florida. We present an update on the status of the COMPS/SEA-COOS programs along with some initial science findings on the control of WFS variability over diurnal to inter-annual time scales. Based on these findings we comment on the design and maintenance of an integrated coastal ocean observing system for societal and scientific applications.

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DOES TURBULENCE MATTER? TESTING THE ROLE OF TURBULENCE IN STRUCTURING PREDATOR-PREY RELATIONSHIPS IN THE FIELD

Substantial experiments in laboratory flumes suggest that crustacean predators cannot navigate through chemical plumes in turbulent conditions. This has lead to the presumption that naturally turbulent habitats are refuges from predators, such as blue crabs, that use olfaction to find prey. Although attractive, this hypothesis has not been tested in complex natural flows, and is complicated by recent evidence suggesting that bivalve prey detect and avoid predators using olfaction, which also is compromised by turbulence. Thus, the impact of turbulence on predation intensity may a function of the relative decrement in perceptual abilities induced by turbulence. We tested the impact of turbulence on predation by crustacean predators on bivalve prey using manipulations of turbulence in natural habitats. Increased turbulence increases prey survival only where ambient flows are benign, which is consistent with associations between foraging ability and turbulence intensity known from flume studies. Interestingly, other predators are not compromised by increased turbulence (discussed in a companion study), suggesting that turbulence provides only a partial refuge from predation, and that predators may coexist by partitioning habitat usage along a turbulence gradient.

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THE SYNERGY OF IRON, COPPER AND THE TOXICITY OF DIATOMS

Outbreaks of toxigenic Pseudo-nitzschia were first recognized only about a decade ago but since then large coastal blooms of these diatoms have caused massive mortalities of marine mammals and closures of important fisheries. Iron additions to HNLC waters often also generate high Pseudo-nitzschia abundance, although toxin production has not been measured in those circumstances. We show that Pseudo-nitzschia spp. have an unusual ability to adapt to iron stress, and that this adaptation is regulated by the availability of copper. The toxin, domoic acid, chelates both iron and copper and while iron deficiency enhances its production a shortage of copper has a far greater stimulatory effect. We speculate that a synergistic linkage exists between iron and copper metabolism, whereby domoic acid may facilitate copper acquisition that, in turn, enables these diatoms to directly access iron bound to strong ligands (e.g., siderophores). The unusual and apparently enormous efficiency of this high-affinity iron uptake system appears to separate toxigenic diatoms from many non-toxic species, and may help explain why large diatoms from this genus can be so abundant in offshore HNLC waters.

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A C-14 BASED METHOD FOR DETERMINING MICROZOOPLANKTON GRAZING RATES

A carbon-based dilution method, utilizing 14C technique, is described here for determining microzooplankton herbivory. The method parallels current dilution-technique procedurally, but differs conceptually in the expected effects of dilution on routine measurements of primary production. The 14C method alleviates potential artifacts associated with the use of pigments as tags for algal prey. The technique effectively integrates prey-specific, and grazer-specific biases, resulting in a bulk, carbon-based estimate for microzooplankton grazing rate, arguably the most relevant ecological common denominator for production studies. In principle, the technique could also be applied to oxygen-based measurements of production, as long as signal strength is adequate. Field data from California to the oligotrophic Central Pacific show a sharp increase in microzooplankton grazing rates with distance offshore. Microzooplankton grazing rates scaled with the ratio, divinyl chl a/total chl a, a rough proxy for the transition from coastal to oceanic planktonic food webs. In all cases tested, the 14C-based technique yielded large positive grazing rates (> 1.5 d-1), even when simultaneous chl-based dilution experiments failed.

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ANTHROPOGENIC IMPACT ON NUTRIENT DYNAMICS IN A MACRO-TIDAL SUB-OXIC-ANOXIC ESTUARY

Changing land uses, and increased surface water runoff and point source inputs have resulted in major changes in the speciation/concentration, and loading rates of nutrients in Danshuei Estuary, third largest river in Taiwan. Both conservative and non-conservative mixing behaviors were observed for all nutrient elements at different times. Mixing behavior is mainly controlled by river discharge, tidal mixing and reaction rates. Conservative mixing occurred at high river flow during rainy seasons, and the nutrient concentrations were relatively low; non-conservative behavior occurred at low river flow during dry seasons, and nutrient concentrations were high. Silicate originates from weathering and erosion of the bedrocks in the watershed, whereas nitrogen- and phosphorus- bearing nutrients mainly come from urban discharges. Observed repeatedly, ammonium is the predominant nitrogenous species, ranged from 10 to 1000 uM. As the ammonia-bearing water reached the river mouth, ammonium was gradually oxidized to nitrite and nitrate by the oxygenated coastal water, reflecting a complicated biogeochemical pathway rather than simple dilution behavior. The nutrient chemistry is complex and dynamic due to anthropogenic perturbation and reactions in the tidally mixed zone of strong redox gradients.

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EVIDENCE FOR THE DEPENDENCY OF THORIUM SORPTION ON PARTICLE COMPOSITION BASED ON LABORATORY EXPERIMENTS AND FIELD DATA FROM A SEAMOUNT SYSTEM

Naturally occurring, particle-reactive thorium radionuclides are widely used to quantitatively trace particle provenance, dispersal and fate in aquatic systems. Sorption of thorium on particles is considered to be controlled both by size and concentration of particulate matter (PM). Moreover, there has been a long standing assumption that thorium is characterized by “nonselective particle reactivity”. There is, however, growing evidence that PM composition also controls the sorptive behavior of thorium. In this context laboratory experiments have been conducted to determine activity-surface-ratios of thorium-234 of biogenic (cyanobacteria and diatoms) and abiogenic (fine-grained till) PM. The results indicate that thorium-234 adsorbes in higher amounts and faster on to organic particles, and that there are non-linear interactions in mixtures of different PM qualities. A combined investigation of particle composition and radioactive thorium-234/uranium-238 disequilibria for a broad range of particle qualities and concentrations in waters surrounding a seamount corroborates the notion that thorium dynamics depend on the concentration as well as on the quality of the PM. Consequences of these results for the use of thorium isotopes as particle tracer are discussed.

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OCEAN COLOR REMOTE SENSING OF TRICHODESMIUM

Trichodesmium spp. can be an important biogeochemical component in both the coastal and open ocean. However, information regarding their spatial and temporal distribution is sparse. It has been shown that Trichodesmium have unique optical properties that should allow for their spectral signature to be evident in ocean color data. Here, a globally applicable bio-optical algorithm has been developed that relates the in situ Trichodesmium biomass to its water leaving radiance signal. This inverse reflectance model was tested against concurrent measurements of Trichodesmium abundance and radiometric measurements compiled from various cruises from 1994-present. Model parameters were optimized to correctly identify bloom values (Trichodesmium-specific chl > 1.0 mg m-3) while minimizing false positive retrievals. Using the in situ dataset, the model correctly identifies ~85% of observed bloom values, while correctly predicting ~95% of non-bloom values. Application of this model to global ocean color imagery shows patterns consistent with historical and anecdotal observations of blooms. Maps such as this provide an alternative means of estimating global rates of N2 fixation, and perhaps their contribution to new production in the world oceans.

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LIGHT INDUCED GROWTH OF WINTER PHYTOPLANKTON COLLECTED FROM THE BENTHIC BOUNDARY LAYER OFF OREGON, USA

The spring phytoplankton bloom off Oregon is an important food source for zooplankton emerging from diapause. However, little is known about sources of phytoplankton seed stock for the bloom or the timing of it. We collected water from the benthic boundary layer over the inner and mid- shelf off northern Oregon in January, 2003, and conducted experiments in shipboard incubators held at 10 C. The water was exposed to 2 daylengths, representative of winter and spring daylengths, and 4 light levels. Significant increases in Chl a, POC, and PON were observed in high light and medium light treatments at both daylengths. No change was observed in the low light treatments and Chl a decreased in the control. Blooms that developed were composed of Thalassiosira sp., Actinopytchus sp., Asterionellopsis glacialis, and other diatoms, consistent with in situ phytoplankton community composition in spring. Growth occurred at light levels that were < 2x that measured in situ at the surface in January, suggesting that light levels at the surface are conducive to growth, but that mixing may prevent significant growth during the winter.

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USING LABORATORY AND IN SITU PHYSIOLOGICAL PARAMETERS TO MODEL TRICHODESMIUM SPP. FLEXIBLE ELEMENTAL STOICHIOMETRY AND VERTICAL MIGRATION CAPACITY IN THE NPSG

The cyanobacterium Trichodesmium is a conspicuous member of the phytoplankton community in the oligotrophic North Pacific subtropical gyre notable for its relatively large size, diazotrophic capacity and buoyancy. Much of the work with this organism has centered on determination of nitrogen fixation rates. Our research aims to look beyond the more salient feature of diazotrophy and delve into some of the underrepresented controls of Trichodesmium productivity. Particularly, we have conducted recent laboratory experiments revealing the remarkable stoichiometric flexibility exhibited by this diazotroph. These results indicate that Trichodesmium spp. are capable of viable growth with carbon to phosphorus ratios approximately 16 times Redfield stoichiometry. Building on this research we have also explored, via integration of physiological studies and modeling exercises, the potential for buoyancy-driven vertical migration to serve as a uniquely biological source of nutrient injection into NPSG surface waters. The knowledge of Trichodesmium bioenergetics gained from this research will serve to further constrain the potential role of Trichodesmium spp. in biogeochemical cycling.

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FLUX OF N AND P FROM SEDIMENT IN THE ST. JOHNS RIVER ESTUARY

Eutrophication of estuaries is a result of decades of agricultural, industrial and urban nonpoint and point source pollution. Internal cycling is an important contribution to the total load. The objectives were to calculate N and P flux rates using and determine the contribution of the sediments to the nutrient load. Sediments were collected from 4 stations to include the oligohaline lacustrine zone and freshwater lacustrine zones. Porewater profiles were determined for soluble reactive phosphorus (SRP) and ammonium (NH4) flux under anaerobic and aerobic conditions. SRP porewater profile fluxes ranged from 1.01 to 8.55 mg m-2d-1 and NH4 fluxes ranged from 12.74 to 31.3 mg m-2d-1 over the year. SRP core flux ranged from 2.34 to 11.7 mg m-2d-1 while anaerobic NH4 core flux rates ranged form 8.23 to 28.0 mg m-2d-1. Anaerobic flux rates of SR were 23 times higher than under aerobic conditions. The contribution of SRP was 25% of the total load to the LSJRE while NH4 contributed close to one third.

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RAINWATER CHROMOPHORIC DISSOLVED ORGANIC MATTER: CHARACTERISTICS AND PHOTOREACTIVITY

Rainwater DOM is a little studied part of the global carbon cycle. Although the flux of rainwater DOC to oceanic waters has been estimated to be on the same order of magnitude as riverine DOC inputs, virtually nothing is known about rainwater DOM composition. Our preliminary investigations using UV/VIS and fluorescence spectroscopy indicate that chromophoric dissolved organic matter (CDOM) is an important rainwater constituent. Many of the rain events analyzed thus far contain CDOM with absorbance and EEM fluorescence characteristics that are similar to humic substances from other aquatic environments. Other rain events contain CDOM with very unique EEM fluorescence signatures, which may be related to photochemical reactions from extensive sunlight exposure. Solar simulator experiments have verified that rainwater CDOM is photoreactive and that its absorbance and fluorescence properties are altered upon light exposure.

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SCIENTISTS, FAMILY AND COMMUNITY LEARNING

Scientists are not only researchers and teachers but quite often they are parents as well. As a parent it is natural to engage your own child in learning activities. As a scientist you can enhance those learning opportunities by using your understanding of science to engage your child's innate curiosity, creating an awareness of science and 'how it works.' However opportunities for science learning with a younger person (between adults and children or in family learning) extend beyond one's own children and immediate family members to the broader community. Programs such as University of Southern California Sea Grant's Parent Child Education Program provide the power and inspiration of learning together through parent/child participation in hands-on science activities, and offer scientists an opportunity to make a difference as well. Program participants explore science principles via exciting learning activities and opportunities in the marine environment. Scientists from established professionals to graduate students can support this learning by contributing content, guidance, and/or personal interaction to inspire interest in science and science careers in parents, children and other community members through these types of programs.

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BRINGING REAL-TIME DATA INTO THE CLASSROOM TO STUDY OCEAN SCIENCE

In addition to lab and fieldwork, data manipulation and analysis is the essence of investigative learning in science. Undergraduate students have the capability and desire to work with real datasets, which provide opportunities to explore difficult concepts such as climate change. The ability for students to manipulate data using different methods (means, maxima, anomalies) can be incredibly powerful in understanding how patterns, interpretations and predictions change using different techniques. However there are impediments that keep real dataset manipulation out of the classroom, including the steep learning curve to use powerful analysis and visualization software. The Ocean Science Data Discovery Center is software that leverages existing technologies into a bridge that connects research visualization tools with educational courseware development. OSDDC offers research-level data visualization and analysis capabilities to its users. This supports inquiry by providing students the technical means to visualize actual datasets acquired via the Internet. This project focuses on examining issues of climate change with OSDDC by linking ocean temperature datasets (e.g., NOAA) with biological, geological and ecological datasets to illustrate environmental concepts relevant to issues of climate change.

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EYE-IN-THE-SEA: A DEEP SEA OBSERVATORY FOR UNOBTRUSIVE OBSERVATIONS OF ANIMAL BEHAVIOR

In spite of relatively recent developments in ocean exploration and monitoring, unobtrusive observation of biological activity remains a scientific frontier. The use of bright incandescent lights is extremely disruptive and can damage the eyes of many deep-sea animals. Although the use of infra-red light is a very effective means of unobtrusive observation on land it is far less effective in the ocean because long wavelength light is so rapidly attenuated by water. The Eye-in-the-Sea is a deep sea observatory that uses an intensified camera with sufficient sensitivity to compensate for attenuation losses resulting from the use of long wavelength light illumination. The system is battery powered and designed to operate in timed or triggered mode, turning on red lights and camera when a photomultiplier tube detects a bioluminescent flash in the field of view of the camera. The system has been successfully deployed by the Johnson-Sea-Link submersible and the remotely operated vehicle (ROV) Ventana. Video data will be shown of fish behavior around a baited trap, recorded with 660 nm and 680 nm light emitting diode (LED) illumination systems.

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DISSOLVED ORGANIC CARBON UPTAKE IN A PIEDMONT STREAM DETERMINED BY A WHOLE-STREAM 13C-DOC TRACER ADDITION

Dissolved organic carbon (DOC) is metabolically important in streams; however, its relative contribution to ecosystem metabolism is not well known because it is a complex mixture of molecules. Here, the uptake of DOC in White Clay Creek (WCC), a third-order stream in Pennsylvania, was determined through a stream release of 13C-labeled tree leachate and measurements of 12C- and 13C-DOC uptake in biofilm reactors. In autumn, a 2-h tracer addition of 13C-DOC to WCC was conducted and its uptake was measured along a 1265-m reach. The 13C-DOC had a readily labile and refractory component. The readily labile component had an uptake length of 292-m and mass transfer coefficient of 15-micrometers/s. Biofilm reactor studies revealed that 26% of the bioavailable DOC (BDOC) in WCC was similar in quality to the readily labile component of the 13C-DOC. We estimate that readily labile DOC in WCC supports 44% of the heterotrophic C demand and 55% of the ecosystem respiration. The remaining stream BDOC (74%) is more refractory and is transported downstream where it may provide energy to larger rivers and the estuary.

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DIVERSITY OF EUKARYOTIC NANOPLANKTON IN SARGASSO SEA EDDIES

Small eukaryotic plankton are ecologically important primary producers and the most abundant heterotrophs in the Sargasso Sea. Mesoscale eddies are common in the Sargasso Sea and may influence the abundance and types of plankton present by affecting the depth of the nutricline. We examined the importance of eddies in structuring eukaryotic nanoplankton (2-20 µm) communities by comparing clone libraries of 18S rDNA sequences collected from three Sargasso Sea eddies in October, 2001. Sequencing revealed considerable diversity among nanoplankton, especially within heterotrophic groups. In addition, 80% of sequence types were less than 95% similar to previously known 18S sequences, indicating a vast diversity of previously unknown genera. Community-level statistics found significant differences in genetic diversity and taxonomic composition between small and large nanoplankton (2-5 µm and 5-20 µm) and between eddy sites. These results suggest that small nanoplankton may be more diverse than large nanoplankton and that eddies may contribute to patchy Sargasso Sea communities. We will also consider these results in context with pico- and nanoplankton 18S sequences obtained in the Sargasso Sea in March,2002.

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PHYTOPLANKTON PIGMENT DISTRIBUTIONS OVER FIEBERLING GUYOT

Horizontal and vertical distributions of phytoplankton pigments were examined during three cruises to Fieberling Guyot in the eastern Pacific Ocean to assess the effect seamounts can have on phytoplankton biomass and composition. The chlorophyll fluorescence maximum in this region of the Pacific Ocean is typically uniform with an average depth of 110 m. Time-dependent vertical excursions of the fluorescence maximum, perhaps the result of enhanced internal waves energy over the seamount, were noted throughout the region with some indication that larger excursions were observed over Fieberling's summit. Besides chlorophyll a, predominant plant pigments in the vertical profiles were zeaxanthin, chlorophyll b, fucoxanthin, 19'-butanoyloxyfucoxanthin, and 19'- hexanoyloxyfucoxanthin. The shape (peakedness) of the fluorescence profile was different above Fieberling Guyot than at the distant stations. Fluorescence levels in the chlorophyll maximum and the chlorophyll a concentration were also lower over the summit of Fieberling Guyot than in the surrounding waters away from the seamount. This difference may be due to differences in zooplankton grazing over and away from the seamount.

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THE EFFECT OF OSCILLATORY MOTION ON CHEMICAL PLUMES AND HOW STOMATOPODS USE THESE PLUMES TO FIND THE CHEMICAL'S SOURCE

Chemical plumes in turbulent flows, which consist generally of intermittent, thin, swirling filaments of variable concentration, do not provide clear cues to the location of the chemical's source. In coastal environments, the filamentous structures are further complicated by surface waves. However, many animals successfully use these plumes to find food and mates. We conducted a series of Planar Laser Induced Fluorescence (PLIF) experiments with live, source-tracking stomatopods (Hemisquilla ensigera) in unidirectional and wave-current flows to (a) characterize differences in plumes caused by oscillatory motion and (b) ascertain the ways stomatopods use this information to locate odor sources. Despite the low signal level, extreme temporal variations in plume characteristics, and meander of the plume, the stomatopods were successful in locating the source in both flow environments. While the time-averaged Reynolds stresses in the two flows were approximately equal, modulations by the waves produced differences in the plumes far from the source. In the wave-affected flow the stomatopods seemed to be able to time their tracking maneuvers to coincide with large odor events. Possible reasons for this are explored in this talk.

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THE IMPACT OF DIATOM-BASED FOOD WEBS ON NUTRIENT DRAWDOWN IN COASTAL UPWELLING AREAS AND THEIR INFLUENCE ON BIOGEOCHEMICAL CYCLING

The coastal upwelling region off Bodega, CA (like many other upwelling ecosystems) is dominated by a diatom based food web. During the recent WEST program to this area, chlorophyll concentrations consistently reached phytoplankton bloom levels (up to 30 ug/l) with accompanying rapid drawdown (2-3 days) of nitrate and silicate. The ability of the diatoms to use high levels of nitrate and sequester the entire standing concentration of nitrate in a few days may be an important factor in their competitive standing among phytoplankton. The growing phytoplankton (showing high rates of new production) and productivity are retained on the shelf in CA, and apparently transported alongshore rather than offshore. Apparently these rapid growth events are characterized by rapid sinking of diatoms, largely avoiding grazing. These large autotrophs dominate the biological pump in ocean margins and the biogeochemical cycling of carbon that results.

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VOS CONTRIBUTIONS FROM THE EXPLORER OF THE SEAS TO THE SEACOOS OBSERVATIONAL NETWORK

The Explorer of the Seas, a 1020 ft cruise liner operated by Royal Caribbean Cruise Lines (RCCL), cruises from Miami, Fl through both the Eastern and Western Caribbean on alternating weeks. In 2000, a cooperative agreement between RCCL and the University of Miami established two staffed onboard laboratories with comprehensive meteorological and oceanographic instrumentation which includes: two ADCPs, flowing seawater environmental sensors, M-AERI, Portable Radiation Package, WeatherPaks, Wind Profiler, WAMOS, and an aerosol/particle sampling system. Using a satellite connection, a data subset is sent shore-side in real-time, with full weekly data offloads. Biweekly crossings of the Gulf Stream and the ship track's coverage of the Bahamas and Carribean regions make the Explorer a valuable asset to the Southeast Atlantic Coastal Ocean Observing System (SEACOOS). The data stream has been adapted to the SEACOOS OpenDAP-compliant distribution system such that real-time and archived data may be easily combined with other SEACOOS observational and modeling products. The Explorer also provides a unique outreach opportunity for SEACOOS through weekly lectures to passengers as well as periodic courses and workshops held aboard in its laboratories.

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DISTRIBUTION OF DIVERSE GENOTYPES OF HALOPHILIC BDELLOVIBRIONACEAE IN OCEANS, SEAS, ESTUARIES AND A SALT LAKE

The halophilic Bdellovibrionaceae (Bd) are ubiquitous in salt-waters having been recovered from oceans, seas, an estuary and a salt lake. The objective of this study was to describe the distribution of various genotypes. Samples were obtained from over 20 bodies of water in the United States and several other countries and cultured for Bd using V. parahaemolyticus as prey. From each isolate an approximately 1400 bp fragment of the 16S rRNA gene was amplified by PCR using universal primers and sequenced. The sequences were aligned by ClustalX and the phylogenetic relatedness determined by PAUP. The results revealed that there were 9 genotypic groups. The groups were diverse in their distribution. Five were geographically widespread and included isolates with identical genotypes recovered from different continents and ecosystems. One group was recovered from an ocean, Great Salt Lake and the Chesapeake Bay, while the others were found in two of the 3 environments. Four groups were restricted being recovered from a single geographical/environmental site: the Chesapeake Bay, Vancouver (tide pool), Great Salt Lake and Cuba.

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SHELF-BREAK EXCHANGE PROCESSES AT A WIDE ARCTIC CANYON: MACKENZIE CANYON, BEAUFORT SEA

Shelf-break exchange processes in the Arctic are critical to the development of the upper halocline and to the flux of deep water onto the shelves. MacKenzie canyon, in the Beaufort Sea shelf near 70N 137W, is hypothesised to be a site of enhanced shelf-break exchange. This canyon runs northward from the coast to the shelf-break where it is approximately 60km wide and 400m deep. Dynamically the canyon is wide, being at least twice the baroclinic Rossby radius. Enhanced upwelling has been found in this canyon and is expected due to adjustment of stratified alongshelf flow crossing the canyon. We show CTD data and current meter, temperature and salinity data from moorings deployed within and on either side of MacKenzie Canyon at various times during 1991 to 1996. The present analysis focuses on describing flow patterns due to the wind-stress and its modification in the presence of sea ice. Upwelling events and the possibility of this canyon acting as a conduit for deep nutrient rich water to the Canadian Shelf are also discussed.

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INTERACTIONS BETWEEN COMMERCIAL FISHING AND WALLEYE POLLOCK

Results from the first two years of a multi-year fishery interaction study near Kodiak Island in the Gulf of Alaska are presented. Findings from acoustic surveys, conducted in August 2000 and 2001, provide important information that begins to address the question of whether the abundance and spatial patterns of various species, including walleye pollock (Theragra chalcogramma) are impacted by commercial fishing activities over short spatio-temporal scales. The biomass and distribution of pollock were stable over periods of days to weeks although during the second year an unusual, extremely dense, small-scale pollock aggregation was detected during one of several survey passes. Several morphological descriptors of the pollock echosign layers were evaluated to better understand whether differences at the scale of the fish aggregations occurred in response to fishing. Results from the second year, when the commercial fishery took place within the study area, do not suggest a significant link between fishing activities and changes in estimates of juvenile and adult pollock geographical distribution, biomass, and vertical distribution. It will be important, however, to evaluate whether these trends persist during subsequent years.

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USE OF ACOUSTIC TAGS AND MOORED-RECIEVERS TO DESCRIBE BEHAVIOR AND FRESHWATER TO MARINE MIGRATION OF POST-SPAWN STEELHEAD, NINILCHIK RIVER, ALASKA.

Little is known about the distribution and behavior of salmonids in the ocean or the role of environmental variation on the survival of salmonids within marine habitats. This requires a better understanding of movements and habitat use at all life history stages. Acoustic tagging and moored receivers provide opportunities to examine migration and behavior of salmonids in marine habitats. We used an ultrasonic gate at the mouth of the Ninilchik River to describe freshwater to marine migratory behavior in post-spawn steelhead. Post-spawn steelhead were captured in a downstream trap within the Ninilchik River and individually coded acoustic pingers were surgically implanted in each fish. Time between tagging and initial detection, time in the tidal zone, residence time within the buoy array, and direction of out-migration was determined based on detection time and location. This study indicates that the use of acoustic tags and acoustic detection arrays are a feasible and potentially productive means to study near-shore marine migrations of salmonids in the North Pacific.

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FOODWEB STRUCTURE AND CARBON FLUX IN THE NEW ZEALAND FJORDS

Fiordland is a globally unique environment that contains exceptional marine biodiversity. Complex physical morphology of the region produces a highly subdivided and diverse array of marine habitats in close proximity to native forests. Because of this there are particularly strong links between terrestrial and marine systems. We used stable isotope analysis to identify carbon source pools from benthic, terrestrial and pelagic environments and were able to quantify the input of carbon from these pools to subtidal assemblages across several environmental gradients in the fjords. Our results highlight the importance of recycled terrestrial production in this system, and the importance of spatial structure in bottom-up influences on metapopulations. In one fjord, Doubtful Sound, we have found evidence for significant changes to the subtidal assemblages, including local extinction, wrought by anthropogenic habitat conversion. These results were used to analyze the consequences of changes in community structure and functional diversity (feeding mode) to pathways of the available carbon sources in the system. Together these data give us a unique view of the biotic and abiotic influences on energy fractionation in this system.

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THE EFFECT OF METAL SUPPLY ON ALKALINE PHOSPHATASE ACTIVITY IN CULTURES OF EMILIANIA HUXLEYI

Emiliania huxleyi is a widespread marine coccolithophore. Past studies have shown the importance of zinc and cobalt as micronutrients for the growth of marine phytoplankton such as E. huxleyi. We are interested in coupling between the zinc and phosphorus cycles in low phosphate environments. E. huxleyi is common in oligotrophic environments and generates the important phosphohydrolytic enzyme, alkaline phosphatase. Alkaline phosphatase is often produced by phosphorus deficient phytoplankton, as the enzyme can cleave a bioavailable orthophosphate from a larger dissolved organic phosphorus (DOP) molecule. Typically, this enzyme has a zinc metal-center, which suggests possible constraints on alkaline phosphatase activity and DOP cycling by low zinc conditions. This research details culture studies performed with batch cultures of E. huxleyi that were grown under conditions of combined metal (zinc, cobalt) and phosphate depletion. In all low phosphate treatments, alkaline phosphatase activity was detectable even when metal concentrations restricted growth. Our data suggest the alkaline phosphatase-related metal requirements in E. huxleyi could be met by either zinc or cobalt and may have interesting implications for zinc, cobalt, and phosphorus cycle coupling in the field.

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A MODEL OF ESTUARINE CORAL REEF ECOHYDROLOGY

Coastal and estuarine coral reefs are being subjected to elevated sedimentation rates and salinity changes. The sedimentation rates are increasing as a result of human activities on land, and they appear responsible for a decline in coral abundance and reef resilience. This decline appears related to fine-sediment flushing rates and these are different for estuarine reefs than reefs in open coastal exposures.
A predictive ecohydrology model has been developed of the change in cover of coral and algae of coral reefs as a result of human, land-use activities in adjacent catchments. This model has now been used in Australia Great Barrier Reef and in Fouha Bay, Guam. The horizontal scales for these two applications are quite different for the two sites, being respectively 400 km and 200 m. In both cases the model is successful in predicting the spatial distribution of coral and algae. The model suggests that, by restoring favorable

ambient water quality, integrated watershed management efforts can allow natural reef recovery to occur. This recovery is predicted to occur faster in open coastal exposures than in estuarine systems.

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CONSEQUENCES OF SEASONAL PATTERNS OF WAVE EXPOSURE IN THE SIZE AND REPRODUCTION OF AN INTERTIDAL SEAWEED

Waves are an important agent of disturbance on rocky shores, causing mortality that may limit the size and distribution of species living there. Climate change models and examinations of long-term data sets indicate that the frequency of large wave events is increasing. Understanding the impact of this trend is important to the effective management of rocky intertidal communities, which are harvested for food and used recreationally. I examined the influence of wave-induced hydrodynamic forces on the intertidal seaweed Pelvetiopsis limitata, comparing the risk of dislodgement at wave-exposed and sheltered sites. Size distributions of the populations at both sites were estimated monthly, and attachment strengths measured at collection. Forces imposed on individuals in the field were calculated using a mathematical model of an alga in oscillatory flow. Seasonal differences in wave height and algal size, along with a weaker attachment strength at the sheltered site, lead to a similar dislodgement risk for individuals of average size between sites and throughout the year. Reproduction in this perennial species occurs during the summer, when the algae are largest and the waves are smallest.

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THE DIVERSE MOLECULAR EVOLUTION OF IRON AND MANGANESE SUPEROXIDE DISMUTASES IN OXYGENIC PHOTOAUTOTROPHS

The evolution of oxygenic photosynthesis is coupled to a highly conserved set of protective enzymes that defend cells from reactive oxygen species. The metalloenzyme superoxide dismutase (SOD) is the most prevalent and comes in several forms distinguished by the biogeochemically significant metal cofactor (Fe, Mn, Cu, Ni) present. We employed a maximum likelihood approach using both DNA and amino acid data to investigate the evolutionary relationships between SODs. Although the iron (Fe) and manganese (Mn) forms are homologous whole sequence maximum likelihood analyses suggest they evolved under different selective pressures. These phylogenetic trees indicate that MnSODs of eukaryotic and prokaryotic phytoplankton group together and share a common origin with the major FeSOD clade whereas their true FeSODs have different recent ancestors. Furthermore, the primary sequence can be divided into two domains, the N and C-terminals, which exhibit different divergence patterns. Although its position is presently unclear, root placement is critical to understanding which SOD form evolved first. Our data suggest that understanding the timing of diversification between these genes elucidates information about the local redox conditions under which they evolved.

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ECOPHYSIOLOGICAL DIFFERENTIATION OF MYTILUS TROSSULUS (BIVALVIA) IN SOUTHERN BALTIC SEA AS AN EFFECT OF INCREASING EUTROPHICATION.

Alterations of environmental conditions by progressive eutrophication of the Gulf of Gdansk brought about a shift in spatial distribution and substantial increase in the biomass of filter-feeders. Comprehensive morphological and biochemical studies of mussels across a vertical profile revealed also apparent variations in ecophysiological features. Individuals from shallow-water region demonstrated elevated body weight, a higher condition index and a greater content of reserves. Females accumulated more reserves than males whereas the reverse was true in deep-water region. Differentiation of physiological performance of Mytilus trossulus is likely induced by dissimilar environmental parameters that tend to deteriorate with depth. With increasing eutrophication, mussels expanded into deeper habitats however, nutritional conditions suffice solely for maintenance basic energy requirements during the periods of enhanced energetic demands, namely winter and reproduction. Ecophysiological adaptations allow animals the optimal using of available food sources to fulfil life cycle successfully. On the basis of the observed ecophysiological differences, two distinct ecotypes of Mytilus trossulus can be distinguished; a shallow-water and a deep-water ecotype. It is suggested that further differentiation may lead to the reproductive or even genetic isolation of the subpopulations.

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DIVERSITY AND COMMUNITY COMPOSITION OF VIRIOPLANTKTON OVER AN ANNUAL BIOLOGIAL CYCLE OF THE CHESAPEAKE BAY.

Recognition of the potential for viral infection to influence the productivity and diversity of co-occurring marine microbial communities led to significant technical improvements in the study of virioplankton. One challenge is to now determine the role of virioplankton in the annual biological cycles of marine environments. To begin to address this issue, a series of field investigations were conducted over one annual cycle. Amidst an encompassing background of environmental and process data (eg. bacterial and phytoplankton production), viral and bacterial diversity as well as virioplankton composition were assayed using several molecular genetic tools. The overall indication is that significant temporal changes occur in the diversity and composition of Chesapeake bacterio- and virioplankton. Surprisingly, despite significant physio-chemical changes occurring along the length of the Bay, or over depth in the water column, few changes in viral or host diversity were apparent. This trend of significant temporal change was apparent regardless of molecular assay indicating that change could be detected both on the genotype and phenotype levels of specificity. Specific findings are discussed in relation to background process and environmental data.

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THE RESPONSE OF C, N AND SI TO FE ENRICHMENT IN THE NORTHEAST PACIFIC OCEAN

An iron enrichment experiment was initiated in July, 2002, in HNLC waters of the northeast Pacific Ocean. Within 3 weeks chla concentrations increased from 0.5 to 5 mg/m3, NO3 decreased from 10 to 5 uM, and Si[OH]4 decreased from 15 to < 2 uM. Occupation of the Fe patch was sufficiently long (24 d) to observe: 1. the drawdown of Si[OH]4 to limiting levels and the drop of dissolved and particulate Fe to background concentrations, and 2. the crash of the Fe-induced phytoplankton bloom and subsequent high fluxes of OC, N and BSi in free-drifting sediment traps. The phytoplankton response to Fe showed two phases. Initially the phytoplankton was of a mixed population (low particulate Si:C), while later was primarily diatoms as inferred from high particulate Si:C ratios. The BSi progression, from accumulation in the mixed layer to export at depth, preceded that of OC. This decoupling may be explained by the exhaustion of Si[OH]4 which, along with Fe limitation, may have led to the crash of the Fe-induced bloom. The sediment-trap data also show that BSi was exported through the permanent pycnocline of the subarctic Pacific more efficiently than OC or N.

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PHYCOERYTHRIN SIGNATURES IN THE COASTAL OCEAN

n this presentation we report the results of a four-year study of the relationship between the optical environment and the distribution and spectral properties of phycoerythrin-containing organisms on the continental margin of North America. This work was designed to test the hypothesis that different spectral forms of PE are associated with Case II waters, “blue” Case I waters, and “green” Case I waters. We examined the abundance of PE-containing organisms, the PE fluorescence signature, the hyperspectral remote sensing reflectance, and a range of other apparent and inherent optical properties at stations in the Gulf of Mexico, Gulf of California, off the New Jersey shelf, and off the West Coast of North America. For most cruises, we also have hyperspectral observations of ocean color by remote sensing. This talk focuses on the high abundance and diversity of PE-containing organisms in Case II waters and nutrient- enriched Case I waters, the distinctive fluorescence signatures associated with these communities, and on their relationship to hyperspectral signatures that can be detected by remote sensing.

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INTERTIDAL INFAUNAL INFRASOUNDS

Many activities by sedimentary inhabitants, including burrowing and feeding, involve hydraulic mechanisms. We expected these activities to generate low frequency pressure waves or infrasounds that would propagate through sediments and be detectable at some distance from the source. Pressure sensors in intertidal sediments recorded large amplitude infrasound signals. Laboratory recordings of single individuals allowed us to identify characteristic infrasounds of Arenicolid and Nereidid polychaetes and Tellinid bivalves. In the bivalve Macoma nasuta, these high amplitude infrasound signals were associated with burrowing and with siphon movements. In the polychaetes Neanthes brandti and Abarenicola pacifica, the high amplitude infrasound signals were associated with burrowing, burrow construction, and burrow ventilation. These signals were detectable at distances of at least 10 cm. Since the infrasounds are species specific as well as activity specific, they may provide a mechanism for predators to detect prey, for prey to avoid predators, for competitor detection and perhaps even mate detection.

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CHARACTERIZATION OF TELOMERASE ACTIVITY IN PHYTOPLANKTON

Knowledge of phytoplankton growth rate is fundamental in understanding marine ecosystems, but difficult to determine experimentally. A new method of determining marine phytoplankton growth rates from levels of telomerase activity is currently being investigated. The telomerase enzyme lengthens structures known as telomeres that protect the ends of eukaryotic chromosomes. The elongation of telomeres prevents degradation of telomeric DNA and inhibits cell senescence. In higher plant cells, telomerase activity varies directly with cell division rate. We present data for initial characterization studies of telomerase in marine phytoplankton, using a polymerase chain reaction (PCR) – based telomerase repeat amplification protocol (TRAP) assay. This assay is being used to determine telomerase expression in individually cultured phytoplankton species and in field samples collected from the Sargasso Sea. We are comparing the results of this assay to traditional methods of phytoplankton growth rate determination (e.g. cell counts, 14C incubations, etc.), to assess the utility of telomerase enzyme activity as an indicator of phytoplankton growth rate.

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LIGHT LIMITATION IN A NUTRIENT-RICH ESTUARY IMPACTED BY HARMFUL ALGAL BLOOMS

The Pearl River (Zhujiang) Estuary receives high nutrient inputs from agricultural runoff and sewage. Due to concern over bottom water hypoxia and harmful algal blooms in Hong Kong, hydrographic surveys were undertaken during the summer and winter monsoon seasons in 1998 to elucidate controls on primary production. During the high discharge summer monsoon season, optical modeling suggests that elevated suspended particulate matter (SPM) and chromophoric dissolved organic matter (CDOM) contributed to light limitation under the turbid freshwater plume in the west, while eutrophic conditions existed near Hong Kong. During the low discharge season, when riverine SPM and CDOM were reduced, the situation was reversed. Stratified, nutrient-rich conditions promoted high chlorophyll a (Chl) in the west, while deep vertical mixing, low riverine nutrients, and low Chl prevailed in saline coastal waters east of a bathymetrically-situated front. Nutrient distributions indicate spatially variable sources, including high riverine nitrate and elevated phosphate associated with bottom resuspension. Phytoplankton dynamics vary seasonally and spatially with hydrodynamics, nutrients, nutrient ratios and light-limiting conditions, making process-oriented estuarine-scale studies imperative for effective water quality management.

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COPEPOD BEHAVIORAL RESPONSES TO ENVIRONMENTAL CUES ASSOCIATED WITH STRUCTURE IN THE OPEN OCEAN

Behavioral responses of copepods to gradients of velocity, density, and dissolved chemicals illustrate the importance of environmental structure in governing predator-prey dynamics in pelagic habitats. Copepods often exhibit area-restricted search behavior resulting in aggregations at these boundaries. In controlled laboratory studies, responses to these gradients are used to identify and define the physical cues that these organisms exploit to aggregate at environmental structure. Copepod response to strain rate gradients are observed in a laminar plane jet in order to isolate specific cues. Utilizing particle image velocimetry (PIV) and video-based behavior observation techniques, behavioral responses to strain rates observed in thin layers are evaluated in the context of foraging and aggregative behavior. The ability of these organisms to exploit environmental cues associated with thin layers and other prey patches will have broad, cascading effects on many ecosystem processes.

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MODELING THE INFLUENCE OF MINERAL PARTICLES SUSPENDED IN SEAWATER ON OCEAN REFLECTANCE AND CHLOROPHYLL RETRIEVAL FROM REMOTE SENSING ALGORITHMS

One important challenge for ocean color remote sensing is the presence of optically significant amounts of suspended mineral particles. Using a simplified model, we examined the effects of minerals on ocean reflectance and chlorophyll retrieval from the standard remote sensing algorithms. We analyzed the ratio of backscattering coefficient to the sum of absorption and backscattering coefficients of seawater, as a proxy for reflectance. The optical properties of minerals were calculated from the Mie scattering theory for different size distributions and refractive index of particles. Pure seawater and phytoplankton with covarying material were described with data from the literature. The error in chlorophyll retrieval due to mineral particles can be very large. For example, when mineral concentration is 1 g m-3 and the real chlorophyll a concentration is low (~ 0.05 mg m-3), the OC2, OC4 and chlor_MODIS algorithms produce chlorophyll overestimation from about 50% up to 20-fold. The effects of mineral particles on reflectance cannot be parameterized in terms of mass concentration of mineral particles alone. The variations in the size distribution and refractive index of minerals are also essential.

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DYNAMICS OF CDOM IN THE MISSISSIPPI RIVER PLUME

Regional and seasonal variations of water constituents are an important factor influencing bio-optical properties of dynamic coastal environments. The Mississippi and Atchafalaya River members release loads of colored dissolved organic matter (CDOM) into the Gulf of Mexico waters. We examined the seasonal variability of concentrations of CDOM from multiple cruises in the Mississippi River Plume and its relevance to remote sensing. Our results indicate that the magnitude of CDOM concentration and salinity differs between cruises. However, the regression lines of CDOM and salinity for each cruise are conservative, respectively. This conservative negative correlation between CDOM and salinity for all cruises provide evidence that the same processes influence the dilution of CDOM. These results simplify remote sensing data because of the very little seasonal variation of the concentration of CDOM in the Mississippi River Plume.

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BOTTOM BOUNDARY LAYER STRUCTURES IN STRATIFIED WATERS: ECOLOGICAL IMPLICATIONS OF PERIODIC AND LOW FLOW

Turbulence and tracer studies identified the Bottom Boundary Layer (BBL) as the location, where mixing and fluxes of water constituents are orders of magnitude enhanced relative to the “inactive” stratified interior. As a consequence, vertical fluxes are concentrated to the BBL above sloping bottoms, which become - from a physical point of view - the most important zones in stratified natural waters. In basins of limited extent, the BBL structure is vertically compressed as a result of the periodicity (typically hours to days) of the near-bottom (seiche) currents. This Stokes’ solution-like characteristics (of oscillating currents) is expected to be important in estuaries and ocean subbasins, with 12 and 24-hours periodicities. Of ecological relevance are the subsequent enhancement of bottom stress, the compression of BBL turbulence to a layer of less than a few meters thickness and the thinning of exchange-limiting Diffusive Boundary Layers (DBL). For seiching, water-sediment fluxes, following the turbulence (not velocity), become very variable and regularly collapse for currents lower than 1-2 cm/s. The implications of the benthic turbulence for the ecophysiology of the aquatic organisms will be discussed.

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COUPLING MANAGEMENT, ECONOMICS AND NATURAL SCIENCES USING A LINKED NEST OF MODELS IN A DECISION SUPPORT SYSTEM FOR THE BALTIC SEA

Models can be excellent tools for analyzing and making complex relationships understandable, for example to show which processes are important on the scale of the environmental problem at hand. Models also serve as powerful tools for communication and can be developed into powerful decision support systems, if the models include descriptions of management objectives and measures as well as associated cost needed to reduce environmental disturbances. The research program MARE has now developed a prototype of a decision support system, NEST, where integrated ecological-economical models can show the consequences of various management options of eutrophication of the Baltic. Minimum-cost solutions for a specified improvement of the environment, in terms of water transparency, in any of the seven major sub-basins of the Baltic are calculated. A total of 16 different nutrient abatement measures in 23 sub-drainage basins covering the 9 Baltic countries are used, coupled to estimates of transports and retentions of nitrogen and phosphorus on land and among the marine basins. Network analysis is used to trace inputs and flows between basins and how these change with changing nutrient load.

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ODT SIMULATION OF DIFFENTIAL DIFFUSION

One-Dimensional Turbulence (ODT) is a computationally efficient 1D simulation technique for turbulent flows. It is a generalization of the Linear Eddy Model (LEM), which simulates mixing of passive scalars based on a specified turbulence parameterization. In both formulations, molecular processes are fully resolved, thus capturing differential-diffusion effects explicitly. Turbulent advection is modeled on the 1D domain using Lagrangian mappings. LEM has been used to investigate the Reynolds-number dependence of differential-diffusion effects and some flow-specific manifestations of differential diffusion. Unlike LEM, ODT evolves velocity as well as scalar profiles. The velocity, and any dynamically active scalars (such as salinity and temperature), are coupled to the turbulent advection process so as to obtain self-contained predictive simulations of diverse turbulent flow configurations (including shear layers, boundary layers, and convective zones), and mixing therein of passive scalars (such as nutrients or trace chemicals) as well as dynamically active scalars. ODT simulations demonstrating the formation of double-diffusive staircases will be presented. The possible use of ODT to evaluate implications of differential diffusion with regard to oceanic measurements involving surrogate scalars will be discussed.

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ON USING OCEAN COLOR IMAGERY TO DISTINGUISH RESUSPENDED BENTHIC CHLOROPHYLL WITH CHLOROPHYLL FROM HARMFUL ALGAL BLOOMS

Since October 1999, the Center for Coastal Monitoring and Assessment has been using SeaWiFS imagery to locate blooms of the toxic dinoflagellate, Karenia brevis, off the west Florida shelf. Anomalously high chlorophyll is used for detection, from an anomaly defined as the difference between real-time observations and a two-month running mean of the SeaWiFS-derived chlorophyll concentrations. This anomaly method has proven useful in detecting K. brevis blooms in the eastern gulf, but has had problematic results along the Texas coast. Various studies have shown that benthic chlorophyll concentrations can exceed chlorophyll concentrations in the integrated water column. Resuspension events, occurring frequently along the Texas shelf, export benthic chlorophyll into the water column, producing

the illusion of a bloom in satellite imagery. Using an anomaly of the 670 nm band as a surrogate for suspended sediment, it is possible to obtain an estimate of chlorophyll resuspension. Subtracting this resuspended chlorophyll from the original chlorophyll anomaly provides a more accurate representation of the chlorophyll distributions associated with blooms. The method has potential for estimating relative amounts of benthic and water column chlorophyll.

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FREQUENCY-DOMAIN CHARACTERISTICS OF SURFZONE BACTERIA, HUNTINGTON BEACH, CA

Fecal indicator bacteria (FIB) has been a major problem for beach water contamination in the Southern California Bight. We applied the Lomb Periodogram technique to the multi-year FIB data, collected by the Orange County Sanitation District at 22 stations along 24 kilometers of shoreline off Huntington Beach and Newport Beach, to show (1) the distinct frequency-domain characteristics of three FIB (total coliform, fecal coliform, and enterococci); and (2) the temporal and spatial variations of these spectral characteristics. An annual cycle exists at all stations for all FIBs, presumably reflecting the annual rain season in winter. A 15-day spring-neap cycle was prominent in enterococci at almost all stations, but for total and fecal coliform bacteria, it was only found in a 2.5-kilometer stretch of surfzone north of Santa Ana River.

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MEDFLUX: COMBINING FLUX AND CONCENTRATION DATA INTO A SEAMLESS DESCRIPTION OF SINKING FLUXES

Recent evidence points to a relatively constant ratio of organic matter to mineral ballast in particles sinking in the deep ocean. To investigate the reasons for this apparent constancy, we collected sinking particles at the French JGOFS DYFAMED site in the western Mediterranean Sea. We used both standard techniques for collecting particles, and also a new conical, free-floating NetTrap, an elutriator, and a sediment trap in the sinking velocity mode (see Peterson et al. poster for details). The elutriator and the sinking velocity trap allowed collection and differentiation of particles with a wide range of sinking rates. Concentrations and fluxes of mass, organic and inorganic carbon, radionuclides, and individual organic compounds were measured. As part of this investigation, we are developing novel modeling and statistical techniques based on likelihood measures to allow data from these disparate sources to be stitched together into a seamless whole. Here we present progress that we have made towards this goal.

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THE INVENTORY AND PARTIAL CHARACTERIZATION OF DISSOLVED PROTEINS IN OCEANIC WATERS

DOM in seawater plays an important role in marine ecosystem through the microbial loop. The occurrence of fewer than 30 dissolved proteins in oceanic waters by one dimensional electrophoresis (SDS-PAGE) which separates proteins according to their molecular weight (Mw), and identification of porin P protein of Pseudomonas aeruginosa and Omp A-like protein of Acinetobater spp. indicating that bacterial macromoleculars are one of the sources of DOM. To clarify the inventory of dissolved proteins, we applied two dimensional electrophoresis (2-DE), which separates proteins according to the isoelectric point (pI) and Mw, to dissolved proteins. The 2-DE distinguished 412 dissolved protein spots from five Pacific waters. Many dissolved proteins were detected as trains of spots on 2-DE, demonstrating that these proteins have same Mw but different pIs. We concluded that such proteins were isoforms of glycoproteins, because these proteins had same amino acid sequences but different glycosylation profiles. One of such dissolved proteins was identified as the low molecular alkaline phosphatase (L-AP) of P. aeruginosa. Mechanistic process by which the enzyme (L-AP) survived and accumulated in DOM is speculated.

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OXYGEN STABLE ISOTOPES IN OTOLITHS OF WALLEYE POLLOCK, THERAGRA CHALCOGRAMMA AS EVIDENCE OF ENVIRONMENTAL CHARACTERISTICS

The ratios of oxygen isotope (δ18O) in pollock otoliths were analyzed to investigate the regional and interannual differences in habitat characteristics in the northwestern Pacific Ocean. Otoliths were obtained off the Korean Peninsula and off Hokkaido in Japan during the 1997~1999 winter seasons. Using the Dremel drill, the central and marginal part of the otolith were extracted and δ18O was measured using a VG OPTIMA mass spectrometer. In general, δ18O values in the otolith varied from year to year depending on environmental differences. Seawater temperature data at the pollock habitat (200-300 m) is compared with oxygen isotope contents. The mean δ18O value for the marginal part of the otolith of Korean pollock was higher in 1998 (2.67‰) than in 1997 (2.15‰), but seawater temperature at the walleye pollock habitat was lower in 1998 (1.60℃) than that in 1997 (1.92℃). Mean δ18O from the core part of the otolith, formed in age-0 near the surface layer (0-100 m) of the ocean and was discussed in relation to the changes in oceanic variability.

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CENSUS OF MARINE LIFE: MARINE BIOGEOGRAPHIC INFORMATION – PAST, PRESENT AND FUTURE

The Census of Marine Life is a growing global network of researchers engaged in a ten-year initiative to assess and explain the diversity, distribution, and abundance of marine life in the oceans — past, present, and future. The research program consists of three components to address what lived/lives/will live in the oceans. History of Marine Animal Populations provides retrospective analysis of the diversity of sea life by bringing together historians and biologists to trace information on populations of marine organisms in the time period preceding significant human exploitation. The Initial Field Projects demonstrate the effectiveness of standardized protocols and novel technologies for observation of marine organisms. This new data ranges from gradients in global intertidal zone biodiversity to electronic tracking of large pelagic animals. Future of Marine Animal Populations integrates biogeographic information into computer models for statistical analyses and forecasting and provides tools for synthesizing the wide variety of Census data types. All information collected through the Census will be available through the Ocean Biogeographic Information System.

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WAKE SIGNATURES OF FREELY SWIMMING PLANKTON

As inanimate or animate objects move through fluids, a wake is created. For many aquatic organisms, these flow features contain information revealing the identity of the source as prey, predator, mate or host - serving as communication channels. Here, we have assembled a particle image velocimetry (PIV) system to sample the flowfields of rapidly free-swimming plankters. Illumination provided by a high repetition rate near-infrared laser did not alter specimens' behavior. Images acquired by a high frame rate camera synchronized with the laser provided sufficient temporal resolution to capture the evolution of the flowfield. The PIV data were used to validate a computational fluid dynamics (CFD) model of a copepod (see Sotiropoulos et al.). The effects of body size, swimming speed, water temperature, and behavior on the wake dynamics were analysed for flows generated by freely swimming krill (Euphausia pacifica, E. superba) and copepod (Euchaeta). The extent and persistence of the detectable hydrodynamic signal can help our understanding of the sensory ecology of pelagic plankton.

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INFLUENCE OF BIO- AND NON-BIOGENIC REFLECTANCE ON THE MAGNITUDE OF UPWELLING OF NEAR-INFRA-RED WAVELENGTHS: THE PLUSES AND MINUSES

The near-infrared (NIR) reflectance from photosynthetic autotrophs is approximately 5-10 times higher than their visible reflectance. Remote sensing techniques used by terrestrial scientists have capitalized on this for the estimation of biomass and biodiversity. Marine counterparts have not used this, to date, because of high water absorption at these wavelengths. In shallow Case 2 waters reflectance by NIR from algae (micro- and macro-) can affect aerosol correction. Another concern is the validity of using line-derived reflectance estimates for solar-induced fluorescence by chlorophyll a. On the plus side, the combined use of visible and NIR reflectance offers unique possibilities for discriminating bottom types from in-water biogenic substances. Data are from tropical and temperate waters.

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CATCHING EDDIES IN THE FLORIDA KEYS: AN EXPERIMENT TO TEST THE EDDY TRANSPORT OF PRE-SETTLEMENT STAGES FROM COASTAL OCEAN TO ESTUARINE NURSERY GROUND.

Keystone marine species in South Florida such as snappers (Lutjanus spp.), the spiny lobster (Panulirus argus), and the pink shrimp (Farfantespenaeus duorarum) use the estuarine Florida Bay for a juvenile nursery, whereas a principal spawning ground for these species lies in the Dry Tortugas some 150 km upstream of the Bay. A semi-permanent cyclonic eddy frequently resides at the Dry Tortugas. Eventually, the Tortugas eddy propagates downstream in the form of a transient eddy towards the coastal waters offshore of Florida Bay. The Tortugas eddy provides a mechanism for the retention and nourishment of early life stages (ELHs) at the spawning source, and its subsequent progress downstream can transport ELHs towards the nursery. To investigate the significance of the eddy process to the supply of ELHs to the South Florida ecosystem, we followed the evolution of the Tortugas eddy using satellite SST and SSH imagery and the Navy Layered Ocean Model (NLOM). When the passage of a coastal eddy offshore of the Florida Keys was imminent according to the remote sensing information, an Ocean Surface Current Radar (OSCR) array was set up to record in real time the alongshore current reversal and enhanced onshore flow that would be brought on by the leading edge of the eddy as it passes. At the same time, channel nets were deployed inshore of the OSCR domain at channels connecting coastal waters with Florida Bay to monitor the onshore transport of pre-settlement stages.

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DOES NH4 OR NO3 DRIVE PHYTOPLANKTON PRODUCTION? AN ISOTOPIC ASSESSMENT

The nitrogen isotopic composition of chlorophyll a as a proxy for phytoplankton, NO3, and NH4 were measured along a gradient from freshwater to full ocean salinity to determine the relative assimilation of NO3 and NH4 by phytoplankton. Samples were collected from two sites: Waquoit Bay, Cape Cod, MA, where NO3 is the dominant DIN form and Tijuana River, Imperial Beach, CA where NH4 is dominant. The nitrogen isotopic value of phytoplankton varied from –1.4 to +11.4 per mil, with generally higher values from freshwater samples and lower values from the oceanic end-member. The isotopic values of NO3 and NH4 showed a similar pattern. Comparison of the nitrogen isotopic values of chlorophyll a with those of NO3 and NH4 suggest that relatively more NH4 is assimilated than NO3. This corroborates the general understanding that phytoplankton prefer NH4 to NO3. However, in a eutrophic system such as Childs River, where NO3 is high, it still appears that NH4 is driving phytoplankton production and carbon assimilation.

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CHANGES OF THE ECOSYSTEM WITH THE IRON FERTILIZATION IN THE WESTERN NORTH PACIFIC SIMULATED BY A ONE-DIMENSION ECOSYSTEM MODEL

We have developed a one-dimensional ecosystem model considering explicitly two species in diatoms, centric and pennate diatoms. The model was applied to the iron enrichment experiment, SEEDS (Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study) in the western North Pacific. We assumed that the pennate diatom is without stress by the iron limitation, but the centric diatom whose photosynthetic rate is high under the free iron limitation is significantly suppressed by the iron depletion before the iron fertilization. The model successfully reproduced the time-series of CO2 fugacity and the vertical distributions of chlorophyll-a and macronutrients observed in SEEDS. We clarified that the reason why the starting timing of diatom bloom lags several days behind iron fertilization in SEEDS is not delay of physiological response of each diatom but the species transition of diatom form pennate to centric. The simulated iron's effect on ecosystem continues for about 40 days. The model results suggest that the export flux during the observation period (13 days) is 20%-30% of total export flux for 40 days.

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DISSOLVED ORGANIC CARBON DYNAMICS DURING IN-SITU IRON ENRICHMENT EXPERIMENT IN THE WESTERN AND EASTERN SUBARCTIC PACIFIC

Dissolved organic carbon (DOC) dynamics were investigated during in-situ iron enrichment experiments in the western (SEEDS) and eastern (SERIES) subarctic Pacific by high temperature combustion method with a high precision analysis (+-0.1-1.8 uM). Samplings were conducted from Day 0 (D0) to D13 during SEEDS and from D16 to D27 during SERIES. In SEEDS experiment, DOC value integrated in 0-20 m was 1.19 mol/m2 on D0 and increased to 1.36 mol/m2 on D9, accompanied by large increase in chlorophyll a (0-20 m) from 15 to 256 mg/m2. The net DOC production comprised 18% of the net organic carbon (POC+DOC) production on D9 and 12% on D13. During SERIES observation, DOC (0-20 m) fluctuated between 1.27 and 1.35 mol/m2, whereas chlorophyll a (0-20 m) decreased from 138 to 27 mg/m2. Comparing the SERIES DOC in the iron-patch with that out of the patch, the net DOC production (0-20 m) was estimated at 0.03-0.11 mol/m2. Thus, significant portion of organic carbon production was observed as DOC during both growth and senescent phase of the iron-induced bloom in the subarctic Pacific.

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THE PRIMARY PRODUCTION PROCESS OF AN AREA OF SAND BANKS IN AKI-NADA, THE COAST OF SHIKOKU ISLAND, JAPAN

Primary production rate is determined by a nutrient supply and the intensity of solar radiation. In stratified waters, phytoplankton trapped in the warm surface layer benefits from sufficient light, but face a short of nutrient supply from the bottom layer. The ideal condition for primary production process is a stratified surface water with a sufficient nutrient supply. Seto Inland Sea has many sand banks adjacent to straits. In Aki-nada, the water column on sand banks was daily stratified in summer, and we could observe a high concentration of chlorophyll in the stratified surface on the sand banks. Here, the water temperature of the lower layer on the banks was identical to that of the strait. These results suggest that a nutrient supply from the well-mixed strait to water column on the sand banks at night leads to the high primary production in the daily stratified surface layer in the daytime. Sand materials have been taken away from sand banks in Seto Inland Sea, but this activity should be stopped for maintaining high productivity in the waters.

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BEDLOAD PREVENTS CORAL REEF DEVELOPMENT IN CARIBBEAN 'HARD GROUND' HABITATS

'Hard ground' habitats are typically characterized by low topographic relief and high water movement, as well as low abundances of scleractinian corals (<20% surface cover) and high abundances of gorgonians. The demographic features of gorgonians suggest why scleractinian coral reefs do not develop in this habitat. Gorgonian survivorship is highly height-specific with small colony survival being relatively low and different among species. These species-specific differences are related to differences in growth rates with faster growing species having higher survivoships. In turn, growth rates are inversely related to branch diameters, probably because less metabolic resources can be allocated for vertical growth with thicker branches. By extension the wide colony diameters (and low vertical growth rates) of newly-recruited scleractinians would result in exremely low survivorships. Sediment bedload probably underlies this survivorship pattern. Because bedload is greater in areas with low topography and high water movement, the development of coral reefs may be largely precluded in hard ground habitats.

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VISION BASED MULTI-AUV SYSTEM INTERLINKED WITH 3D POSITIONING SENSORS FOR HIGH-SPEED SCANNING

Photo mosaicked images are very important materials for understanding of biology of undersea. The AUV(Autonomous Underwater Vehicle) is a useful tool for carry out the mosaicking task. Because their swimming ability can cover up wide scan area and their superior positioning accuracy allows to taking pictures at the planed camera view. Introduction of conventional AUV systems to the task have two major problems: Generally, the AUV can hardly observe the linking part of every picture for generating the mosaicked image from each picture. Considering its limited scan sector in comparison with the total scan area, it may take long time to cover wide area for a small AUV.
These problems can be overcome by introducing the vision based multi-AUV system interconnected by a smart cable that provides 3D relative position data of each AUV in real-time. Laser pointers are attached to each AUV and they point where is the edge of camera's view of each AUV. Using these laser points, two AUVs near-by can clearly recognize the linking part of pictures each other in real-time.The panoramic image has been generated when AUVs are located a line abreast by laser points and AUVs can scan the target area as

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GENETIC VARIATION IN SURVIVAL AND GROWTH RECOVERY FOLLOWING PROLONGED STARVATION OF INVERTEBRATE LARVAE

Growth variability of individual zooplankton in the presence of food, and the ability to survive for highly variable periods in the absence of food, is well established in oceanography. A genetic basis is likely to explain much of the variability in growth and survivorship of individuals, but it has been difficult to test this experimentally. The bivalve Crassostrea gigas offers a unique experimental system because of the availability of defined genetic families. In comparing larval growth of crosses from different genetic families cultured with identical food amounts, certain genotypes grew up to 30% faster than others. In the absence of algae, larvae of the same genotype had a 33% longer 'starvation' lifespan. Based on utilization rates (respiration) of energy reserves for all genotypes, larval survival exceeded predictions by up to 5-fold. Even after 40 days without algae, starved larvae when subsequently fed were capable of growing at rates equivalent to those of larvae fed immediately upon reaching the first feeding stage (2-days-old). Recovery from prolonged starvation indicates that larval dispersal capabilities are less constrained by food limitation than previously assumed.

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FASTGROUP II: A WEB-BASED BIOINFORMATICS PLATFORM FOR ANALYSES OF LARGE 16S RDNA LIBRARIES

Prokaryotes are the most abundant and diverse components of coral reef communities. We have been using high-throughput 16S rDNA sequencing to study the bacteria associated with reef-building corals. This has created a data glut because there are few bioinformatic tools for the analyses of large number of 16S rDNA sequences. To address this problem, FastGroup II has been developed. FastGroup II is a web-based software tool for dereplicating large 16S rDNA libraries using several different algorithms. FastGroup II also automatically calculates standard diversity and richness indexes, including Shannon index, Chao1, and rarefaction. A case study will be presented analyzing the bacteria associated with Caribbean and Pacific Porites sps corals.

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IN-PIXEL VARIATIONS IN CHL A FLUORESCENCE IN THE NORTHERN GULF OF MEXICO AND IMPLICATIONS FOR CALIBRATING REMOTELY SENSED CHL A AND OTHER PRODUCTS

Remote sensing instruments such as SeaWiFs are often calibrated or tested by comparison with in situ data. These comparisons are based on the premise that there is uniform in-pixel variation of in situ properties. This uniformity assumption appears to be the result of convenience rather than of any serious examination. We conducted an analysis of in-pixel variation of chl a fluorescence by examining fluorescence data from a flow-through system on an underway vessel mapping surface properties for 10 days on the continental shelf in the vicinity of the Mississippi River delta. Significant variations of in-pixel standard deviation of chl a fluorescence were observed which indicates that this uniformity assumption is not valid in the Northern Gulf of Mexico. Furthermore, our analysis indicates that a large apparent error by the remote sensor is generated if uniformity of standard deviation is assumed. Our results suggest that one should take into account both in-pixel mean and standard deviation when comparing remotely sensed ocean color data with in situ measurements. Similar measures should be taken when comparing other remotely sensed products with field determinations.

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THE UTILITY OF THE MENGE-SUTHERLAND ENVIRONMENTAL STRESS MODEL TO INVASION BIOLOGY: A CASE STUDY OF A CARIBBEAN BARNACLE IN HAWAII

One of the goals of invasion biology is to understand the conditions that make invasions succeed or fail. When might biotic interactions limit invaders and when might abiotic processes be more important? A model of community regulation developed by Menge & Sutherland (1987) makes some explicit predictions about what factors are likely to be important in ecological communities over gradients of environmental stress and recruitment density. This model could be useful in predicting how invaders might interact with resident species. The Caribbean barnacle Chthamalus proteus is one of the most abundant recent invaders in the Hawaiian intertidal. As in its home range, its distribution in Hawaii is generally limited to protected bays and harbors, where it attains high densities. Smaller populations are found in areas with moderate to high wave intensity. I carried out laboratory and field experiments to examine competition for space between the invader and other barnacles and a pulmonate limpet, and predation by a native whelk. I also monitored recruitment of barnacle species at three sites. My results are a good general fit with the Menge-Sutherland model.

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A ROBUST UNDERWATER VISIBILITY PARAMETER

We review theoretical models to show that contrast reduction at a specific wavelength in the horizontal direction depends directly on the beam attenuation coefficient at that wavelength. If a black target is used, the inherent contrast is always negative unity, so that the visibility of a black target in the horizontal direction depends on a single parameter only. That is not the case for any other target or viewing arrangement. We thus propose the horizontal visibility of a black target to be the standard for underwater visibility. We analyze the effect of different ambient light spectra and beam attenuation spectra such as might occur at different depths in case 2 waters, on the visibility parameter. We show theoretically and experimentally that the relationship: visibility is equal to 4.8 divided by the photopic beam attenuation coefficient, originally derived by Davies-Colley, is accurate with an average error of less than 10% in a wide variety of coastal and inland waters and for a wide variety of viewing conditions. We also show that the beam attenuation coefficient measured at 532 nm, or attenuation measured by WET Labs commercial 20 nm FWHM transmissometers with a peak at 528nm are adequate substitutes for the photopic beam attenuation coefficient, with minor adjustments.

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THE EFFECTS OF NITROGEN CONCENTRATION ON HERBIVORY OF TURTLEGRASS, THALASSIA TESTUDINUM, IN THE FLORIDA KEYS NATIONAL MARINE SANCTUARY

Nitrogen plays an important role in the growth of all organisms, and seagrasses and their associated algae contain nitrogen that is vital to the growth of specialized herbivores such as the bucktooth parrotfish, Sparisoma radians. Many herbivores possess mechanisms, whether behavioral, morphological, or physiological, that enable them to select plants that will provide the nitrogen they require. We used tethered shoots of turtlegrass, Thalassia testudinum, to investigate how differing nitrogen levels affected rates of herbivory by bucktooth parrotfish in the Florida Keys National Marine Sanctuary. Results indicated that tethered shoots of higher nitrogen were selected preferentially. Analysis of the C/N ratios of bitten leaves collected from three different locations showed them to contain significantly less nitrogen, and therefore higher C/N ratios (t-test; p=0.014), than unbitten leaves. This unexpected result might be indicative of an induced response that protects against further herbivory by reducing nitrogen concentration in injured shoots. Thus, it would be beneficial for bucktooth parrotfish to seek leaves without bites, which will contain higher levels of nitrogen.

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SPATIAL TRENDS OF PRIMARY PRODUCTION IN THE ALEUTIAN ISLANDS, A POSSIBLE FACTOR IN STELLER SEA LION DECLINE.

Steller sea lions populations have been declining in the Aleutian Islands, while still thriving in southeastern Alaska. One hypothesis to explain this decline is that food webs have been perturbed along the Aleutians. As part of a study to investigate several hypotheses, primary production was measured in several passes along the Aleutian chain between Unimak pass and Tanaga pass. It was hypothesized that there would be a decline in productivity from east to west. In cruises during summers of 2001 and 2002 we saw such trends of primary production. In 2002 primary production at Unimak and Akutan passes was 2.8 and 3.9 g C m-2 d-1, while in passes further west production was less than half that, ranging between 0.04 and 1.6 g C m-2 d-1. Similar trends were detected the previous year. Even though slopes of the relationship between production and east-west distance were significant, ANOVA failed to detect significant differences in primary production among the passes. The trends of primary production would argue that less energy is available to higher trophic levels in the western part of the Aleutian chain. This would lend credence to the hypothesis that food web effects could be involved in the decline of sea lion populations, perhaps in concert with other factors.

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THE CALIFORNIA MARKET SQUID, LOLIGO OPALESCENS, FISHERY 1981-2002

The California market squid, Loligo opalescens, has been harvested since the 1800's and has become the largest fishery in the state in terms of tonnage and dollars since 1993. The fishery began in Monterey Bay, and then shifted to Southern California, where effort has increased steadily since 1983. The California Department of Fish and Game (CDFG) collects Loligo opalescens squid-landings information including tonnage, location, and date of capture. We compared landings data gathered by CDFG to sea surface temperature (SST), upwelling index anomaly (UIA) and the southern oscillation index (SOI). Based on these data we found that Monterey Bay requires twice the effort of Southern California. Squid landings decreased substantially following large El-Niño events, 1982/3 and 1997/8, but not the smaller El-Niño events of 1987 and 1992. Spectral analysis revealed annual and 4.5-year periodicities - similar to the El-Niño cycles, but did not reveal any fortnightly or monthly period; squid spawning does not correlate with the tides. We compiled a stock–recruitment analysis of catch per unit effort (CPUE) from a paralarvae density index (PDI) for four years of data, which was significant for the same year, but not yet significant for the following year.

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SUMMER ABUNDANCE AND DISTRIBUTION OF CETACEANS IN COASTAL WATERS OF THE WESTERN GULF OF ALASKA AND THE EASTERN AND CENTRAL ALEUTIAN ISLANDS.

The Aleutian Islands (AI) have been poorly surveyed for cetaceans. In the summer of 2001-2003, line transect surveys were carried out in coastal waters from the Kenai Peninsula (60N, 150W) to Tanaga pass (52N, 178W) to investigate cetacean abundance and distribution. Cruises were designed in a systematic random fashion and were limited to waters up to 83km from shore. Abundance was estimated as: humpback (N=2866, CV=16.0%), fin (N=1484, CV=16.1%), minke (N=1512, CV=33.6%), sperm (N=159, CV=31.3%), killer whales (ecotypes combined, N=1472, CV=51.2%) and Dall's porpoise (N=30248, CV=12.8%). Species composition appears to change in the eastern AI between Unimak and Samalga Passes. Density of humpback and fin whales, and harbour porpoise was much higher to the east near Kodiak Island and the Alaska Peninsula, but was low west of Unalaska Island. In contrast, minke, killer, sperm and Baird's beaked whales were relatively more abundant in the AI. Dall's porpoises were seen throughout the study area. The presence of deep-water habitat relatively close to shore provides a partial explanation for the greater occurrence of deep-diving species (e.g., sperm and Baird's) in the Aleutians.

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INTER-ANNUAL VARIABILITY OF SATELLITE-MEASURED CHLOROPHYLL A IN THE TAIWAN STRAIT DURING MONSOON TRANSITION FROM 1999 TO 2001

Taiwan Strait is a shallow channel linking the East China Sea and the South China Sea. Southwest monsoon prevailing in summer turns to northeast monsoon when fall comes. How different Chla dynamics would be from year to year during fall, the monsoon transition season, was investigated in this paper by analyzing multi-sensor remote sensing data set of Chla (SeaWiFS), sea surface temperature (AVHRR) and sea wind (Quickscat) in fall (from September to November) from 1999 to 2001. It was found that the case of 2000 obviously differed from those in 1999 and 2001, when monthly mean SeaWiFS Chla concentration greatly increased from September to October and exceeded 1.0mg/m3 in October. In 2000, less productive (<1.0mg/m3) waters dominated the strait during the monsoon transition. Higher monthly mean AVHRR SST and weaker QuickSCAT wind were also observed in this year. It seemed like that the changing Chla dynamics was highly coupled with the changing strength of intrusion for the cold, nutrient-enriched Zhe-Min coastal water into the southern Taiwan Strait driven by northeasterly monsoon.

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COMPARISONS OF MEASURED AND MODELED BRDF OF PREPARED SURFACES

The Bi-directional Reflectance Distribution function (BRDF) describes the angular distribution of light reflected from a surface. The BRDF is a critical parameter needed to accurately model the light field in shallow coastal waters. To determine a model for the BRDF, based on the physical properties of the sediment, it is necessary to understand how the single particle optics are transformed to the optics of a packed surface. To understand this process we have carried out both BRDF and transmission measurements on polymer sphere layers with different thicknesses together with RTE calculations. The measurements show that despite being closely packed, significant features of single scattering, such as the rainbow peaks, are preserved. However, the strong multiple scattering tends to smooth out these sharp features into broader ones. The RTE models, in particular DISORT, predict the rainbow region quite well, but have large errors in forward scattering directions. These discrepancies have been attributed to the non-ideal factors such as internal inhomogeneity and surface roughness.

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SPATIAL AND SEASONAL VARIATION IN DINOFLAGELLATE DIVERSITY IN LONG ISLAND SOUND ANALYZED WITH MITOCHONDRIAL CYTOCHROME B

Mitochondrial cytochrome b, a gene widely used for phylogenetic studies for various organisms, was isolated for dinoflagellates, and dinoflagellate-specific cob primers were designed. Water samples were collected from the western (WLIS) and the eastern Long Island Sound (ELIS) in February, April, July, and October, and DNA extracted was used in PCR with the primers. The amplicon was cloned, and over 20 clones from each water sample were sequenced. Phylogenetic analysis revealed clear spatial and temporal variation in dinoflagellate diversity. Prorocentrum-type taxa were distributed mainly in WLIS, and exclusively in July. Karlodinium-Akashiwo taxa were common spatially and seasonally except one subgroup was absent in July. An otherwise undocumented cluster occurred at both stations and all seasons except in October. A genetically homogeneous and abundant Pyrodinium-Alexandrium cluster was distributed widely spatially and temporarily. A Pfiesteria-like cluster appeared as a spring-summer type taxon distributed in ELIS. Microscopic analysis confirmed high dinoflagellate abundance in July, agreeing with quantitative PCR results. Based on the sequence information, RFLP was conducted for samples collected weekly at Avery Point. More detailed temporal succession of dinoflagellates will be presented.

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TEMPORAL AND SPATIAL VARIABILITY IN PATTERNS, COHERENCE AND COVARIANCE OF HYDROGRAPHIC VARIABLES AND ZOOPLANKTON BIOMASS ALONG THE AXIS OF THE CHESAPEAKE BAY

Sampling surveys were conducted in spring, summer and fall for six years using a towed sensor package (Scanfish) that included hydrographic sensors and an Optical Plankton Counter (OPC) in the Chesapeake Bay. Hydrographic variables (i.e. temperature, salinity, oxygen, fluorescence) and zooplankton biomass were measured simultaneously throughout the water column on a continuous basis along the axial transect of the Bay and the 24 cross-bay transects. The results showed that the variability in trends, patterns, spatial coherence, and covariance of hydrographic variables and zooplankton biomass were influenced by freshwater discharge and were temporally and spatially dependent. Zooplankton biomass and hydrographic variables showed much better relationships for data binned by latitude (1-dimension) than for data binned by latitude and depth (2-dimension). The whole-Bay scale trends of the 1-dimensional distributions of hydrographic variables and zooplankton biomass could be well represented by fitting second order polynomial curvilinear functions. After the trend removal, the coherence length of variables was on the scale of 20-40 km and the length of the dominant patchiness was on the scale of 25-60 km.

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THE OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM AS A RESOURCE FOR OCEAN RESEARCH AND MANAGEMENT

As the information component of the Census of Marine Life, the Ocean Biogeographic Information System (OBIS) is an online resource for data on species distributions in the ocean. By allowing users to search and integrate data across multiple distributed data providers - natural history museums, fisheries organizations, taxonomic specialists, government data centers, etc. - OBIS provides access to near a million records of species observations. Taxonomically, species from plankton to whales are represented. Geographically, the scope is global. Tools on the OBIS portal map and download data, model species ranges from point distribution data, search for scientific names from common names and find synonyms for scientific names. This quickly-growing system is designed to support marine environment monitoring, resource management, and sustainable development, as well as scientific research. OBIS facilitates these services through a global portal and a network of heterogeneous yet interoperating databases distributed around the world. OBIS is currently building rigorous connections with other international programs, among them the Global Ocean Observing System and Global Biodiversity Information Facility, to create the next generation of interdisciplinary marine cyberinfrastructure.

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A MODEL FOR AN INTERNATIONAL REALTIME OCEAN OBSERVATORY FOR HIGH SCHOOL STUDIES

Miami-Dade County, has launched a plan to establish a real-time ocean observatory to facilitate students' research projects. The observatory will be developed initially as a local component within selected schools within Miami Dade County, Florida. Once this component has been successfully implemented it will be extended to US National and then international components. The local component is a wet laboratory established in Biscayne Bay at a Stiltsville multi-use structure within Biscayne National Park. This laboratory will also be equipped with a suite of ocean and meteorological sensors and will use the SeaKeepers data and transmission module to relay the data from the observatory back to the high schools in real time. The students will also have access to real-time and archived observations from dozens of similar SeaKeepers modules that have been installed worldwide on yachts, cruise ships, merchant vessels, ferries, piers, buoys, and light towers. Students involved in this cooperative research effort will thus have the resources available to pursue a variety of ocean studies covering a wide range of disciplines, temporal and spatial scales.

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A QUANTITATIVE PCR ASSESSMENT OF THE POPULATION STRUCTURE AND DYNAMICS OF THE MARINE CYANOBACTERIUM, PROCHLOROCOCCUS, IN THE NORTH ATLANTIC OCEAN

The phytoplankton of the world's oceans are dominated numerically by the cyanobacterium Prochlorococcus. To date six phylogenetically-distinct clades of Prochlorococcus have been discovered. While differences in 16S rDNA sequences are low between these clades (up to 2% difference maximum), the clades have significantly different physiologies and genome composition. Hence, they are likely to occupy distinct niches in the oceans and contribute differently to the ecology of those systems. To understand the contribution of Prochlorococcus to marine ecology, it is therefore crucial to determine the relative abundances of the distinct clades in nature. Here we describe the development and field application of a quantitative PCR approach to assess the structure and dynamics of natural populations of the Prochlorococcus clades. We have determined that the technique is sensitive, robust, and efficient. Application of this technique to field populations in the Sargasso Sea, Gulf Stream, and continental slope has demonstrated that the different clades show different depth distributions and contribute unequally to overall abundance of Prochlorococcus at these sites.

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IN SITU UV OPTICAL PROPERTIES DURING THE EVOLUTION OF AN FE-STIMULATED PHYTOPLANKTON BLOOM

Solar ultraviolet (UV) radiation in the ocean initiates almost all photochemical reactions important to global chemical cycles, producing CO2, CO, HOOH and radicals that can lead to dimethylsulfide loss in sunlit waters. During July 2002, in situ UV optical properties were measured in the NE subarctic Pacific within a tagged phytoplankton bloom resulting from a purposeful addition of Fe (SERIES). Two Satlantic optical instruments were deployed at each of 22 stations over 19 days. A floating Ocean Colour Radiometer (OCR) served as surface reference for depth profiles of downwelling irradiance (Ed) in 13 wavebands (305 to 700 nm) and measured surface upwelling radiance (Lu) in the same channels (plus 590 nm) for correlation to remotely sensed ocean colour. Chromophoric dissolved organic matter (CDOM) absorbance, the main absorber of UV radiation, was also measured at each station. Attenuation of visible radiation due to phytoplankton growth increased dramatically, UV attenuation also increased, but CDOM absorbance exhibited smaller changes. Spatial and temporal changes in UV spectral characteristics, quantitative relationships among ecosystem dynamics, CDOM absorbance spectra, UV attenuation, and DOC concentrations will be examined.

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