UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

PRELIMINARY REPORT
UNOLS LONG-RANGE PLANNING MEETING

UNIVERSITY OF SOUTHERN CALIFORNIA
SANTA CATALINA MARINE LABORATORY

UNOLS Office
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

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SUMMARY

A long range plan for university research facilities, and research vessels in particular, is considered necessary for continued and orderly replacement and acquisition program to meet future academic research needs.

At the invitation of the UNOLS Advisory Council, a group of twenty practicing scientists representing fifteen university laboratories met at the University of Southern California Santa Catalina Marine Laboratory from 23-25 October 1974, to consider the future trends in oceanographic research and the seagoing facilities required.

The results of the meeting indicated that oceanographic research will be guided by the needs to better understand the oceans - its life and its boundaries and their history, processes structure and variability. Although technological breakthroughs will continue to have impacts on the nature of science at sea, societal needs may have an equal or greater impact.

In terms of numbers, ship requirements for the future do not appear to be significantly greater than at present. (An exception may be in coastal type vessels). But the capabilities of research ships to do good science must be drastically upgraded.

This is a preliminary report of the meeting, the final report will be a draft long range plan for submission to UNOLS and other reviewing bodies.

UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

PRELININARY REPORT
LONG RANGE PLANNING MEETING

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PRELIMINARY REPORT
UNOLS LONG RANGE PLANNING MEETING
23-25 October 1974

University of Southern California
Santa Catalina Marine Laboratory

BACKGROUND

A Goal of UNOLS - and one of the objectives for which UNOLS was established - is to develop and update a Long Range Plan for university oceanographic facilities. The importance of such a plan cannot be understated. Because most oceanographic facilities - especially ships - are constructed with Federal funds all new acquisition must compete in an increasing rigorous manner for support. Unless requests for new ships and other facilities are accompanied by substantive, creditable and approved plans showing how new facilities fit into the needs for and future of oceanographic research, those requests will be at a disadvantage and have little likelihood of succeeding.

There have been two previous long range plans developed, one of these was included in the National Academy of Sciences Committee on Oceanography (NASCO) Report of 1960 which was for the decade 1960 - 1970. The second was by the Council of Laboratories Directors (COLD) in 1970 for the decade 1970-1980. Both these plans served a purpose but are now obsolete. It falls to UNOLS to develop a plan for the years ahead.

The UNOLS Advisory Council has recommended that a long range plan be developed aimed at the next generation of research ships. This is the 1990 time frame when the majority of the present ships will be approaching obsolescence. A plan should include the following guidelines:

- *It should be responsive to the anticipated future trends of oceanographic research and engineering*
- *It should be realistic in terms of the national economy*
- *It should bear the general approval of the academic community*
- *It should be creditable sufficient to compete in the Federal funding infrastructure*

- *It should provide a logical implementation scheme bridging the current and projected time frame*
- *It should provide for periodic updating*

As a start the UNOLS Advisory Council convened a working group which met at the University of Southern California, Santa Catalina Marine Laboratory, October 23-25, 1974. The group comprised about twenty scientists and ocean engineers who were nominated by UNOLS Members and the NAS Ocean Science Committee. The meeting was charged with discussing and reporting on the trends of academic oceanographic research over the next 15-20 years, and attempting to project the kinds and numbers of facilities - chiefly research ships - needed to meet those trends.

SUMMARY OF MEETING

The group met at the Santa Catalina Marine Laboratory of the University of Southern California which acted as host.

The Meeting comprised twenty-three participants representing fifteen academic institutions. Dr. John P. Craven, Dean of Marine Programs, University of Hawaii, was Chairman. R. P. Dinsmore, UNOLS Office acted as Secretary.

In its proceedings the members met both as a whole in several general sessions and in separate groups according to scientific disciplines. The approach to long range projections were deliberated and agreed upon as a whole group. Reports on future trends of oceanographic research were prepared by the various disciplinary working groups. Projections of required facilities, their kinds and numbers were once again discussed in open sessions as a whole.

It was agreed that an accredited plan could not be completed by this group at this meeting and that final efforts should be subjected to the additional inputs, review and approval of individual institutions and appropriate scientific reviewing and recommending bodies.

Participants at the UNOLS Long Range Planning Meeting
Santa Catalina Marine Laboratory
October 23-25, 1974

Captain Peter Branson	Scripps Inst. of Oceanography
Professor Rita Colwell	University of Maryland
Dr. Charles Cox	Scripps Inst. of Oceanography
Dr. John P. Craven	University of Hawaii
Capt. R. P. Dinsmore	UNOLS Office, W.H.O.I.
Dr. Richard C. Dugdale	University of Washington
Dr. Robert L. Fisher	Scripps Inst. of Oceanography
Dr. Dirk Frankenberg	University of North Carolina
Mr. Robert D. Gerard	Lamont-Doherty Geological Observatory (Columbia University)
Dr. Donn Gorsline	University of Southern California
Dr. Christopher Harrison	Rosenstiel School of Marine & Atmospheric Sciences (U. Miami)
Dr. Donald W. Hood	University of Alaska
Ms. Mary K. Johrde	National Science Foundation (NSF)
Dr. John A. Knauss	University of Rhode Island
Dr. Charles B. Miller	Oregon State University
Dr. Worth D. Nowlin, Jr.	Texas A&M University
Dr. Michael Pilson	University of Rhode Island
Dr. Adrian F. Richards	Lehigh University
Dr. Gilbert Rowe	Woods Hole Oceanographic Institution
Dr. Jay M. Savage	University of Southern California
Dr. Irving Swatzburg	University of Hawaii
Dr. Allyn C. Vine	Woods Hole Oceanographic Institution
Dr. Richard Von Herzen	Woods Hole Oceanographic Institution

The participants agreed to continue to work together chiefly as a committee of correspondence and meetings of small working groups as necessary. The <u>preliminary report</u> would contain the results of the Catalina Meeting. Its final report would transmit a Draft Long Range Plan to UNOLS.

Part II

FUTURE TRENDS OF OCEANOGRAPHIC RESEARCH

It is with some misgivings and no little reluctance that scientists attempt to predict the future trends and courses of scientific research. In general an investigator responds that the problems occuring in his current research should be further pursued to a satisfactory understanding and that undoubtedly further problems will occur which, given technological break throughs, will permit further understanding.

As a starting point it was agreed that much of the future course of science will undoubtedly be related in some way to societal impacts. These can be broadly classed as: (1) Food, (2) Energy, (3) Industry and Transportation, (4) Climate and Weather, (5) Environmental Quality, (6) Military and (7) Urban Development. Using these as focal points Disciplinary Working groups undertook to draft reports on the future trends of Oceanographic Research. Working Groups were comprised as follows:

Physical Oceanography: Charles Cox, Worth Nowlin, John Knauss, Robert Gerard

Marine Geology & Geophysics: Robert Fisher, Donn Gorsline, Chris Harrison, Richard Von Herzen

Biological Oceanography: Dirk Frankenberg, Rita Colwell, Charles Miller, Jay Savage, Richard Dugdale, Gilbert Rowe

Chemical Oceanography: Donald Hood, Michael Pilson

Ocean Engineering: Allyn Vine, Adrian Richards, John Craven, Peter Branson, Irving Swatzburg

The Reports of these groups are contained in the following pages of this Part.

FUTURE TRENDS OF OCEANOGRAPHIC RESEARCH

Reports of Working Groups at the UNOLS Long Range Planning Meeting Santa Catalina Marine Laboratory 23-25 Oct. 1974

PHYSICAL OCEANOGRAPHY

Prediction of the future course of science is similar to the prediction of weather: forecasts of short range, mainly based on persistence, have a degree of validity but long range forecasts have to be based on climatology. Examples of more ambitious attempts are more noted for the enthusiasm of the prognosticators than successful verifications. In these circumstances we have taken the unimaginative approach of projecting 'more and better' of presently known trends in physical oceanography. We recognize that the actual course of the science will be far different from our projections and we have affected a succession of brilliant discoveries, developing understandings, and powerful new tools which we cannot conceive at present.

According to this view we project continued strength and expansion in all the branches of physical oceanography and, indeed, the impact of the social needs outlined in other parts of this report will be to demand further knowledge in all these aspects.

The main divisions of physics of the ocean can be classified in terms of the length and time scales of the phenomena. To some extent this is a natural classification because the large and small scale phenomena require rather different approaches and, therefore, facilities.

(1) Description and Understanding of the Overall Structure of the Ocean and Its 'Steady State': This is the classical field of descriptive physical oceanography and is still far from complete, but is receiving a powerful thrust from new tools through development of geochemical and radiochemical tracers, through use of current meters and profiling salinity/temperature devices, and through gradual understanding of the role of fluctuation phenomena in controlling lateral and vertical momentum and dissolved material. Conventional and widely ranging ships are needed with full capabilities for sampling. The application of numerical models for simulating the general circulation is increasing. Large machines are required in order to handle the vast amount of calculations necessary for simulation of the complex of action and reaction even when the representation of fluctuation phenomena is only crudely parameterized. We foresee improved numerical simulation utilizing methods based on increased knowledge of the mechanisms by which fluctuation phenomena affect the overall structure. We foresee continued descriptive studies by conventional means, but greatly improved by reason of the existence of far more precise and easily used instruments for profiling the physical and chemical structure of the ocean.

It is already clear that a true 'steady state' never exists in the ocean. There are profound long term climatic changes. Through paleontological and isotopic analyses, together with paleomagnetic and radioactive dating, there is unfolding a remarkable ability toward descriptive paleo-oceanography. We expect this work to expand and to call for further understanding of the influence of changes of atmospheric circulation on the behavior of the ocean, both through numerical simulation and direct observation, leading towards documentation of very long term changes in the ocean.

(2) Plans for Statistical Representation, Mapping, and Detailed Study of Meso- and Large-Scale Fluctuation Phenomena: In some parts of the ocean it is now known that meso-scale velocity structures dominate the kinetic energy distribution within the body of the ocean. We foresee continuation of the present exploratory and descriptive phase of studies of the geographical and seasonal variations of meso-scale 'eddies'. This will require a variety of approaches extending all the way from collection of data at a few moored ocean stations or along a repeated commercial ship track, and continued for a time of the order of a year or more, to far more elaborate experiments involving very large arrays of moored and drifting instruments supplemented by observations made from a fleet of research ships. It is clear that the largest experiments will require international efforts in order to approach adequate coverage of the phenomena.

Beyond these initial studies of the kinematics of eddies we expect that there will be studies directed toward recognition of the mechanism, or more probably, the several mechanisms of generation of the eddies, as well as their coupling to each other and to the overall circulation. Such experiments will demand increasing efforts and special arrays directed toward examination of particular processes. The importance of fluctuations in the economy of heat momentum and substance will be undertaken.

There seems to be a moderately narrow range of scales involved in one class of meso-scale eddies. It is not yet clear whether a larger space scale of dynamical fluctuations is also involved in the sea. If such exist, their importance in the oceanic and atmospheric climate problems will be large and their thorough understanding important. Such studies require development of new tools; for example, a moored ocean station able to provide very long time series of appropriate observations and administrative mechanisms for collection of repeated observations from regularly scheduled commercial ships.

Another field of great importance for weather and climate studies involves the large scale interactions of the ocean and overlying atmosphere. This work requires continuous monitoring of the fluxes of momentum and energy between the ocean and atmosphere over very large areas and for long time, ultimately extending toward global monitoring. The tools for such work can be only dimly foreseen. They require a mixture of vehicles extending from conventional moderate-size ocean research vessels, long range aircraft and moored and drifting atmosphere and ocean monitoring buoys, to the extensive use of observation from commercial ships. We expect to see the devel opment of a suite of remote sensing methods: electric and acoustic methods of integrated current measurement; over-the-horizon radar monitoring of waves and winds; satellite scans of albedo, sea surface temperature, wind stress and waves, and possibly mean sea elevation.

Upwelling and downwelling are important in a variety of fields and will be extensively investigated. We foresee a continuation of coastal studies similar to CUEA and an extension to more of the difficult problems of equatorial upwelling and mid-gyre downwelling regions. A more important facility needed is an open sea, long term, manned moored laboratory station from which geochemical and physical observations can be carried out to derive, economically, long term data; and from which nearby instruments can be controlled. Studies will be made of mid-scale processes in special regions: estuaries, circulation inflow and outflow at sills and straits and the dynamics of ice-covered areas. The facility requirements include coastal ships, deep sea ships, and ice strengthened ships.

(3) Smaller Scale Processes Including Ocean Surface and Internal Waves, Tsunamis, Intrusive Phenomena, 'Fronts', Benthic Fronts, Mixed Layer Dynamics, etc.: The heavy investment in fundamental studies of wind waves is probably past. We foresee an applied science effort at monitoring both by over-the-horizon radar, satellite and buoy methods, as well as predictive efforts and attempts to reconcile measurements with the prediction. Such efforts will have a great social importance with respect to shore processes, sediment transport, shoreline protection, ship routing, facility safety, etc.

Studies of internal waves will increase with application to acoustic phenomena, ocean mixing and energetics. The nonlinear dynamics which couple surface and internal waves, winds, and bottom irregularities will be explored. These projects will require specialized instruments and vehicles: manned spar buoys, mid-ocean manned platforms, unmanned neutrally buoyant floats and other devices.

The dynamics of fronts, the mixed layer, and intrusive phenomena are of immense importance in the dynamics and thermodynamics of the sea. The accessibility of these phenomena to measurement and analysis by modern tools is increasing. We foresee application of highly precise, T, S, ρ, p profiling, current measurements and position monitoring methods as leading to fundamental improvements in knowledge of these features. Facilities needed include moderate range blue water ships with capability to handle modern instrumentation, and methods of obtaining long term data. These will be most conveniently obtained from the mixed layer from moored and manned ocean stations with a very wide capacity for monitoring the atmosphere and adjacent oceans.

There are a number of near shore problems of ocean dynamics which are especially important to attack. These include shelf and surf zone circulation and erosion and sediment transport, as well as interactions of internal waves with the shelf, continental slope, and submarine canyons. The ships needed are small, but capable near shore types, able to utilize XBT, CTD, current meters and similar instrumentation. Other fixed and buoyed devices will be utilized.

At the sea bottom the boundary layer will be studied. Important parameters are the transport of momentum, heat and chemical substances; the stability of the water, erosion and the presence of suspended matter; flow of tides and internal waves. We foresee use of various probes, some controlled from shipboard and some left in situ.

(4) Microprocesses: Under this heading comes the study of the smallest scales, i.e., those extending down to the limits imposed by molecular diffusion and viscosity. Understanding and measurement of these fields is increasing rapidly and has applications to transport phenomena of all kinds, including those of the atmospheric boundary layer. We foresee studies to develop an understanding of these processes in the presence of turbulence, density, stability, gravity waves and gross shear. Instrumentation of ship supported, spar buoy supported, and free-fall types will be required. Studies extending over long times and carried out from open sea, manned moored stations is required to extend our weak knowledge of the variations in time.

(5) Sound and Light in the Sea: Oceanic acoustics will be utilized in two ways - to understand the effects of the environment on the acoustical properties and to utilize acoustics as a tool to monitor some features of the structure of the sea. To some extent light will be utilized in the same two ways, with additional emphasis on monitoring for biological purposes and some use of light as a probe for oceanic surface or internal structure. The needs are for flexible, inexpensive ships and extensive instrumentation.

Impacts of Societal Problems:

Major classes of societal problems which are likely to have an impact on oceanographic research during the next fifteen years include:

- Exploration for and extraction of minerals and petroleum
- Extraction of food from the sea
- Monitoring and understanding of climate and weather
- Military uses
- Energy production
- Transportation, industry and urban development

For each of these problem areas, we have tried to identify the sub areas of physical oceanography in which additional study and knowledge will likely be required in order to develop rational plans of attack or to effect solutions. The identified elements of this interaction between physical oceanography and major societal problems are given in Table I.

The societal problems on which the physical oceanographer will likely have the most consequential impact are those associated with waste disposal and pollution and with the monitoring and understanding of weather and climate. This is true both because these problems may have most severe lasting effects on our environment and because the solutions require additional knowledge of all scales of physical phenomena in the ocean

TABLE I

A. Food Extraction

To improve understanding of marine ecosystems

Light in the sea
Small scale density structure
Variability of oxygen and nutrient concentrations
Upwelling studies

To provide information for optimum fisheries management

Seasonal temperature variation
Seasonal variability of current structures
Estuarine circulation

B. Energy Production

To examine the physical consequences of engineering schemes

C. Mineral and Petroleum Exploration and Extraction

To improve understanding of processes in shelf/coastal region

Estuarine circulation
Long wave effects, incl. storm surge problems
Near shore wave problems
Sediment transport processes
Shelf circulation

To improve predictions of surface conditions

To aid in design of deep ocean structures

Structure and variability of deep sea currents
Variability of physical properties

D. Military uses

Environmental acoustics

Micro and meso structure of temperature and salinity fields and their temporal variability, including particularly: internal waves, meso-scale rings and eddies, thermocline studies, variability of major currents

To improve surface layer forecasts

- Ice cover
- Sea-air boundary layers

In design & siting of bottom-mounted objects

- Bottom boundary layer studies

E. Understanding Climate and Weather

- Air-sea interactions
- Heat (radiation) balances
- Mixed layer dynamics
- Ice cover
- Ekman layer studies
- Water mass formation-processes and rates of formation
- Thermodynamics of ice cover and underlying water
- Transport of stored heat
- Western boundary currents
- Antarctic circumpolar current
- Frontal dynamics
- Large-scale fluctuations
- Meso-scale eddies

F. Waste Disposal and Pollution

- Near-shore oceanography (Sec. C)
- Atmospheric circulation patterns
- Air-sea exchanges
- Micro-surface layer
- Mixed layer dynamics
- General ocean circulation patterns
- Diffusion studies
- Bottom boundary layer exchanges
- Heat balances and transports
- Bottom erosion by long waves, currents, turbidity currents

G. Transportation, Industry and Urban Development

- Descriptive oceanography of Arctic and Antarctic
- Ice dynamics (including coverage)
- Sea state prediction
- Surface current prediction
- Long-wave effects (erosion)
- Near shore oceanography (Sec. C)

FUTURE TRENDS OF OCEANOGRAPHIC RESEARCH

Reports of Working Groups at the UNOLS Long Range Planning Meeting Santa Catalina Marine Laboratory 23-25 Oct. 1974

MARINE GEOLOGY & GEOPHYSICS

General Statement

We now have a broad overall idea of the morphology of the ocean basins and some idea of the structure of the oceanic crust. Although many details remain to be determined, our knowledge of the geologic history of the ocean basins has taken a large step forward in recent years and is described in general principles by the associated theories of sea floor spreading, subduction, and plate tectonics. The thrust of marine geological research (geology taken in its broadest terms) will probably be in the following areas:

(1). Filling in details of plate tectonics where present information is sparse, such as in high latitudes, especially the Arctic.

(2). Determining the mode of the original split up of the continents, by studying continental margins and their deformation.

(3). Determining second order effects, inconsistencies and anomalies which are not explained by plate tectonics.

(4). Deeper geophysical penetration into the oceanic lithosphere.

(5). Reconciliation of the structure of the oceanic crust determined from geophysical data with composition. What are the crustal layers made of, why are they apparently so clearly layered, and what are the possible compositional variations within each layer?

(6). Study of the continental margins and boundaries, especially near shore processes. These studies are important as the continental margins are likely to be increasingly more important sources of raw materials, and they need to be studied from an environmental and ecological point of view.

(7). Study of the processes of plate tectonics (what happens in detail at ridges, subduction zones and fracture zones).

(8). Studies of paleooceanography, as revealed in vertical and horizontal changes in sediment type and composition. These studies are especially important as they may lead to a better understanding of the Earth's climate, the variation of which is so important in making long range predictions of food supplies.

The types of information necessary to achieve these goals may be broken down into the following fields: (a) Morphology (b) Structure and Tectonic Processes (c) Composition. Thse will be discussed in turn.

MORPHOLOGY

(1). Morphology of fracture zones must be known in more detail as it is in these regions that deeper crustal and possibly mantle material is exposed on the surface, and available for collection by rather simple collection techniques.

(2). The fabric of morphology, if known in enough detail, reveals events in the history of the stress field experienced by the oceanic crust, and also processes of emplacement of oceanic crust at the ridge crest.

(3). Micro-fabric of the ocean floor, as revealed by deep tow, submersible, and bottom photography will probably be a very useful tool along the same lines as item 2.

(4). Use of narrow beam echo sounders to produce a more easily interpretable picture of the ocean bottom.

STRUCTURE AND TECTONICS

(1). Deeper penetration into the oceanic lithosphere. Ocean bottom seismometers and explosion seismology could be used, or earthquakes occurring at the ridge crest or along the fracture zones could be used as the energy source for penetration well below the oceanic moho. Magneto-telluric and electro-magnetic techniques are also useful for penetrating deeper into the lithosphere, and require

(1). bottom mounted instruments.

(2). Ocean floor seismicity should be measured using arrays of bottom mounted seismometers.

(3). Finer scale resolution of the oceanic crust by more carefully controlled seismic refraction measurements, to determine in more detail the vertical and horizontal velocity variations.

(4). More precise magnetic field observations to allow us to study the origin of the magnetic anomalies. Currently, magnetic field observations have a scatter of several nannotesla. An interpretation of magnetic anomalies involves basically a downward continuation, in which small wavelengths become intensified with respect to large wavelengths. For instance a one nannotesla signal of the same wavelength as the water depth becomes intensified to over 500 nannotesla at the ocean bottom. The source of the noise is probably in part ionospheric, and can be removed in principle by making magnetic gradient measurements, for which instruments are presently being developed.

(5). Gravity data will become much more useful in the oceanic basins, where free air gravity anomalies are in general very small, only if the measurements can be made with more accuracy than heretofor. This will involve increased accuracy in navigation, as an error in the east-west speed of the vessel of only one seventh of a knot will produce an error of 1 milligal in the free air anomaly at the equator. In general, a satellite fix accurate to a hundred or two hundred meters every two hours should be sufficient to give this accuracy in east west speed, provided that variations in the velocity of the vessel are accurately known between the two satellite fixes. This will probably involve more sophisticated

(5). dead reckoning programs in which the heading of the vessel with respect to the prevailing wind, and with respect to the direction of the predominant wave system, the velocity of the wind and the wave height are taken into consideration.

(6). Variability of structure near the ridge crests must be studied in more detail, especially the change in the seismic layers with distance from the ridge crest. Heat flow studies should be made on the hard rock outcrops near the ridge crest, possibly by drilling into the rock. Temperature anomalies in the bottom water will help in determining the role of hydrothermal circulation in the ridge province. Hydrothermal circulation is important in understanding the thermal regime of the ridge crest areas, and also because of its effect on the composition of the rocks and the metalliferous sediments found close to the ridge areas. Heat flow studies will also be done in fracture zone areas, in order to try and see whether there is evidence for volcanic activity in these areas. Heat flow observations should always be tied in with local environmental conditions, such as the shape of the sediment basins in which they are taken, in order to remove some of the large amount of scatter which is commonly seen in heat flow measurements.

(7). Seismic reflection profiling will be developed along the following directions. Deeper penetration into the sediments of the continental margins, where many raw material deposits remain to be discovered and exploited. Greater resolving power is necessary to determine more about the structure of the deep ocean deposits, which are frequently very thin, and in the region of the oceanic island arcs, (7). where the sediments are contorted so that the current techniques are unable to resolve details of the structure. We therefore need to use higher frequencies and finite apertures (such as parabolic reflectors) or standard techniques of oil companies such as multi-channel receivers, which are necessary to remove bottom multiples in shallow waters of the continental shelf areas. In terms of vessels, we need vessels which are capable of deploying finite aperture sources or receivers, or which have the large data processing capability necessary for the multi-channel work.

(8). For studying near shore processes, it is necessary to have a greater monitoring capability, as many of these processes may be dominated by relatively rare events. This will require a greater use of coastal zone vessels capable of servicing the monitoring equipment.

COMPOSITION

(1). Our knowledge of the composition of the sedimentary layers of the ocean floor has been greatly extended in recent years by the efforts of JOIDES, the Deep Sea Drilling Project and the GLOMAR CHALLENGER. To some extent we shall also improve our knowledge of the upper layers of the igneous oceanic basement in future years, as the GLOMAR CHALLENGER continues to drill deeper into the crust. However, there are several regions where our knowledge is severely limited because of the lack of technical capability. One of these regions is the mid-oceanic ridge system and other places where there is no sediment cover. This lack of sediment cover means

(1). that no samples can be retrieved by the GLOMAR CHALLENGER, and all our information has been obtained by the imprecise dredging method of collection. We urgently need a capability of sampling several tens of meters into hard rock outcropping on the surface, with an added capability of locating the samples so obtained with respect to each other and also with respect to detailed topography.

(2). Another increased capability which we need is the capability of collecting long cores from the surface sediments, the coring process being such that little or no disturbance is produced by the process in the sedimentary layers. The GLOMAR CHALLENGER does produce disturbance and also there are frequently discontinuities in the recovery of sediments from core to core, even when continuous coring is attempted. The necessity of long continuous undisturbed cores is necessary to study time changes with respect to glaciation, and other climatic and environmental factors. From a greater understanding of paleoclimatology and paleoenvironmental conditions we shall be able to predict these time variations better into the future. By allowing long undisturbed sediment cores to be collected in rapidly depositing areas of the continental shelf, we shall gain a better insight into the nature of the processes occurring there, and hence make predicitions about the nature of the changes which might be expected.

FUTURE TRENDS OF OCEANOGRAPHIC RESEARCH

Reports of Working Groups at the UNOLS Long Range Planning Meeting Santa Catalina Marine Laboratory 23-25 Oct. 1974

BIOLOGICAL OCEANOGRAPHY

I. Introduction

The biological working group began by considering the forces that seem likely to stimulate biological oceanographic research in the period 1975-1990. We agreed that these forces will include both scientific curiosity and, increasingly, social-political pressures associated with the explosion of ocean use by man. Parts I and II of this report summarize the trends we see in these two areas. Part III summarizes general trends in research in biological oceanography. Part describes the facilities which will be needed for this research.

I. The principal current trend in basic marine ecology is that traditional descriptive and inductive approaches are being augmented by a deductive-theoretical and observational interplay. This trend will continue past 1990. We see also some important trends in our theories which will affect the kinds of observations we will want to make in the future and the kinds of facilities we will need to make them. Our models of the tropho-dynamics of marine (particularly pelagic) ecosystems are going to move away from lumped approach in which all primary producers are treated as a unit, secondary procedures as a unit, and so on, toward much more detailed models involving the dynamics of the dominant species populations constituting the systems. This will lead to increasing emphasis upon measurements of ecologically important characteristics of individual marine species: tolerances for temperature, salinity, oxygen content, and microconstituents will reassume importance. Rates of feeding, or growth, of completion of development, of egg production in zooplankton will be increasingly important. Rates of nutrient uptake, enzymatic mechanisms of nutrient uptake, cell growth rates and processes will continue to be important areas of research on the phytoplankton. All of these directions imply that improved sea-going laboratories on comfortable vessels with long endurance at sea should have high priority.

The type of field observations which will be most sought after because of trends in theory will be those which emphasize the clear separation of temporal and advective processes as they determine the distribution of biological characteristics of the ocean ecosystem. The spatial scale which seems most likely to receive emphasis is the so-called mesoscale (greater than 3 km and less than 100 km). This trend will emphasize improved interactions with physical oceanographers studying current and diffusion processes. It is clear that repeated sets of synoptic data will be important, and that this will lead to emphasis upon automated data production and handling systems. The desirability of synopticity may also lead to a demand for fast ships.

There are a number of fundamental ecologic problems presented by marine environments, and a number of such problems that will most readily be solved in marine environments. Frequently these problems are not capable of definitive solutions because of the time and space scales of the necessary experiments. They will continue to be stimulating nevertheless.

For example:

1) What are the differences in the suites of selective pressures in oligotrophic and eutrophic environments which have led to the observable differences in the communities which inhabit them?

2) What are the differences in adaptive mechanisms for individual species and for communities which permit survival in highly seasonal high latitude and in more predictable invariant low latitude ecosystems?

3) What are the effects of the lack of physical structuring in pelagic ecosystems? How do they differ in their essential character from highly structured terrestrial ecosystems? Does the lack of investment in biologically generated structural facilities (trees) give the pelagic ecosystem better or worse stability in the face of the sorts of perturbations caused by climate and likely to be caused by man?

4) What controls species diversity in marine ecosystems? Which historical events have led to the differences in the numbers of species in different marine habitats?

II. Human uses of the ocean and the research it is likely to stimulate by 1990

A. Food from the sea

Total harvest from conventional marine fisheries is not predicted to increase greatly during the period 1975-1990. This is based upon our best estimates of photosynthesis rates and food chain efficiencies in the sea and upon recent fishery statistics. However, increasing world protein requirements will stimulate biological research on new food supplies. Some of this research will involve basic studies of photosynthesis, the production and role of dissolved organic materials, and the trophic roles of very small (and therefore little studies) plants and animals. It will also involve applied food technologic and ecological impact studies of the potential harvest of forms lower in the marine food web than are currently harvested. The study of aquaculture will continue to be prevalent, although an increasing body of experience suggests that the principal product will be luxury food items with a high cost per unit. Specific biological research on individual exploited and exploitable stocks will continue to be important. However, because of the character of fishery data, it is likely that this will be done most efficiently by the governmental agencies that regulate the fisheries. Universities can probably contribute most effectively by continued basic research on the climatic and ecologic factors generating constraints on fisheries.

B. Mining for minerals, gas and oil:

Minerals sought in the oceans will include sand and gravel on the continental shelf; Manganese modules in the deep ocean and, eventually cobalt-copper-nickel ores on the outer continental shelf and, possibly, silver and gold ores on volcanic slopes of atolls and sea mounts. Such activities will disturb the ocean bottom and thus have an impact on the organisms that live and feed there (benthic and ormercal fish). Biologists can be expected to be asked to assess the magnitude of this impact. Mineral recovery will also liberate mineral and nutrient substances into the water column overlying the mining sight. The impact of these liberated materials on the plankton and nickton of overlying waters and the entrophication of these ecosystems will also be the subject of biological study.

Recovery of oil and gas from shelf, outer continental shelf and even deeper ocean regions will result in new structures in the oceans and new materials entering the ocean. The structures will provide habitats that will become new sites for recreational fishing in many otherwise habitat-limited areas. The added materials may include potential carcinogens as well as materials already known to interfere with breeding, behavioral, and response processes in marine organisms. Biologists will be called upon to assess both types of impact.

C. Transportation and Industry:

Large stable platforms are predicted as the sight for production and storage of petroleum and other products. These developments will provide new habitats and chemical additions to the marine environment with the nature of each dependent on the types of platforms and their uses. Assessing the biological impact of each type of use will create new research. Super tankers and super ships imply super spills. These will generate research needs and opportunities.

D. Energy production:

Energy will be produced at sea from floating nuclear power plants, coal and oil fired power plants on platforms, and, potentially, from energy produced by dissipation of the temperature differential in the upper parts of the oceanic water column. All of these energy production schemes will liberate large concentrations of heat into the environment, and biologists will be asked to assess the impact of this heat on mortality, physiology, development, breeding periods and growth of organism, and communities exposed to it. In addition, any materials escaping from such plants (ash from coal powered plants, copper, other toxins and chelators from heat exchange devices) will need to be assessed for their potential biological impact. Many of these studies will require interdisciplinary research programs involving biolgists, chemists and physical oceanographers if realistic appraisal of environmental impacts are to be accomplished.

E. Military Uses:

Biologists will continue to be involved in studies of underwater sound producers and attenuators, but we forsee no major increase in this activity. The physical changes in the naval fleet resulting from response to "smart missile" development may result in deployment of large stable platforms which will have biological impacts similar to those described for similar industrial platforms described above.

F. Waste Disposal:

The ocean is the ultimate sink for society's waste and this role can be expected to be increasingly exploited in the 1975-1990 period. It seems reasonable to expect nuclear, industrial, and domestic wastes as well as dredge spoil to be increasingly dumped at sea. The environmental impact of such disposal practices will require cooperative research programs involving physical oceanographers, marine chemists and biologists. The range of potential impacts and dangers are as varied as the materials disposed of: nutrients, organic food stuffs, toxins, heavy metals, disease organisms and carciuogens will each have an impact as well as unknown, but potentially significant, synergistic effects when acting in concert.

Because of the relative paucity of life in the deep-sea, and in an attempt to prevent harm to fisheries and nearshore amenities, there will be increasing pressure to dispose of selected wastes off the continental shelf. This will require basic research programs on each coast which are involved in ellucidating rates of biological activity and the effects of man-made perturbations on biota not adapted to unpredictable events. While the academic community will continue to investigate the many basic questions, they will be called upon with increasing frequency to assess dumping impacts both nearshore and in the deep sea. These research efforts will require the use of 6,000m-depth submersibles or manipulators, bottom-marking navigation systems and freer vehicle monitoring systems. A technological hurdle will be limitations by rough weather at the air-sea interface.

Understanding the impact of waste disposal will require more study of marine microbiology. In particular we need more knowledge of asteral degradative pathways active in the sea and more knowledge of the extent of genetic plasticity in marine microbiota which could lead to new pathways. If degradative capacity is fixed and limited we need to know it at an early date.

G. Recreation and coastal zone development

Increasing populations, increasing concentration in coastal areas and with increasing amounts of free time, will increasingly seek recreational outlets in the coastal zones. This use of coastal areas will generate strong social pressure for maintenance of aesthetically refreshing coastal areas with reliably clean and attractive water quality, traditional coastal amenities and recreational outlets such as sports fishing. These demands will stimulate biological research on the impact of potentially conflicting uses of coastal resources, as well as measures for protecting and enhancing recreational fisheries and traditional sea foods.

III. General trends in Biological Ocean research 1975-1990

Predicting the course of any enterprise that depends upon the creativity of individual human minds is at best a tenuous undertaking, however, the preceeding analysis of basic and applied questions that will influence biological oceanography in the next 15 years suggests that research will follow a finite number of general trends although the range of specific projects may be much closer to infinite. Some of the general trends include:

1. Interdisciplinary research on ecosystem processes. These efforts will build on the success of the CUEA

program and will involve increasingly close cooperation between physical, chemical, and biological oceanographers in pelagic ecosystems and between physical, chemical, geological and biological oceanographers in coastal and benthic ecosystems. We can expect that such cooperative undertakings will seek to establish the boundary conditions of ecosystem functions and evolution by making conscious comparisons between upwelling regions with high aducction and central gyres with low adducction, or continental shelf systems with seasonal productivity and breeding pulses in comparison with low latitude systems where productivity and breeding are year-round. The applied problems associated with ecosystem impact of major developments such as floating nuclear reactors or offshore industrial platforms will involve similar interdisciplinary program. Thus we envision similar programs oriented towards both basic and applied questions of ecosystem functions.

2. Experimental approaches to biological oceanography problems will increasingly displace purdy discipline approaches. These experiments will range from physiological studies of dominant marine organisms utilizing the best tools of biochemistry, cell biology and microbiology; through natural history studies of behavior, growth, assimulation capacity, and reproduction of typical and foundation species from particular communities, to ecosystem perturbation and manipulation experiments designed to elucidate the role of individual species in regulating egosystems

structure and function. This emphasis on experimentation does not deny the importance of descriptive observations, but suggests that such observations will increasingly be made as tests of specific
and in experimental contexts rather than simply as

IV. Facilities required to support anticipated Biological Oceano-Graphic Research: 1975-1990.

A. Interdisciplinary research on ecosystem processes will probably concentrate mesoscale phenomena and will require large stable platforms that can comfortably accommodate interdisciplinary teams of 35-50 and their modern laboratories in oceanic regions of interest. These platforms normally would be towed to the study area, but must have self-contained propulsion systems for slow speed operation. The platforms will be used for long time-series studies and for intensive studies of processes by teams of investigators. One of the most important investigations requiring use of such platforms is the study of continental shelf productivity. (Major efforts in this area are needed urgently on the Atlantic and Bering Sea coasts.) Housing of computer centers, storage of current meters and associated mooring gear, maintenance facilities for current maters, a tracking center for a variety of sub-surface free floats are just a few of the tasks that can be envisioned for large stable platforms in the next decade.

B. Modern experimental studies will require modern laboratories. In some cases, the laboratories will be brought to the experiment site, aboard the platforms described above. In other cases the organisms will be conducted in traditional shore-based laboratories. In either case modern laboratories will be needed if the complex basic and applied biological oceanographic questions of the next 15 years are to be realistically approached much less solved. Such biological oceanography laboratories will include culture facilities of the chemostat design with temperature, oxygen, ph, nutrient, light, and pressure control. Some of these will, of necessity, be fermentation vat-sized, with the more common, however, the 30-80 liter culture chambers, particularly in the case of experimental arrays for toxicity tests, nutrient requirements, etc.) Culture facilities will require access to a glassware washer, glassware drying oven, and a modern, large autoclave (the shipboard pressure-cooker-sized autoclave should be sent to the Smithsonian Institution as a historical object.)

High pressure chambers for study of deep ocean benthos are a necessity and no longer a luxury. Ecological, physiological, cellular and biochemical studies of the archibenthic and abyssal biota cannot be accomplished efficiently or fully without appropriate sampling and culturing gear available on site.

The shipboard laboratories for modern biological, microbiological and biochemical work must be chemically and biologically clean. Laminar flow, filtered, positive pressure type rooms must be available for trace element analyses, virus isolation, cell lysate preparations, etc. in the on site experimentation. Analytical equipment and instrumentation must include analytical balances, gas liquid chromatography, atomic absorption, radioisotope counters, mass spectrometry, ultra-centrifuges, amino acid analyzers, spectrophotometers, and real-time computerization. Shipboard scanning electron microscopes, perhaps computer-linked for mass, rapid scanning of samples, will become a routine tool for the biological oceanographer.

The engineering problems to be overcome so that the biological-biochemical-chemical facilities can be constructed are:

1. Platform stability and vibrational damping for operation of highly sensitive instruments such as the analytical and preparative centifuges analytical balances and electron microscopes.

2. Maintenance of chemically and biologically clean rooms. Perhaps the modular or van lab concept will best apply. Nevertheless, the retention of clean air flow and prevention of chemical and biological contamination must be accomplished.

3. Platforms with the modern laboratory module might be designed to be used in embayments, as well as deep ocean, as a cost-saving consideration. Otherwise, both coastal and deep-sea laboratory facilities must be provided. It is important to emphasize that excellent laboratory facilities on highly stable platforms at important ocean and coastal sites are required for the work to be accomplished between 1975-1990.

C. Nearshore research on basic and practical problems will require both experimental platforms for maintaining scientists at the sampling sites and small vessels for semi-synoptic profiling, sampling, and return of organisms to shore laboratories. These small vessels should be as fast as practical. Improvement of many of the capabilities of our conventional fleet will promote coastal biology: better buoy laying and retrieval equipment, machinery for trawling with large nets, better data logging and data handling systems, better equipped chemical and biological laboratories abroad.

FUTURE TRENDS OF OCEANOGRAPHIC RESEARCH

Reports of Working Groups at the UNOLS Long Range Planning Meeting Santa Catalina Marine Laboratory 23-25 Oct. 1974

CHEMICAL OCEANOGRAPHY

A. Introduction.

The panel on marine chemistry and geochemistry has attempted to assess the kinds of problems which this discipline will face over the next 15 years in the pursuit of important national needs in oceanography and to project a plan for acquisition of facilities which will be required to accomplish these goals.

The recent and anticipated increases in man's use of the ocean will inevitably drive the need for increased investigation of the oceanic phenomena. While there will be a great increase in routine monitoring we address here primarily the needs for new knowledge and increased understanding of oceanic processes necessary to comprehend the impact of man's activities on the ocean, and the effect of oceanic processes on matters of concern to man.

In order to obtain an overview relating chemical and geochemical oceanography to national needs and uses of the oceans, a matrix was constructed listing marine chemical components versus uses.

The list of uses and national needs is given in Table 1 and represents the suggestions of the conferees as approximately representative of important present and future ocean uses.

The list of chemical oceanographic process areas of concern is given in Table 2.

The matrix is shown in Fig. 1. A value between zero and three was entered at each intersection.

B. Uses of the Ocean.

The use categories in which chemical oceanography was most completely involved were mining, food, energy, waste disposal and transportation.

Other features brought out in the matrix can be summarized as follows:

1. The processes diffusion and dispersion represent the single most important area of invovlement of chemical oceanography with ocean uses.

2. Nutrients and biological-chemical interactions rank second in importance.

3. Trace elements, CO_2 system, air-sea material exchange and water-sea floor exchange rank third in importance.

4. The single most important sub-category involving chemical oceanography is transportation catastrophies. Curiously the next ranking sub-category was that of sea weed farming.

TABLE 1

Man's Uses of the Ocean

I. Mining.
- A. Oil and gas
- B. Sand and gravel
- C. Phosphorite
- D. Placer
- E. Managanese nodules
- F. Heavy metals
- G. Water

II. Food.
- A. Fishing
- B. Ocean ranching
- C. Aquaculture
- D. Sea weed harvest
- E. Lower trophic levels

III. Energy.
- A. Nuclear power
- B. Natural energy
    1. Waves
    2. ΔT
    3. Tides
    4. Wind
    5. Solar
- C. Storage
- D. Catastrophe

IV. Military.
- A. Logistic Platforms
- B. Barrier lives
- C. Surface missile ships
- D. Listening nets
- E. Submarines
- F. Accidents

IV. TRANSPORTATION
- *A. Deep ports*
- *B. Fleet of LNG super tankers*
- *C. Ports in shallow areas*
- *D. Ice negotiating vehicles*
- *E. Catastrophes*

V. Waste disposal.
- A. Nuclear
- B. Corrosion products
- C. Municipal wastes
- D. Dredge spoils
- E. Ocean dumping
- F. Heat
- G. Organic compounds
- H. Combustion products

VI. Climate.
- A. Ocean monitoring
- B. Modification and restoration
- C. Prediction

VII. Recreation.
- A. Marinas
- B. Swimming and surfing
- C. Fishing
- D. Preserves

TABLE 2

Chemical Oceanographic Areas of Concern in this Context

Trace elements
Nutrients
Trace gases (incl. N_2, O_2)
CO_2 - system
Radioactive nucleides
Natural organic matter
Anthropogenic organic matter
Petroleum hydrocarbons
Particulates
Air-sea material exchange
Water column-sea floor exchange
Kinetics (homogenous and heterogeneous)
Pathways and fluxes (including geochemical balances)
Diffusion and dispersion
Mineral digenesis
Biological-chemical interactions

USES	TRACE ELEMENTS	NUTRIENTS	TRACE GASES	CO_2 SYSTEM	RADIOACTIVE NUCLEIDES	NATURAL ORGANIC MATTER	ANTHROPOGENIC ORGANIC MATTER	PARTICULATES	AIR-SEA MATERIAL EXCHANGE	WATER COLUMN-SEA FLOOR EXCHANGE	KINETICS	PATHWAYS AND FLUXES	DIFFUSION AND DISPERSION	MINERAL DIGENESIS	BIOLOGICAL-CHEMICAL INTERACTIONS	PETROLEUM HYDROCARBONS	
I. MINING																	
A. Oil and gas	3	1	3	1	1	3	3	2	3	1			1			3	25
B. Sand and gravel	1	1						3	1	3	2	2	3		2	1	18
C. Phosphorite	1	1	1	2	1			2		3	1	1	2	2	1	1	19
D. Placer	3	3	2	2		1		3	1	3	2	2	3		2	1	28
E. Manganese nodules	3	3	1	3	1	2		3		3	3	3	3	3	1	1	33
F. Heavy Metals	3	3	1	1	1	1	1	3		3	2	2	3		2	1	27
G. Water	2	3	1	2									3		2		13
II. FOOD																	
A. Fishing	3	3	1	3	3	3	3	1		3	2	3	3		3	3	37
B. Ocean ranching	3	3	1	3	3	3	3	1		3	2	3	3		3	3	37
C. Aquaculture	3	3	2	3	3	3	3	1		3	2	3	3		3	3	38
D. Sea weed harvest	3	3	2	3	3	3	3	3		3	2	3	3		3	3	40
E. Lower trophic levels	3	3	2	3	3	3	3	1		3	2	3	3		3	3	38
III. ENERGY																	
A. Nuclear power	3		3	3	3	1	1		3	3	2	3	3		3		31
B. Natural energy																	
1. Waves																	
2. Δ T	3	3	3	3		2	2		2		2	2	3		3		28
3. Tides																	
4. Wind																	
5. Solar																	
C. Storage										2			3		2	3	10
D. Catastrophe	3		3	3	3		3	3	3	3	3	3	3		3	3	39
IV. TRANSPORTATION																	
A. Deep Ports	3	1	3	1	1	2	3	3	3	3		2	3		3	3	34
B. Fleet of LNG super tankers									2							3	5
C. Ports in shallow areas	3	3	3	1	1	2	3	3	3	3		3	3		3	3	36
D. Ice Negotiating Veh		2	2	2					3						2	3	14
E. Catastrophe	3	3	3	3	3	3	3	3	3	2	3	3	3		3	3	43
V. MILITARY																	
A. Logistic platforms	1	1			1		1									1	5
B. Barrier lines																	
C. Surface missile ships																	
D. Listening nets																	
E. Submarines																	
F. Accidents	1	1		1	(3)		(3)	1	2	3	2	2	3		2	3	25
VI. WASTE DISPOSAL																	
A. Nuclear	3		3	1	3	1	1	2	3	2	2	3	3		3		30
B. Corrosion products	2	1			1	1	1	1			3		2		2		14
C. Municipal wastes	3	3	2	2	1	3	3	3	1	3	3	2	3		3	2	36
D. Dredge spoils	3	3	2	1	2	2	3	3		3	1	2	3		3	3	34
E. Ocean Dumping	3	2	2	2		1	3	3	3	3	3	3	3		3	2	35
F. Heat		1	2	2					1		1		3				10
G. Organic Compounds																	
H. Combustion products	3		3	3	3		1	3	3	2	3	3	2	1	3	2	35
VII. CLIMATE																	
A. Ocean monitoring				3	3												6
B. Modif. & restor.			1	3	3				3								10
C. Prediction				3	3					1				1			8
VIII. RECREATION																	
A. Marinas	2	3	2	2		2	3	3	3	3	1	2	3		2	3	34
B. Swimming & surfing	1	2			1	3	1	2	1		1	1	2		1	3	19
C. Fishing	2	2	1	2	2	1	2	1	1	2		1	3		3	3	26
D. Preserves	3	3	1	2	2	3	3	3	1	1	1	2	2		1	3	31
	71	69	56	69	58	49	58	59	52	68	51	60	85	7	72	66	

C. Need for new Knowledge.

In its consideration of the needs for new knowledge of the chemical environment and processes in the ocean, the panel had the benefit of two previous reports which have recently addressed this question.

In 1971 the Marine Chemistry of the Committee on Oceanography, National Academy of Sciences presented a report (the result of several years of study by a dozen chemical oceanographers) entitled "Marine Chemistry." This report dealt with the current status and anticipated directions of marine chemistry.

In 1972 a workshop was sponsored by the Office of Naval Research to deal with these questions. Some 30 prominent chemical oceanographers deliberated for a week, and the result, a report entitled "Chemical Oceanographic Research: Present Status and Future Direction" was published in 1973. We have drawn heavily on these reports in formulating our comments below.

Certain types of marine chemical research are not emphasized in our discussion because they do not require a lot of ship time. This report is directed primarily to the kinds of research which utilize ships or other types of environmental sensors such as buoys, platforms and satellites.

The list in Table 1 suggests a great range of man-ocean interactions, some of much more consequence than others. The list in Table 2 suggests types of substances and general processes which marine chemists study. The following discussion amplifies the matrix shown in Fig. 1.

TRACE ELEMENTS

While the major element composition of seawater has long been well known, this is not true for many of the trace elements. Certain elements in this category may be analysed for with confidence. For many others including such important elements as mercury, copper, cadmium, iron and cobalt, it is not yet convincingly demonstrated that we have any accurate data from open ocean areas. It follows then that for such elements we have little beyond conjecture upon which to base our ideas of their distribution in seawater, the processes they affect, the pathways by which they enter and leave the ocean and their true residence time in the ocean.

Many of these elements act as essential nutrients or poisons or sometimes both (depending on concentration). With man measurably accelerating the geochemical transport of many of these elements and with major ocean mixing and perhaps mineral processing schemes anticipatated in the near future we foresee an increasing need to understand the natural fluxes and pathways of these elements. We should know, or be able to predict, the recovery time of the ocean systems to induced changes in the concentrations of many of these elements.

Investigations in support of these goals will be continuing in 1990 and probably for some time thereafter. Necessary for such studies must be advanced sampling and analytical techniques and studies of the speciation of elements in seawater, rates of air-sea, river-sea and water column-sea floor exchange, mineral diagenesis on the sea floor, and biological interactions.

NUTRIENTS

The nutrients are normally thought of as including phosphate, fixed nitrogen compounds such as ammonia, and silicate. They also include CO_2, and many other trace elements. The intensification of fisheries and mariculture efforts will require continued study of the movements of nutrients through the oceanic and biological systems and their interactions. Intense studies of highly productive areas (and of non-productive areas as well) require a continuing study of the various nutrients since they are basic to the whole process of productivity.

The possible advent of artificial upwelling systems requires that we know more about the rates of turnover of selected nutrients.

TRACE GASES

These are taken here to include such gases as O_2, N_2, Radon, and the non radioactive noble gases. Trace naturally occurring organic gases (such as methane and carbon monoxide) are often included here. These are tracers for many biological, oceanic and geophysical processes, and their continued study is anticipated. For example, the best present data on the rates of turbulent diffusion in deep bottom waters have come from studies of radon distribution, while suggestive evidence on the extent of outgassing of the earth's mantle in regions like the East Pacific Rise has come from studies of the helium distribution in the ocean. There is still much to be learned about biological processes in the ocean by continued study of the trace organic gases.

CO_2 - SYSTEM

While the basic nature of the CO_2 system is well established its continued study and measurement will be necessary. As man continues to introduce fossil CO_2 into the atmosphere it is vital to continue monitoring the atmospheric increase and to investigate the pathways and sinks for natural and industrial CO_2. At the present time about ½ of the industrial CO_2 appears to enter the ocean, leaving about ½ in the atmosphere. We need to be able to predict how long this will continue, and to anticipate future atmospheric and oceanic changes.

Furthermore, studies of the past climatic history of the earth are dependent to some extent on knowledge of the CO_2 cycle, both to calculate the atmospheric concentration and to understand the processes of solution of $CaCO_3$ on the sea floor.

RADIOACTIVE NUCLEIDES

As man continues to generate power from nuclear processes, the questions of what happens to radioactive nucleides introduced deliberately or inadvertantly into the environment will continue to haunt us. Just as we know little of the geochemical checks and balances, pathways and fluxes of many natural trace elements, so we know little of the ultimate fate of many radio nucleides and their continued study will be essential.

NATURAL ORGANIC MATTER

The study of the estimated 10^{12} tons of natural organic matter dissolved in the oceans is only beginning, and most of this material consists of compounds whose nature we do not understand. Much insight may be gained about biological processes in the ocean through the study of this material. Geochemical processes are also thought to be influenced by this organic matter, for it may bind trace metals, and coat the surfaces of particles, thus changing their reactivity.

ANTHROPOGENIC ORGANIC MATTER

The worldwide problems consequent to man's introduction of DDT and related organic chemicals into the environment are well known. Man's civilization increasingly manufactures organic chemicals which may end up widespread on earth, and continued investigation of these in all the environmental regions of interest will continue.

PETROLEUM HYDROCARBONS

By 1990 the total rate of transport and utilization of petroleum will probably still be at least comparable to present levels, because the reserves will not yet have been exhausted. Therefore the fate of such materials if discharged into the ocean will continue to be of interest.

PARTICULATE MATTER

The enormous surface area of the particulate matter discharged into the oceans by rivers, and even of the wind-borne material which falls on the ocean provides sites for adsorption and desorption of chemical species and for the localization of chemical reactions. In addition there is much biogenic particulate matter which is responsible for much oceanic transport of substances of interest. Increased studies of the occurrence and properties of particulate matter are anticipated.

OCEANIC PROCESSES

Because of the necessity to study the pathways, fluxes and fates of so many diverse substances of geochemical or environmental interest, marine chemists will for the forseeable future be vitally interested in the details of many oceanic processes.

The rates of exchange of gases and particulate matter between the air and the sea are of concern in following all those materials which have an atmospheric pathway.

Recently there has been increasing interest in exchange processes between the sea floor and the water column. The ultimate control of seawater composition probably resides in such exchange processes, and it seems likely that both sediment-water and basalt-water interactions are important. Understanding the fate of trace metals introduced into the ocean or the source materials for manganese nodules and other sea floor minerals will depend on understanding such exchange processes and on the mineral diagenesis and other chemical reactions which proceed on the sea floor.

The anticipated further use of the ocean as a dump for man's waste and the possibility of the use of such places as deep ocean trenches for the "ultimate" disposal of nuclear and other wastes requires intense effort in the study of diffusion and dispersion processes, natural geochemical pathways, and the rates of reaction of certain materials introduced into the ocean.

D. Ship Facilities Needed.

It appears from a consideration of Fig. 1 that a considerable need exists for shelf and coastal research vessels, but that work in the deep ocean will also be important.

The marine chemistry panel did not foresee the need for chemically-dedicated ships or special platforms. We do foresee the need for much better facilities on the typical oceanographic research vessel. The study of trace elements would be greatly furthered if clean rooms, and modern chemical laboratories and instrumentation facilities were available. Since these facilities would be incorporated in multi-purpose oceanographic vessels, the ships should be of at least the minimum size necessary to accommodate them.

We believe that while some ships in the present oceanographic fleet are suitable for the chemical needs of 1990, most are not. At least some of the replacement vessels and the increase in vessels should be designed with these needs in mind.

Modest multi-purpose chemical laboratories can be accommodated in 125-foot coastal research vessels, but more sophisticated laboratories require larger vessels.

We are enthusiastic about the possibilities of using large stable platforms as floating laboratories. The ability to sample the oceanic water column repetitively and in detail from nearly the same location and from the bottom up to the surface, both by conventional means and by deep pumping would greatly enhance our present knowledge of oceanic distributions and processes. We could investigate bottom processes in detail, from submersibles or with other devices. We could obtain high quality chemical data, because of the availability of laboratory space and time to work on freshly collected samples.

We would encourage that other types of oceanographers join forces to investigate the feasibility and cost of establishing a large multipurpose floating laboratory as a national oceanographic facility.

Part III

ESTIMATE OF SHIP REQUIREMENTS

Based on the proceedings of working group developments on future trends of oceanographic research and joint discussions of common needs, there began to emerge agreements with which to project a first estimate of the kinds and numbers of ships and other facilities to meet the needs envisioned.

In many cases these needs are current and even immediate. It was an accepted premise that the inclusion of current unfilled needs are valid - if not urgent - candidates for future planning.

There was general, almost surprising, agreement amongst the members of the meeting that the numbers of university ships needed for the foreseeable future is not significantly greater than presently exist. One exception to this might be the "Continental Shelf" (or larger coastal type vessel).

A unanimous point of agreement was that, while the numbers - and even sizes - of future ships need not be significantly greater - their capabilities for doing science at sea must be vastly improved. Furthermore, existing ships having a reasonable life remaining should be included in a general capability upgrading - especially in the quality of laboratories and overside gear handling.

Areas of priority needs - some to the point of being critical - included suitable vessels for coastal research; vessels so adapted and equipped for geological and geophysical research that they become - or very nearly so - dedicated vessels; and a specially constructed vessel for operating in ice.

There was general support for a large mobile stable platform as a fully found, but movable, laboratory both for the deep sea and coastal shelves.

In general regard to ships there was a majority conservative viewpoint against experimenting with untested hull designs. Although innovative science experiments are projected for the future, the scientist suspecting austere budgets ahead is reluctant to endorse experimental types of vessels until he is convinced such vessels will have a long and successful life.

The meeting did not address to any extent facilities other than ships, but deep submersibles and a mobile shallow-shelf habitat were singled out among future needs.

In arriving at ship requirements tentative needs for each discipline were presented by that working group, and then modified during general discussion and hopefully achieving an interaction between disciplines.

UNOLS LONG-RANGE PLANNING MEETING

23-25 Oct. 1974

PRELIMINARY SHIP REQUIREMENTS SUMMARY

1

Class of Vessel: Far ranging General Purpose

Size: 250 - 300 ft.

Accommodations: 25-30 Scientists; Excellent habitability with seminar spaces.

Endurance: 5 - 7 weeks

Laboratories: Permanent, clean, controlled bio and chem labs; excellent suite of multi-purpose labs; provision for portable labs.

Special Capabilities: Quiet (i.e. vibration free); major shipboard data reduction and analysis system; heavy handling capability for moored arrays and overside gear; long, heavy wire cap.; max. storage; large bio trawls; bio assay sonars; large volume water handling; hyperbaric aquaria.

Comment: This is a multi-purpose vessel for very large scientific parties and long global wide voyages. It should have maximum capabilities.

Numbered required: 2

2

Class of Vessel: Ocean wide-general Purpose

Size: 200 - 250 ft.

Accommodations: 20-25 Scientists

Endurance: 4 - 6 weeks

Laboratories: Clean, controlled bio and chem labs; excellent suite of multi-purpose labs, provision for portable labs.

Special Capabilities: Same as 1 above.

Comment: Multi-purpose vessel for medium sized scientific parties, maximum capabilities. This same class vessel can meet the requirements of 3 below when outfitted for geology and geophysics.

Number required: 5

Class of Vessel: Underway Geology and Geophysics

Size: 200 - 250 ft.

Accommodations: 20 Scientists

Endurance: 5 - 6 weeks

Laboratories: Principally G & G Instrumentation. May contain some multi-purpose labs.

Special Capabilities: Highly Instrumented principally for underway G & G; Quiet (i.e. electrically and vibration free); High resolution SRP.

3 Comments: It is envisioned that one such ship (first priority) would be dedicated G & G ship for high resolution SRP with on board data reduction; intended for worldwide operation principally on continental margins. A second such ship would be outfitted for regular underway G & G work (and station work) but to much more exacting standards than present; generally available to other discipline but essentially limited to G & G control.

Number required: 2

Class of Vessel: Medium size multi-purpose

Size: 150 - 200 ft.

Accommodations: 12 - 20 Scientists

Endurance: 3 - 5 weeks

Laboratories: Clean, controlled bio and chem labs; some provisions for portable labs.

4 Special Capabilities: Large bio trawls; large water volume handling; bio-assay sonars; some to have heavy facilities for mooring deployments and recoveries and other overside weight; upgraded lab facilities from present.

Comment: Probably at two types needed. One-laboratory, accommodation and storage oriented; and another tradeoffs to achieve large deck space for gear handling and vans.

Number required: About 10

Class of Vessel: Arctic and Antarctic Research

Size: 150 - 200 ft

Endurance: 6 - 9 weeks; 10,000 miles

Accommodations: 15 Scientists

Laboratories: Clean, controlled bio and chem labs; excellent suite of multi-purpose labs; ice labs.

5 Special Capabilities: Specially constructed for ice navigation and ice worthiness - Min. ABS Class 1AA ice strengthening; Also capable of working in open sea. Special adaption for work in ice (i.e. center well).

Comments: This is not intended to be a true polar ice breaker but should have to be able to withstand pressure ice and work in winter pack up to 60 oktas. This vessel intended principally for Arctic use but should be available to Antarctic as needed. (Note: an equal or superior vessel should be assigned permanently to Antarctic service under Federal operation but available to academic use).

Number required: 1

Class of Vessel : Coastal - Regional

Size: 125 - 150 ft.

Endurance 2 - 3 weeks

Accommodations: 12 - 15 Scientists

Laboratories: Clean, controlled bio and chem labs; other good multi-purpose labs; provision for portable lab(s).

6 Special Capabilities: Large trawl capabilities; flexibility for varied continental shelf work.

Comments: Intended for coastal shelf work of a regional nature on a cooperative basis or by large institutions which require this type. Priority for lab space over storage or fuel capacity. This is a high priority type to biologists.

Numbered required: About 8

Class of Vessel: Coastal - Institutional

Size: 85 - 125 ft.

Endurance: 1 - 2 weeks

Accommodations: 8 - 12 Scientists

Laboratories: Clean bio and chem lab; other good multi-purpose labs.

7 Special Capabilities: Flexible for coastal work as required. Shallow draft where appropriate.

Comments: Intended for coastal work or for single institutions or by regional labs on a cooperative basis. Priority for lab space or fuel capacity. This class replaces many of the currently inadequate 65 ft. conversions.

Number needed: About 16

Class of Vessel: Specialized Geo-Sampling

Size: Unspecified

Accommodations: Unspecified

Endurance: Unspecified

8 Special Capabilities: Handle heavy weights (5-10 tons), oversized gear; equipped for in-situ testing; long heavy electrical cable; hard rock coring (10-20 meters) and continuous undisturbed sediment cores (100-200 meters).

Comments: This is a high capability sampling and in-situ testing which might be incorporated into other ships or platforms which can handle it.

Number required: 1 (may be included in 1,2,3,4, (above) or 9 (below).

Class of Vessel: Manned Ocean Station

Size: Large (comparible to current semi-sub drilling rigs).

Accommodations: Large, highly habitable

Endurance: 12 - 18 months

Laboratories: Excellent suite of clean laboratories.

9 Special Capabilities: Dynamic positioning or mooring; heavy weight handling (in excess of 10 tons); good data processing capability; logistics and docking services for other vessels; large water volume and deep pumping capability; hard rock and continuous undisturbed sediment cores (100-200 meters). Mobility to cruise between stations.

Comments: This is a mobile stable platform which can occupy shelf or deep sea station for long periods for a variety of research and ocean engineering work as well as support base. It has a high priority among almost all disciplines.

Number required: 1-2

Class of Vessel: DSRV

Special Capabilities: 6,000 meter depth; good manipulators; not air-sea interface limited.

10 Comments: These are intended as manned, submersibles available one on each coast, but unmanned vehicles may be an alternative for one.

Number required: 2 (one on each coast).

Class of Vessel: Shallow Shelf Habitat

Special Capabilities: Mobile diver lockout habitat for shallow coastal shelves.

11 Comments: The mobility and self-support of a habitat are considered important. In the past the effect of emplacing and supporting a habitat has overshadowed its research usefulness.

Number required: 1

UNOLS LONG-RANGE PLANNING MEETING

23 October. 1974

PRELIMINARY SHIP REQUIREMENTS SUMMARY

	Cat.	Class of Vessel	Preliminary Long-Range Req.	Present Inventory
over 200'	1	FAR-RANGING GENERAL PURPOSE	2	0
	2	OCEAN WIDE GENERAL PURPOSE	5	7
	3	UNDERWAY GEOLOGY & GEOPHYSICS	2	0
		(tot)	(9)	(7)
150-200'	4	MEDIUM SIZE MULTI-PURPOSE	9	9
	5	ARCTIC RESEARCH	1	0
		(tot)	(10)	(9)
125-150'	6	COASTAL REGIONAL	8	5
85-125'	7	COASTAL INSTITUTIONAL	16	14
	8	SPECIALIZED GEO-SAMPLING	[1]	0
		TOTAL SHIPS	43	35
	9	MANNED OCEAN STATION	1	0
	10	DSRV	2	1
	11	MOBILE SHALLOW SHELF HABITAT	1	0

NOTE: Present inventory is based on size (or nearly so) and the number is limited to fully found and operated vessels