UNIVERSITY - NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

UNOLS

DEep Submergence Science Committee

Annual Planning Meeting

Summary Report

Thursday, December 14, 2000

Moscone Convention Center, Room 250
San Francisco, CA

DESSC Planning Meeting
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Introduction - DESSC Chair's Report - Patty Fryer welcomed the meeting participants and reviewed the day's agenda. She announced that reports from deep submergence operators are available in the rear of the room. Over the past year two new members have been added to DESSC, Mark Chaffey of Monterey Bay Research Aquarium (MBARI) and David Mindell of Massachusetts Institute of Technology (MIT). Additionally, Shirley Pomponi from Harbor Branch Oceanographic Institution (HBOI) has joined the DESSC as an ex-officio member. She has been added to help reach the shallow water submergence community. Patty went on to report that the DESCEND executive summary has been published as a brochure. The full Proceedings report is posted on the UNOLS website <http://www.gso.uri.edu/unols/dessc /descend/descend.htm>. The brochure is available in the rear of the room along with many other handouts and posters.

The agenda for the meeting is included as ***Appendix I.*** The participant list is contained in ***Appendix II.***

UNOLS Report - Bob Knox, UNOLS Chair, provided the UNOLS Report, see *Appendix III.* A number of key events took place over the past year. The UNOLS Office moved to Moss Landing Marine Laboratory (MLML) with Mike Prince as the new Executive Secretary. Annette DeSilva stayed on in her role as Assistant Executive Secretary in Rhode Island. Bob extended his thanks to Jack Bash for his many years of service to UNOLS.

A major initiative of UNOLS over the past year has been quality assessment and improvement. The NSF Fleet Review Committee recommended that UNOLS strive to improve the quality of service. There needs to be a better process for assessment and feedback regarding operations. UNOLS with the help of NSF and experts in the field have been studying various quality improvement initiatives. It has become clear that UNOLS as an organization is complex and to institute a program of excellence requires professionals. NSF has put UNOLS in touch with two researchers that study quality of organizations. They plan to submit a proposal to study UNOLS. They will study UNOLS as a Highly Reliable Virtual Organization (HRVO). It looks to be an interesting project.

Bob reported that ship scheduling has been a complex process over recent years. Next year's schedule (2001) is finally coming to a resolution. There will be a letter to the community in the next UNOLS Newsletter explaining the difficulties experienced this year.

A highlight of the year was bringing the US Coast Guard Icebreaker HEALY onboard. UNOLS' involvement with the USCG in conducting science systems tests has been very successful. Our relationship with the USCG has been very healthy. The ship's first science operations are scheduled to begin in summer 2001 in the Eastern Arctic.

Another initiative of UNOLS is the development of a long-range fleet renewal plan. Both the Fleet Improvement Committee (FIC) and the agencies are involved in this activity. The intermediate class vessels are a focus of immediate attention for UNOLS because their retirement age is quickly approaching. The agency representatives have recently drafted a discussion paper on long-range fleet planning in response to their FOFC tasking. The paper will be available for community input.

2000 Science Reports - Patty Fryer continued by reemphasizing the importance of the cruise assessment process. The annual science reports by PIs at the DESSC meeting offer a forum for feedback to the operator of the facilities, as well as presentation of innovations in approach to field operations and research for fellow users. Users of ALVIN and the ROV/AUVs in 2000 have been invited to present a brief report on their cruise program.

Craig Cary – Craig Cary reported on his January cruise aboard ATLANTIS in the Sea of Cortez, see ***Appendix 4a***. Craig and George Luther were co-PIs for this NSF funded program. The cruise included scientists from the University of Delaware as well as an international team of PIs. A focus of the cruise was to provide education outreach, which was reported later in the meeting by Craig. The primary research program included eight dives with an objective to survey and sample specific diffuse flow habitats with a new microelectrode array and thermocouples. The program included:

- Intensive geochemical characterization of sulfide structures
- Sampling of beehive/flange structures
- Sediment coring.

Craig reported that the cruise was very successful and great support was provided by WHOI. The cruise allowed a comparison between the vent environments found at Guaymas with those found at 9-degrees North. It was a very enjoyable program.

Anna Louise Reysenbach – Anna Louise was a co-PI on the Luther/Cary cruise to Guaymas in January. She reported on the key objectives and findings of her NSF funded program that included testing the hypothesis that pyrite formation equals energy (H_2). Her viewgraphs are included as ***Appendix 4b.*** The objectives of the program were to characterize microbial diversity associated with active sulfides, isolate novel microbes H_2, and study the chemistry. Focus was on the archaea. They discovered that they were wrong in their hypothesis at both JDF and Guaymas. A new species within the chimneys was isolated. It had never been cultured before. They would like to see if the new species is also associated with the new vents discovered on the Mid-Atlantic Ridge.

Anna Louis extended her thanks to NSF, the ALVIN team and the ATLANTIS crew. The ALVIN team was extremely supportive in obtaining samples. She also thanked the co-PIs, Luther and Cary. The program made a lot of progress toward describing the microbiological structures of the vent communities.

Dan Fornari – Dan began by reporting on his dive program at 9°N on the East Pacific Rise in the first part of February 2000. The dive days were supported by a grant for exploratory research and development testing. The program allowed further demonstration of the near bottom gravimeter (NAVO BGM-3) installed in ALVIN. The objective was to conduct near bottom geophysical data collection on closely spaced east-west lines. The science activities included collection of near bottom continuous gravity data and magnetometer data. Jim Cochran was a co-PI on this program. The cruise was a success.

Dan continued by reporting on his NSF funded MELVILLE cruise, "Marine geology investigation west of the Galapagos Islands, and in the Galapagos rift-EPR intersection." The cruise began in March and ended in May 2000. Three areas on the East Pacific Rise crest were surveyed using DSL-120 and Argo II (3°20'N, 1°40'N and between 9°-10°N). Two of the three survey areas showed good indications of recent eruptions that corroborated the NOAA autonomous hydrophone data Tphase events. This was followed by a 3-day survey at the Galapagos Rift (97.5°W). In addition to the surveys, multibeam bathymetric data was collected and rock dredging was conducted at the Galapagos Rift. The surveys showed strong evidence of recent eruptions.

Dana Yoerger – Dan Yeorger discussed use of the Doppler system and data. During Dan Fornari's February ATLANTIS cruise, the navigation was enhanced with a new Doppler system. The Doppler provided bottom-lock tracking to fill in the gaps between 15-second long base-line navigation. The Doppler sonar data was also used during Peter Rona's Jason program to derive the flow rates in the flumes. Dana explained that although the Doppler data has some errors, it works well when integrating it with other systems. Dana showed a sample track line.

Cindy Van Dover – Cindy reported on her two cruises over the past year (her viewgraphs are included as ***Appendix IVc***). The first cruise was in "search for phototrophs at deep-sea hydrothermal vents." It consisted of four dives at Juan de Fuca ridge in July. NSF and NASA supported the project. The cruise operations included use of the "gattling gun" sampler, HPLC extractions and florescence spectroscopy, biophysical measures, culture, and direct counts. The bottom line is that they found no evidence of phototrophs. They found evidence of phototrophs in high levels in the upper water level – 0 to 125 meters. This was an important finding. Their first article from this research was published in *Nature* earlier in the year.

Cindy continued by reporting on her three-dive program in October to the South Florida Escarpment. This project studied biodiversity - seep census Florida Escarpment deep-sea mussel beds and was funded by NOAA-NURP. Cindy showed the species effort curves. Cindy pointed out that once the species are known, biodiversity patterns could be studied. Four additional censuses dives have been funded and will be scheduled in late 2001.

In conclusion, Cindy reported that during both of her cruises rookie divers were given the opportunity to participate.

Meg Tivey –Meg Tivey presented a report on her ATLANTIS cruise programs as well as Jeff Seewald's program. Meg's project took place at the Juan de Fuca Ridge, Endeavor Segment in June/July, with a return cruise in September. NSF funded 35 dives and two dives were funded by NOAA/NURP. Her cruise titled, "In-situ time series experiments to define thermal and compositional variability in tidally perturbed submarine hydrothermal systems," utilized both ALVIN and Jason. The program required intense co-registered instrumentation of both high- and low-temperature diffuse vents and round-the-clock water sampling. Scheduling logistics of the instruments became a major issue in planning for the cruise. Many of the problems were related to navigation and will need to be resolved prior to any future operations of this type. For Meg's cruise, the problems were worked out by May. A diverse set of instruments was deployed. Meg showed a table listing the equipment deployed and utilized and the data collected. See ***Appendix IVd***. The logistics of sending the instruments and equipment down to the sea floor were complex. Some items were elevatored down. There were some constraints with Jason's 26 lb lift capability; however, these are being addressed by the new Jason II design. The new high-temp fluid particulate sampler (Butterfield) worked very well. The instrument recorded for the entire summer. The inductively coupled link was used during the cruise. This system, developed by Al Bradley, has been used successfully by a number of parties. It can "eaves drop" on the data. Meg reported that they had no instrument failures. They discovered two new areas, the Cathedral Complex west of MEF and a new field just north of Salty Dawg Field. Meg commented that additional Jason operators should have been assigned to the cruise to support the extensive number of instrument/equipment recoveries. Meg also noted that there were too many PIs assigned to the cruise, nine PIs.

Meg continued by reporting on **Jeff Seewald**'s 10-dive program, "Quantitative Investigation of Aqueous Organic Compounds in Ridge-Crest Hydrothermal Fluids." He was a co-PI on Cindy Van Dover's July cruise. The goals of his NSF funded cruise were to develop a gas-tight fluid sampler for quantitative characterization of aqueous organic species and to determine the composition and abundance of organics in Middle Valley and Endeavour vent fluids. His viewgraphs are included as ***Appendix IVe***. The system was prototype tested in Sept 99. The sampler was deployed 35 times without malfunction. It was suggested that a reliable, non-hardwired, off-the-shelf, digital communications device such as ICL could improve functionality of the system.

Ian MacDonald – Ian MacDonald provided a report on his ATLANTIS cruise in the Gulf of Mexico in October. NOAA, DOE and MMS funded the program. Ian learned that there was no smooth mechanism for transferring the funds from these agencies to WHOI and this problem should be addressed. Fourteen ALVIN dives were conducted for biological and geological surveying. The science activities included sediment collection at oil seeps, photo/video transects of escarpments, extreme macro, and mussel collections. They were searching for furrows to determine if they are being formed by strong currents and in the present day – yes to both. They were surprised to find that there were no tubeworms at the seep sites. An off-the-shelf Nikon camera placed in a watertight housing was tested using ALVIN. The camera was controlled using a palm-pilot. They hope that this camera will be available to the community in the future. A map of the study area along with photos of the camera are included as ***Appendix IVf***.

Peter Rona – Peter reported on his July THOMPSON cruise, Vents Imaging Pacific - VIP 2000. The program was funded by NSF and took place at the RIDGE Observatory - Main Endeavour Field. Peter's viewgraph is included as ***Appendix IVg***. The Simrad SM 2000 sonar was adapted for use on ROV Jason to conduct acoustic imaging of the hydrothermal plumes and diffuse flow. Peter reported that the cruise was very productive with eight days on station and seven of these days in the water. The Jason and THOMPSON crews provided excellent support. They did a 24-hour time series at the Grotto vent. Peter showed the views taken from Jason. The group used Doppler sonar data to derive the flow rates in the flumes. They observed low velocities at Grotto. Another innovative method applied during the program was the acoustic scintillation mapping using the SM2000. Peter extended his special thanks to Dan Fornari and Jon Alberts for working out this difficult schedule.

Paul Johnson – Paul reported on his NSF funded "Thermal Grid" program aboard THOMPSON using Jason in September/October 2000. His complete set of viewgraphs is included as ***Appendix IVh***. He showed a map of the study site. The goals of the thermal grid program were to:

1. Quantify the thermal budget of crustal formation,
2. Specifically, determine the heat dissipated as diffuse vents and conductive heat flux, and
3. Determine the patterns of crustal fluid circulation.

The cruise was scheduled at the bitter end of the season, but still was very successful. A near-bottom survey of an area of 2500 meters by 650 meters was conducted. The SM2000 was used for high-resolution bathymetry and acoustic scintillation to find diffuse vents. They have been trying to determine if the west wall is venting or has recently vented. The individual sulfide mounds could be observed. They expect to be able to find all of the venting in their survey area. Paul listed the instruments deployed for 12 months. The next leg of Thermal Grid is planned for June 2001. The deployed instruments include MAVs, magnetometer and tiltmeters, thermal blanket, and high- and low-temperature HOBOS. It was non-trivial getting the instruments down to the sea floor. Andy Bowen was extremely helpful. There were a lot of instruments and equipment being sent up and down to the sea floor. The elevator was used non-stop.

Lastly, Paul provided recommendations for equipment modifications for Jason II. The recommendations are included in the appendix. He is advocating that the software be modified so the existing RDI ADCP can be used in a mode that permits collection of water column velocity as well as bottom-track velocity data.

Lisa Levin – Lisa Levin reported on her Jason cruise aboard THOMPSON in October. The operations really pushed the weather window. Lisa's viewgraphs are included as ***Appendix IVi***. The program titled, "Patterns of Infaunal Community Structure, Nutrition and Settlement Associated with an Upper Slope Methane Seep" was funded by NOAA/NURP. Lisa reviewed the specific research questions asked by the program. The program required two cruises separated by approximately six months for deployment and recovery of instruments and equipment. Specific requirements included accurate location and relocation of seep patches, precise coring of small-scale seep features, collection of undisturbed core samples, collections of individual specimens, and photographic documentation. They performed stable isotope analyses and sulfide-release colonization experiments. Lisa reported that they had a very successful cruise with five full days of science. The Jason vehicle and its support were excellent. THOMPSON lost a few days at the start of the cruise because of mechanical problems. The video grabs were good, but not publication quality. Lisa recommended a higher quality digital imaging system.

Miriam Kastner – Miriam presented a report on her ALVIN cruise in August 2000 to the Cascadia margin. The cruise, titled "Active C Flux on the Cascadia Accretionary Prism: In-situ Measurement of Hydrocarbon Sequestration as Gas Hydrates and Authigenic Carbonate Deposits" was funded by NSF. She was co-PI with Bobb Carson and Doug Bartlett. The cruise operations included recovery of experimental packages left at ODP Hole 892B and on the seafloor, sampling of gas hydrates and carbonates from the seafloor, and water sampling from ALVIN. Night operations included water sampling from the hydrowire using a rosette and gravity coring. It was a very complicated cruise to determine how methane was coming out of ODP Hole 893B, where it is going in the water column, and whether any is released to the atmosphere. ODP Hole 893B was drilled into a hydrate ridge in 1992. Miriam explained that they deployed the sampling equipment at the site using ALVIN. The ALVIN group was very helpful in advising implementation of the equipment. She showed a schematic of the system, a map of the study area, and charts of the data collected. She showed a photo of the system.

Miriam noted that it was a very interesting and successful cruise. She also recommended that it is very important to be in touch with the ALVIN team early in the cruise planning process. Miriam's viewgraphs are included as ***Appendix IVj***.

Break

2000 Science Reports – continued

Dana Yoerger – Dana reported on Russ McDuff's Juan de Fuca cruise, "Precise measurement of the heat flux from a Hydrothermal vent system." The NSF funded cruise took place in August aboard R/V THOMPSON and featured the use of ABE. They have had a lot of successes and the system worked well. Dana showed examples of the various types of data collected including bathymetry data. The last ABE dive of the cruise was 30 hours long and made six passes. In all, ten dives were made with good results on all dives. They achieved coverage of the top and sides of the rectangular volume surrounding the main Endeavour vent field.

Mike Perfit – Mike Perfit reported on his WESTERN FLYER cruise at Blanco Ridge with Maurice Tivey and Debra Stakes. They had ten dives using Tiburon. Maurice Tivey's geocompass and magnetometer were successfully interfaced with the vehicle to permit both instruments to be used on a single dive. A set of 12 wax cores was developed at MBARI for basalt glass sampling from Tiburon. A navigation computer was added to the control room to permit the use of the ArcView-based real-time navigation. The Tiburon rock-coring sled recovered four rock cores in basalt in the Blanco Fracture Zone and the southern Cleft Segment. Two of these will be used for detailed magnetics studies. Nine dives were successfully completed on the Cleft Segment and Blanco Fracture Zone. Only one dive required an early recovery resulting from vehicle problems. An estimated four hours were lost on this dive. All other dives were a minimum of 12 hours duration. One dive was successfully completed at Axial Caldera for instrument deployment and recovery. A total of 137 geological samples, and approximately 700 biological samples were recovered using the ROV Tiburon. They had great success and the vehicle and ship performed well. They made some interesting discoveries.

Morta Torres – Marta Torres reported on her NOAA/NURP funded ATLANTIS cruise in March/April 2000. Seven ALVIN dives were made at the San Clemente Fault Zone and revealed recent rupture of the fault. The cruise objectives included mapping the localities and aerial distribution of venting in a geotectonic/structural framework, evaluating the rates and composition of fluid discharge, determining element fluxes from cold seeps, comparing them to the benthic fluxes on the San Clemente seafloor, and characterizing the mineral deposits associated with the seeps. Marta showed photos of the scarp area. See ***Appendix IVk***. Some navigation problems were experienced in the early part of the cruise; however, they were able to find the seeps, which were very rich in barium. The chemistry and biology were very different between the two seep sites. They did a SeaBeam survey and they collected push cores. Marta reported that the new SeaBeam mapping, merged with older data and existing soundings now allows a reconstruction of major faults of the Southern Borderland.

Patty Fryer wrapped up the science presentations by reporting that the ATLANTIS cruise in progress on the Mid Atlantic Ridge (30°N) is very exciting and huge chimneys have been discovered in ultramafic hosted systems. **Donna Blackman** and **Jeff Karson** are co-PIs on the cruise. ALVIN, Argo II and DSL-120 are being used. They are at 30° N.

Public Outreach

Dive & Discover - Dan Fornari reported on the Dive and Discover – Expeditions to the Seafloor program (see ***Appendix V***). The program provides near real-time access to deep submergence research via the web, <http://www.divediscover.whoi.edu>. The program was coordinated by Susan Humphris, Dan Fornari, and Danielle Fino all of WHOI. The program was aimed at the middle school age level. It offered an opportunity for broad public outreach. More than a million people accessed the site. The website provides daily access to deep submergence and oceanographic research using the WHOI facilities. Dive and Discover was carried out on three different cruises in 1999 and 2000. The next cruise will be in the Indian Ocean in April 2001. The website will be tested and refined during these four cruises. The program provides a stimulating learning environment and promotes a better understanding of ocean sciences. They hope that this will provide a template for future programs. SeaNet was an integral part of this system. Funding for Dive and Discover is provided by WHOI and the National Science Foundation.

SeaNet Status - Steve Lerner reported on the status of the SeaNet system. His report is included as ***Appendix VI.*** The objective of SeaNet is to extend the Internet to the oceans with worldwide coverage. Six UNOLS vessels have SeaNet installed. They recently received an NSF grant to continue SeaNet operations and install systems on three additional vessels in 2001.

Steve presented some of the highlights of the system. SeaNet supports high speed batch file transfers to and from anywhere on the internet, as well as live interactive Internet sessions at sea. SeaNet offers technical and administrative support. The SeaNet support team is always looking at new technologies. Steve showed the SeaNet usage chart by ship. For additional information on SeaNet, visit their website at <www.seanet.int>.

Steve continued by reporting on the **ROV Virtual Control Van** application. The virtual van is a web-based application that takes "snapshots" of the information that occurs inside the Control Van during vehicle operations and makes this information available for scientists and the public on the web. SeaNet makes this system possible. A demonstration of the virtual van will be available during the lunch break. A description of the system is included in Appendix VI. Steve reviewed the capabilities of the Virtual Van that includes:

- Real-time Monitoring of Control Van for Scientific use and Public Outreach
- On-line Integrated Cruise Synopsis
- Search Capabilities – Keyword, Time, Events
- Plot Capabilities – Geographic and Time series Plots

- Cruise Synopsis Repository Available On-Ship and On-Shore
- Built-in Automatic Data Acquisition System
- Support of Real-Time Playback of Prior Cruise Data Scientific Applications
- Real-time searchable data access for dive planning
- Integrated events, video snapshots, and vehicle data for rapid searching and data analysis
- Plotting capabilities for quality assurance and anomaly detection
- Easily locate specific data within data archive (e.g.; video clips)

The virtual van development was funded by the Keck Foundation as part of the Jason II/SeaNet upgrade effort.

REVEL Project - Veronique Robigoue presented a report on the Research and Education: Volcanoes, Exploration and Life (REVEL) program. The project provides general public outreach as well as direct teacher involvement. Selected teachers participate in seagoing research expeditions as formal members of the scientific party. The teachers then bring their experiences from the ship back to the classroom. The program has been running for five years and includes various partnerships including its directors, participating PIs, and webmasters. NSF and the University of Washington support the program. Collaborations have been useful in extending the reach of the program. Collaborators include Pennsylvania State University, the American Museum of Natural History, and Marine Advanced Technology Education (MATE). Since the program's start, they have taken approximately 45 teachers to sea. They have trained some of the earlier participant teachers to be able to bring new teachers to sea. This is helping to make the program more sustainable. The website continues to grow. The daily journal that is maintained by the teachers is updated on the web. Teachers are normally scheduled for their cruises during the summer since this is when the teachers do not have teaching obligations. One teacher participated in Paul Johnson's THOMPSON cruise to Juan de Fuca during the school year; enabling a lot of classroom interaction. REVEL is extending its reach to the European community.

REVEL has been operating on a year-to-year budget. To achieve better long-range planning, they are seeking a 5-year funding source. They hope to include more scientists and expand the program nationally. Information about REVEL is included as ***Appendix VII***.

Extreme 2000- Voyage to the Deep - Craig Cary reported on the educational outreach program Extreme 2000 – Voyage to the Deep. During Craig's January ALVIN dive program in Guaymas, students and the public could follow along via an interactive web site, <www.ocean.udel.edu/deepsea>. The site highlighted daily discoveries through video clips, dive logs, journals, and interviews. A resource guide was developed as well as an educational video. ***Appendix VIII*** includes information about the program. Participation included 800 children from 14 schools. They were provided assistance from a public television station. The project required minimal funding but a lot of effort. There is a lot of similarity between Extreme 2000 and the Dive and Discover program. Craig reported that one of the highlights of Extreme 2000 program was a conference call

between Craig and 11 classrooms in Delaware, New Jersey, and California. Craig provided an audio clip of one of the phone calls. Over a 30-minute period on the sea floor they were able to transmit the phone calls. The students completed a survey at the end of the program and it was very positive. The program received coverage in both the New York Times and on CNN. It was very positive for the students to see this. Another Extreme cruise is planned in 2001.

In closing the outreach presentations, Mike Prince reported that the UNOLS Office will establish a list of outreach programs that are conducted from UNOLS vessels and post these on the UNOLS website.

Agency Reports

National Science Foundation (NSF) - Dolly Dieter began the NSF report by noting personnel changes in the agency. Mike Purdy has moved to Lamont-Doherty Earth Observatory to serve as their new director. Don Heinrichs is serving as the Interim Division Director of NSF's Ocean Sciences. The Division will be reorganized into three sections, Ocean, Integrative Programs, and Marine Geosciences. Facilities falls under the Integrative Programs Section. Linda Goad is joining NSF and will cover scheduling and ship operations funding. Dolly will continue to interact with the DESSC group.

Office of Naval Research (ONR) - Sujata Millick provided the ONR report. The design of the SWATH AGOR 26 is complete. The ship will be operated by University of Hawaii. Vessel construction will begin in January 2001 and should be complete in seven months. The Navy will take ownership in early 2002. The ship is designed to be able to support ROV operations.

Patty Fryer added that the Navy's ATV has been decommissioned. Scripps Institution of Oceanography (SIO) and the University of Hawaii are working on an agreement that will provide shared operational support responsibilities between the two institutions.

National Oceanic and Atmospheric Administration/National Undersea Research Program (NOAA/NURP) - Barbara Moore provided the NURP report. NURP continues to support the National Deep Submergence Facility (NDSF) at $500k annually. At this time, NURP does not have their budget for 2001. They are currently on a continuing resolution with level funding. However, they have already funded the 2001 NDSF work. They hope to have new funds available to support ocean exploration initiatives in 2002. The funds for ocean exploration will largely fall outside of the NURP budget. They are budgeting 10% of their budget for public outreach and education activities.

National Aeronautics and Space Administration (NASA) – John Rommel provided the NASA report. His viewgraphs are included as ***Appendix IX***. Through NASA's Astrobiology Science and Technology Instrument Development (ASTID) program, they are actively looking for instrumentation that will work in the deep ocean. The scope of the program is to develop instrumentation capabilities that will help meet astrobiology

science requirements on future space flight missions, as well as unique astrobiology science objectives on Earth. They would like to advance the development of scientific instruments or instrument components to the point where the instruments could be credibly proposed in response to future flight opportunity announcements. The development of laboratory instruments designed to significantly advance Astrobiology science will also be considered. John reviewed the scientific goals and objectives for astrobiology. They are investigating answers to the questions of "How does life begin and evolve?" and "Does life exist elsewhere in the Universe?" The new instrumentation is desired to address the specific objectives:
"• To determine whether the atmosphere of the early Earth, hydrothermal systems, or exogenous matter were significant sources of organic matter;
• To search for evidence of ancient climates, extinct life, and potential habitats for extant life on Mars; and
• To determine the presence of chemical precursors and potential habitats for life in the outer Solar System."
Mars, Europa, Titan, comets, the Space Station, and Earth are areas of interest.

NASA support can be provided for:
• Long lead-time definition studies,
• Innovative approaches that may provide new classes of instruments, and
• Development of new enabling technologies for missions further in the future, and/or for development studies that may advance the technology for a wide range of instrumentation applications.
NASA is receptive to necessary field-testing requirements of new technologies. ASTID Instruments and Technologies will need to operate in harsh environments (temperatures, pressures, vibration, impacts, etc).

John reviewed the types and levels of proposals that will be considered and gave examples of future missions. The ASTID program awards are expected to range from $30,000 to $300,000 per year. The proposal deadline is January 19, 2001. Details of John's presentation are included in the appendix. The website <www.nasa.gov>, "research programs" provides additional information.

National Deep Submergence Facility Operator's Report (WHOI) - Dick Pittenger provided a response to some of the user comments. Scheduling continues to be a very challenging process for all parties. There is also a funding problem. In particular, the trickiness of scheduling the NOAA work in 2000 and securing the funds makes things challenging. Dick thanked everyone for his or her patience in this process. The scheduling process and associated logistics needs improving. The demand for use of the facilities has grown; it is not the situation that it was in 1991.

In response to some of the other specific problems identified in the science reports, Dick agreed that there are not enough people onboard to support the Jason operations. This year marked only the second time joint operations with Jason and ALVIN have been carried out. They are still experimenting and will do a better job in the future. As for frame grabs, they are not intended to be of publishable quality. Plans are underway to

obtain recordable material for all video. To address navigation problems, WHOI is implementing RDI on all vehicles. The hand-held digital cameras are very successful. These were funded by a private donor and NSF. Dick addressed weather windows. Operations are often pushing the weather windows. As an example, ALVIN operations in 2000 were scheduled on the Mid-Atlantic Ridge for the middle of December. They got lucky and the cruise was successfully carried out. There are limits to the platforms and this needs to be a driver in creating schedules that work.

Break for Lunch

A Virtual Jason Van demonstration was provided by Steve Lerner during the lunch break.

NDSF Report (Continued) - Dick Pittenger stated that ATLANTIS has now been in operation for four years. A shipyard period is planned in early 2001 as well as ALVIN's overhaul.

NDSF Vehicle Operations Summary - Rick Chandler reported on vehicle operations in 2000. His viewgraphs are included as ***Appendix X***. It was a busy year. ALVIN began the year in Guaymas and continued with operations on the East Pacific Rise, off California, at Juan de Fuca, in the Gulf of Mexico, and ending on the Mid Atlantic Ridge in December. The ALVIN operations totaled 330 operating days with 136 dives. The average dive depth was 2200 m. One dive was lost to battery problems and three days were lost to weather. Highlights of the year included the addition of two new pilots and the introduction of the successful Dive and Discovery program.

ROV operating areas included the East Pacific Rise, Juan de Fuca, the Black Sea and the Mid Atlantic Ridge. All three vehicles were used during the year with 20 lowerings for Jason, 13 DSL120 lowerings and 18 Argo II lowerings. The total bottom time was 1273 hours with 1844 km of the seafloor covered. Highlights included the longest Jason lowering of five days.

Vehicle and Ship Upgrades/Overhauls/Synchronization/Response to User Suggestions:

ALVIN - Dudley Foster reported on plans for ALVIN's overhaul. His viewgraphs are included as ***Appendix XI***. The overhaul is scheduled to begin on January 2, 2001 and be completed on June 12, 2001. Sea Trials and certification are scheduled for 13-22 June. Progress of the overhaul can be followed on http://www.marine.whoi.edu/ships/alvin/alvin.htm.

The community has provided input regarding improvements and upgrades that they wish to have implemented on ALVIN. Dudley reviewed these suggestions along with WHOI's response.

- Hard mount user video controls – A second pan and tilt will be installed and the observers will be provided with control and flexibility.

- Modify bottom of science racks – Better cushions and more floor space in sphere will be provided for comfort.
- Modify equipment interface for basket – WHOI will provide an interlocking component system.
- Replace external stills with digital camera. – WHOI is not ready to take that step. Digital frame grabs will eventually replace external film cameras. WHOI will retain one Benthos 35mm until a digital camera is available.
- Improved single chips and smaller 3-chip cameras
- Install flat screen displays – pilot and observer monitors will be provided.
- Develop fiber optic penetrator – This is not planned as part of overhaul. WHOI needs to investigate if it is needed. A new penetrator will require an involved certification process.
- Acoustic modem for depth/position telemetry – Increased navigation options will be provided.

Dudley reviewed other planned improvements:
- Digital video recorders – The DV-cam is a professional type system.
- Doppler Navigation - WHOI hopes to have this available when the overhaul is complete.
- Lateral thruster – This will allow for improved position holding.
- Replace port manipulator.
- Install Sunwest SS300 system – This will provide a 100 meter range.
- Beta ALVIN power simulator – This is temporarily at CRCG site, http://alvin.crcg.edu

The power requirements of most of these improvements will not have an impact on the length of dive.

Dudley reviewed the ALVIN video duplication process block diagram. He compared the capabilities of the previous duplication system with the new system. The new facility provides 3 channels of simultaneous cloning or overlay of DV Cam tapes, with six identical decks. Twelve hours of video can be cloned in 4 hours. Black and white monitoring of all decks with color monitoring of any selected deck will be provided. The new system is smaller and simpler that the previous one. This is the system that will be used to make first generation video cam tape. The science duplication features were reviewed. The user will need to let the operator know if data overlay on the tape is desired at the start of the cruise. WHOI will provide a list of compatible DV decks. The archive will not have the overlay on it. The master original copy will not have any data burned on it.

A question was asked regarding the cost of a recorder and decoder. The cost is approximately $5k. The 2-hour DDV tapes cost approximately $30. There was a discussion on the time stamp issue. The time is always recorded on the data. The PI needs the ability to place it on the video. There was concern that 20 years from now the ability to play these videos will be gone.

Jason, Argo II, DSL-120 – Andy Bowen reported on the upgrade program underway for the ROV and tethered vehicles. His viewgraphs are included as ***Appendix XII***. The viewgraphs provide a great deal of information about the new systems. A brief description of some of the plans and features are provided below. A website has been developed that also provides information and status of the upgrade program: <http://www.marine.whoi.edu/ships/rovs/upgrades.htm>. The key project milestones were presented. Acceptance testing of DSL120a sonar electronics is planned for March. Final testing and sea trials of DSL120a will be in June with the first deployment in August on Eli Silver's cruise in the Huon Gulf. The decommissioning of Jason will be in November 2001. By May 2002 Jason II will be ready for science.

Andy provided the ROV upgrade progress summary. A science design review meeting was held at the June DESSC meeting. Some of the highlights of the project include selecting the telemetry system, adding personnel, 3-D modeling of the Jason II design, completion of the Jason II and DSL120a overall layout, and identification of the thruster candidates. The full list of items is included in the appendix. The new power delivery system plans are well underway. The new system will use .680" cable. The new system will deliver 18kW at 2500VAC, as compared to the current system's 8kW at 2000 VAC. The final power level may change depending on the cable capability. Andy reviewed the Jason II telemetry specifications. A lot of time has been devoted to the modeling of the system. Jason II will have some unique capabilities, mostly in manipulation and sampling capabilities. Andy presented the computer-automated model of the Jason II vehicle.

The floor was then open to questions:

(Q) When the Jason II design is finalized, will the model be available to the community for viewing? (A) Andy explained that it would be available and in fact it would be a useful cruise planning tool.

(Q) Should two vehicles have been built? (A) This is a funding issue. An estimated cost for the system is roughly $5.7 m. Funds permitted the construction of one vehicle at this time.

(Q) Is keeping Jason operational an option? (A) Andy explained that Jason's telemetry system is ten years old and it is not feasible to keep it running.

(Q) Is there a Medea II as well as the Jason II? (A) Yes. It will have the ability to support a tethered support system.

(Q) Will the Jason II manipulators have the same capability as Alvin's manipulators? (A) Yes, they will use T-handles.

ATLANTIS Shipyard Plans - Dick Pittenger reported that ATLANTIS will arrive at homeport in Woods Hole tomorrow (12/15). Dick's viewgraphs are provided as ***Appendix XIII***. ATLANTIS plans call for dry-docking during its shipyard visit. Dick

reviewed the shipyard plans that include a long list of improvement items. The cost for implementing the total list of improvements is estimated at $1.2M; however, the funds available for this shipyard period are $650k. The remaining $550k of improvements will be deferred based on available funds. The funding came from a variety of sources; ship ops funds, major maintenance reserve, and ONR supplementary funding. The core maintenance includes underwater body, topside painting, renewing doors, new sewage pumps, engine repairs, and ABS and USCG inspections. Other projects include HVAC improvements, bow thruster quieting and improved 01 deck access topside aft. WHOI has decided to remove the air compressors from the ship because they have never been used. This will free up some space aboard the ship. Cavitation and noise problems will be addressed. The anchor problems have already been remedied. Most of the shipyard items are fairly routine. The drain problems identified by Cindy Van Dover will be addressed. The option of adding a work sink on the outside deck will be considered. There was some concern about the items that did not get funded. Dick indicated that community input regarding these items would be helpful.

Archiving Update - Dan Fornari provided an update on WHOI outreach activities and data archiving. His viewgraphs are included as ***Appendix XIV***. Dan explained that WHOI, as the UNOLS National Deep Submergence Facility Operator, undertakes outreach activities on behalf of the ocean sciences and deep submergence research communities. Part of this responsibility entails maintaining and providing access to the Deep Submergence Data Archives at WHOI.

Dan gave the status of the archives. Data from ROV and tethered vehicle cruises are current to the Lisa Levin cruise in October, 2000. Data from ALVIN cruises are up to date including Ian McDonald's Gulf of Mexico cruise in October. For ten ROV and Tethered Vehicle expeditions 1,527 video and data tapes have been archived. 745 hi-8 videotapes were archived from ALVIN's twelve dive series. The full list of archived media is included in Appendix XIV. Approximately 35 requests for deep submergence data of various types have been made during 2000.

Dan reviewed Museum and other Outreach Activities. These include the WHOI-BBH "Extreme Deep " Exhibit. "Extreme Deep " is an exhibit that includes models, displays and videos about deep sea vehicles including ALVIN, Jason, ABE, and REMUS; hydrothermal vent animals and geology; a section on shipwrecks; and other displays related to deep sea exploration. "Extreme Deep " has been on display at the Boston Museum of Science, the Children's Museum of Indianapolis, and the Oregon Museum of Sci. & Industry, Portland. Over 700,000 people have viewed "Extreme Deep "at these sites.

In other outreach activities, WHOI maintains an Exhibit Center that provides information and displays of oceanographic and deep submergence science and research technologies. Each year approximately 30,000 people visit the WHOI Exhibit Center. WHOI also maintains a media relations office that handles approximately 2,000-3000 requests per year for visual and other materials related to deep submergence. Printed articles in newspapers and magazines number ~500 per year and are primarily handled through this

office. This office also coordinates use of deep submergence archive footage for educational television programming and film and TV specials. The total number of requests to the WHOI Media Relations Office for imagery during this year was 248 (179 still image requests, 48 video image requests and 21 combination requests)

Dan reviewed the annual expenses and revenues for CY2000. The annual expenses related to WHOI's exhibit center and media relations office is approximately $400,000. Maintenance of Deep Submergence Archives is approximately $75,000. The approximate revenue from various sources is approximately $55,000.

Future outreach efforts include:

1) Continuing the national tour of "Extreme Deep " exhibit,
2) Collaboration with National Geographic Television on weekly science news programming,
3) Assisting S. Lowe and R. Lutz with an IMAX movie on hydrothermal vents partly funded by NSF to be filmed next summer on MAR using Alvin, and
4) Continued efforts at contacting various media organizations to encourage highlighting of deep submergence and oceanographic science and technology.

Long-Range Planning, Expeditionary Voyages, and Vehicle Access - Jon Alberts reviewed ALVIN and ROV 2001 scheduled operations. His viewgraphs are included as ***Appendix XV***. ATLANTIS will operate in the early part of the year in the SE Atlantic and the Mid Atlantic Ridge (MAR) without ALVIN. ALVIN operations will begin in June on the MAR. The remainder of the year will be on the East Pacific Rise. In 2001 ALVIN will not operate at Juan de Fuca. The ROVs will be busy in 2001 with operations planned in the Indian Ocean, off California, Juan de Fuca, Huon Gulf and the East Pacific Rise.

Jon continued by showing the requested ALVIN and ROV programs for 2002 and beyond. The geographic areas of interest were also shown. Jon explained the difficulties in compiling the lists. Many of the vehicle and ship time requests that are posted on the website have not been updated to show the current funding status. For 2002 there are many requests, of these, quite a few are already funded.

6k to 7k Meter New Occupied Submersible Capability – Bob Brown provided an overview of the WHOI study, "Comparison of Options for an Improved Manned Deep Submersible Vehicle for Research." The study has been posted on the WHOI website at http://www.marine.whoi.edu/ships/SeaCliff/report.htm. His viewgraphs are provided as ***Appendix XVI***. The study investigated options for maintaining a U.S. 6,000 m manned capability. As part of the study WHOI:

- Assessed SEA CLIFF equipment,
- Surveyed other 6,000 m submersibles,
- Surveyed current technologies,
- Surveyed users and operators,
- Evaluated possible modifications to ALVIN and / or Sea CLIFF,
- Investigated hull replacement / modification possibilities,

- Conducted a cost analysis on depth and construction of a new submersible, and
- Evaluated the various options.

Bob reviewed the options, as well as, WHOI's recommendations. Based on their survey regarding an improved submersible, the study concentrated on efforts to rearrange the viewports, improve imaging, power capacity, bottom time and manipulative capabilities. WHOI's study concludes that a new submersible will provide the best opportunity for the US to regain its 6,000 meter manned capability and to achieve significant improvements in other areas. Bob reviewed the improvements that are listed in the appendix. Lastly, Bob showed a timeline for construction of a new submersible. The entire process is estimated to take four and a half years. Dick added that WHOI is drafting a proposal for conceptual development of the new submersible. The cost for the entire project is estimated at $14 million. The new submersible would be operated/scheduled the same way as ALVIN is managed.

The topic was open for discussion. (Q) Would the new sub would be a replacement for ALVIN. (A) Yes. (Q) What kind of batteries will be used? (A) The batteries will likely shift to NiCads. (Q) Is a new submersible needed, or should the funds be used to construct say three new ROVs? (A) Patty Fryer indicated that there are a number of justifications for a new submersible:

- Maneuverability
- Un-tethered operations
- Manned presence
- Power capability.

She added that the majority of the abstracts submitted for the DESCEND workshop indicated a desire for a deeper diving capability.

Break

ATV Status Report - Patty Fryer reported earlier in the meeting.

Discussion of follow-up for DESCEND Workshop Recommendations - Patty Fryer reported on the various activities in response to recommendations made at the DESCEND workshop:

Shallow Water Liaison to DESSC – There was concern that the needs of the shallow water community are not being heard or met. To try to address this problem, the DESSC has invited Shirley Pomponi to serve as an advisor to their committee. Shirley introduced herself and explained that at the workshop there seemed to be a consensus that there is both a deep and shallow element to the submergence future facility needs. There is a good deal of interest in gaining access to the full suite of vehicles, those that exist now as well as future developments. Several shallow water facilities exist. The key to their scientific use is access and funding. Availability is not a problem, but funding is the issue. Some of the shallow water facilities will need upgrading. Shirley suggested that a coordinated management and scheduling of all facilities is needed.

DESCEND Website and Brochure –Patty continued with a review of the DESCEND brochure. The document is the executive summary of the DESCEND proceedings report. Patty reviewed the brochure findings and recommendations:

Key Findings

1. The oceans remain a scientific frontier for the 21st century, with broad societal and academic relevance to issues such as the role of the oceans in moderating global climate change, and the limits of life-processes in extreme environments on Earth and other planets.

2. Dramatic advances in submergence vehicle technologies and instruments, including autonomous underwater vehicles (AUVs), occupied submersibles, remotely operated vehicles (ROVs), specialized sensors, and in situ samplers, now provide the potential for unprecedented access to the oceans and sea-floor. These new technologies and vehicles will foster a revolution in our ability to synoptically measure the chemical, biological and physical processes that occur in the oceans.

3. New mechanisms are required to improve access to all types of submergence vehicles and tools by the scientific community. These should be developed in order to address issues relating to scheduling existing assets, conducting field work outside traditional operating areas, and the need to respond to time-sensitive processes at the seafloor or in the water column (e.g. submarine eruptions). The broadest range of vehicle capabilities needs to be provided to investigators throughout the U.S. while preserving the existing capabilities achieved by our National Deep Submergence Facility.

4. Long-standing U.S. leadership in submergence science and technology is being challenged by other countries, principally France, Germany and Japan. These countries have greater funding levels for submergence science and vehicle facilities and long-standing support for the advancement of submergence technologies.

Recommendations

- Develop new sensors and tools
- Accelerate development of autonomous underwater vehicles (AUVs)
- Construct a new, state-of-the-art, deep diving (>6000 meter) occupied submersible
- Plan for a new, robust deep-diving (>7000 meter) ROV for science
- Increase access to submergence vehicles and tools
- Convene a submergence technology meeting

The full proceedings of the DESCEND workshop as well as the brochure are posted on the UNOLS website at: <http://www.unols.org/dessc/descend/descend.htm>. The brochure is being widely distributed throughout the community.

Technology workshop - As a next step, we would like to convene a technology workshop. The workshop would provide and opportunity for engineers, scientists, and technicians to review the available technologies and future technological directions. The workshop participants will be asked to identify research and development priorities and strategies for acquiring new sensors, tools and approaches to submergence science. Jim Bellingham is planning a robotics workshop at MBARI. His plans include a day aboard WESTERN FLYER with the ROV Tiburon. His workshop would include hands-on demonstrations and would address vision systems, navigations, imaging, etc. His workshop would be complimentary to the DESCEND technology workshop. The option to hold a joint workshop instead of two separate meetings will be further explored. A UNOLS proposal for support of a technology workshop will be submitted to the agencies.

The Ocean Exploration Panel Report - Dan Fornari reported on the Ocean Exploration Panel that he participated in over the past year. Shirley Pomponi was also a member of the panel. Realizing that there is still much to learn about the oceans, former President Clinton directed the Department of Commerce to convene a panel to recommend a national strategy for ocean exploration. The panel included ocean explorers, scientists and educators from both academia and industry. Agency Science Advisors interacted with the panel. The recommendations of the panel are just released and a Press Conference is planned tomorrow during the AGU Meeting. The panel's report is titled, "Discovering the Earth's Final Frontier: A U.S. Strategy for Ocean Exploration". Information about the Ocean Panel and can be found on the web at: http://oceanpanel.nos.noaa.gov/. Some of the recommendations of the panel report dovetail nicely with the interests of deep submergence science. The panel identified the following key objectives of an Ocean Exploration Program:

- Mapping the physical, geological, biological, chemical and archeological aspects of the ocean to broaden the U.S. knowledge base.
- Exploring ocean dynamics and interactions at new scales.
- Developing new technologies.
- Public outreach and education is a major goal.

The panel recommends that an Ocean Exploration Program be established for an initial period of ten years at the $75M/year funding level. The objective is to get new funding into the system.

NEPTUNE - John Delaney continued with a discussion of the NEPTUNE Project. Details of the NEPTUNE project can be found on the website, www.neptune.washington.edu. NEPTUNE proposes real-time, long-term ocean and earth studies at the scale of a tectonic plate. They have conducted a feasibility study of the project. The study was funded by NOPP and the NEPTUNE Phase I partners. The proposal calls for laying out 3000 km of cable and 31 nodes on the plate. Some of the characteristics of NEPTUNE include:

- tectonic plate scale
- huge data capacity
- real-time data return
- robust design

- available for 20-30 years.

There are events at the plate scale that have not been observed. Distributed sensors that report back to land are needed. No single group can afford this; it must be a coordinated effort. Some potential benefits of NEPTUNE include a new approach at research, educational and outreach, and digital, high-resolution images that can be beamed back to the classroom in real time. John reviewed the timeline and progress made to date.

General Business

- 2001/2002 DESSC Planning Meeting – Patty Fryer reported that we hope to have a DESSC meeting at The Oceans Science meeting in 2002. We need to reach out to the biological community. Stay tuned. DESSC also plans to hold their traditional meeting at the Fall AGU meeting in 2001.

- The DESSC Terms of Reference are awaiting endorsement from the UNOLS Council they are on the web.

- DESSC Call for Nominations – Thanks goes to Cindy Van Dover for her service on DESSC. There are four members who are completing first term, all have agreed to run again. A call will go out for Cindy's vacant seat.

Adjourn

Appendix I

Revised 12/6/00

UNOLS DEep Submergence Science Committee
Planning Meeting
Moscone Convention Center, Room 250
San Francisco, CA
THURSDAY, December 14, 2000

08:00 **Coffee, Distribution of Meeting Material (Written Reports)**

08:30 **Introduction - DESSC Chair's Report**

08:40 **UNOLS Report**

08:45 **2000 Science Reports - Presentations by Principal Investigators**
- ALVIN users
- ROV/AUV users

10:15 **Break**

10:30 **2000 Science Reports - Presentations by Principal Investigators (cont.)**
- ALVIN users
- ROV/AUV users

11:15 **Public Outreach**
- Dive & Discover: http://science.whoi.edu/DiveDiscover/
- SeaNet Status: http://www.whoi.edu/seanet/
- REVEL project: http://www.ocean.washington.edu/outreach/revel/
- Extreme 2000- Voyage to the Deep: http://www.ocean.udel.edu/deepsea/

11:35 **Agency Reports**

11:50 **National Deep Submergence Facility Operator's Report (WHOI)**
- Operator's Response to User Comments

12:00 - 13:00 **Break for Lunch** (Lunches will be available for a fee of $15.00 at the meeting)
A Virtual Jason Van demonstration will be presented during the lunch period.

13:00 **NDSF Report (Continued)**
- NDSF Vehicle Operations Summary
- Vehicle and Ship Upgrades/Overhauls/Synchronization/Response to User Suggestions
  - ⇒ ALVIN
  - ⇒ Jason, Argo II, DSL-120: http://www.marine.whoi.edu/ships/rovs/upgrades.htm
  - ⇒ ATLANTIS
- Archiving Update

14:00 **Long-Range Planning, Expeditionary Voyages, and Vehicle Access**

14:20 **6k to 7k Meter New Occupied Submersible Capability**

- SEACLIFF Engineering Study: http://www.marine.whoi.edu/ships/SeaCliff/report.htm
- Open Discussion

14:45 **Break**

15:00 **ATV Status Report**

15:10 **Discussion of follow-up for DESCEND Workshop Recommendations**

- Shallow Water Liaison to DESSC
- DESCEND Website and Brochure: http://www.unols.org/dessc/descend/descend.htm
- Technology workshop

16:10 **The Ocean Exploration Panel Report**

16:15 **General Business**

- 2001/2002 DESSC Planning Meeting
- Terms of Reference
- DESSC Call for Nominations

16:30 **Adjourn**

Appendix II

DESSC Meeting – December 14, 2000
Moscone Convention Center – San Francisco, CA
Attendees

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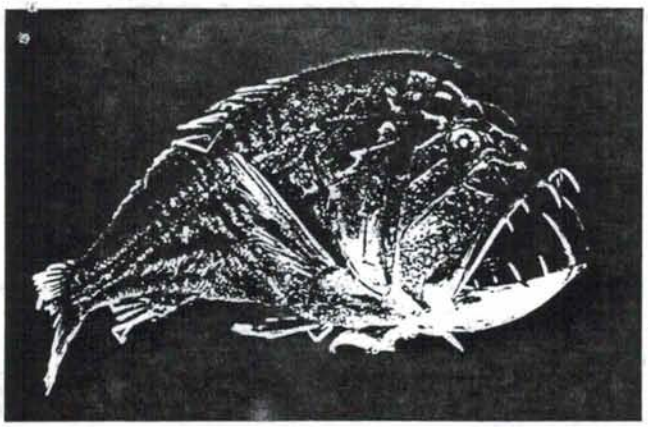
Appendix III

UNOLS 2000

- **Office to MLML, Mike Prince Exec. Sec.**
- **Quality assessment, improvement**
- **Scheduling issues, change in supply/demand**
- **AICC and USCSG Healy**
- **Long-range fleet renewal planning, FIC and FOFC**

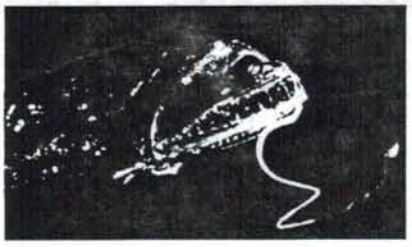
Appendix IV



Food is scarce in the deep sea. The fish that live there have big mouths, sharp teeth, and stretchy stomachs to catch prey in the dark and swallow it whole. This fish, called fangtooth, is found at depths of 2,600 – 5,000 feet. It grows to about 10 inches long.

Due to the tremendous pressure created by the ocean's weight, the depth to which a diver can descend is very limited. The deepest dive made by a scuba diver is about 440 feet.

In 1934, American oceanographer William Beebe reached a depth of about 3,280 feet in a round steel chamber called a *bathysphere,* which had a porthole for viewing and room for two people. It was attached to a ship on the surface by a long cable.



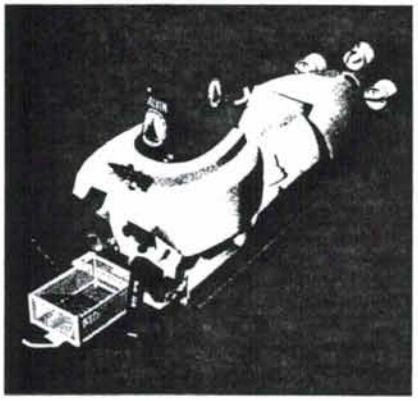
Since there is no natural light in the ocean below 3,300 feet, many deep-sea fish use light-producing organs to find a mate and lure prey. This fish has a chin barbel that glows in the dark.

In 1948, Swiss physicist Auguste Piccard began testing a much deeper-diving vessel he invented called a *bathyscaphe.* In the 1950s, Auguste Piccard's son, Jacques, helped his father build new and improved bathyscaphes, including *Trieste.* In 1960, Jacques Piccard and U.S. Navy Lieutenant Donald Walsh descended in *Trieste* into the Earth's deepest waters in the Mariana Trench about 200 miles southwest of Guam. The two men made the deepest dive in history: to a depth of 35,810 feet.

Today, scientists are making exciting discoveries about the ocean floor, thanks to deep-sea submersibles such as *Alvin*. Operated by Woods Hole Oceanographic Institution in Massachusetts, this three-person submarine made its first dive in 1964. Since then, *Alvin* has made more than 3,000 dives to average depths of 6,000 feet.

In 1967, *Alvin* was attacked by a swordfish, which became trapped between two pieces of the sub's fiberglass skin. The fish was brought back to the surface and cooked for dinner.

Scientists aboard *Alvin* have conducted a variety of research missions, from discovering giant tubeworms on the Pacific Ocean floor near the Galápagos Islands, to locating the wreck of the *Titanic* in the Atlantic Ocean.



Sophisticated submarines such as Alvin *are helping marine scientists learn more about the ocean's greatest depths.*

EXTREME 2000

Voyage to the Deep

Would you like to explore the deep sea? In January 2000, University of Delaware marine scientist Craig Cary (right) led an international team of scientists on Extreme 2000, the first deep-sea expedition of the millennium. The mission: to explore hydrothermal vents over a mile deep in the Sea of Cortés off Mexico's west coast.

During the 11-day expedition, the scientists studied the unique organisms that inhabit the vents, took samples of the toxic vent chemicals and collected rock and minerals for examination in the lab back home.

As the scientists dived to the seafloor aboard the submarine *Alvin,* students and the public were invited to travel along via an interactive Web site where the scientists shared each day's discoveries through video clips, dive logs, journals, and interviews. A resource guide also was developed, as well as an educational video by WHYY-TV (PBS).

One of the highlights of the outreach project was a conference call between 11 classrooms in Delaware, New Jersey, and California, and the call is available on the Web site: *www.ocean.udel.edu/deepsea.*

The next deep-sea expedition is planned for 2001. To learn how your classroom can participate, contact UD Marine Communications at (302) 831-8083, or *MarineCom@udel.edu*.

UD marine scientist Craig Cary examines a spiny spider crab collected on an Extreme 2000 dive.

DIVE IN TO *www.ocean.udel.edu/deepsea*

The Deep Sea

Perhaps no area of the ocean is more shrouded in mystery than the deep sea. Years ago, it was believed that the ocean's greatest depths were devoid of life. But recent discoveries have revealed that the deep sea is home to many fascinating creatures.

Here live huge clams, 8-foot-tall tubeworms that resemble giant lipsticks, and bizarre-looking fish equipped with big mouths, spiked teeth, and stretchy stomachs to catch prey in the dark and swallow it whole.

But exactly where is the deep sea? The ocean bottom is divided into three major areas: the continental shelf, the continental slope, and the deep ocean basin.

The *continental shelf* extends underwater from the shore, and its features are very similar to those we see on land, including hills, ridges, and canyons. On the map above, the continental shelf is the light-blue area that edges the continents. While its size varies, the shelf's average distance is about 40 miles.

It is beyond the continental shelf that the "deep sea" begins. The shelf ends at a depth of about 660 feet, giving way to the steeper *continental slope*, which descends about 12,000 feet to the *deep ocean bottom*.

Here, the ocean floor deepens sharply and its features resemble those on land, only on a much larger scale, with great plains and mountains. In fact, the Earth's longest mountain range is under the sea. Over 35,000 miles long, this mountain range, called the Mid-Ocean Ridge system, snakes its way around the globe.

The Mid-Ocean Ridge marks the area where the Earth's crustal plates are moving apart. It is one of the most geologically active areas on Earth. It is where new seafloor is being born, giving rise to underwater geysers called *hydrothermal vents* and volcanoes.

NOAA, National Geophysical Data Center

Where Is the Deepest Point in the Ocean? *The Mariana Trench is a depression in the Pacific Ocean east of the Mariana Islands. In this trench, about 200 miles southwest of Guam, lies the deepest point on Earth (starred above). Called the "Challenger Deep," it plunges to a depth of nearly 7 miles!*

Robert Cohen

Dr. Craig Cary

Deep-Sea Worm Is Earth's Hottest Animal

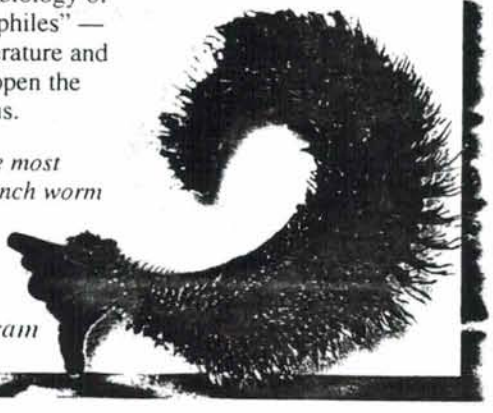
University of Delaware marine scientist Craig Cary (left) recently discovered that an inhabitant of the deep sea is the most heat-tolerant animal on Earth. The Pompeii worm *(Alvinella pompejana)* can survive temperatures up to 176°F — nearly hot enough to boil water.

Formerly, the Sahara desert ant was believed to be the most heat-hardy creature, foraging briefly in the desert sun at temperatures up to 131°F.

Cary's research was conducted on board the submersible *Alvin* at hydrothermal vent sites in the Pacific Ocean west of Costa Rica. Using a long probe called "The Mosquito," he found that the worm's rear end sits in super-hot water, while its head, which sticks out of the worm's tube home, rests in water that is much cooler, about 72°F.

Covering the Pompeii worm's back is a fleece of bacteria that can also "take the heat." These bacteria may harbor enzymes useful in such high-temperature industrial applications as processing food and drugs, making paper, and dislodging oil inside wells.

By learning more about the unique biology of the Pompeii worm and other "extremophiles" — organisms that thrive in extreme temperature and pressure conditions — scientists may open the door to new products useful to all of us.

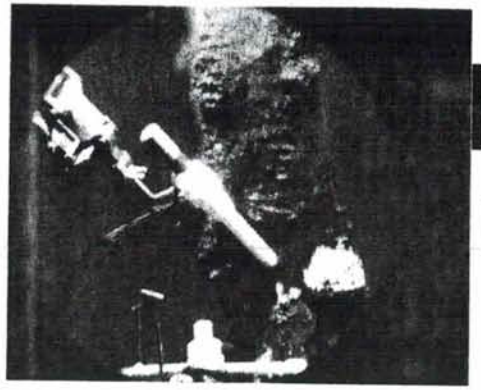


The Pompeii worm is believed to be the most heat-tolerant animal on Earth. This 5-inch worm can live at temperatures up to 176°F.

Sea Grant
University of Delaware

Produced by the University of Delaware Sea Grant College Program

- May 1999 (Luther and Cary)- 9N
- Oct 1999 (Rita Colwell et al.)-Juan de Fuca
- Jan 2000 (Luther and Cary)- Guaymas



Key objectives and findings

Hypothesis: Pyrite formation =Energy (H_2)

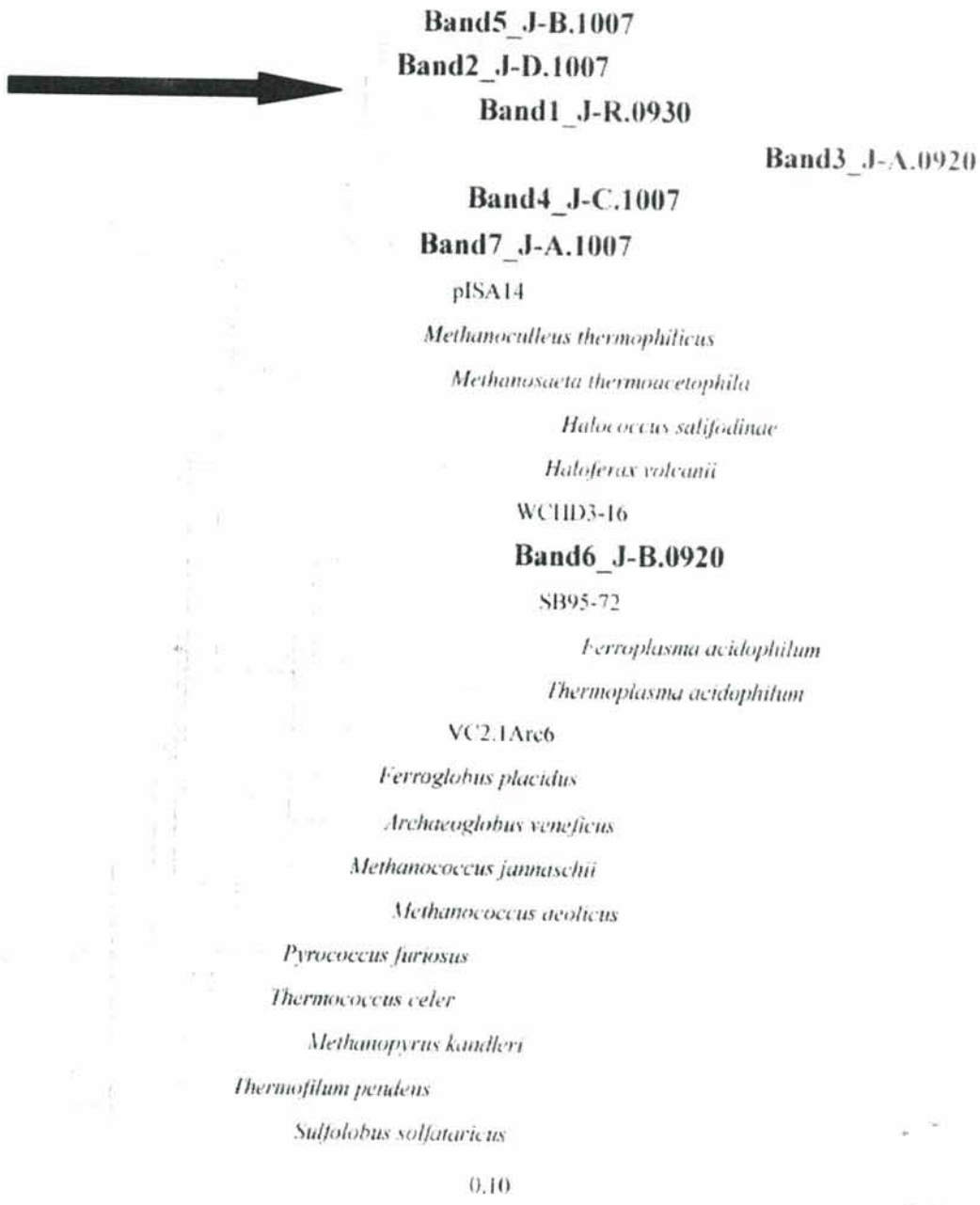
- Characterize microbial diversity associated with active sulfides
  - Used molecular methods
    - >>>> diversity
    - Novel groups never reported from vents
    - Lab/vent rats not found
- Isolate novel microbes-H_2
  - chemolithoautotrophic thermophiles
  - Culturing methods
    - methanogens associated with FeS and pyrite
    - Novel isolates NEVER reported from terrestrial/deep-sea hydrothermal vents
- Chemistry

What we thought we knew about thermophilic (*Archaea*) diversity at vents

- *Thermococcus* spp- lab rat of thermophiles?
- *Methanococcus jannaschii*
- Others-single isolates, *Archaeoglobus, Methanopyrus, Desulfurococcus* etc.

We were wrong!- Juan de Fuca

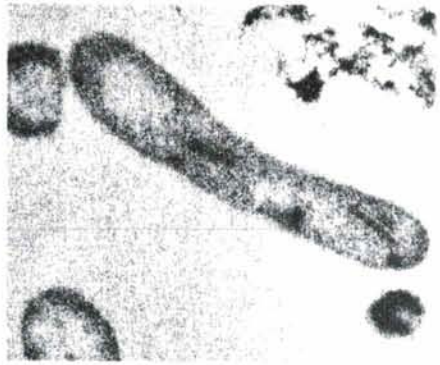
- 1 dive
- 1 flange
- Colwell et al, manuscript in prep.

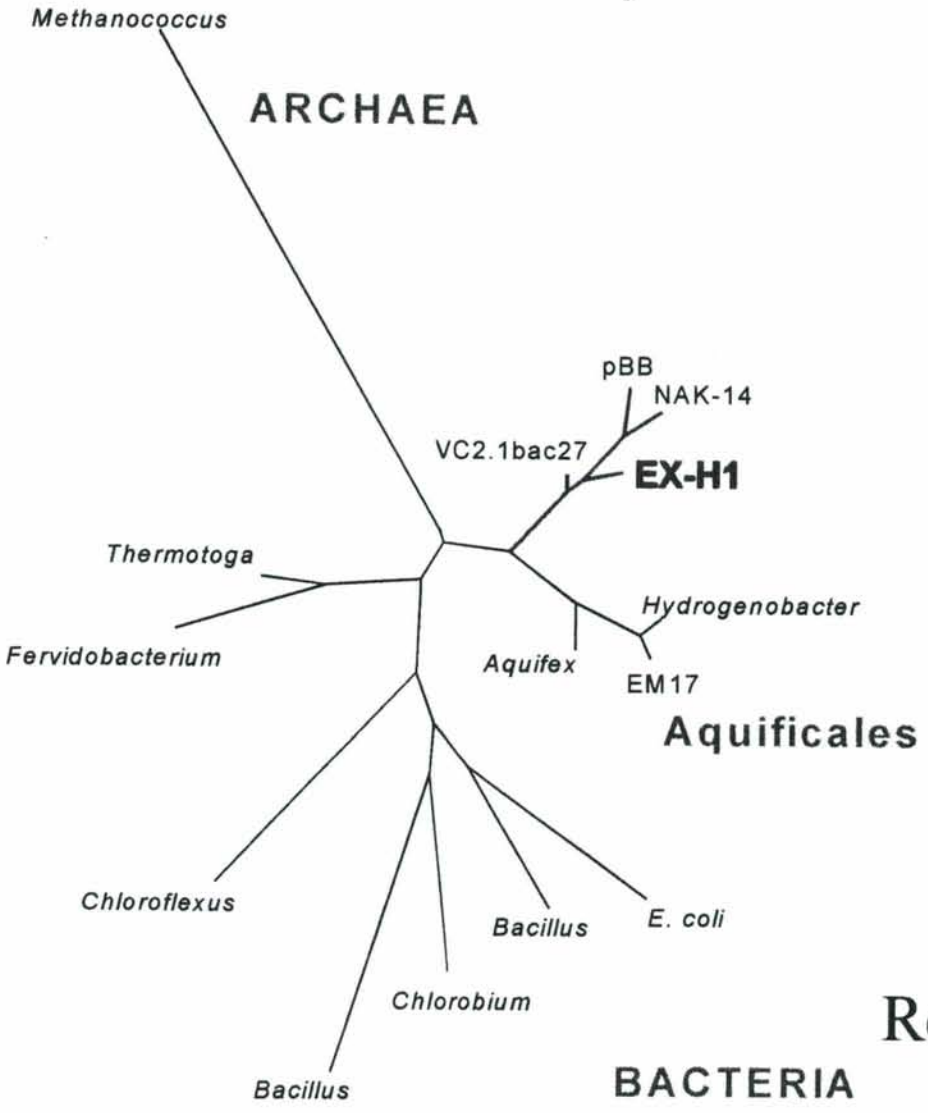


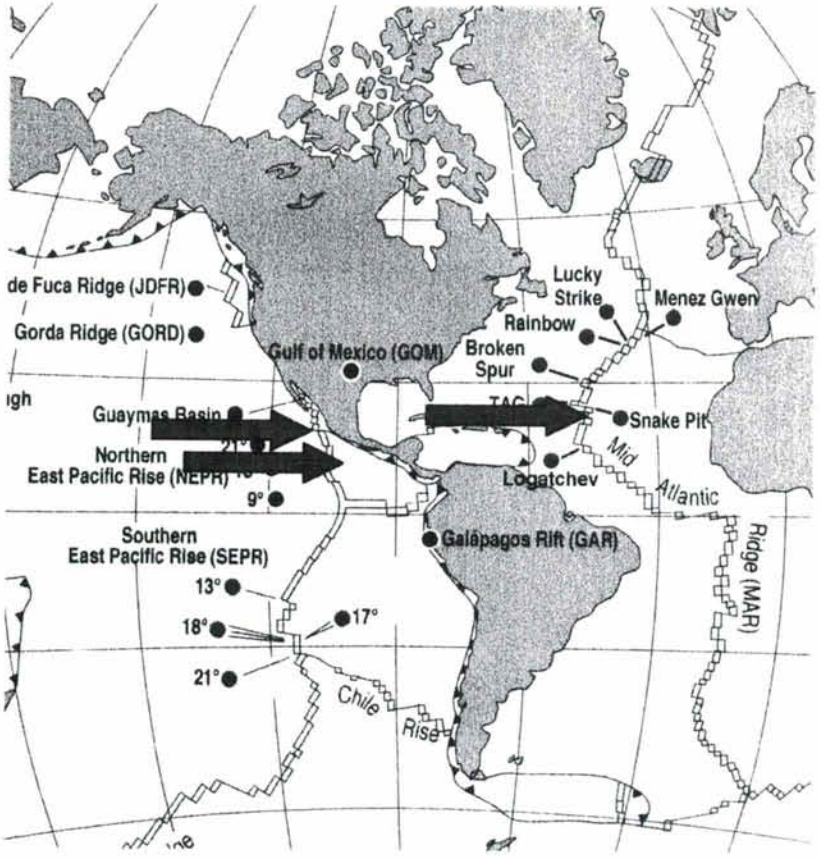
We were wrong, twice!-Guaymas

And how about cultures?

"*Persephonella* spp."

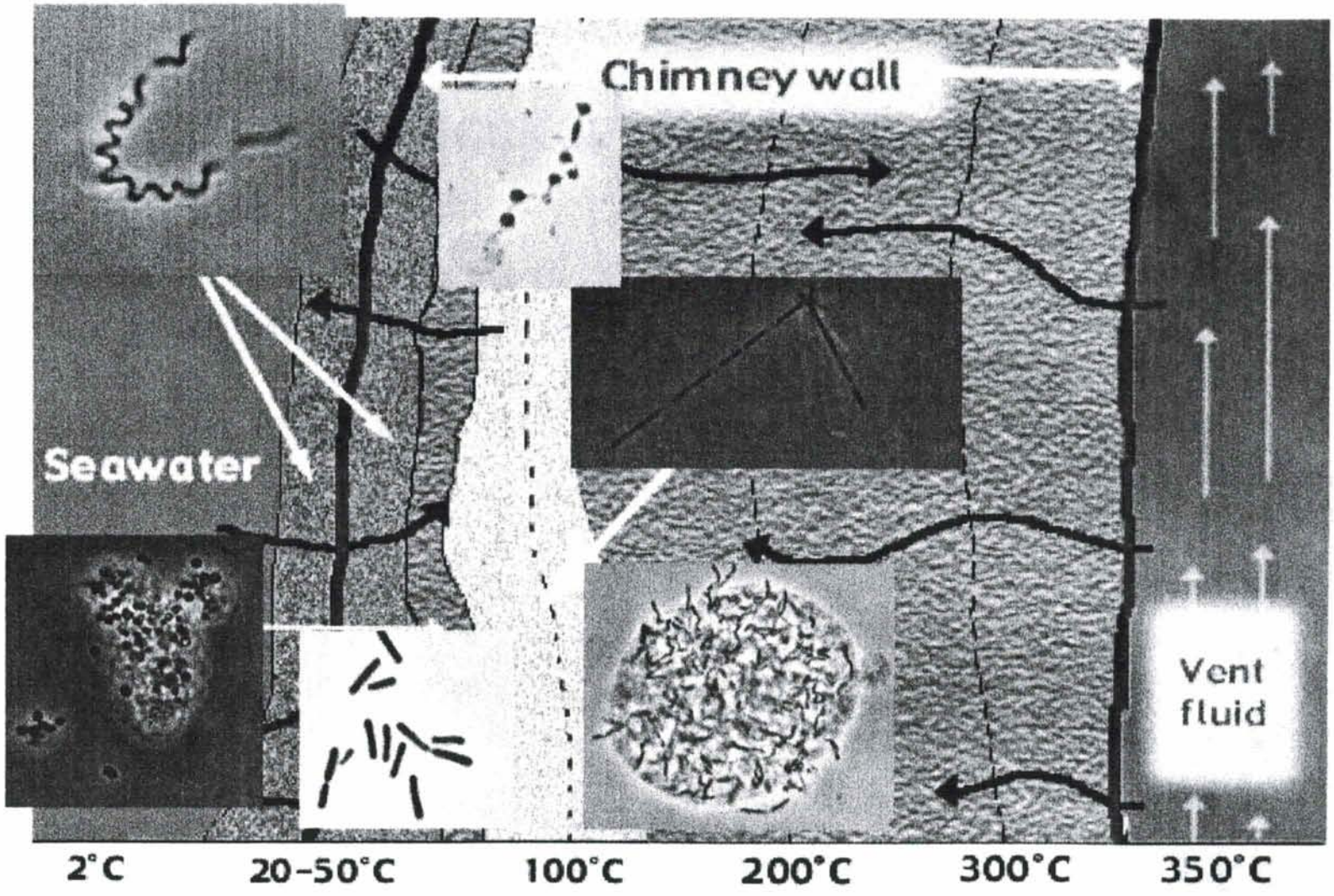






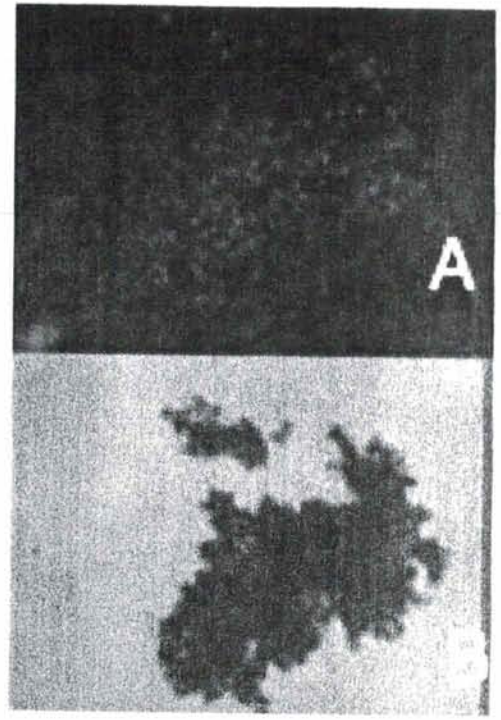
Reysenbach et al. 2000.Nature 404:835

And so many more…



After McCollom and Shock, 1997

Thanks



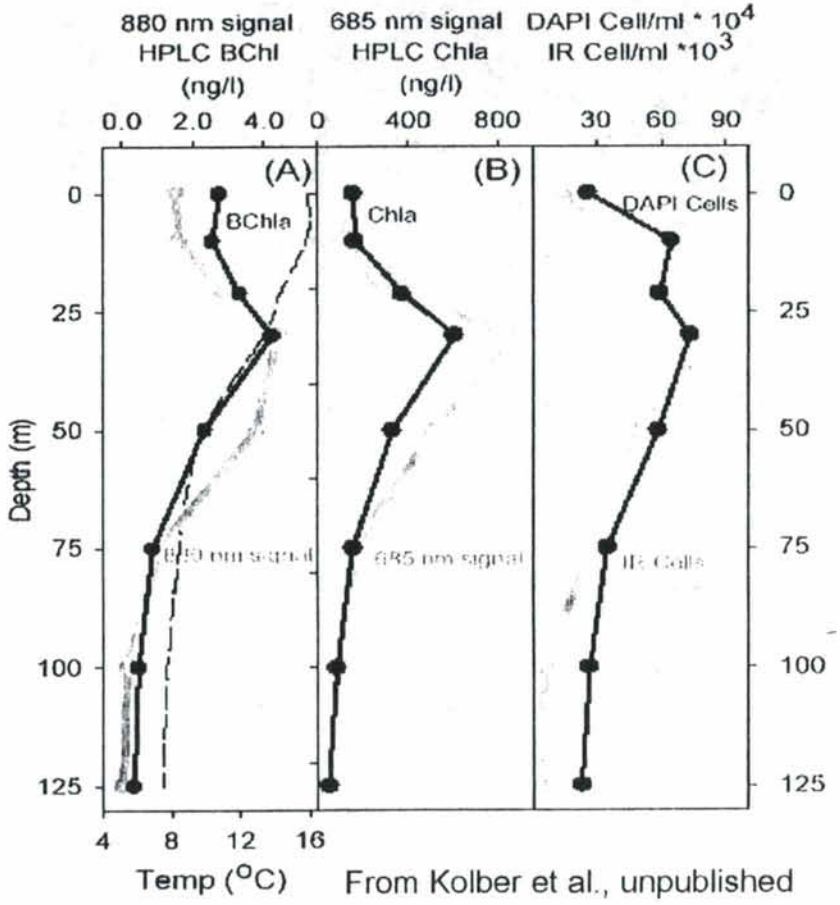
- NSF
- Alvin team
- Atlantis crew
- Collaborators-Luther and Cary and their labs
- Krista Longnecker, Dorothee Gotz, Amy Banta

Search for Phototrophs at Deep-Sea Hydrothermal Vents
(4 dives, JdF)

Supported by NSF BIO OCE
NASA Exobiology
ASU NASA Astrobiology Institute

- C. Taylor "gattling gun" sampler
- HPLC extractions and fluorescence spectroscopy
  - *Gerry Plumley UAF
  - *Bob Blankenship ASU
  - *Steven Sczekan PTI, INC
  - *Bill Smith, Medico, INC
- Biophysical measures -- fluorescent transients in reaction center
  - *Paul Falkowski Rutgers
  - Zbigniew Kolber Rutgers
- Culture
  - Vladimir Yurkov U. Manitoba
  - *Chris Rathgeber U. Manitoba
- Direct Counts
  - Tom Beatty -- UBC
  - *Andrew Lang -- UBC

* Rookie Divers



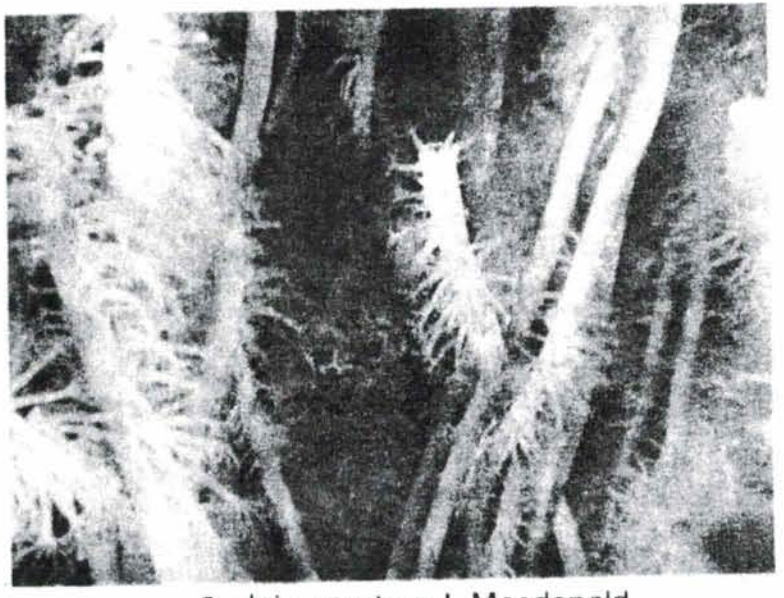
From Kolber et al., unpublished

Appendix IV - c

Seep Census Florida Escarpment
Deep-Sea Mussel Beds (3 dives)

Supported by NOAA-NURP
UNC-Wilmington NURC

- Florida Escarpment
  - 16 replicates
  - 27 liters of mussels
    - biomass dominated by echinoderms
      - holothurians, ophiuroids
  - ancillary sampling:
    - Costa Vetriani Rutgers
    - Zoe McKiness Harvard
    - Bob Vrijenhoek MBARI
    - Chuck Fisher Penn State
    - John Freytag Penn State
    - Stephane Hourdez Penn State
    - Joe Bonaventura Duke

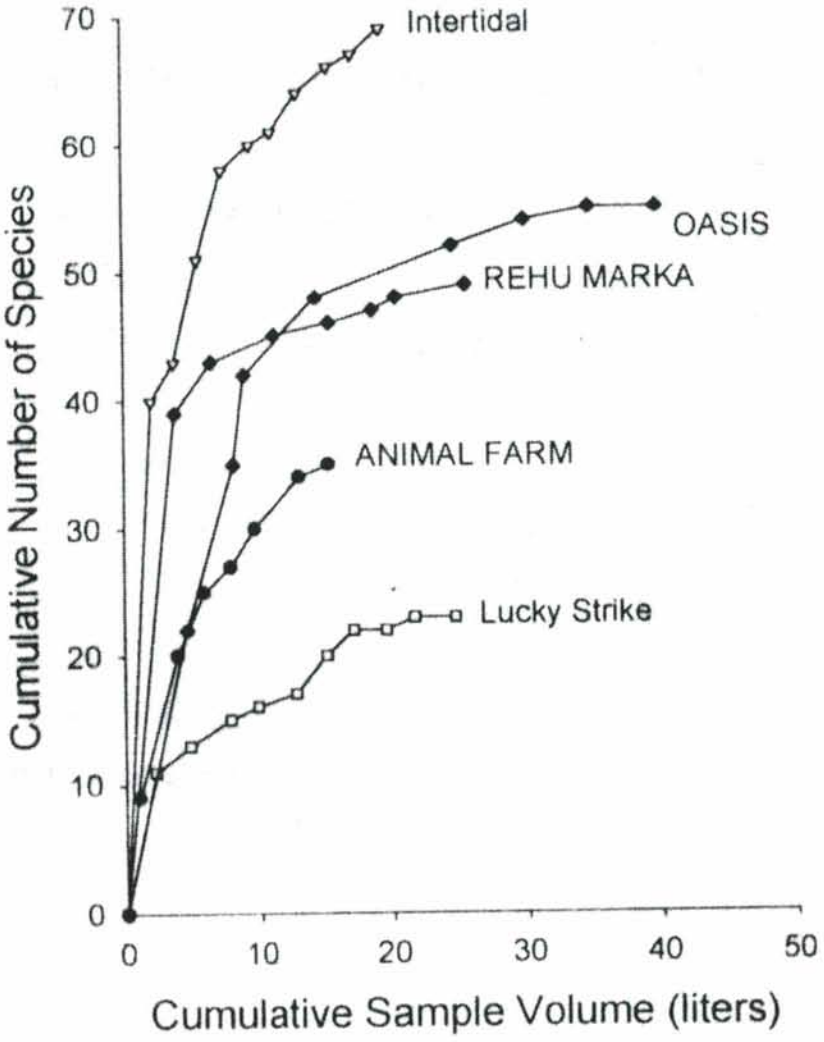


Coolpix courtesy I. Macdonald

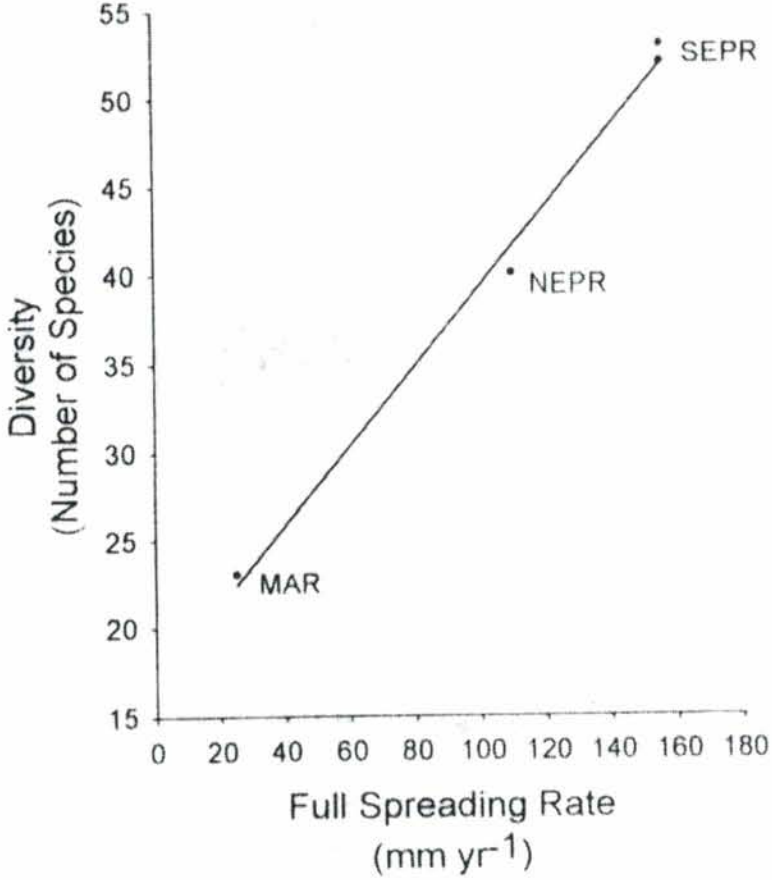
Rookie Divers

Cheryl Jenkins	W&M Res Assoc Prof
Mary Turnipseed	W&M MSc Prog
Josh Osterberg	W&M 2001

Species-Effort Curves



Biodiversity Patterns



Vent Census 9N:
Mussel Bed Fauna, East Pacific Rise

1. Nov 1999:

   Established Census Sites

   Train Station -- *post* 1991 eruption
   East Wall -- *post* 1991 eruption
   Biovent -- *pre* 1991 eruption

2. Four additional censuses funded

   (first of these in December 2001)

3. Integrated measures of habitat change:

   A. HOBO temperature logs (2/site)

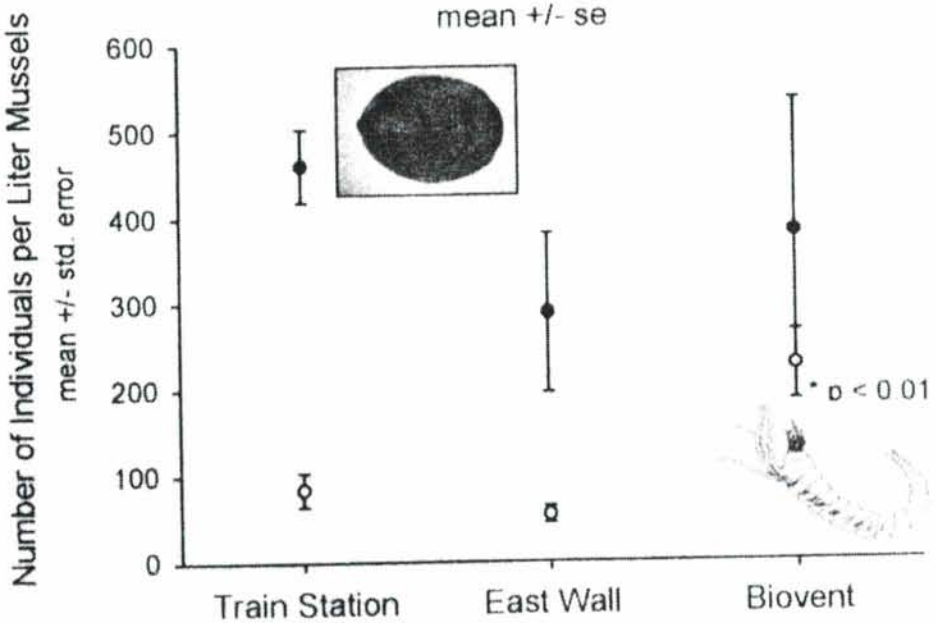
      (Fornari loan)

   B. Mussel tissue index

Supported by NSF- BIO OCE
NSF-RIDGE

Comparison among sites, 9N EPR

mean +/- se



filled circle: limpet (*L. elevatus*)
open circle: polychaete (*A. galapagensis*)

N = 6 Train Station, East Wall
N = 5 Biovent

IN SITU TIME-SERIES EXPERIMENTS TO DEFINE THERMAL AND COMPOSITIONAL VARIABILITY IN TIDALLY PERTURBED SUBMARINE HYDROTHERMAL SYSTEMS

Principal Investigators

University of Washington
John R. Delaney
Deborah S. Kelley
Marvin D. Lilley
David A. Butterfield

Cardiff University
Adam Schultz

Woods Hole Oceanographic Institution
Margaret K. Tivey
Albert M. Bradley
Jozee Sarrazin

University of Miami/RSMAS
David Kadko

Table 1. Data Collected, and Equipment Deployed and Utilized and Recovered

JASON	*Alvin*	Instruments	
SM2000 Sonar	Navigation	9 High-T Probes	12 Vemcos
Digitial Still and Video Grabs	Hi-8	5 T-Resistivity Probes *	3 Gamma Detectors
Data-Event Logger	SVHS Copies	3 MAVS Current Meters	1 Pressure Sensor
HTFP Sampler (Beast) *	8 Gas Tight Water Bottles	Stand Alone Methane (RAS) *	4 Thermistor Arrays
Gas-tight Manifold	5 Major Water Bottles	2 SUCUP data loggers *	Beast-14 samples/ea *
35 mm stills	35 mm stills	3 Medusa/GTX	4 OsmoSamplers
3-Chip video	ICL comms		
ICL comms	Digital stills		
Hi-8			

*Newly developed instruments being used for first time.

Instruments were deployed in June/July during the *Jason/Alvin* program (AT03-53), and recovered in September using *Alvin* (AT03-56). Hobos were placed at Hulk, Grotto, Salut, and a T-Resistivity probe placed at Grotto. All other instruments were placed within a 150 m x 150 m area encompassing the Bastille cluster, the S&M structure, and MilliQ. Instruments were placed in 6 areas of diffuse flow (north of S&M, southeast of S&M, Easter Island, at the north point of MilliQ (DK-1), and just west of MilliQ (DK-2)). Instruments monitored high-T activity at Bastille, Peanut (just south of Easter Island), Cannaport, Puffer, Sully, MilliQ, and S&M. Digital stills were taken as well as video mosaics of faunal communities at instrumented sites. Repeat fluid sampling was done at numerous sites allowing characterization of diffuse and focused fluids, and investigation of temporal changes in fluid chemistry.

Night program: CTD and Sea Beam
Discovered two new areas:

- Cathedral Complex west of MEF
- New field north of Salty Dawg Field

ICL communications and SUCUP dataloggers allowed communication with instruments while they were in place on the seafloor.

The ICL (Inductively Coupled Link) interface allows:

- non contact serial communication using the pulsed ac magnetic field of a coil of wire
- communication between instrument and sub or ROV *without* direct electrical contact
- half duplex bi-directional communication at any baud rate up to 9600

It uses two or more loops with associated electrical interfaces ("modems"), operates on an unregulated supply between 8 and 15 volts, and uses only about a microwatt of power while waiting for a signal.

The ICL can be used:

- to talk to small ROV or sub tools (e.g., temperature sensors attached to water bottles; includes "wake up on incoming data" capability so instrument can shut down when idle and wake up whenever queried)
- to monitor an instrument's performance (eavesdrop) and sample data being collected
- as a terminal interface to an instrument (with the ICL providing total electrical isolation)
- to change data sampling rates or other parameters

The SUCUP Data Recorder (Standalone Underwater Communications UPlink) is a flea powered data logger w/16 Mbytes of storage and two serial ports interfaced to ICL coils

It can be used:

- to "eavesdrop" on instruments to get snapshots of their data or to verify proper operation
- as "inquisitors" to initiate and record data dumps without disturbing instruments

Quantitative Investigation of Aqueous Organic Compounds in Ridge-Crest Hydrothermal Fluids

Jeff Seewald

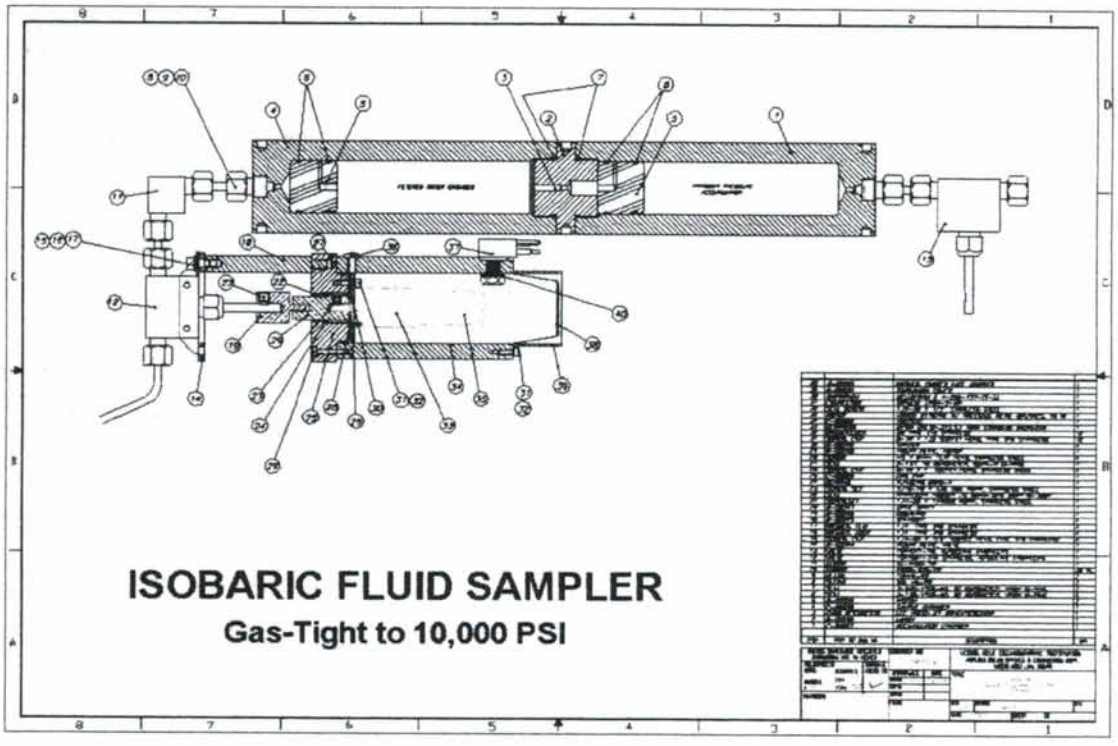
Woods Hole Oceanographic Institution

Goals:

- Develop a gas-tight fluid sampler for quantitative characterization of aqueous organic species
- Determine the composition and abundance of organics in Middle Valley and Endeavour vent fluids

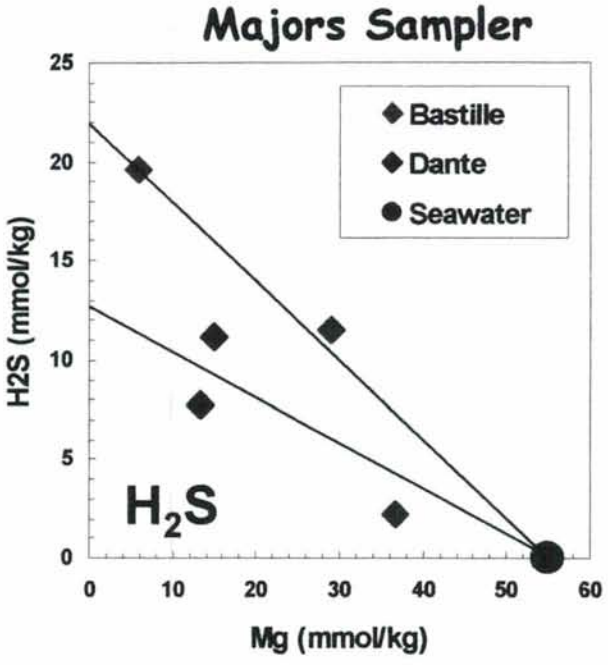
Motivation:

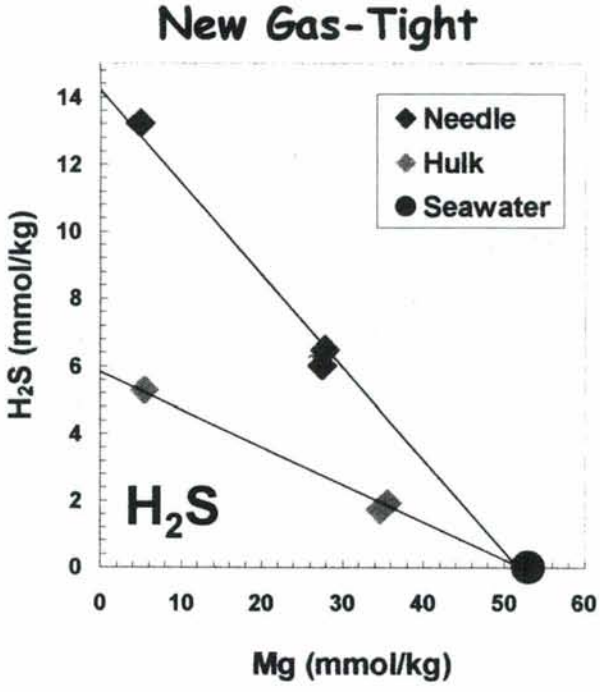
- Semi-volatile organic species
- Diffuse fluids require control of fill rate
- Eliminate separate major and gas-tight fluid samples



Results:

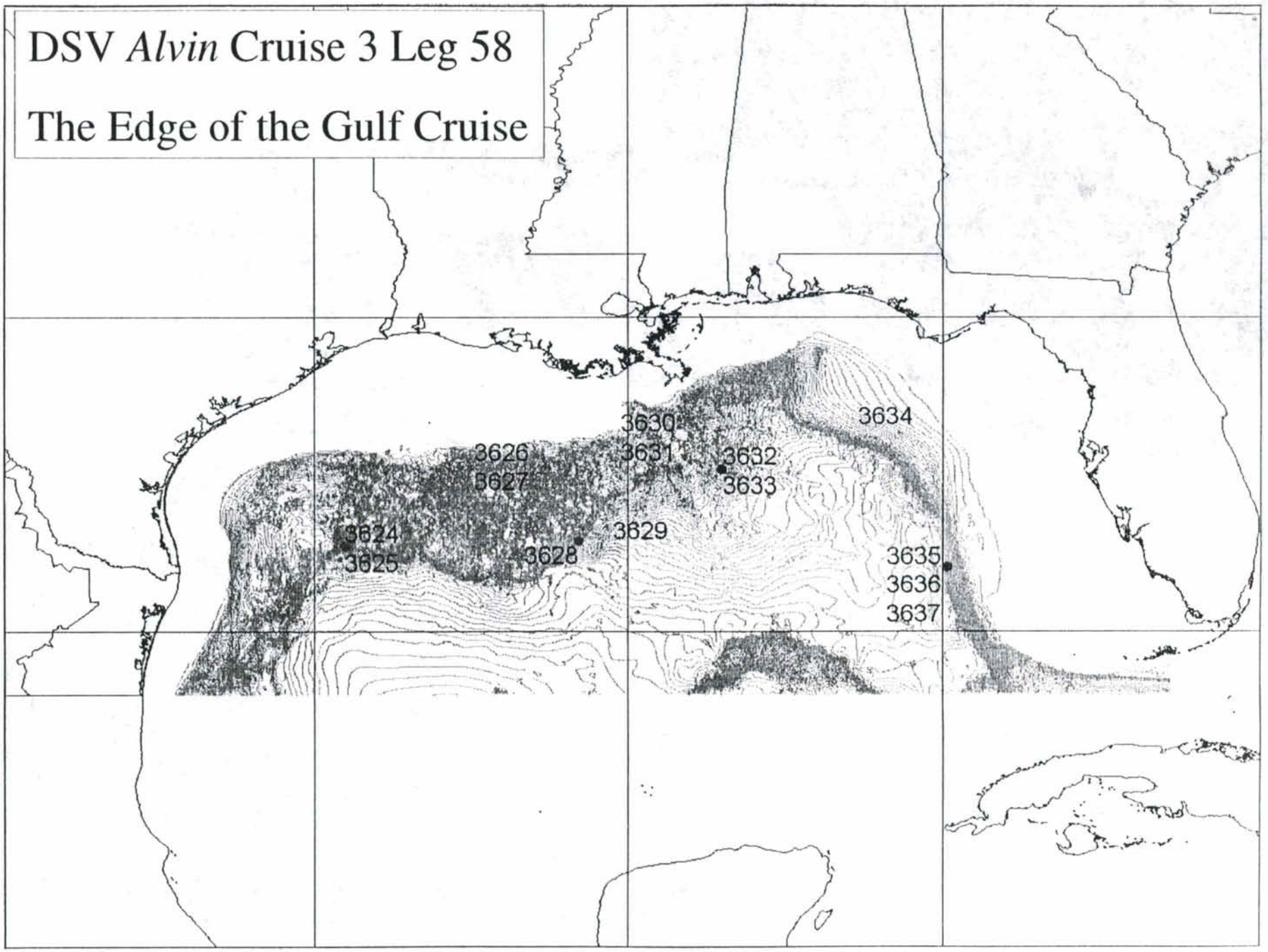
- Prototype tested in Sept. 1999
- 10 dives at Main Endeavour and Middle Valley, July 2000
  - Sampler deployed 35 times without a malfunction
  - Comprehensive dataset for quantitative characterization of aqueous organics





Suggestions:

- Functionality would be improved by a reliable, non-hardwired, off-the-shelf, digital communications device such as ICL



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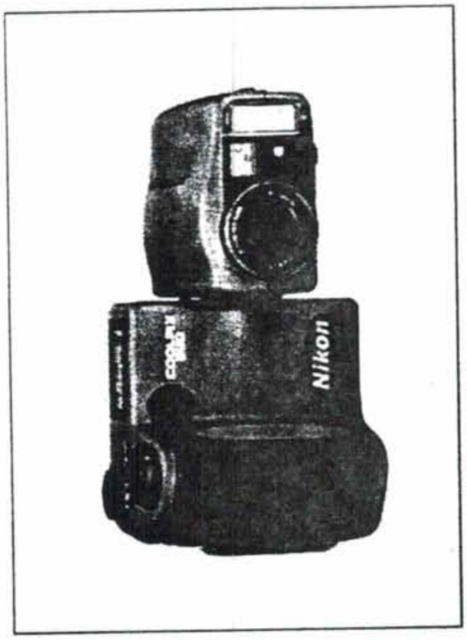
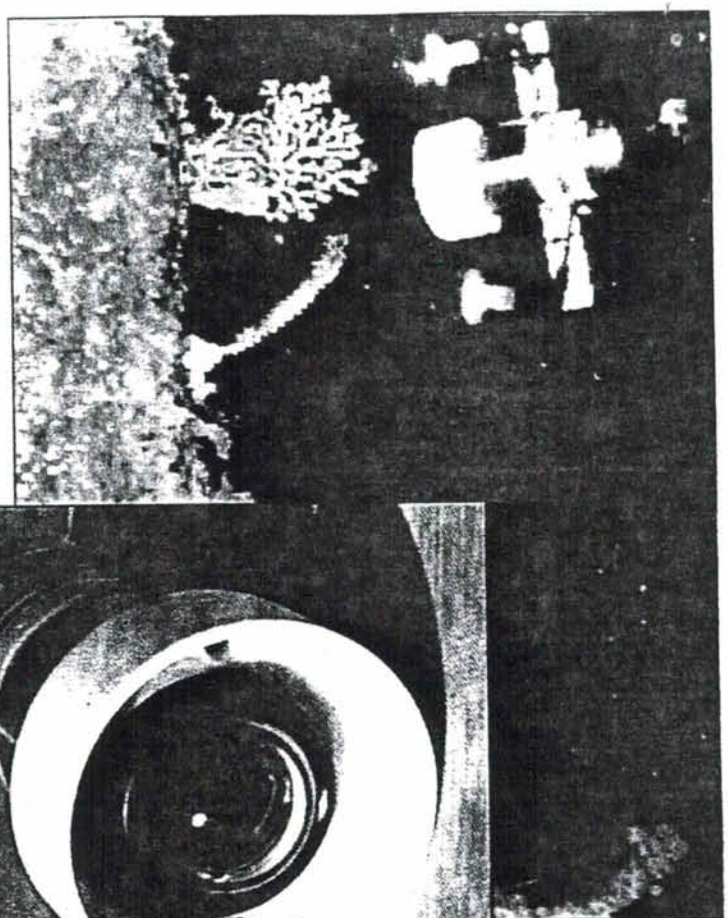
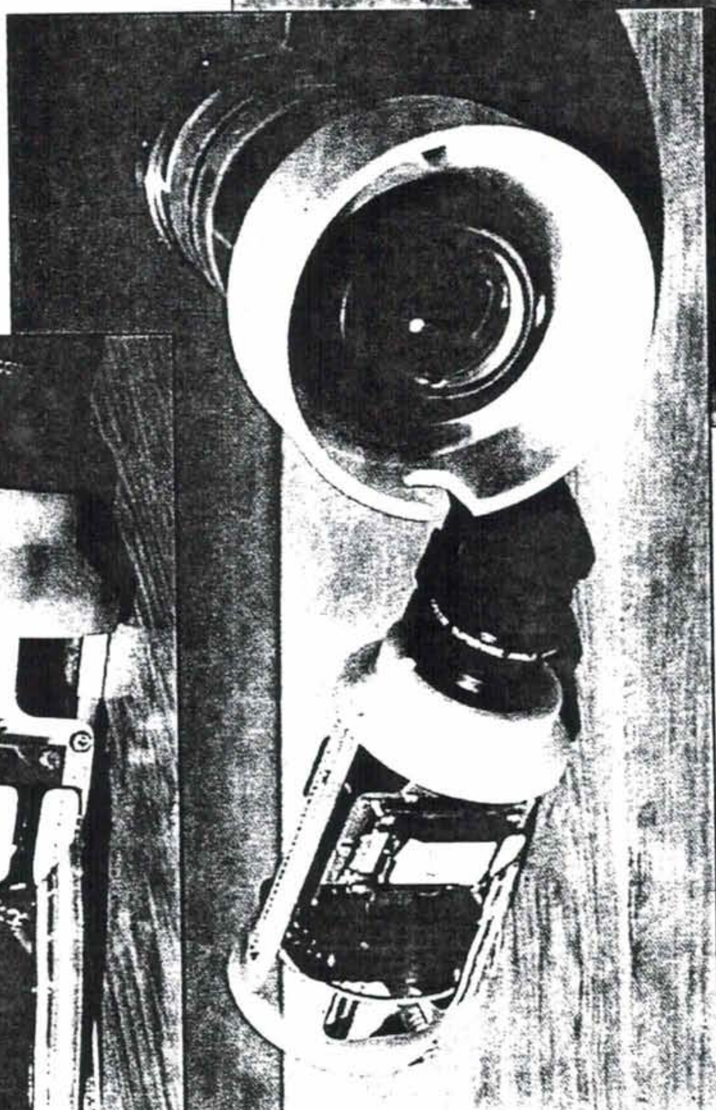
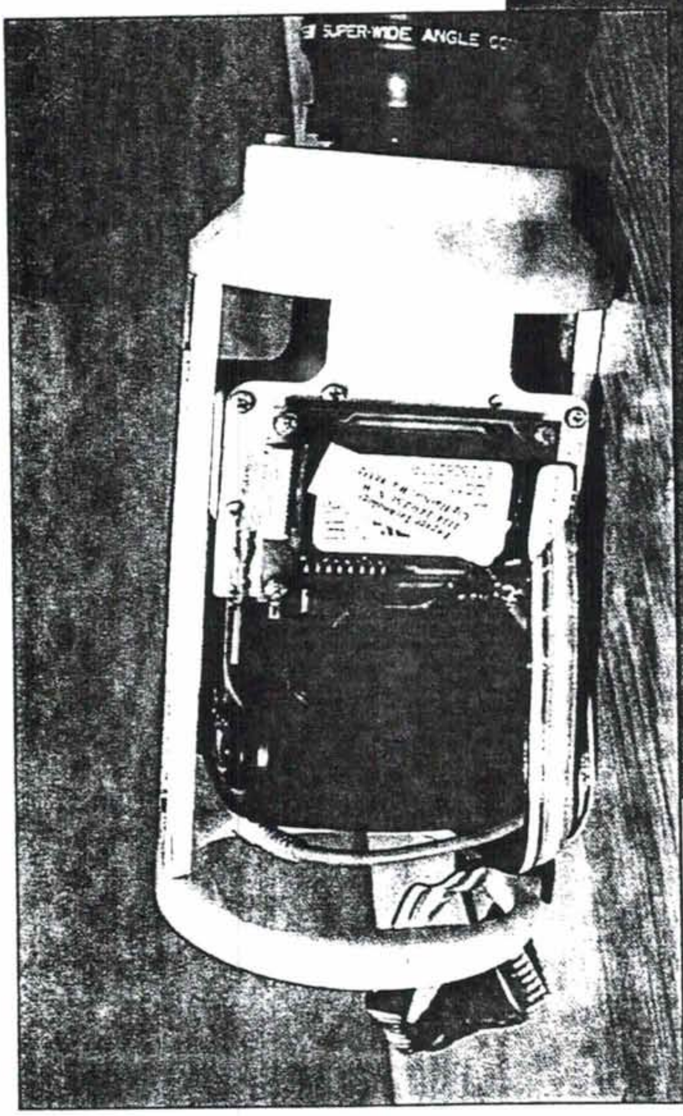

Nikon





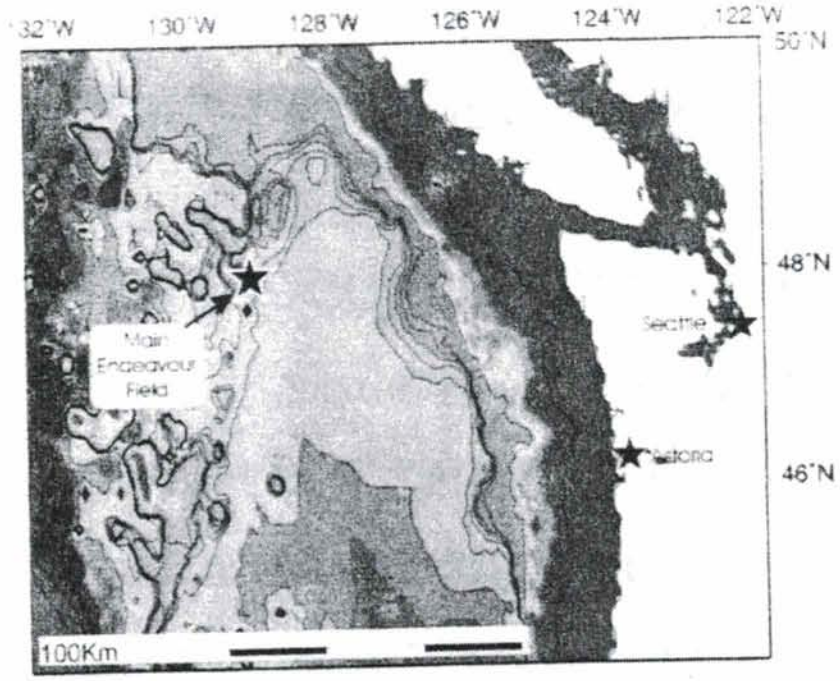


vip1.ppt

VIP (Vents Imaging Pacific) 2000 Cruise (Thompson/Jason 21-31 July)

RIDGE Observatory: Main Endeavour Field

- Panoramic imaging: Salut, S&M, Grotto, Peanut-Puffer-Bastille cluster
- Time series: Grotto 24 hours
- Flow rates:Grotto plumes;coherent Doppler
- Diffuse flow:Acoustic scintillation mapping
- *In situ* T and flow rate: VIP@ Grotto; Observatory instruments @other sites



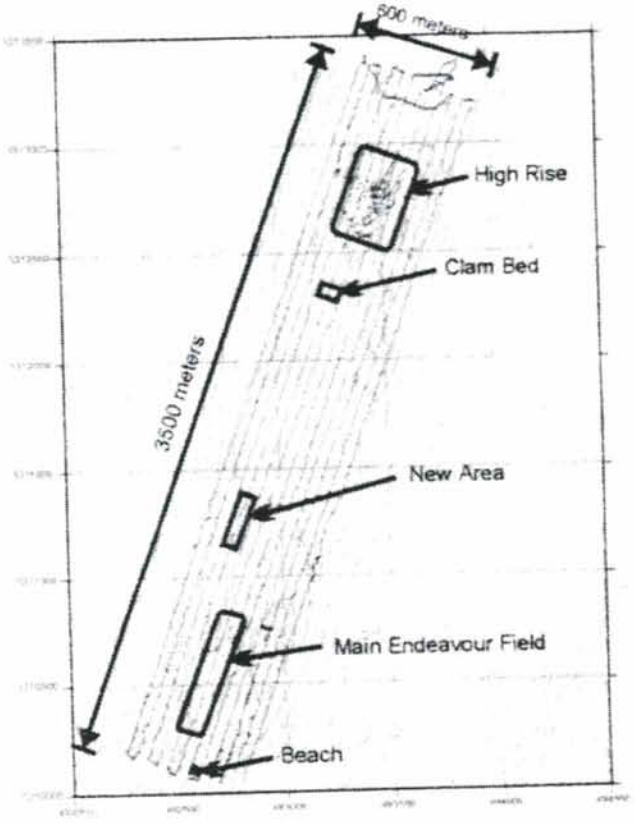
THERMAL GRID

Sept 27 - Oct 8, 2000

Paul Johnson, Susan Hautala, Chris Jones, Maurice Tivey, Matt Pruis, Irene Garcia-Berdeal, Lisa Gilbert, Janet Voight, Maia Tsurumi, Tomoko Kurakawa, Phyllis Lam, Bill Fredericks,

JASON GROUP: Andy Bowen, Matt Heinz, Will Sellers, Jon Howland, Tom Crook, Bob Elder, Steve Lerner, Mark Drewery, Fran Taylor, Sarah Webster

and Dana Yoerger helped with the map...



GOALS OF THE THERMAL GRID PROGRAM

1. **QUANTIFY THE THERMAL BUDGET OF CRUSTAL FORMATION,** [how much?]
2. **SPECIFICALLY, DETERMINE THE HEAT DISSAPATED AS DIFFUSE VENTS AND CONDUCTIVE HEAT FLUX,** [how?]
3. **DETERMINE THE PATTERNS OF CRUSTAL FLUID CIRCULATION.** [where?]

METHODS

1. **IDENTIFY REGIONS OF DIFFUSE VENTING** [near bottom CTD & AST surveys]
2. **MEASURE VERTICAL HEAT FLUX IN THESE AREAS** [MAVs and thermal blanket]
3. **INVERT THE SURFACE EXPRESSION OF HEAT FLUX TO CONSTRAIN SUB-SURFACE CIRCULATION PATTERNS.**

JASON NEAR-BOTTOM SURVEY OF ENDEAVOUR AXIAL VALLEY

area: 3500 meters by 650 meters

20 m altitude: 50 m line spacing

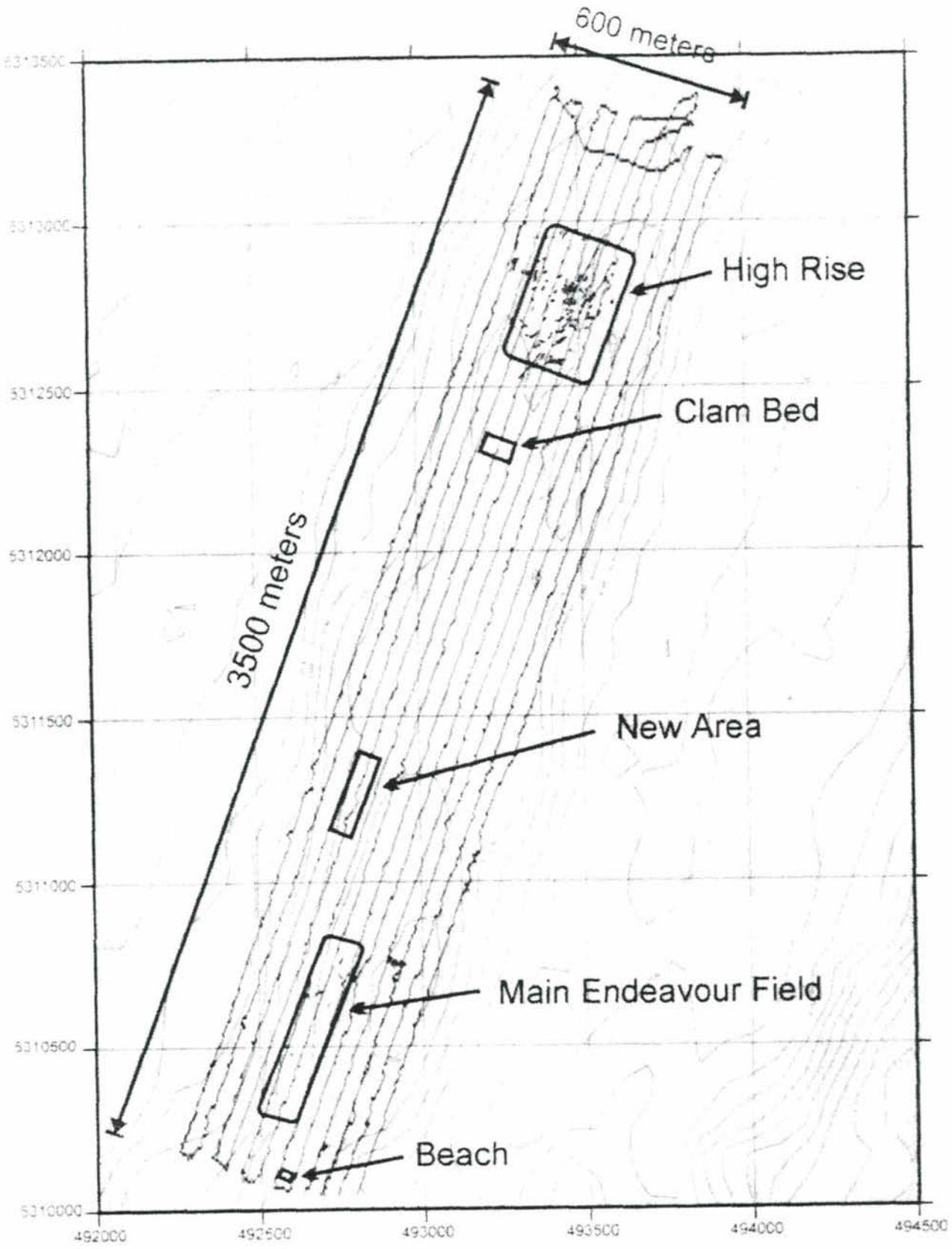
SM2000 (high resolution bathymetry and acoustic scintillation to find diffuse vents)

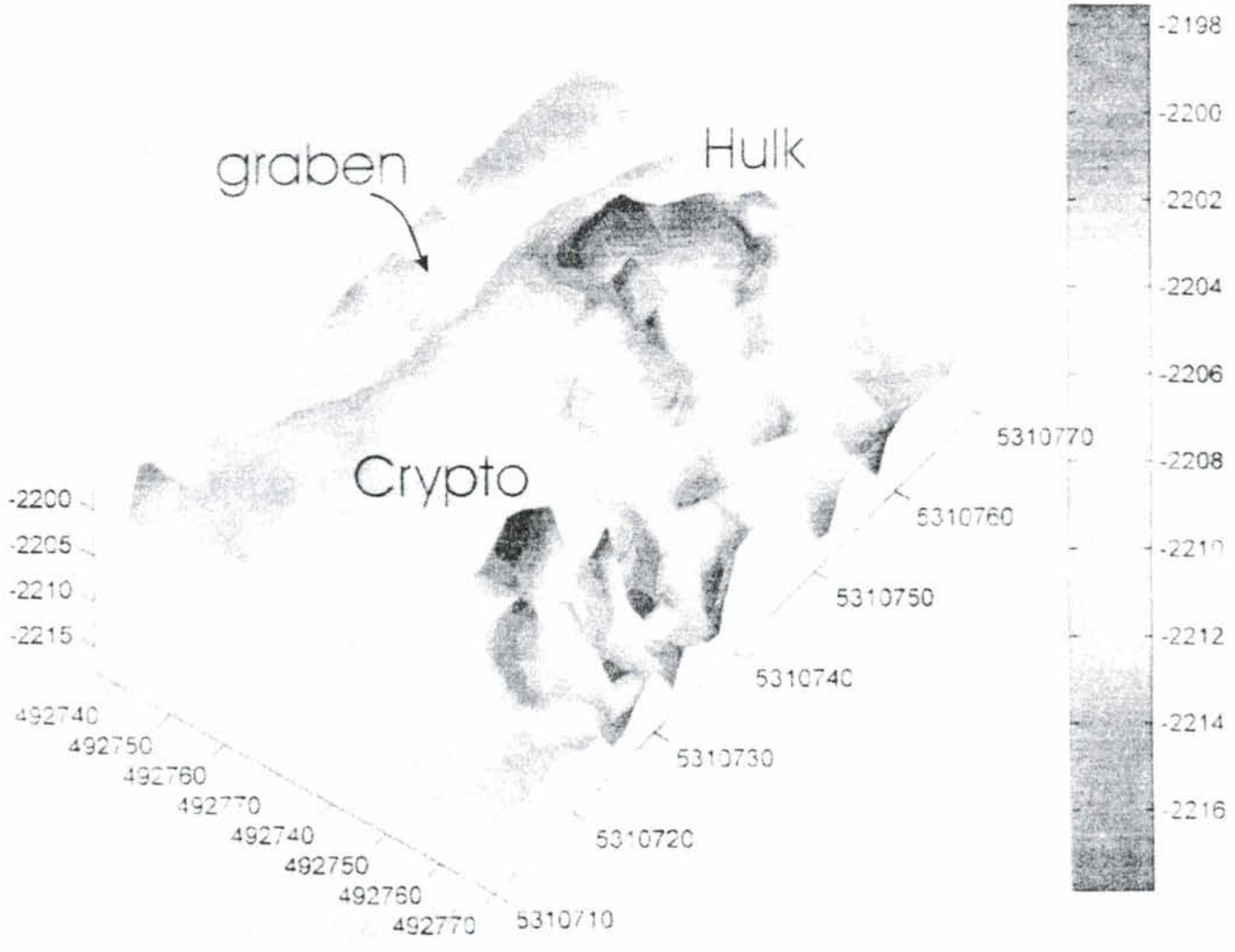
TWO CTDs (as vertical gradiometer)

magnetometer

particulate flux (backscatter and transmission)

dissolved oxygen


600 meters
3500 meters
High Rise
Clam Bed
New Area
Main Endeavour Field
Beach
5313500
5313000
5312500
5312000
5311500
5311000
5310500
5310000
492000
492500
493000
493500
494000
494500


graben
Hulk
Crypto
-2200
-2205
-2210
-2215
492740
492750
492760
492770
492740
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492760
492770
5310770
5310760
5310750
5310740
5310730
5310720
5310710
-2198
-2200
-2202
-2204
-2206
-2208
-2210
-2212
-2214
-2216

INSTRUMENTS DEPLOYED (for 12 months)

1. MAVs current meters and thermistor strings (8)

2. Seafloor magnetometer and tiltmeters (4)

3. Thermal Blanket (1)

4. High Temperature HOBOS (2: at Milli-Q and Clam Bed)

5. Low Temperature HOBOS (8)

SECOND LEG OF THERMAL GRID IS

13 JUNE to 3 JULY, 2001

[now, all we need is an earthquake...]

Recommendation for Equipment Modification for JASON II

• Evaluate impact of integrating bottom track XYZ velocities in topside code for JASON auto X-Y control system (instead of using displacements).

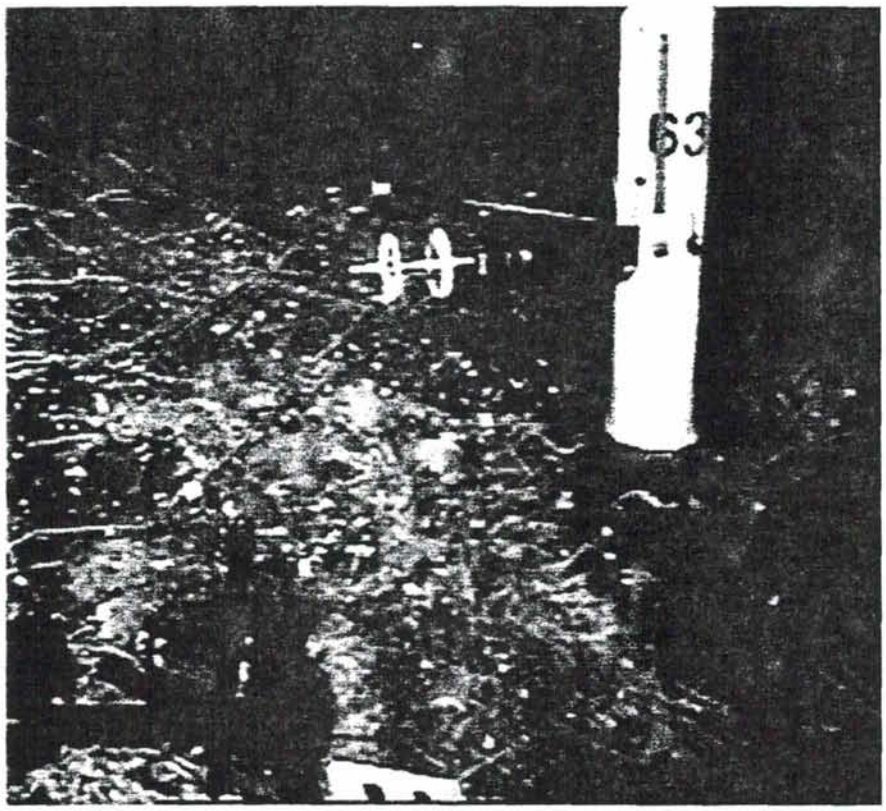
• Assuming quality of positioning information does not degrade, modify software so that existing RDI ADCP can be used in a mode (e.g., PD0) which collects water column velocity data as well as bottom-track velocity data.

Reasons:

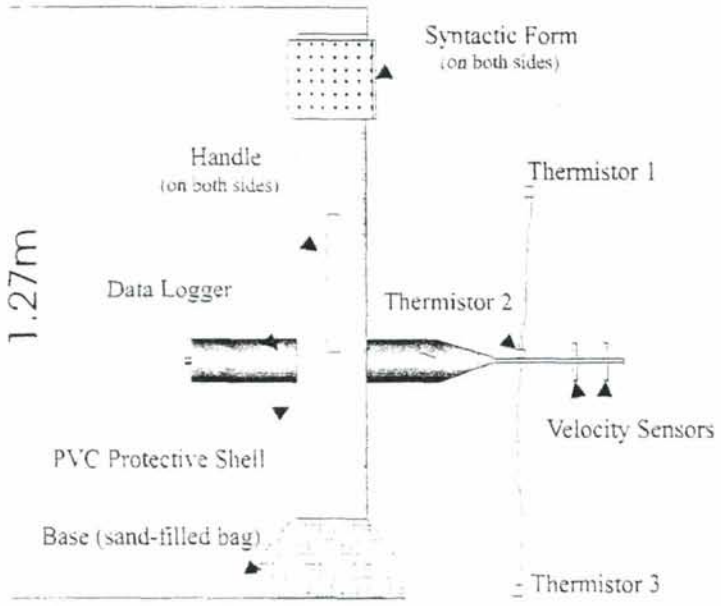
• Cost-effective enhancement of measurement capability

• Velocity data would be useful for existing operations
  - Finding location of sources of thermal anomalies or "smoke"
  - Deciding in-situ instrument location and/or orientation
  - Establishing best direction of approach to high temperature vents

• With water velocity measurement capability, a number of new questions could be explored
  - Simultaneous mapping of property and velocity fields
  - Assessing near field differences at given locations from moorings measuring larger scale flow
  - Timeseries studies of property (acoustic scintillation, temperature, salinity, particle concentration, etc.) variation with local tidal flow
  - Mapping of near bottom (to 30 m.a.b.) flow environment in mean and on tidal timescales.
  - Alteration of near bottom flow by high temperature sources ("the entrainment problem")



MAVs DIAGRAM



Deep Submergence Requirements

1. Accurate location and relocation of seep patches and gear elevator on the seabed for experiment deployment and recovery (colonization trays, flux meters)

2. Precise coring of small-scale seep features (microbial mats, clambeds, pogonophoran patches.

3. Collection of undisturbed core samples that maintain the vertical integrity of porewaters, bacteria and animals (in tough sediments)

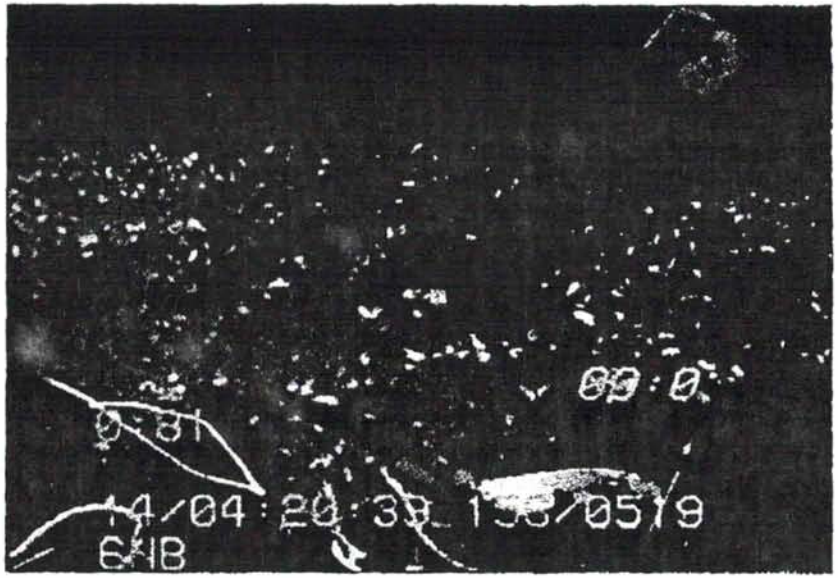
4. Collection of individual specimens from known settings

5. Photographic documentation of sampling, expt. gear, surroundings

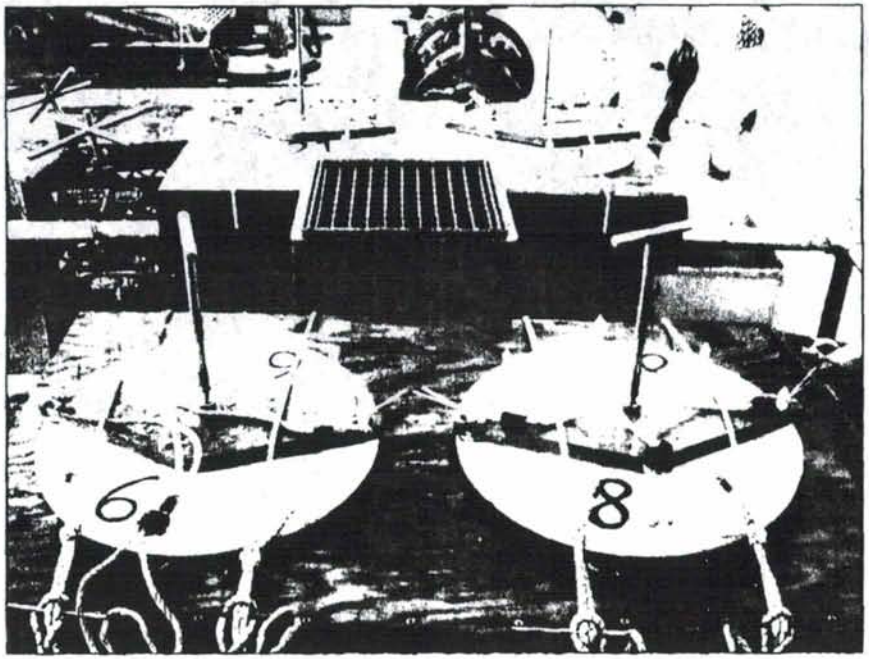
6. Versatile support ship:

- **multicore, gravity core, CTD deployment**
- **accomodation of ROV and Isotope van**
- **sufficient space for scientific party/laboratory work**

Stable isotopic analyses ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$) of sediments, animal tissues, dissolved CO_2, and methane are used to examine the role of methane and chemosynthesis in nutrition of seep animals and nearby epifauna.



Sulfide-release, colonization experiments (6 mo deployment)are examining the recruitment of macrofauna to slope sediments with and without sufide, both inside and outside seep patches.



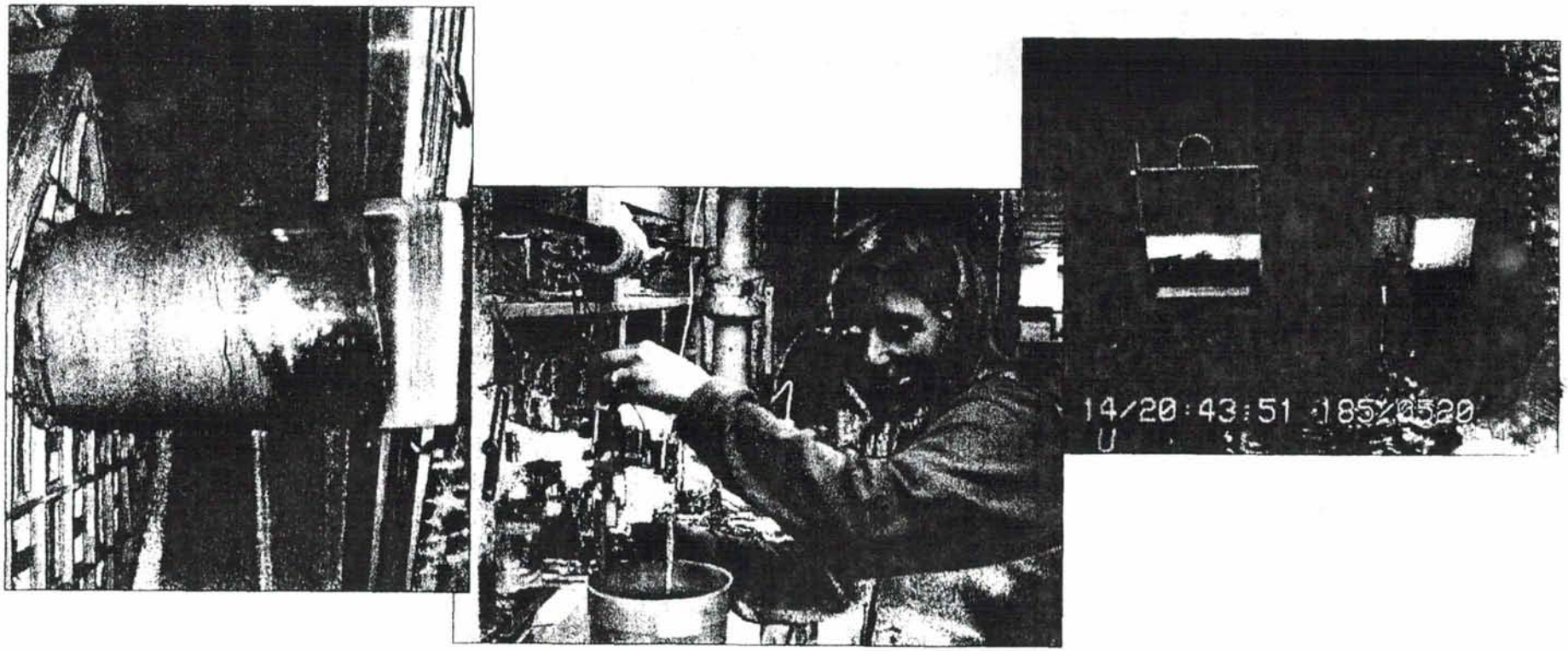
Gear elevator with 4 trays

Colonization Tray on seabed

Research Approaches

Mensurative studies involving combined use of :

* biological community data (coring)
* porewater chemical profiles (microelectrodes,squeezing)
* fluid flow rate measurements (flux meters)



Research Questions

1. Do seep macrofaunal communities exhibit distinct taxonomic composition, standing stock and diversity relative to other continental margin assemblages?

2. How important is chemosynthesis as a nutritional pathway for seep macrofauna? Do they contain chemosynthetic symbionts? Do seep faunas provide energy for adjacent, non-seep assemblages?

3. To what extent does the seep geochemical environment structure macrofaunal communities?

- **Do porewater geochemistry and fluid flow rates determine the composition, abundance or vertical distribution of macrofauna?**
- **Do sulfides provide settlement cues for macrofauna?**
- **Are sulfides required for successful growth or are they toxic to some infauna?**

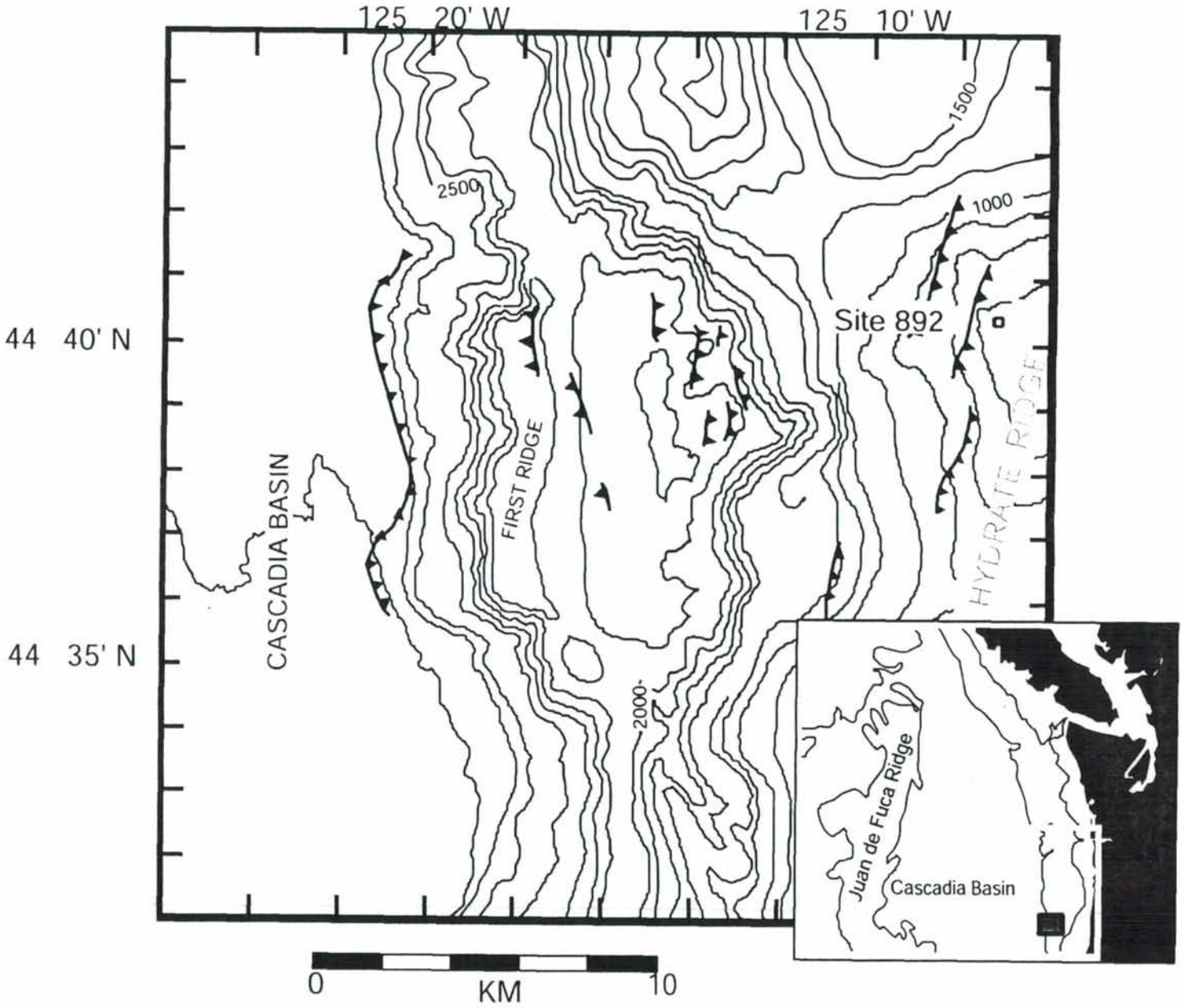
4. Do foraminifea tests at seeps record methane release isotopically?

- **Can they be used as paleoclimate indicators?**

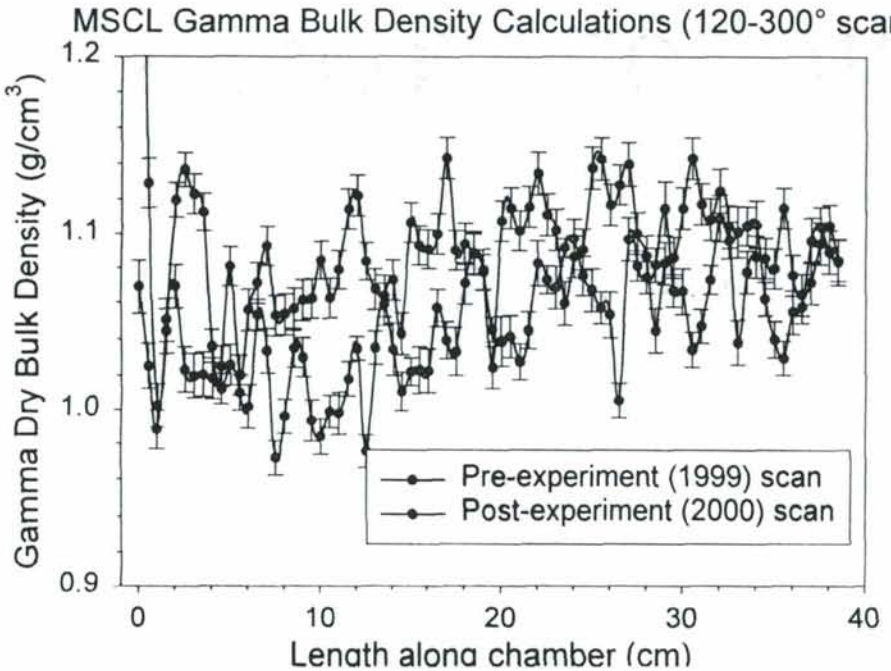
Active C Flux on the Cascadia Accretionary Prism: *In-situ* Measurement of Hydrocarbon Sequestration as Gas Hydrates and Authigenic Carbonate Deposits

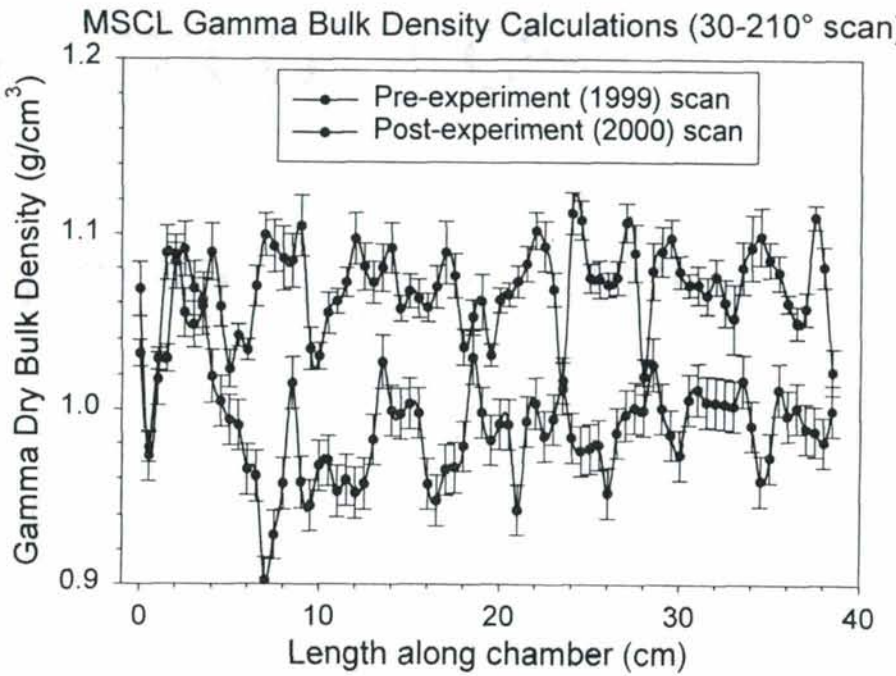
Co-PI's: Bobb Carson, Miriam Kastner and Doug Bartlett

(Hans Jannasch)


125 20' W
125 10' W
44 40' N
44 35' N
1500
2500
1000
2000
Site 892
CASCADIA BASIN
FIRST RIDGE
HYDRATE RIDGE
Juan de Fuca Ridge
Cascadia Basin
0
KM
10

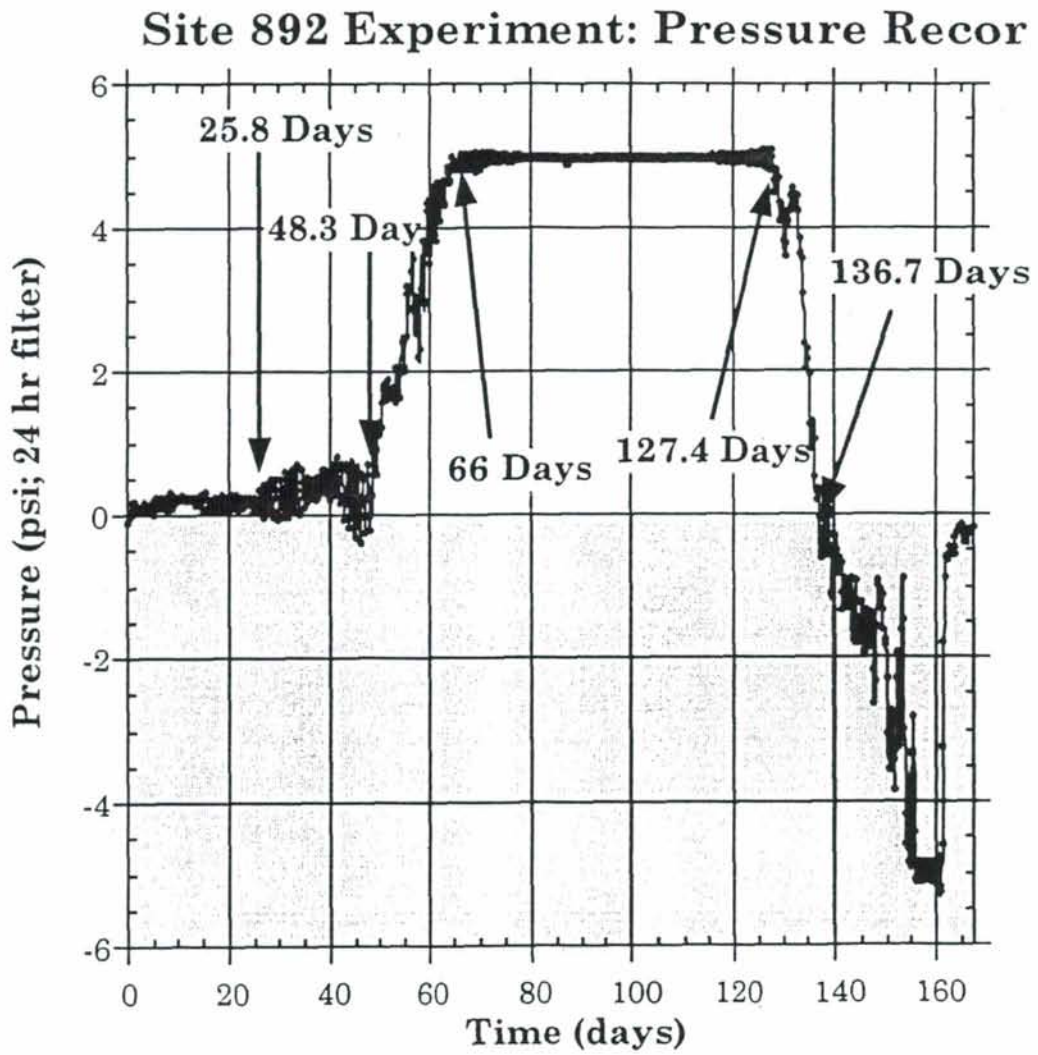
Oxic Carbonate Chamber



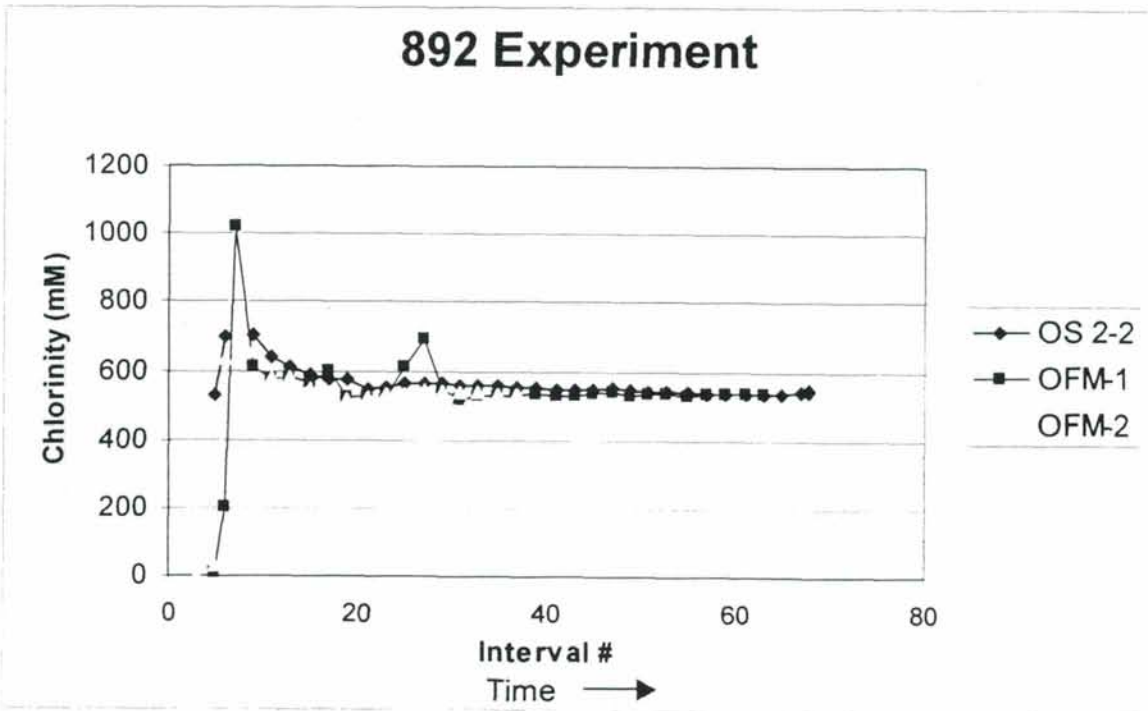


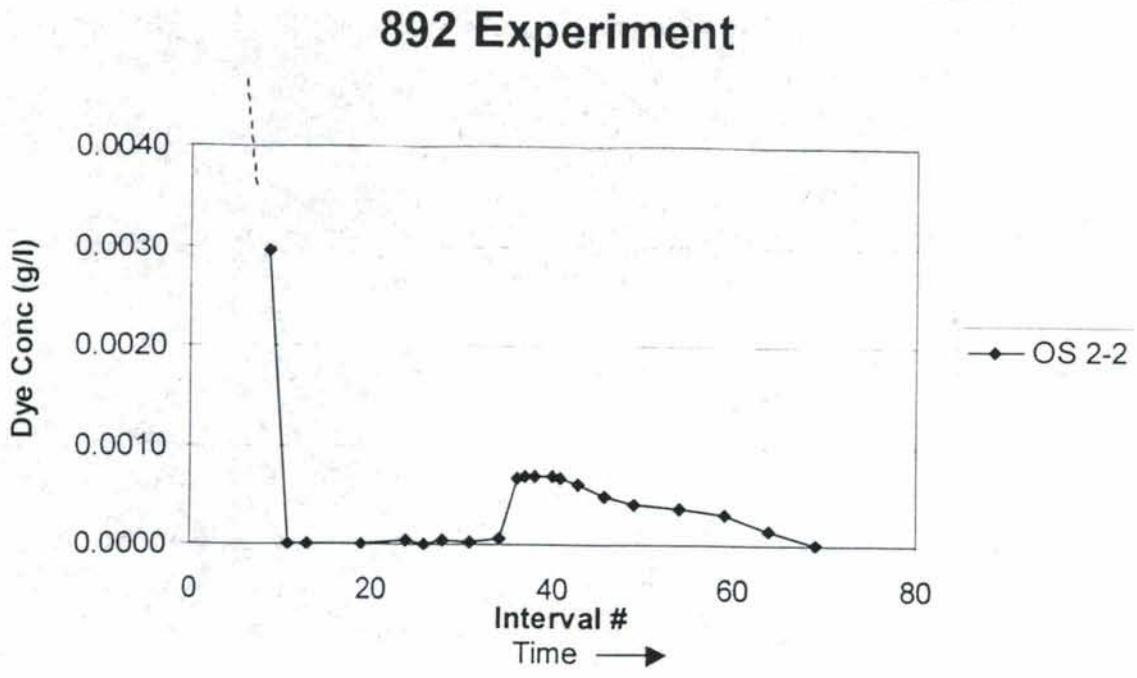
Methane Oxidation and Carbonate Precipitation & Dissolution Reactions

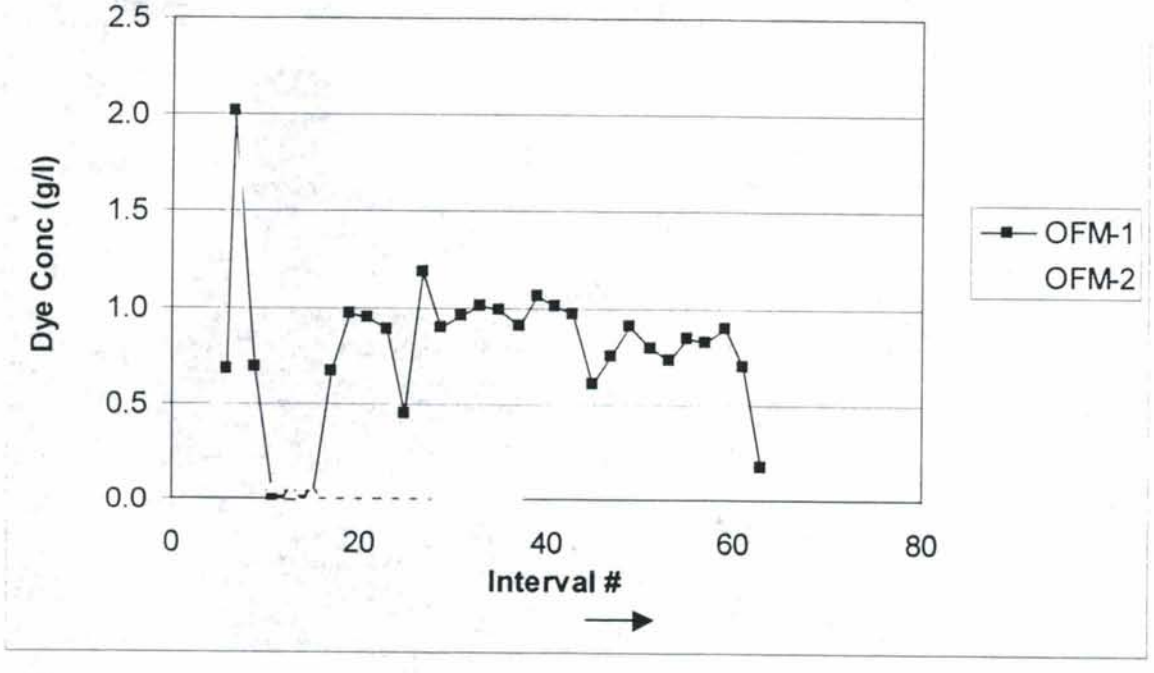
- $CH_4 + 2O_2 = CO_2 + 2H_2O$
- $CH_4 + SO_4^{-2} + Ca^{2+} = CaCO_3 + H_2S + H_2O$
- $CaCO_3 + CO_2 + H_2O = 2HCO_3^{-} + Ca^{2+}$

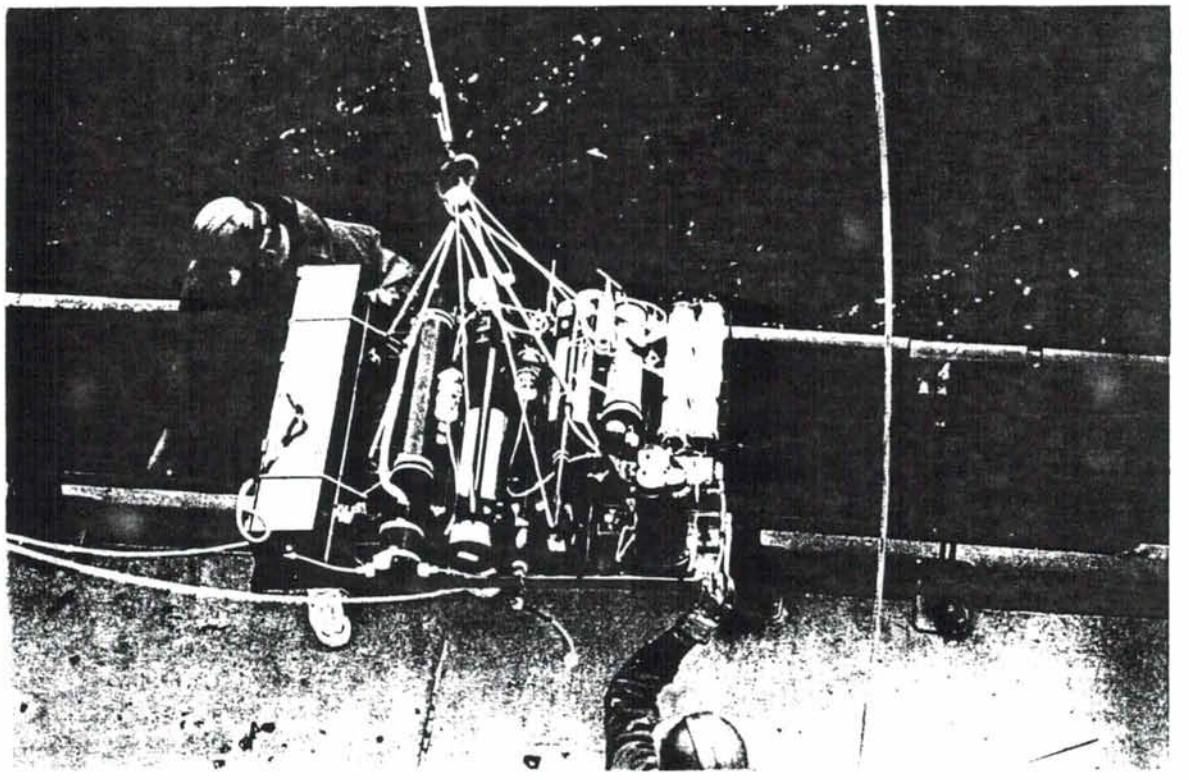


Here is the entire pressure record (with 24 hour filter). It covers 167.4 days. Note that after day 48, the pressure climbed rapidly to 5 psi. Clearly this increase is due to a blockage of the instrument's flow path downstream from the pressure transducer. PLEASE NOTE that the 5 psi value that extends from day 66 to day 127.4 DOES NOT REFLECT THE MAXIMUM PRESSURE IMPOSED. The pressure transducer used had a maximum capacity of 5 psi. I do not know how to interpret the decline in pressure after 127.4 days. My best guess is that an obstruction formed between at the borehole connector that isolated a the pressure transducer from the hole so that it may have recorded pressures induced by the osmopumps.

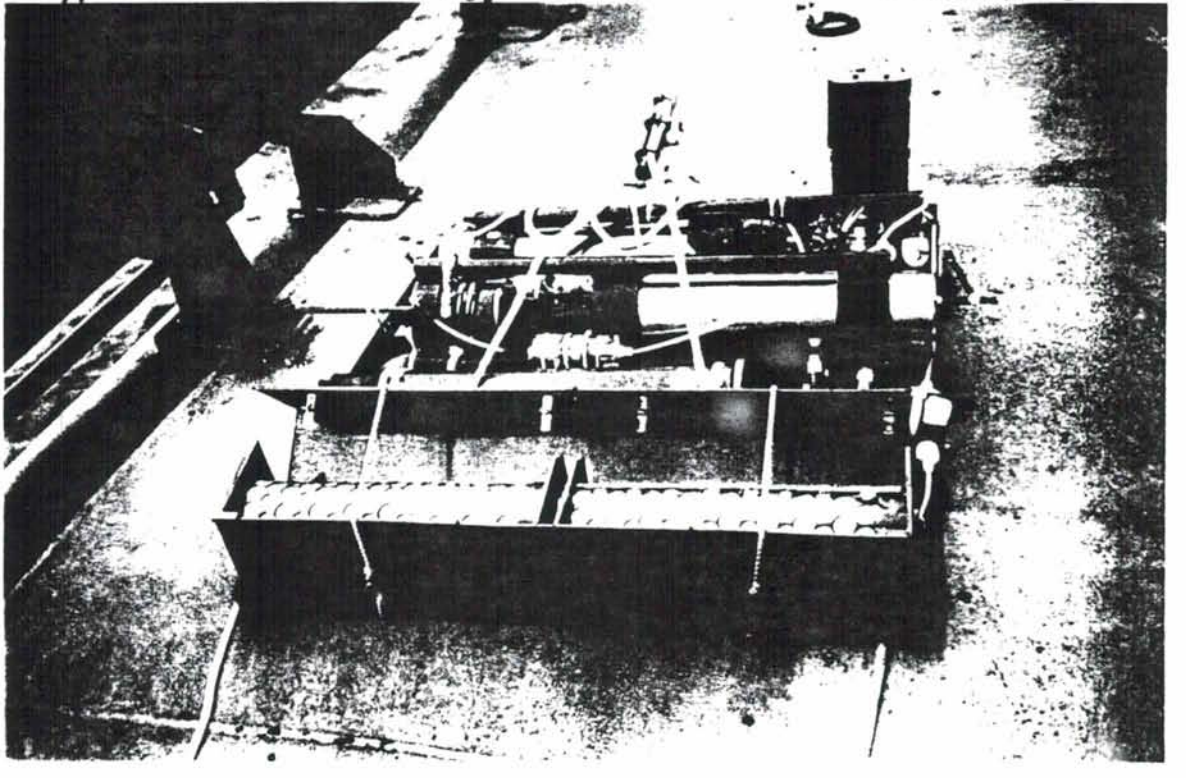

892 Experiment
Chlorinity (mM)
1200
1000
800
600
400
200
0
0
20
40
60
80
Interval #
Time
OS 2-2
OFM-1
OFM-2


892 Experiment
Dye Conc (g/l)
0.0040
0.0030
0.0020
0.0010
0.0000
0
20
40
60
80
Interval #
Time
OS 2-2


Dye Conc (g/l)
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
Interval #
OFM-1
OFM-2

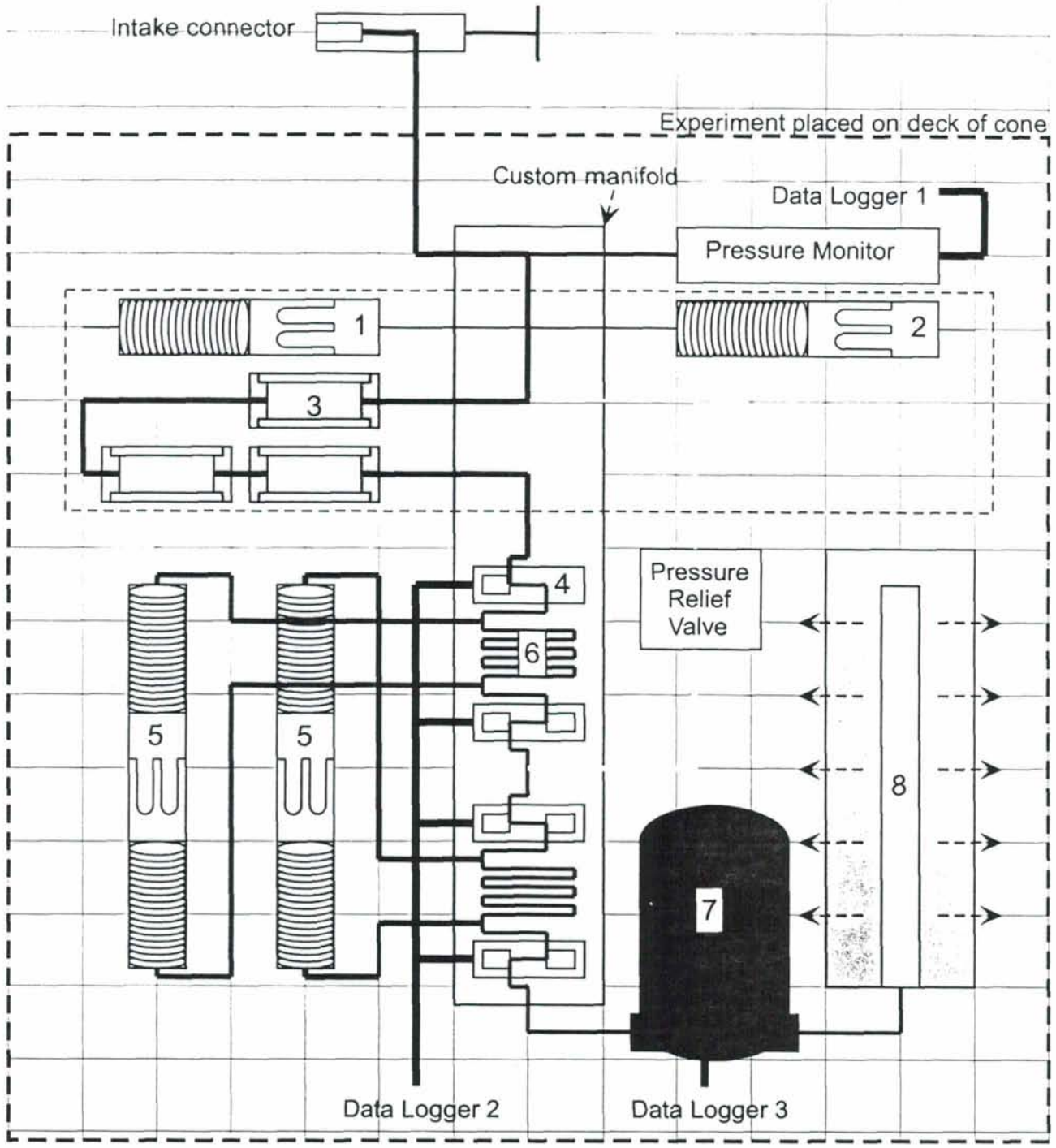


- Osmosamplers → teflon / Cu
- Differential Press. Transducer
- Bypass valve; Data logger
- Reaction Chambers → Anoxic / oxic → carbo / Biolog
- Flowmeters → Osmosamples / Optical Dectors / Heat Pulse

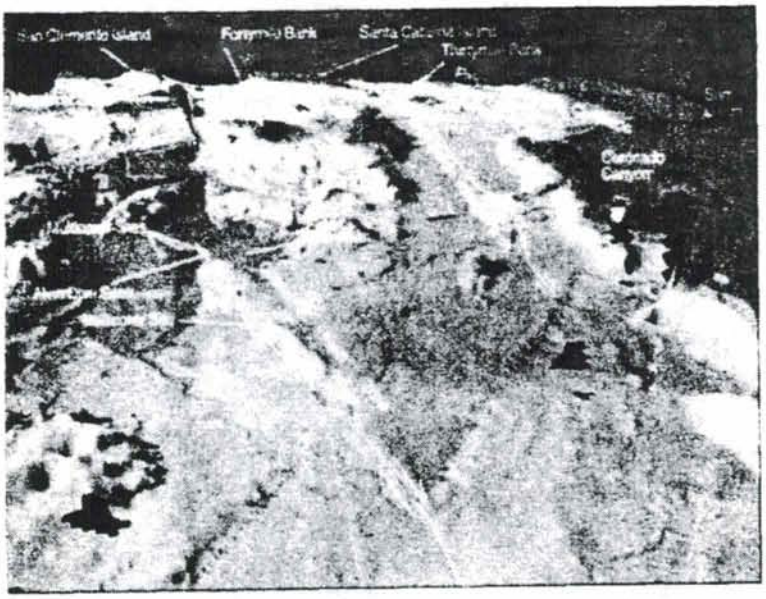


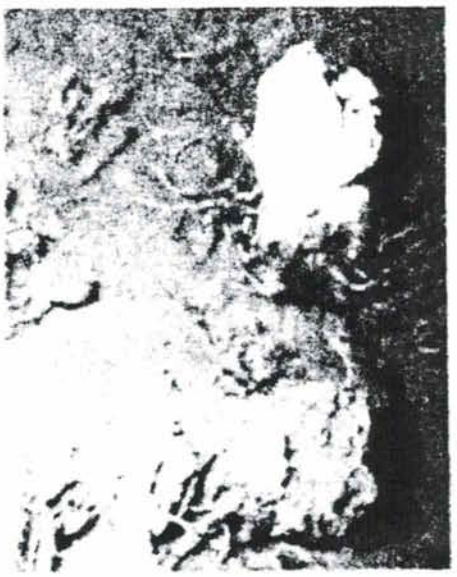
892b Experiment

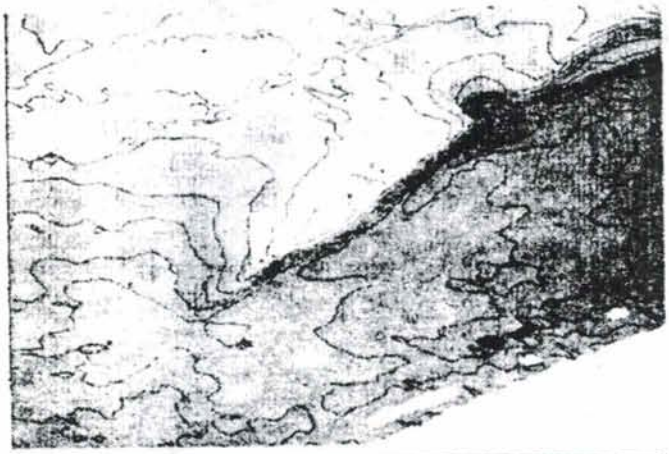
Experiment consists of:
1) Teflon OsmoSampler
2) Cu OsmoSampler
3) 3 @ anoxic cartridges
4) 4@ Optical detectors
5) 2@ OsmoFlowMeters
6) 2@ Mixing coils
7) Heat-pulse flowmeter
8) Oxic chamber

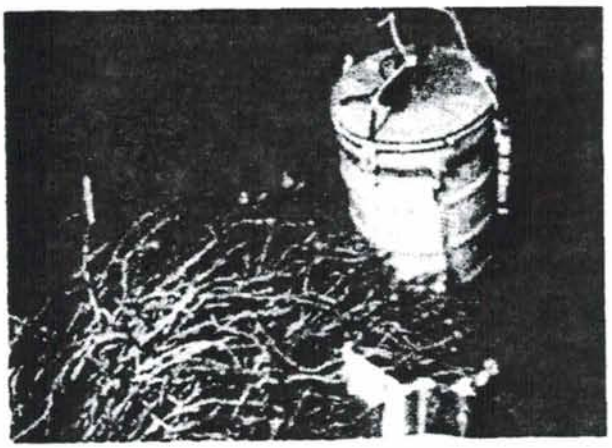


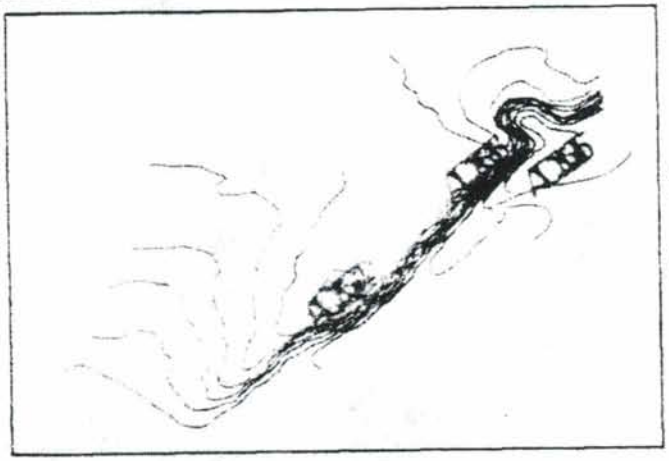
SAN CLEMENTE FAULT ZONE

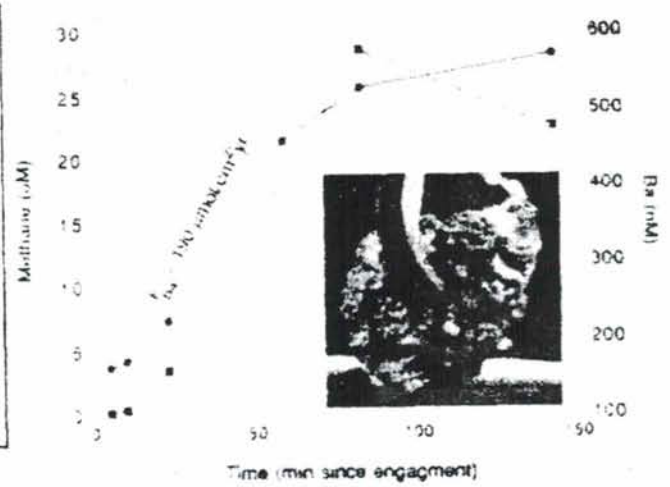










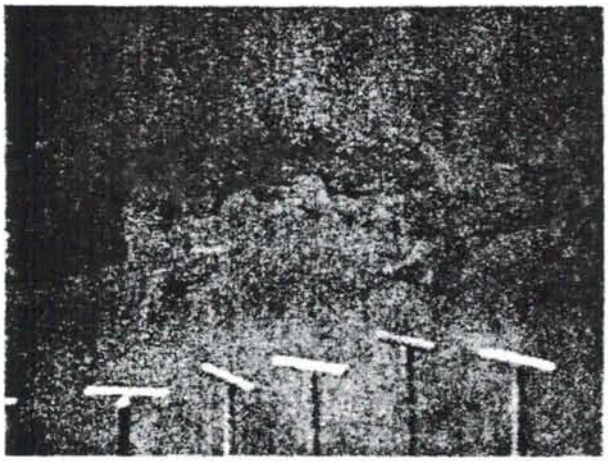


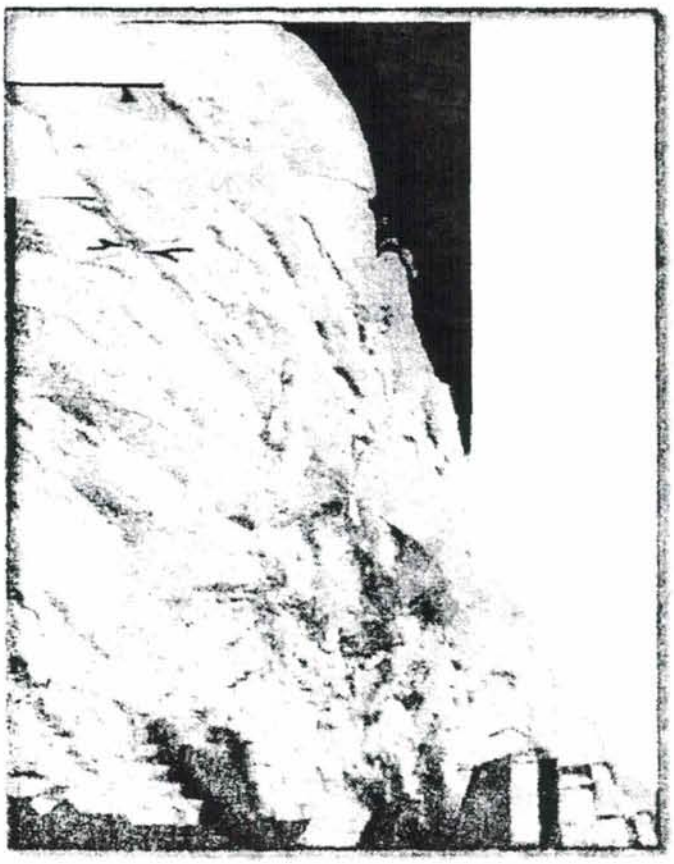
Holocene Rupture of the San Clemente Fault

Alvin dives along the southern San Clemente Fault at Navy Fan reveal young rupture of the fault. These photos show the active scarp with a height of ~ 60 cm. This scarp represents a probable single event rupture, probably less the ~ 300 years old. The blocky scarp has failed along secondary fractures in a more recent slump.

Net Offset Along the San Clemente Fault

New SeaBeam mapping, merged with older data and existing soundings now allows a reconstruction of major faults of the southern Borderland. The reconstructed separations of four piercing points along the dextral San Clemente fault are 59.9, 57.0, 57.6, and 58.9 km respectively. (colored arrows show matching points before and after fault motion). The average value is 58.3 km. The good agreement suggests the point selection is reasonable, and also that the basins and uplifts have been little modified since Miocene extension.





Appendix V

Near Real-Time Access to Deep Submergence Research for Middle-School Students

ED71A-17

Susan Humphris, Dan Fornari, Danielle Fino
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

Dive and Discover

EXPEDITIONS TO THE SEAFLOOR

Objective:

To develop near real-time, web-based links to scientists at sea that will:

- Provide a stimulating learning environment as students share and participate in exploration of the deep ocean
- Promote a better understanding of ocean sciences by the general public

Expedition

Introduction

Daily Update

About the Cruise

Deeper Discovery

Mail Buoy

Introduction

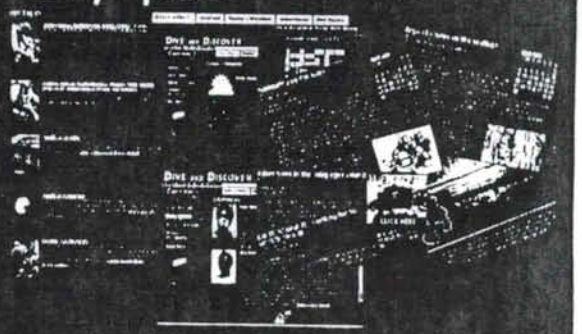
Strategy:

- Develop a web site for middle school (grades 6-8) and the general public to provide near real-time, daily access to deep submergence and oceanographic research conducted using the facilities of the Woods Hole Oceanographic Institution
- Test and refine this web site during four NSF-funded, multidisciplinary field programs in the Pacific and Indian Oceans (1999-2001)
- Provide access to the web site through computer links in selected museums and aquaria throughout the country

Ultimate Goal:

- The conceptual approach we develop will have broad application for ocean-going marine scientists, and will allow them to use similar techniques to promote ocean science education and public outreach at their own institutions

Daily Update



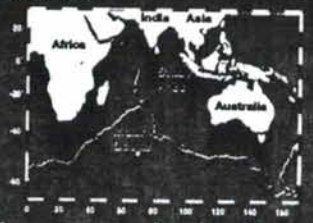
About the Cruise

Mail Buoy

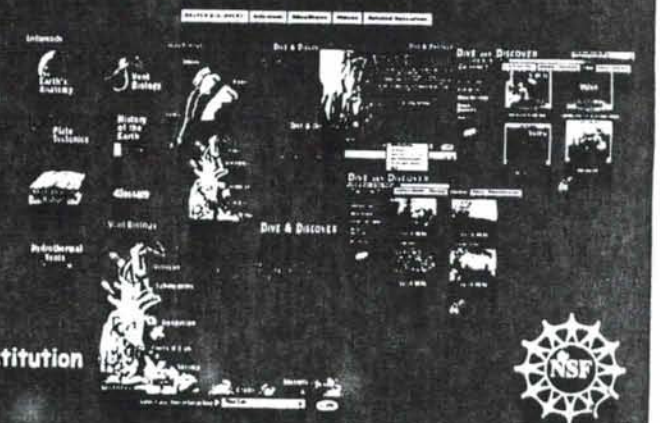
Expedition #4
27 March - 5 May 2001

Join Dive and Discover for a 40 day cruise to explore the mid-ocean ridge in the central Indian Ocean for hydrothermal vents and animal communities.

Scientists from 7 universities and research institutions will use the ROV Jason and other towed instrument systems to make detailed maps of the ridge axis that will help them find and sample hydrothermal vents and their biological communities. What new discoveries will they make? Keep track of the expedition in near real-time through the Dive and Discover web site.



Deeper Discovery

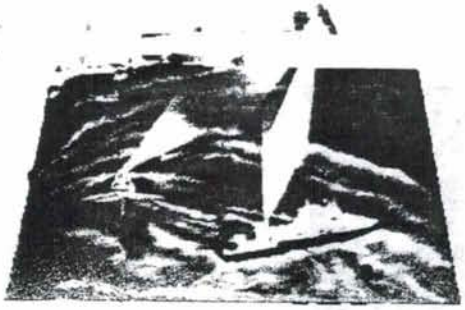


http://www.divediscover.whoi.edu

Funding for Dive and Discover is provided by Woods Hole Oceanographic Institution and the National Science Foundation

Illustrator: E. Paul Oberlander

Appendix VI



http://www.seanet.int

Extending the Internet to the Oceans
Status Update – DESSC, December 2000

- Installed on 6-UNOLS Vessels (Atlantis, Ewing, Melville, Pelican, Seward Johnson, Knorr)
- NSF Award to Continue Operations and Add 3 Additional Vessels in 2001
- Support wireless communications including INMARSAT BHSD (64-kbs)
- Support High Speed Batch File Transfer to/from anywhere on the Internet
- Support Live Interactive Internet Sessions at Sea
- Applications include remote scientific collaboration, outreach, regular satellite image/data transmissions, live Internet access, website mirroring, email, video conferencing, etc.
- Provide Technical and Administrative Support. Provide World-Wide Coverage.
- Additional Benefits: Coordination with UNOLS, Negotiated satellite rates, New technology

Usage Summary

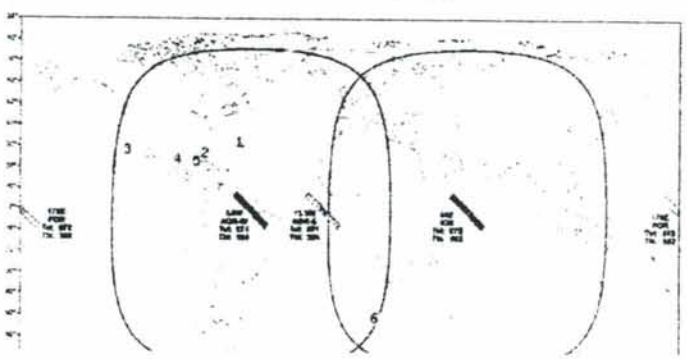
1999: 973 Transmissions, 97 Interactive, 876 Batch, 296.6MB
2000: 2367 Transmissions, 161 Interactive, 2206 Batch, 646.3MB

Summary Usage for 2000 as of December 12

Vessel	Transmissions	Int	Batch	ElapsedTime	Bytes
Atlantis	787	24	763	1 21:40:34	328.7M
Ewing	119	36	83	06:20:00	30.7M
Melville	129	2	127	15:13:21	140.3M
Pelican	203	89	114	09:46:18	60.1M
Seward Johnson	824	1	823	22:57:48	50.1M
Knorr	305	9	296	07:44:56	36.4M

Recent Science Websites: earthguide.ucsd.edu/mar, www.ocean.udel.edu/deepsea
www.divediscover.whoi.edu

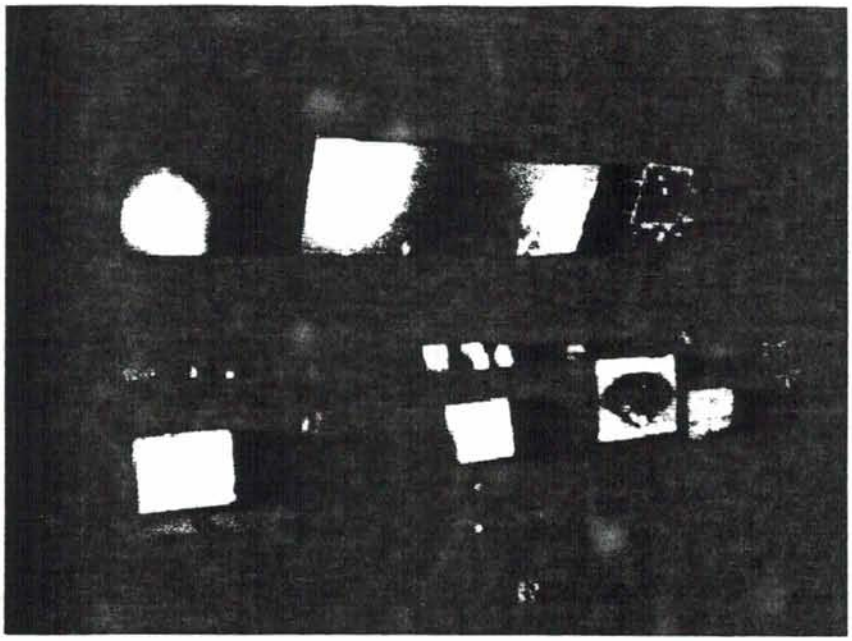
SeaNet Shipboard Locations and Inmarsat Coverage Map
Tue Dec 12 19:22:10 2000 GMT



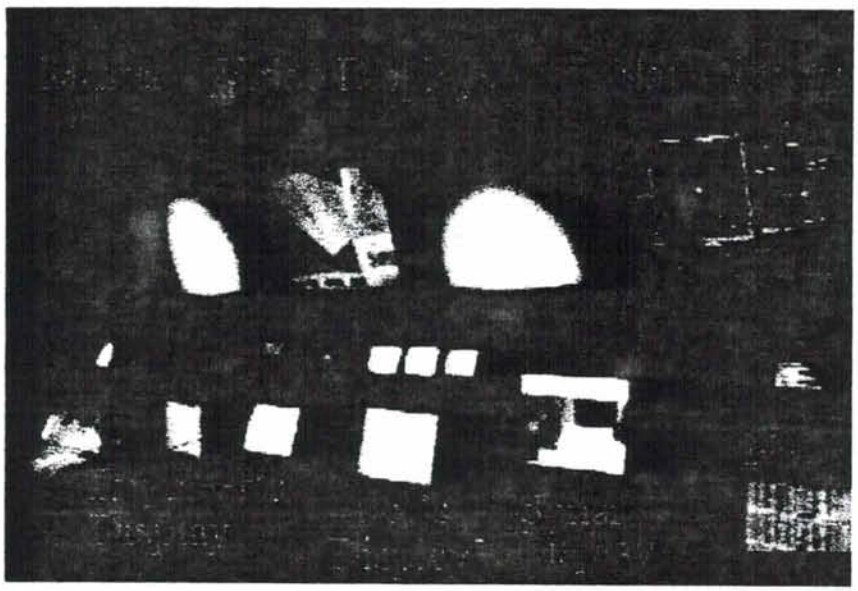
For more information, visit
http://www.seanet.int

At AGU – TOS Booth

Jason Control Van

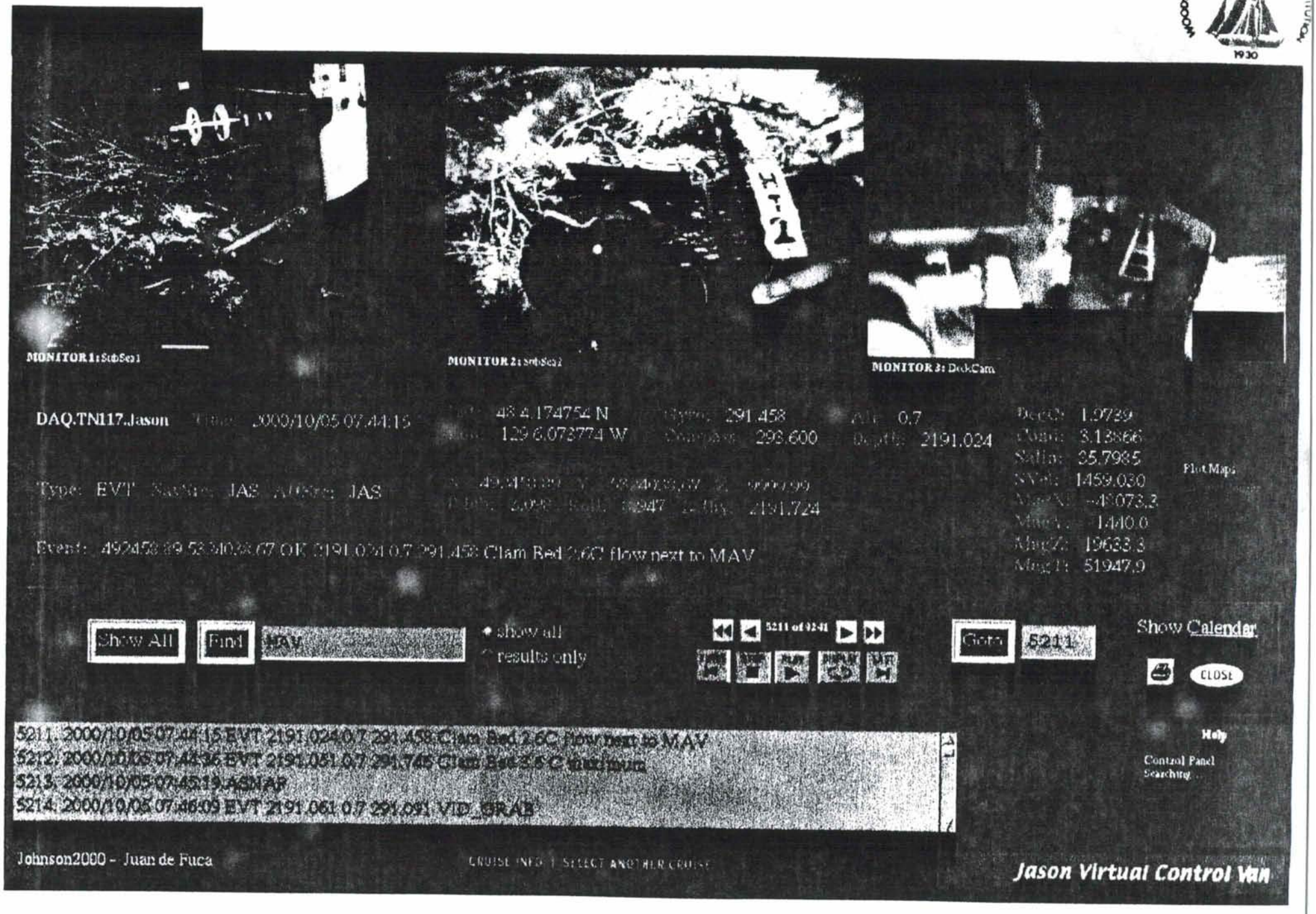


The Control Van is where Pilots, Navigators, and Engineers control remotely operated vehicles (ROV) such as Jason and Argo. Scientists use these vehicles for underwater scientific research.



There is a wealth of information available in the Control Van during ROV operations. This information includes live Video Displays, Navigation Data, Vehicle Data, Scientific Instrument Data, and Events that are entered by Scientists. All of this information is captured and index using a Master Time clock. The Virtual Van is a web-based application that takes snapshots of the information that occurs inside the Control Van during vehicle operations and makes this information available for Scientists and the Public on the web.

Virtual Jason Control Van



This work funded by the Keck Foundation as part of the JasonII/SeaNet upgrade effort.

Virtual Van Capabilities

- **Real-time Monitoring of Control Van for Scientific use and Public Outreach**
- **Provide On-line Integrated Cruise Synopsis**
- **Search Capabilities – Keyword, Time, Events**
- **Plot Capabilities – Geographic and Time series Plots**
- **Cruise Synopsis Repository Available On-Ship and On-Shore**
- **Built-in Automatic Data Acquisition System**
- **Support Real-Time Playback of Prior Cruise Data**

Scientific Applications

- **Real-time searchable data access for dive planning**
- **Integrated events, video snapshots, and vehicle data for rapid searching and data analysis**
- **Plotting capabilities for quality assurance and anomaly detection**
- **Easily locate specific data within data archive (eg; video clips)**

Future Capabilities and Applications

- **Develop Public Outreach User Interface**
- **Integrate with SeaNet for Live Remote Access**
- **Enhance Virtual Van Prototype**
  - **Support for Video and Audio clips**
  - **Additional plotting capabilities**
  - **Algorithm development, data mining, etc.**
- **Integrate with other vehicles such as AUVs, Alvin, etc.**

This work funded by the Keck Foundation as part of the JasonII/SeaNet upgrade effort.

Appendix VII

This website can be best viewed with the Web browsers Netscape Navigator version 3.01 and above, and Internet Explorer

Mission Statement

REVEL (**R**esearch and **E**ducation: **V**olcanoes, **E**xploration and **L**ife) **Project**

The essence of the REVEL Project is the interaction of highly-motivated science teachers hungry for opportunities to engage in science and innovative scientists pursuing cutting-edge research. The scope of this research encompasses a wide variety of scientific problems that range from the origin of life to new aspects of biotechnology.

For example, recent research indicates that in the presence of liquid water, volcanoes on the seafloor can sustain life-forms without sunlight. By inference, volcanoes on other planets may sustain similar life-forms. REVEL explores the relationship between different types of volcanoes and life, using this central concept to entrain teachers and their classes in today's scientific quest. Selected teachers participate in seagoing research expeditions as formal members of the scientific party thus providing those responsible for educating our children with the experience of active scientific inquiry.

Credits

REVEL Project Directors
John R. Delaney and Véronique Robigou, University of Washington

Principal Investigators hosting REVEL 2000 on their research cruises
Dr. Russell E. McDuff, University of Washington, R/V Thomas G. Thompson
Dr. John R. Delaney, University of Washington and Dr. Margaret K. Tivey, Woods Hole Oceanographic Institution, R/V Atlantis

Webmistresses
Diane Nielsen, REVELer 1999, Mercer Island High School, Washington - August cruise
Véronique Robigou, University of Washington

Web land liaison during cruises
David Randle, REVELer 1998, Museum School, New York

Contributing Authors

Participants of REVEL 2000 expeditions and program

Financial Support
National Science Foundation, Directorate of Geosciences, Division of Ocean Sciences
University of Washington, School of Oceanography

Partners and Collaborators
Pennsylvania State University, University Park, PA
American Museum of Natural History, New York, NY
Marine Advanced Technology Education (MATE) Center, Monterey Peninsula, CA

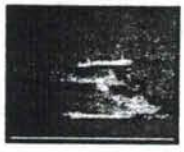
For information contact revel@ocean.washington.edu

Revel Project Logos and Website designed by Josh Bestwick

Background

The REVEL Project was initiated in 1996 at the University of Washington's School of Oceanography with support from Washington State. Each year, REVEL offers science teachers an opportunity to participate in seagoing research and provides them with material and experiences to bring back into their classrooms. Like the ocean itself, seagoing research cruises are dynamic and rapidly-changing environments. Because of the competitive nature of funding for basic research, the success of such cruises depends on high levels of flexibility and adaptation to provide the best conditions possible to accomplishing the planned scientific goals. As a result, the REVEL Project adapts every year to take advantage of funded scientific programs. Since 1998, two partner institutions have joined the REVEL Project, the Pennsylvania Sate University and the American Museum of Natural History. **Thirty eight science educators from Washington, Pennsylvania, New-York, California and Canada have become REVELers since the Project's inception.**

In 1996, **nine** 7th to 14th grade science teachers were selected to participate in a scientific research cruise. The inaugural seagoing expedition took advantage of an international and multi-institutional group of funded programs studying biological, geological and chemical processes associated with the formation of new ocean floor. In the North East Pacific Ocean, these volcanic processes occur along the Juan de Fuca Ridge, a spreading center from which the Pacific and Juan de Fuca plates diverge at a rate of 3 cm per year.



The research was conducted on board the Research Vessel (R/V) Thomas G. Thompson operated by the University of Washington during a two-week long research cruise in the open ocean. The principal research tool was the Canadian remotely operated vehicle (ROV) ROPOS attached to the ship via a fiber optic tether. Science teachers from Washington State and Canada became research assistants for the duration of the cruise and stood regular watches at sea as part of the scientific party.

In 1997, **two** science teachers were selected to participate in a research cruise on the R/V Atlantis using both the remotely-operated vehicle Jason and the manned submersible Alvin operated by the Woods Hole Oceanographic Institution. These teachers participated in cutting-edge imaging and mapping of the hydrothermal vent field that had been first visited during the 1996 expedition. For more information on the 1997 program, check the REVEL 1997 program.

1998 was an exceptional year for the REVEL Project as **fifteen** teachers from the states of Washington, Pennsylvania and New-York participated in two ambitious and extraordinary cruises.
The studies of hydrothermal processes and their possible link to extraterrestrial life on other planets undertaken during the R/V Thompson, ROV ROPOS and R/V John P. Tully cruise were documented by the **NOVA** show **"Volcanoes of the Deep"** that first aired on PBS channels on March 30, 1999.
During the second research cruise on the R/V Atlantis, Kathie Robertson dove to the seafloor in Alvin to investigate the evolution of hydrothermal biological communities. Read about her fantastic experience in the August 8, 1998 story "Lepetodrilus stimulus Changed My Life!". Finally to close off this incredible year, twenty-one of the Revelers gathered in New-York to attend the opening of the new **"Hall of Planet Earth" at the American Museum of Natural History** in June 1999. This event was particularly precious to the REVEL project as the large samples of sulfide, hydrothermal chimneys that were recovered that summer serve as icons in the center of the exhibit. All Revelers since 1996 have been part of the long and patient research process which resulted in the exhibition of these magnificent chimneys in the Museum. Now, millions of visitors will witness some of the dynamic earth through the Museum.

In 1999 **twelve** more science educators joined the REVEL program from Washington, New-York and Pennsylvania to participate in two seagoing cruises on the Juan de Fuca Ridge. During the late summer cruise on the R/V Atlantis, Kenneth Harasty, science teacher in Pennsylvania, had the extraordinary opportunity to dive to the seafloor on August 4. He

summarizes his experience with these words: **"Please excuse my inability to fully and properly describe my dive in the Alvin. Although English has the largest vocabulary of any language in use, I couldn't find the right words to do justice to what I experienced today. Maybe no language contains the words I needed. They haven't been invented."**
The REVEL 99 program ended in April with a visit of Dr. Fisher's biological laboratory at **Penn State University**. Thirty one REVELers from 1996 to 1999 took part in this event.

After their experience at sea, these science teachers participate in post-cruise events including the Washington and Pennsylvania Science Teachers Association conferences every fall, the National Science Teachers Association conference every spring, the National Marine Educators Association conference and several teaching activities development workshops at the University of Washington. During the school year, they create, implement and test teaching activities based on their REVEL experience in order to bring their newly acquired knowledge of the deep sea to their classes. They continue to be involved in REVEL by presenting talks and demonstrations of class activities to science teachers at regional and national professional meetings. All teaching activities are adapted to reflect the Essential Academic Learning Requirements in Science adopted in Washington State in alignment with the American Association for the Advancement of Science recommendations for science literacy .

For more information on the 1996, 1997,1998 and 1999 summer expeditions, check
1996 REVEL
1997 REVEL
1998 REVEL
1999 REVEL

For information contact revel@ocean.washington.edu

2000 Plans

This year, the REVEL Project selected **10 science teachers** from the states of Washington, Pennsylvania, and California to participate in the program. The chief scientists from two submarine expeditions have invited teachers to contribute to their scientific programs this summer. The goals of the first seagoing expedition, led by researchers from the University of Washington and Woods Hole Oceanographic Institution will be to conduct a detailed analysis of the plume of vent fluids rising from the Main Endeavour Field of the Juan de Fuca Ridge. This expedition will use the Autonomous Benthic Explorer (ABE) on board the UW Research Vessel Thomas G. Thompson. The second expedition led by researchers from the University of Washington and Woods Hole Oceanographic Institution will focus on understanding the relationship between the variations of temperature and chemistry of hydrothermal fluids and the tidal fluctuations of the N.E. Pacific Ocean. And how these variations affect the habitat of microorganisms thriving in these hydrothermal environments.
We encourage teachers, students and community members to join these underwater adventures by following the events that unfold on board these ships on the World Wide Web (choose "Submarine Expedition" and then "logbook" on the REVEL 00 Project Toolbar).

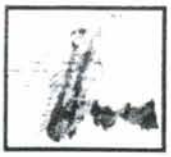
August 3 to August 21
Expedition on the R/V Thomas G. Thompson with the Autonomous Benthic Explorer (ABE).

September 2 to September 19
Expedition on the R/V Atlantis with the manned submersible Alvin

This year, the REVEL Project is joining two research cruises involving cooperation of several institutions in the United States.
The **first scientific program**, funded by the , the National Science Foundation, and the University of Washington will focus on the Main Endeavour Field (MEF) at a depth of approximately 2500 meters.

The Endeavour Segment is the northernmost segment of the Juan de Fuca Ridge, and has been visited by submersibles in 1984, 1987, 1988, 1991, 1995, 1996, 1997, and 1999.
Spreading centers such as the Juan de Fuca Ridge are volcanic mountain chains along which oceanic plates diverge and new oceanic crust is formed. The main goal of this year's mission is to measure the flux of heat through time at the Main Endeavour Field. The information gathered this year will help scientists to determine the heat transfer and chemical exchange deep within the crust at hydrothermal vent fields. This will lead to a deeper understanding of the tectonic and volcanic processes operating at mid-ocean ridge spreading centers.

Hydrothermal vent fields are areas along these spreading centers where hot



springs discharge warm and hot fluids into the cold bottom water (2°C). These hot springs are the consequence of submarine volcanism and circulation of sea water through the oceanic crust. Striking features of these vent fields are complex mineral deposits accumulated by venting of high-temperature (350°C) sea-water derived fluids also known as "black smokers". Large areas of gentle, warm (10 to 30°C) flow diffusing through the porous walls of these actively-forming mineral deposits provide nutrients for remarkable animal communities.

Quantifying the nature of the rising hydrothermal plume off the MEF will be the main focus of this research cruise. The study will attempt to answer two fundamental questions about active hydrothermal systems:

- What are the characteristics, origin, and dominant physical processes that account for the spatial and temporal variability in hydrothermal systems?
- What is the extent of heat, fluid volume, and chemical mass exchange between hydrothermal systems and the overlying ocean?

The support vessel for this expedition is the R/V Thomas G. Thompson from the University of Washington operating the Autonomous Benthic Explorer ABE (choose Submarine Expedition on the REVEL Project Toolbar to access Technology).

Five science teachers and one returning teacher leader will be joining this submarine expedition.

The **second scientific program**, funded by the National Science Foundation is the second leg of a RIDGE Observatory program at the Endeavour hydrothermal field on the Juan de Fuca Ridge. This program was designed to deploy instruments on selected areas of high-temperature and low-temperature vents in the Main Endeavour Field and monitor in-situ changes over a period of several months. The first leg of this program took place in June 2000 during which most instruments were deployed on the seafloor using the submersible Alvin and the remotely-operated vehicle (ROV) Jason. In September, instruments will be retrieved from the seafloor and data analyzed to produce a series of interdisciplinary models linking the processes that produce these changes. The chemistry and temperature variations measured in the hydrothermal fluids escaping from the seafloor might have an important influence on the habitats that extemophiles (or microbes living in extreme environments) are capable of inhabiting. The support vessel for this expedition is the R/V Atlantis from the Woods Hole Oceanographic Institution operating the famous manned submersible Alvin. (choose Submarine Expedition on the Revel Project Toolbar to access

Technology).

Four science teachers will be working alongside Alvin during this submarine expedition.

As in the past, Revelers will continue to collaborate with scientists during the school year to produce teaching activities based on their experience at sea. Under the leadership of the National Center for Science Literacy, Education and Technology at the American Museum of Natural History, REVEL scientists and teachers are collaborating to develop a set of learning activities for middle schools inspired by the deep-sea vents environment. These web-based activities should be available fro the public in mid-2001. REVELers continue to join efforts to share their experiences with as many other teachers as possible through local, regional, and national education conferences.

The REVEL team, a collaborative group from the University of Washington, the Pennsylvania State University and the American Museum of Natural History and new collaborators from the Marine Advanced Technology Education (MATE) Center will continue to seek funding to improve the REVEL Project and to facilitate the distribution of oceanographic teaching activities to a large audience of enthusiastic science teachers.

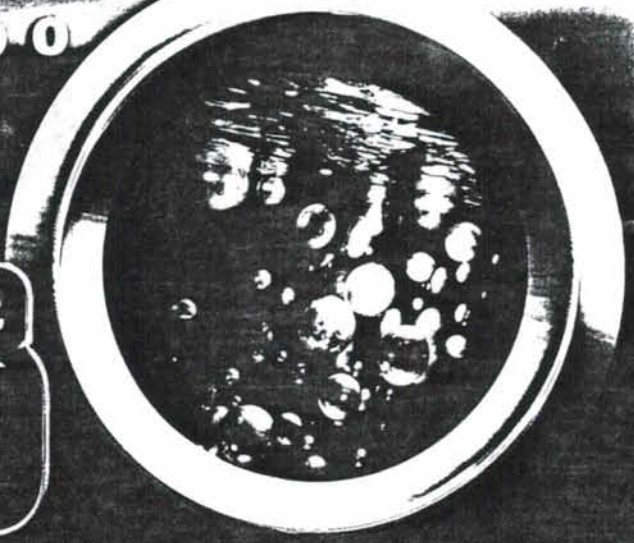
For information contact revel@ocean.washington.edu

Appendix VIII

Sponsored by the National Science Foundation ▼ University of Delaware College of Marine Studies ▼ WHYY-TV

EXTREME 2000

Voyage to the Deep



Dive Mission

On January 12, a team of marine scientists at the University of Delaware will depart on their first deep-sea expedition of the millennium: "Extreme 2000."

Dr. Craig Cary

Led by chief scientist Dr. Craig Cary, the team will explore areas where underwater geysers called *hydrothermal vents* occur in the Sea of Cortés off the west coast of Mexico.

The scientists will study the unique organisms that inhabit the vent sites, take samples of the toxic chemicals released by the vents, and collect rocks and minerals for examination back home in the lab at the University of Delaware.

The scientists will travel to the ocean bottom aboard the famous deep-sea sub *Alvin*, operated by the Woods Hole Oceanographic Institution.

For a daily log of the scientists' activities, information on the marine life they are studying, and other Extreme 2000 details, dive in to *www.ocean.udel.edu/deepsea!*

What's Inside

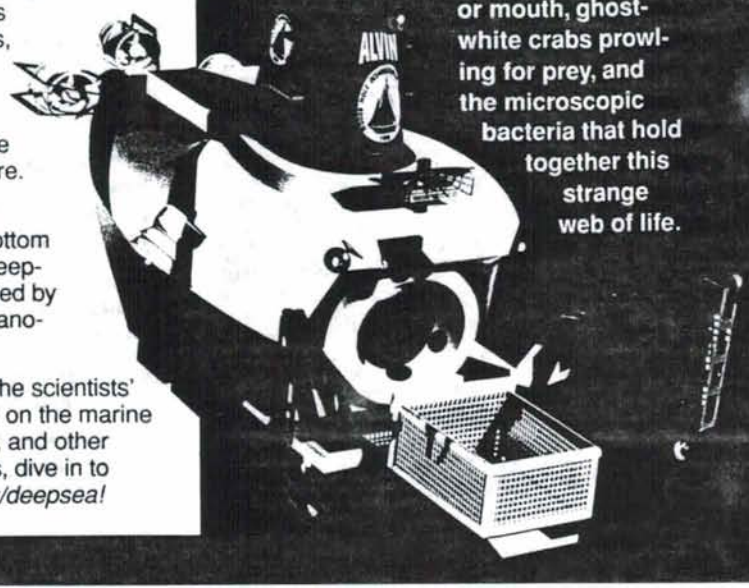
Geology: Find out what forces shape the ocean floor.

Biology: Take a look at some of the strange creatures that inhabit the deep.

Tools: Check out the scientific equipment used in "extreme" research.

The discovery of life in the deep sea was made only about a century ago. Previously, the ocean's depths were believed to be devoid of life. Today, scientists are particularly intrigued by a number of unusual marine organisms that inhabit some areas of the deep sea — at geysers called *hydrothermal vents.*

Here live foot-long clams wreaking of sulfur, giant tubeworms with no eyes or mouth, ghost-white crabs prowling for prey, and the microscopic bacteria that hold together this strange web of life.



Currently, scientists at the University of Delaware College of Marine Studies are conducting research at hydrothermal vent sites to learn more about this "extreme" environment and its bizarre community of organisms.

After all, vent dwellers thrive under some of the most demanding conditions on Earth. They live in a world of darkness where toxic chemicals abound, water temperatures exceed 113° C (235° F), and the atmospheric pressure exerted on them from the tremendous weight of the vast ocean above is more than 250 times the pressure we feel here on land.

Turn the page and learn more about this unique environment, the creatures that inhabit it, and the discoveries that scientists are making to benefit humankind. Let's dive in!

Visit us at www.ocean.udel.edu/deepsea

EXTREME 2000 Voyage to the Deep

DELVE DEEPER!

This eight-page resource guide is designed to serve as a brief introduction to the deep sea and hydrothermal vents. Additional information can be found on our Web site: *www.ocean.udel.edu/deepsea.*

The following list of suggested classroom activities and resources may help expand your deep-sea learning experience. Use it as a starting point to your own voyage of discovery!

Geology

Word Definition

Here are some terms to define:

- bathymetry
- boiling point
- continental drift
- fracture zone
- ocean mapping
- ocean trench
- precipitate
- Ring of Fire
- seismograph
- volcanism

Math Activities

Let's test your knowledge of the metric system. Convert the British units of measure in the "How Deep Is the Ocean?" article in the Geology section to metric units.

One other article in this guide features British units. Find it, and convert the units to metric.

Extra-Credit Essay Topics

Why are hydrothermal vents important?

How does Old Faithful geyser work? Compare it to a hydrothermal vent.

Biology

Word Definition

Here are some terms to define:

- bioluminescence
- chemosynthesis
- eelpout
- hydrostatic
- vent crab
- microbe
- Pompeii
- photosynthesis
- sulfur
- symbiosis

Go Fishing!

Many deep-sea fish look monstrous! Your mission is to find pictures and descriptions of at least five different deep-sea fish. Why do you think so few of them live at hydrothermal vent sites?

Extra-Credit Essay Topics

Compare and contrast photosynthesis and chemosynthesis.

Oceanographer William Beebe wrote the book *Half Mile Down* about his descent to the seafloor in 1938. Read a chapter and report on his observations.

Exploring the Deep

Word Definition

Here are some terms to define:

- bathyscaphe
- bathysphere
- jimsuit
- electrode
- fiber optics
- magnetometer
- ROV
- scuba
- sediment core
- sonar

Design a Diving Vessel

If you could design a deep-sea diving vessel, what would it look like? Sketch it!

Extra-Credit Essay Topics

Jason is used in deep-sea research. Do some research and tell us all about it.

What other scientific tools are revolutionizing our study of the ocean?

Resources

Many excellent resources were used to develop this guide and may help you in your search for more information.

Web Sites

The Bridge — Ocean Sciences Education Teacher Resource Center
www.vims.edu/bridge

Encyclopaedia Brittanica
search.eb.com

Jones and Bartlett Publishers — *Invitation to Oceanography* by Paul Pinet
www.jbpub.com/oceanlink2e

Neptune's Web
www.cnmoc.navy.mil/educate/neptune/student.htm

Nova Online — "Into the Abyss"
www.pbs.org/wgbh/nova/abyss

ThinkQuest — "Ocean AdVENTure!"
library.advanced.org/18828/index.html

University of Delaware Graduate College of Marine Studies
www.ocean.udel.edu

U.S. Geological Survey — *This Dynamic Earth: An Introduction to Plate Tectonics* by W.Jacquelyne Kious and Robert Tilling
pubs.usgs.gov/publications/text/dynamic.html

Woods Hole Oceanographic Institution
www.whoi.edu

Books & Magazines

Davidson, Keay, and A.R. Williams. "Under Our Skin: Hot Theories on the Center of the Earth." *National Geographic* 189, no. 1 (Jan. 1996): 100–112.

Dybas, Cheryl Lyn. "Life in the Abyss." *Ocean Realm,* Winter 1997–98, 78–95.

Greene, Thomas F. 1998. *Marine Science.* New York: Amsco School Publications.

Lemonick, Michael D. "The Last Frontier" *Time,* Aug. 14, 1995, 52–60.

Acknowledgments

Funding for this resource guide was provided by the National Science Foundation. The guide is part of a collaborative deep-sea educational project involving the University of Delaware and WHYY-TV in Wilmington/Philadelphia.

For more information about the University of Delaware's "Extreme 2000" deep-sea research expedition, dive into *www.ocean.udel.edu/deepsea.*

This publication was produced by the University of Delaware Marine Communications Office: Tracey Bryant, marine outreach coordinator; David Barczak, art director; and Pamela Donnelly, production manager.

For information about other publications available from the University of Delaware Graduate College of Marine Studies and the Sea Grant College Program, visit our on-line catalog at *www.ocean.udel.edu/seagrant.* Or contact University of Delaware, Marine Communications Office, Newark, DE 19716-3530. Phone: (302) 831-8083. E-mail: MarineCom@udel.edu.

UNIVERSITY OF DELAWARE whyy NATIONAL SCIENCE FOUNDATION

Appendix IX

ASTROBIOLOGY

Office of Space Science

Amendment to NASA Research Announcement (NRA) 00-OSS-01,
"Research Opportunities in Space Science (ROSS) - 2000"

As of October 18, 2000

Astrobiology Science and Technology Instrument Development (ASTID)

Scope of Program

- To develop instrumentation capabilities that will help meet Astrobiology science requirements on future space flight missions, as well as unique Astrobiology science objectives on Earth

- To advance the development of scientific instruments or instrument components to the point where the instruments could be credibly proposed in response to future flight opportunity announcements

- The development of laboratory instruments designed to significantly advance Astrobiology science will also be considered.

ASTROBIOLOGY

Scientific goals and objectives for Astrobiology

- "How does life begin and evolve?"
- "Does life exist elsewhere in the Universe?"

Specific objectives that could be addressed by new spacecraft instrumentation:

- To determine whether the atmosphere of the early Earth, hydrothermal systems, or exogenous matter were significant sources of organic matter;
- To search for evidence of ancient climates, extinct life, and potential habitats for extant life on Mars; and
- To determine the presence of chemical precursors and potential habitats for life in the outer Solar System.

Major targets of Astrobiology interest include Mars, Europa, Titan, comets, Space Station, and Earth

Support can be provided for

- Long lead-time definition studies
- Innovative approaches that may provide entirely new classes of instruments
- Development of new enabling technologies for missions further in the future, and/or for development studies that may advance the technology for a wide range of instrumentation applications
- NASA also recognizes that some approaches may require field testing to improve instrument utility and robustness.

ASTID Goals for Flight Instruments and Technologies

- Successful instruments will have to operate in environments characterized by extremes of temperatures, pressures, dormant periods while in transit to other worlds, gravity, high-g landing impacts, vibration, and/or high radiation

- Sensors already exist that range from fingernail to matchbook sizes, and a wide array of miniaturized chemical laboratories exist that can fit on a compact disk; however, relatively few are ready to be proposed successfully for space flight.

Proposals in all areas relevant to Astrobiology goals and objectives will be considered for the ASTID program, although a particular need in the following areas is recognized:

- The handling of samples collected for Astrobiological objectives
- In situ detection of possible biomarkers such as isotopic and organic measurements, and
- Development of novel access technologies such as drilling into rock or deep drilling into the subsurface—bedrock, soil, or ice.

ASTROBIOLOGY

ASTID proposals are sought at three general levels:

(i) feasibility study and instrument definition (i.e., proof of concept),

(ii) instrument development and definition (i.e., the bread board stage), and

(iii) development of instruments to the point where they may be proposed in response to future announcements of flight opportunities (the brass board stage).

- Proposals to define or develop one or more instrument components, rather than whole instruments, are allowed, particularly for immature or very complex new instruments. However, at least one or more likely scenarios for possible follow-on instrument development activities must be described in the case of component-only proposals.

- Scientific objectives of proposed instruments or components must be discussed in the proposal, and proposers are encouraged to relate their proposals as closely as possible to future missions of interest to the Astrobiology Program and demonstrate how their technology addresses their goals and objectives.

Examples of Future Missions

Comet Missions

Mars Surveyor Missions

Outer Solar System Missions

- Possible missions to Europa include the Europa Orbiter, Europa Lander, Europa Ocean Observer, and Europa Lander Network.

- Instrument development proposals for the Europa Ocean Observer and Europa Landers are appropriate under this ASTID program element, for example:

  – miniaturized in situ robotics and other instruments for icy bodies, including chemical and exobiological analyses;
  – sample targeting, acquisition, and handling, including sampling of the dark (linea, etc.) surface features;
  – orbital flight instruments to determine the inventory of organic compounds and biogenic elements on Europa's surface; and
  – for the Europa Ocean Observer, which might include a penetrator for melting through the ice to reach the purported subsurface ocean, a "hydrobot" that could then be released to explore the ocean in search of biomarkers as possible evidence of life, characterization of the water column, and subsurface sediments.

ASTROBIOLOGY

Availability and Size of Awards:

- Up to $6M may be available for support of selections for the ASTID program.
- Awards are expected to range from $30,000 to $300,000 per year
- Submission of Proposal -

  Due date by close of business: January 19, 2001

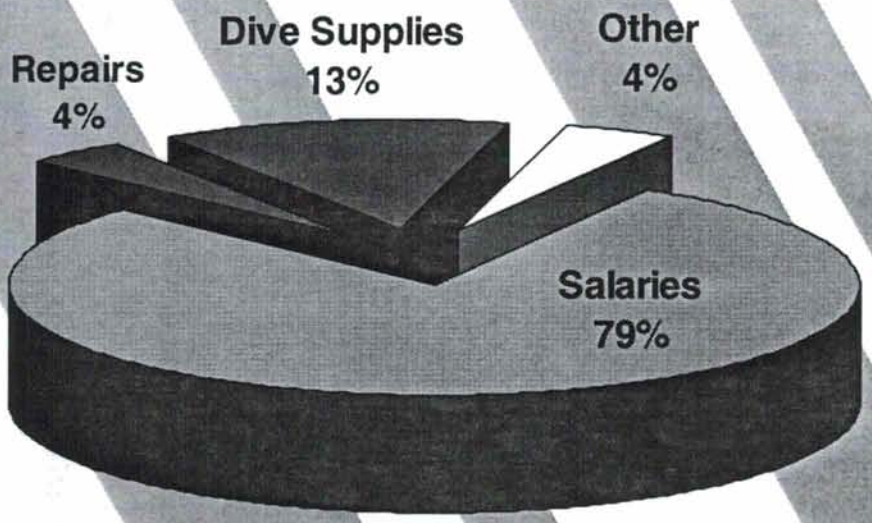
Contact for further information:

Dr. Michael A. Meyer
Astrobiology Discipline Scientist
Research Program Management Division
Code SR
Office of Space Science
National Aeronautics and Space Administration
Washington, DC 20546-0001
Phone: (202) 358-0307
E-mail: mmeyer@hq.nasa.gov

Appendix X

National Deep Submergence Facility

Operating Costs: $3,926,180

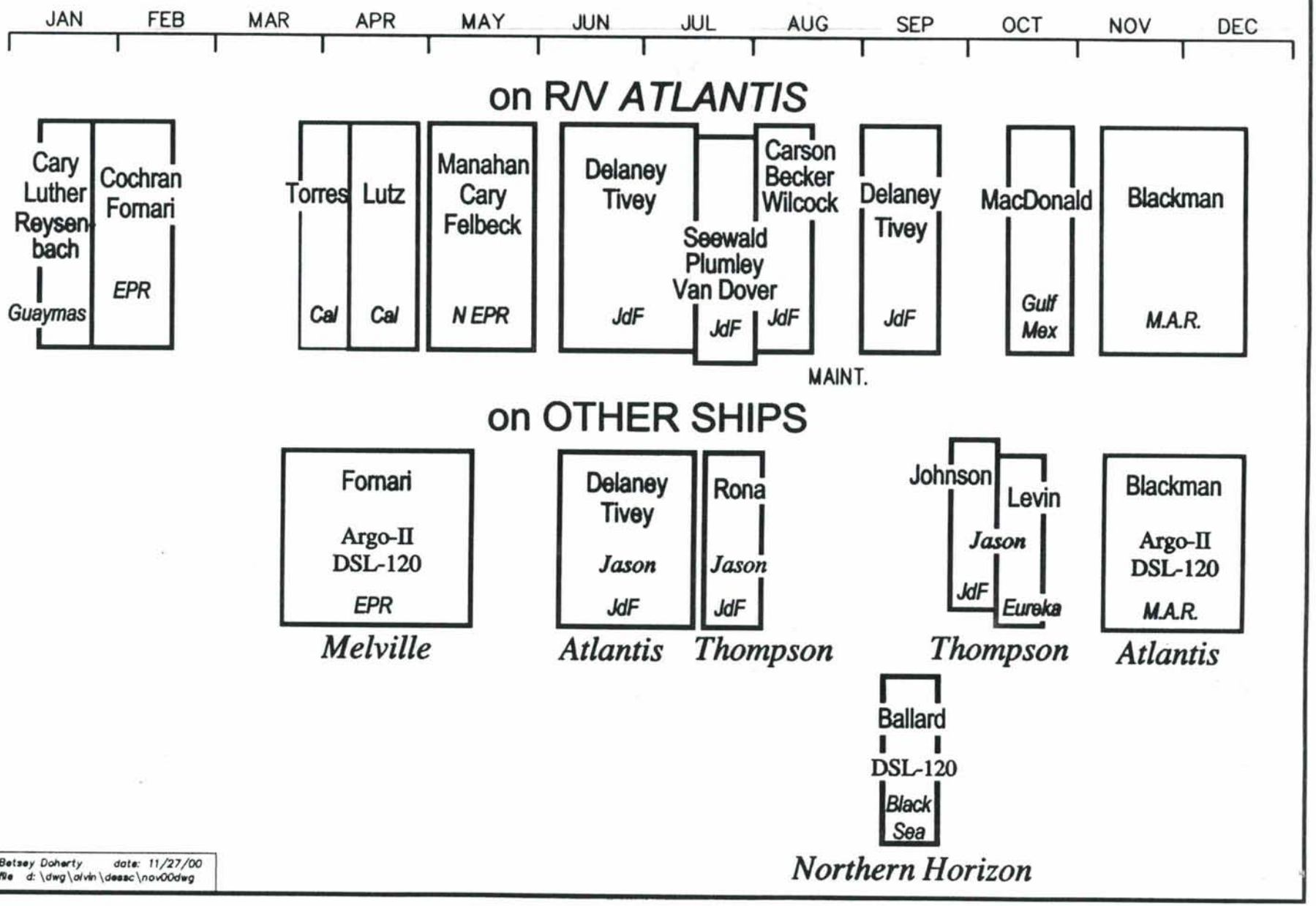


- **16** ALVIN/ROV science voyages supported in 2000
- **5** Vehicles
- **17** Operations personnel
- **16** Engineering/mgmnt personnel

National Deep Submergence Facility
www.marine.whoi.edu

Scheduled 2000 *Alvin* & ROV Operations

Deep Submergence Group
Woods Hole Oceanographic Institution



Betsey Doherty date: 11/27/00
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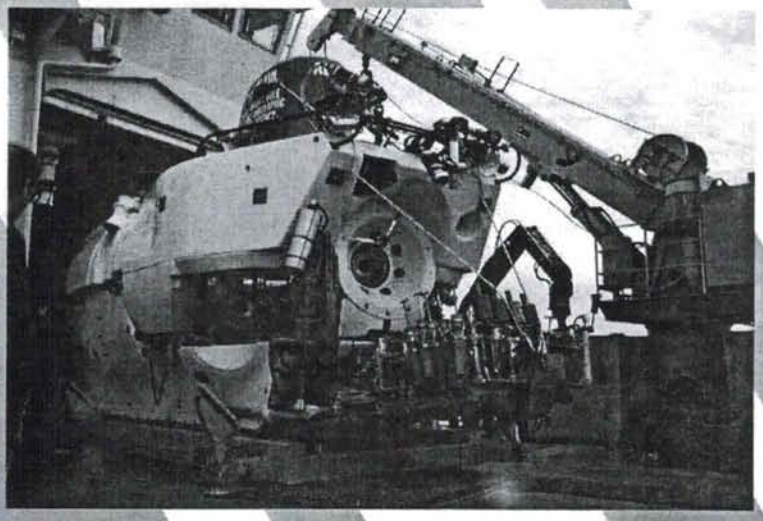
2000 ALVIN Operations



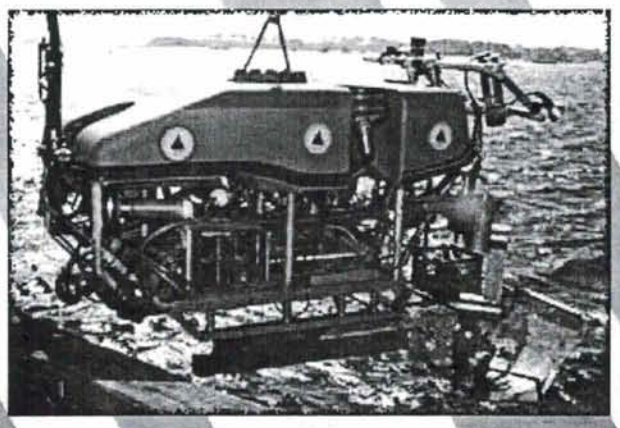
- **330** Operating Days
- **136** Dives
- **2200** m Average Depth
- **7.7** hrs Average Dive Duration
- **5.2** hrs Average Bottom Time
- **4** Dives Lost (3 weather, 1 mechanical)

✓ *Two new pilots (Strickrott, Forte)*

✓ *Dive & Discover web site a hit*

National Deep Submergence Facility
www.marine.whoi.edu

2000 ROV Operations

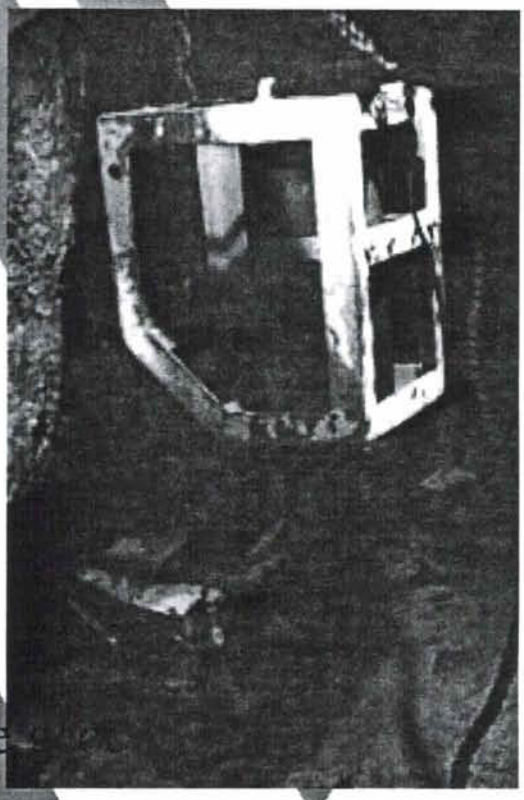


- **20** Jason lowerings
- **13** DSL120 lowerings
- **18** Argo2 lowerings
- **8** TowCam lowerings
- **1273** hrs total bottom time
- **1844** km covered
- **1600** video/data tapes and
- **120** CDs archived

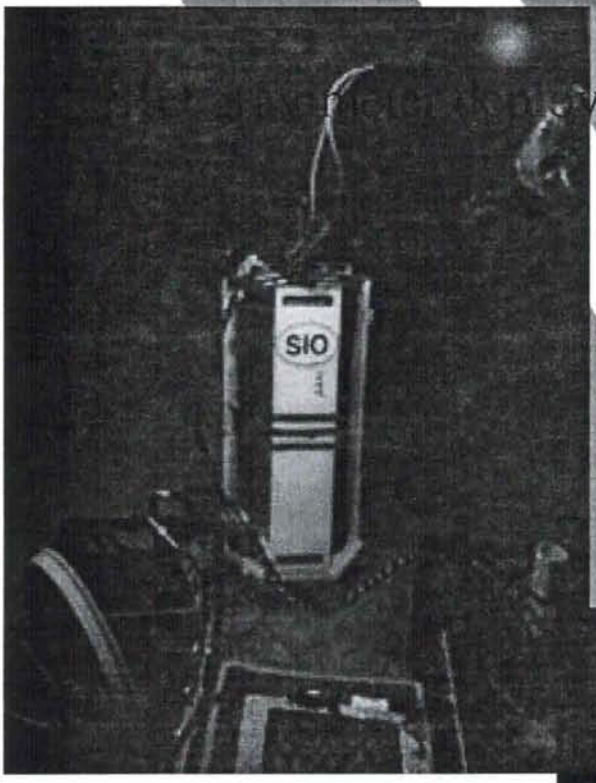
- ✓ *Longest Jason Lowering (5 days - Rona)*
- ✓ *Concurrent operations of Jason and DSL 120 (Rona - JdF/Ballard - BlackSea)*
- ✓ *Integration of SM2000 Multibeam and Benthos DSC*
- ✓ *Evaluation of SeaNet data presentation system (Johnson and Levin)*

Images from AT03-60 MAR

ATLANTIS Mass[illegible] ydrothermal vent



[illegible]vment



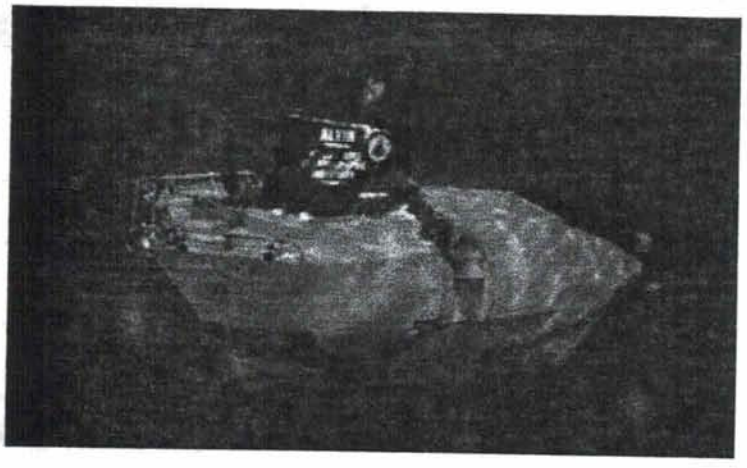
Duke [illegible]

Flange

National Deep Submergence Facility
www.marine.whoi.edu

Appendix XI

ALVIN Overhaul Plans and Upgrades



National Deep Submergence Facility

December 2000 DESSC Meeting

Overhaul timeline

Upgrades: community survey

Other improvements

Video duplication

Overhaul Timeline

- **Offload ATLANTIS after December 16 arrival**
- **Begin overhaul work January 2, 2001**
- **Complete overhaul work June 12, 2001**
- **Sea trials and certification June 13-22, 2001**
- **Operational June 23, 2000**
- **http://www.marine.whoi.edu/ships/alvin/alvin.htm for progress updates**

Community Input

- Hard Mount User Video Controls
  - Second pan/tilt
  - Observers control, flexibility
- Modify Bottom of Science Rack
  - Better cushions, more floor space in sphere
- Modify Equipment Interface for Basket
  - Interlocking component system
  - Other interface issues?
- Replace External Stills with Digital camera
  - Digital frame grabs will eventually replace external film cameras
  - Retain one Benthos 35mm until digital is available

Community Input Cont.

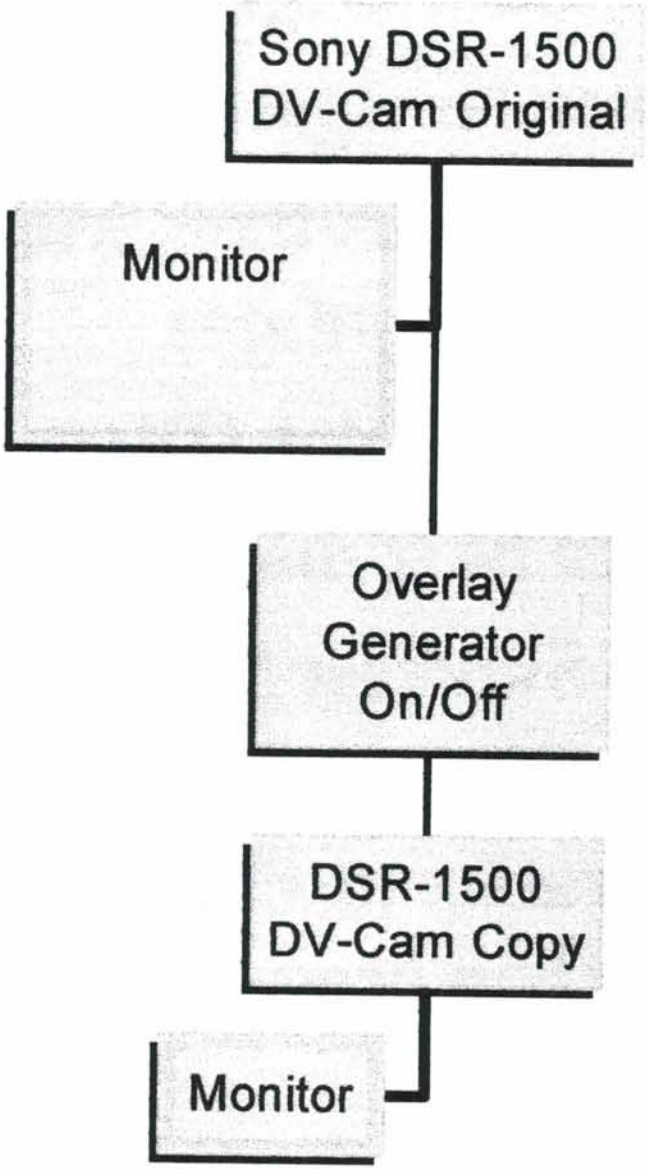
- Better single chips and smaller 3-chip cameras
- Install flat screen displays
  - Pilot and Observer monitors
- Develop Fiber Optic penetrator
  - Being investigated, not in overhaul
- Acoustic modem for depth/position telemetry
  - Increased navigation options

Other Improvements

- Digital video recorders
  - DV-Cam originals
- Doppler Navigation w/RLG
  - Continuous fixes with acoustic updates
- Lateral thruster (DP control?)
- Replace port manipulator (?)
- Install Sunwest SS300 CTFM
- Beta ALVIN power simulator temporarily at CRCG site, http://alvin.crcg.edu/

ALVIN Video Duplication

ALVIN Duplication Facility (x3)
(ALVIN provides this media)



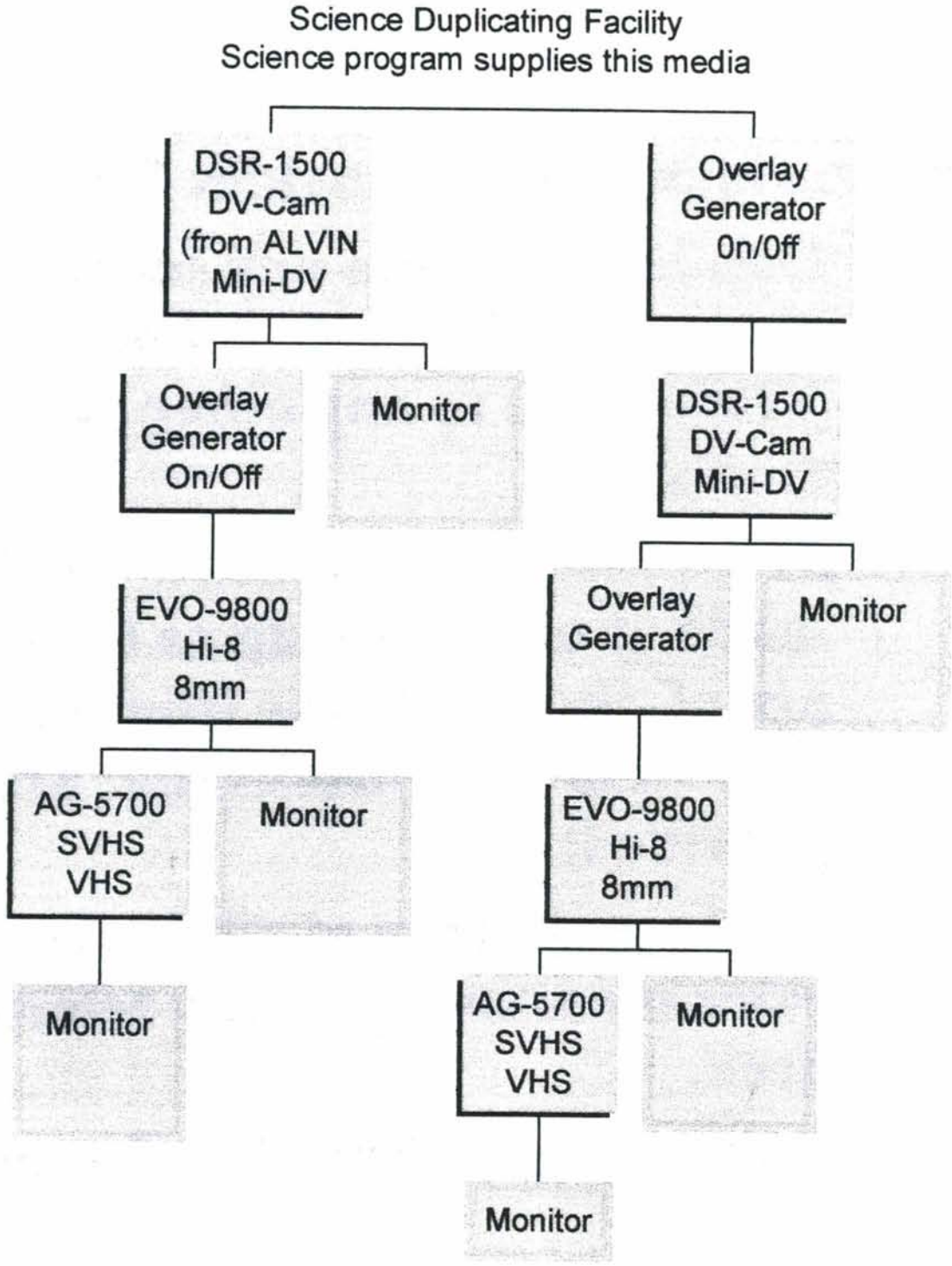
ALVIN duplication

- Previous facility provides for:
  - 3 channels of simultaneous duplication of Hi-8 tapes, with 3 source decks (EVO-9800) and 3 duplication decks (CVD-1000)
  - Analog duplication
  - 12 hours of video can be duplicated in 4 hours
  - B/W monitoring of all decks, color monitoring of any selected deck
  - Master genlock and time-base-correction for all equipment

ALVIN Duplication Cont

- New facility provides:
  - 3 channels of simultaneous cloning or w/overlay of DV-Cam tapes, with 6 identical decks (DSR-1500)
  - 12 hours of video can be cloned in 4 hours
  - B/W monitoring of all decks, color monitoring of any selected deck
  - New system is smaller and simpler than the previous one

Science Video Duplication



Science Duplication

- Previous facility provides for:
  - Duplication from any source analog medium (Hi-8, 8mm, S-VHS, VHS) to any other analog medium.
  - More than one duplicate can be made at once, as long as they are of the right type (that is, they fit into the decks that are provided).
  - B/W monitoring of all decks, color monitoring of any selected deck.
  - Editing capability of Hi-8 tapes

Science Duplication cont

- New facility provides:
  - Designed for two main classes of users: those who want to make additional copies of the DV-Cam distributions, and those who want an analog format other than DV-Cam
  - Perform DV-Cam cloning
  - Perform analog duplication from DV-Cam to any analog format (Hi-8, 8mm, S-VHS, VHS)
  - Text overlay possible during analog or digital duplication
  - During analog duplication, up to 4 copies of one DV-Cam source tape can be made at once, as long as they are of the right type, or up to 2 copies can be made of 2 different DV-Cam source tapes

Appendix XII

Key ROV Project Project Milestones

March -- Acceptance testing of DSL120a sonar electronics at HMRG

-- Telemetry delivered

April -- Selection of J2 thrusters

-- Floatation design complete

May -- Final manipulator selection

June -- Final test and sea trial of DSL120a

August -- First deployment of DSL120a (E. Silver @ Huon Gulf)

Nov. -- Decommission of Jason

Feb. '01 -- Ready for J2 sea trials

May '01 -- J2 Ready for science

ROV Upgrade Project Progress Summary
2000

- **Science Design Review Meeting held at June DESSC**
- **Detailed Specification for Jason/Medea, Argo and DSL120a Written**
- **Telemetry purchase order placed.**
- **Subsea 120 sonar electronics purchase order presently underway with HMRG.**
- **New syntactic foam floatation material identified**
- **New personnel added**
- **3D Modeling of Jason II design**
- **Manipulator candidates identified**
- **Extensive evaluation of other science ROV systems completed.**
- **Documentation system established**
- **Power system design well underway including voltage stress testing of UNOLS E-O cable**
- **Various components purchased (lights, video cameras)**
- **Test/evaluation of RLG based attitude/heading reference**
- **Main umbilical tested for strength and insulation qualities**
- **Jason II and DSL120a overall layout completed**
- **Sensor Suite Selection**
- **Thruster candidates identified with test plan underway**
- **TMS specification written and RFP presently circulated**
- **New neutral tether cable in house**

New Power Delivery System

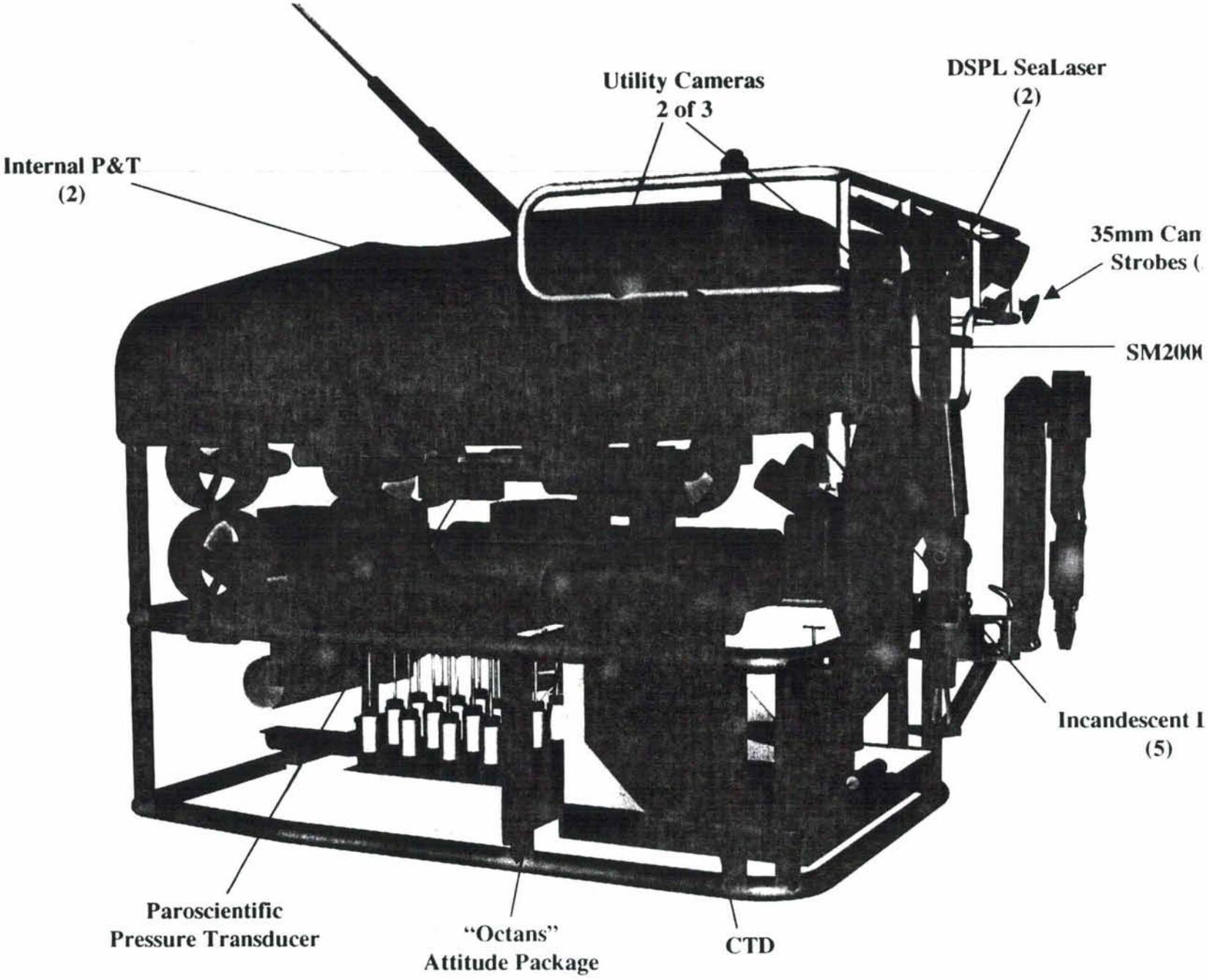
- **Designed for operation using 10km of .680" cable**
- **Present system delivers 8kW at 2000VAC**
- **New system will deliver 18kW at 2500VAC**
- **Power delivery increases as the square of the operating voltage**
- **Attempting to increase power to the vehicle by increasing conductor is much less effective and causes cable heating.**
- **Operating at higher voltage places stress on conductor insulation material which might affect service life of the cable**
- **Test plan to confirm final operating voltage**

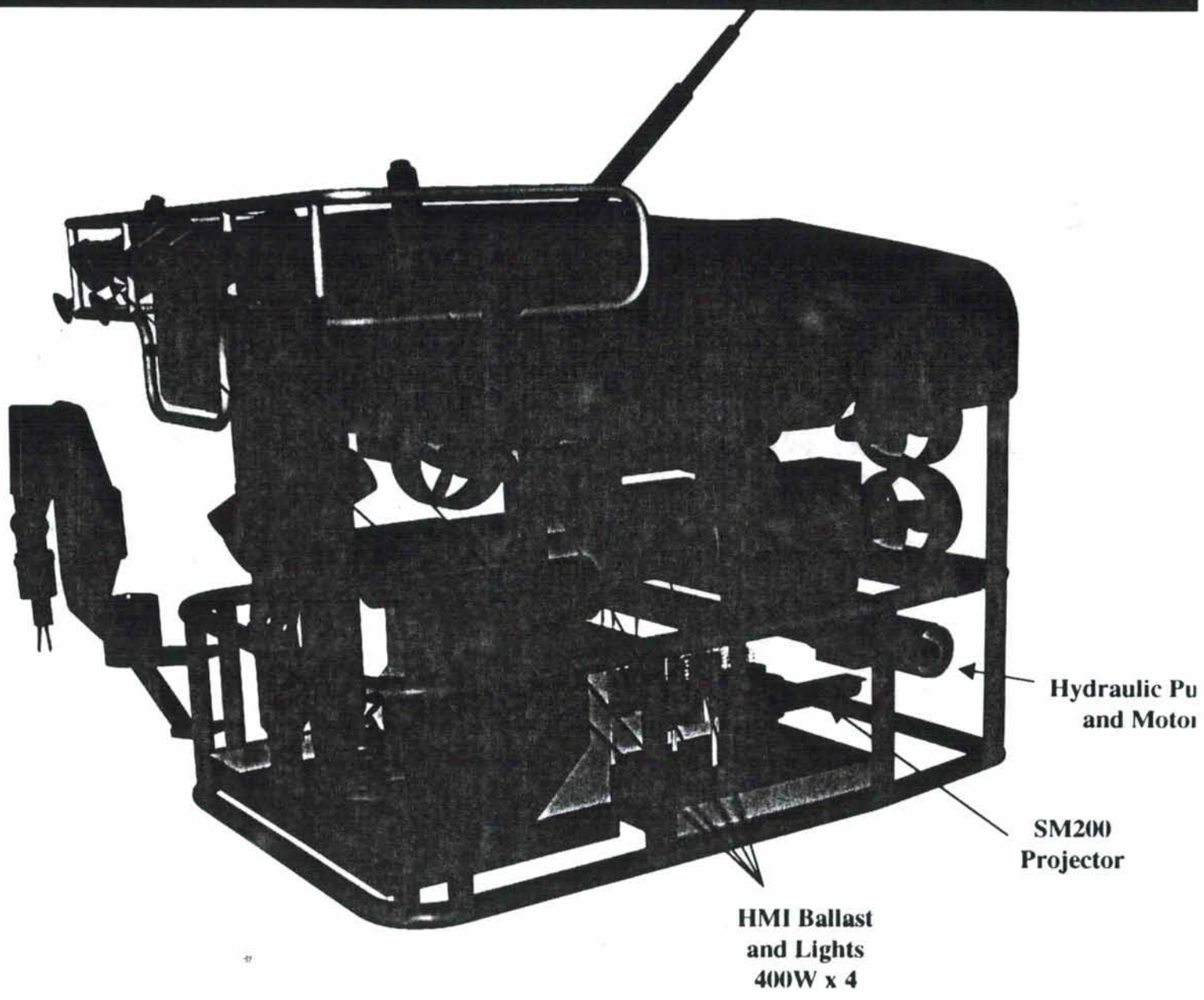
Jason II Telemetry

Signal Type	Bandwidth	Number
Video	6MHz	8
Audio	1MHz	2
Analog	16KHz	2
RS-422	10Mbit/sec	11
RS-485	10Mbit/sec	2
RS-422	19.2Kbaud	40
RS-485	19.2Kbaud	80
10 Base T		2

Sampling and Manipulation Objectives

- **To better utilize the work space of the manipulators.**
- **Work on both sides of the vehicle as well as in front of the vehicle.**
- **Pan and tilt camera on both sides of the vehicle.**
- **Sliding drawers allowing access to sample storage from both sides of the vehicle.**
- **One large sliding drawer in the front of the vehicle.**
- **Modeling the manipulator kinematics to determine drawer and manipulator position.**
- **Modular Tool Sled**
- **Science, electrical and hydraulic interface equipment on the core vehicle rather than on the tool sled.**


Utility Cameras
2 of 3
DSPL SeaLaser
(2)
Internal P&T
(2)
35mm Can
Strobes (
SM2000
Incandescent I
(5)
Paroscientific
Pressure Transducer
"Octans"
Attitude Package
CTD


Hydraulic Pu
and Motor
SM200
Projector
HMI Ballast
and Lights
400W x 4

How Many Oxford-English Dictionaries Can Travel Through JASON II's Umbilical In ONE SECOND?

(a demonstration of data transmission efficiency)

	number	*source*
Oxford-English Dictionary (One 20-Volume Set)		
number of Entry Words described per OED	500,000	advertised
Descriptive Words per Entry Word	30	estimated average
Descriptive Words per OED	15,000,000	= 30 x 500,000
total Words per OED (Entry and Descriptive)	**15,500,000**	= 500,000 + 15,000,000
Digitizing Words (Information as Data)		
Bits per Character	2	a given
Characters per Word	6	estimated average
Bits per Word (Entry or Descriptive)	12	= 2 x 6
total Bits per OED	**186,000,000**	=15,500,000 x 12
Fiber Optic Video and Data Telemetry		
Gigabits per Second telemetered per single Optical Fiber on JASON II	3	design specification
Optical Fibers per single JASON II Umbilical	3	a given
maximum Gigabits per Second telemetered to/from JASON II	9	= 3 x 3
Bits per Gigabit (1 billion)	1,000,000,000	a given
total Bits per Second telemetered to/from JASON II	**9,000,000,000**	9 x 1,000,000,000
total number of Oxford-English Dictionarys telemetered per Second	**48**	= 9,000,000,000 / 186,000,000

M. Bowen, M. Naiman, R. Elder 03/08/00

Thruster Comparison

BRAND	DIMENSIONS IN	WEIGHT LB AIR/SW	BOLLARD LB FWD/REV	HP	POWER V/A
TECNADYNE 2010	L16.3 OD4.2 PROP 7.51 NOZ OD 10	23.2/17.4	205/115	5	260/17
TECNADYNE 8010	L21.4 OD4.88 PROP 12 NOZ OD 13.5	48/36	470/263	10	260/33
SUBSEA SSE500 SINGLE PROP	L14.25 OD5.25 PROP 12.5 NOZ OD 14.75	24/18	250/210	5 TO 6	260/18
SUBSEA EDT500 COUNTER ROTATE DUAL	L20.5 OD4.75 PROP14.5 NOZ OD17.5	27/23	260/260	5	260/18
DSSI THL-202B	L24.5 OD4.5 PROP 12 NOZ OD 15.5	68/39	303/217	5	285/13.7
MBAR	L35 NOZ OD 15	68/44***	240/225	5	280/17.1

*** MCON THRUSTER

Criteria for Thruster Selection

- Reliability
- Commercial Availability
- Size
- Weight
- Bollard Thrust
- Low speed control
- DC Brushless
- Vector Drive Integration

Decision to Increase Operating Voltage

- **Maximum rated operating voltage of cable is 2800VDC which translates to a 3-phase line voltage of 3400VAC .**
- **Visual inspection of used section of cable by a power cable test consultant shows no sign of high-voltage damage.**
- **Oceaneering International has operated the same cable at 3200-3400VAC for more than 400 hours. They have offered us a sample of the cable for visual inspection and perhaps other testing.**
- **WHOI is approaching MBARI, Oceaneering, NAVO and Rochester to participate in the development of a full elevated voltage life test program.**

Vehicle Power Management

- **Power available to the vehicle is limited by both the voltage stress capability of the cable and the amount of power that can be lost in the cable.**

- **Jason II will be a power limited vehicle in the sense that it will be capable of consuming much more power than it tether can safely.**

- **A power management system will be required to supervise and control the allocation of power at the vehicle to make optimum use of the power capacity while protecting the cable from damage.**

Limitations of Existing Systems:

Jason/Medea

- Limited Payload (samples and sensor equipment)
- Limited manipulative capabilities
- Slow speed (low thrust)
- Poor range of motion from Medea
- Outdated telemetry
- Minimal auxiliary hydraulic supply
- Poor workspace design and minimal sample storage volume
- Obsolete components becoming increasingly hard to maintain
- Poor fault protection/location

Anticipated Missions

- High resolution mapping and survey (multi-frequency acoustic and image based)
- Installation/service of seafloor observatories
- Manipulation and sampling in a more "Alvin like" manner
  - → multi-disciplinary hydrothermal sampling
  - → large volume biological sampling
  - → high demand hydraulic tools (e.g. rock drill)
  - → large volume/weight geological sampling (e.g. box cores, in-place rocks)
  - → deployment/retrieval of large scale instrumentation

Power Manager Requirements

- **Must prevent the vehicle from consuming more power then the system can safely deliver**
- **Must provide the ability to monitor power usage**
- **Must no distract operators**
- **Must exercise control of loads only by denying request to turn loads on not by turning loads off.**
- **Must not interfere with vehicle directional control or navigation.**
- **Should allow allocation of power capacity among major vehicle load groups (e.g. thrusters, lights, hydraulics, etc.) by a combination of preset mode buttons or manual controls.**

Appendix XIII

R/V Atlantis Shipyard Plans

- **Total cost ~$650K**
  - **Total list was $1.2M**
  - **$550K Deferred based on available Funds,**
- **Funded from a variety of sources**
  - **Ship Ops**
  - **Major Maintenance Reserve**
  - **ONR Supplementary Funding**
- **Core Maintenance includes**
  - **Underwater body, topside painting, renewing doors, new sewage pumps, engine repairs, normal ABS & USCG Inspections, etc.**
- **Other Projects include**
  - **HVAC improvements 01 dk. fwd.**
  - **Bow Thruster Quieting, Phase 3**
  - **Improved 01 access topside aft**

ATLANTIS SHIPYARD

TASK	DESCRIPTION		International
2.1	Services	A-G	$ 27,852.16
2.2	Dock And Undock		$ 28,692.00
2.3	Routine Dry Docking		$ 1,645.00
2.4	Hull Painting (Bid Each Item Separately)		
		A	$ 10,613.00
		B	51022.00H
		C	$ 21,985.40
		D	$ 6,461.50
2.5	Skin Valves		$ 7,905.00
2.6	Zincs		
2.7	Bow Thruster Inspection		$ 1,649.00
2.8	Open And Inspect Thruster Gears		$ 15,604.80
2.9	Anchor Chains	A-H	$ 9,175.50
2.10	Ballast Tank Access		
2.11	Fuel Oil Tank Access		
2.12	Paint Exterior House		$ 60,681.00
2.13	Install Forward Preheater 01 Level		$ 5,016.80
2.14	Convert Alvin Dehumidification System		87416.30H
2.15	HVAC Modifications To 01 Level		$ 75,192.80
2.16	Air Conditioning For Ship's Office		44622.10H
2.17	Air Conditioning For Bosun's Workshop		51622.20H
2.18	Linen Locker Condensation		12628.70H
2.19	New Dryer/Laundry Ventilation		$ 55,078.30
2.20	Potable Water Tank Modification		119126.00H
2.21	Watertight Door Modifications		$ 15,272.00
2.22	Lab Receptacles Installation		47748.40H
2.23	Phase 3 Bow Thruster Sound Deadening		$ 89,273.70
2.24	Replace Two Weather Doors On 01 Level		$ 16,814.00
2.25	Replace Oil Pans On Two Ship Service Generators		$ 40,374.70
2.26	Relocate Generator F.O. Coolers		27310.50H
2.27	Replace Jacket Water Coolers		18261.40H
2.28	Remove Seismic Air Compressors		$ 38,236.00
2.29	Provide Overflow For Day Tanks To 5 Center		$ 26,437.00
2.30	Replace Sewage Pumps		$ 13,398.80
2.31	Add Fixed Fire Protection To Battery Locker		23219.80H
2.32	Install New Varo Searchlight		$ 4,080.80
2.33	Provide Access To 01 Level Aft Port Side		$ 11,460.00
2.34	Thruster Lube Oil Piping		21110.50H
2.35	Thruster Hydraulic Oil To Propulsion Motor Room		22681.10H
2.36	Relocate Traction Winch SCR's		37614.70H
2.37	Contract Security		$ 23,373.00
	TOTALS excluding zincs and tanks		**$ 606,272.26**

Appendix XIV

CY-2000
WHOI Outreach Related to Deep Submergence

WHOI, as the UNOLS National Deep Submergence Facility Operator, undertakes outreach activities on behalf of the ocean sciences and deep submergence research communities

Part of this responsibility entails maintaining and providing access to the Deep Submergence Data Archives at WHOI.

WHOI also provides deep submergence and general oceanographic imagery and information to the news media (print, TV, and magazine), educational organizations and publishers, and the commercial- entertainment industry.

Summary of WHOI Activities

- **Deep Submergence Data Archives**
- **Museum and other Outreach Activities**
- **Future Outreach Efforts**

Deep Submergence Data Archives

Data from ROV and tethered vehicle cruises are current to the Levin cruise in October. The D. Blackman program with DSL-120, Argo II and Alvin is currently in progress.
Data from Alvin cruises are up to date including AT-3-58 (October Gulf of Mexico cruise for MMS et al.).

ROV and Tethered Vehicle cruises -- 10 expeditions

1,527 -- video and data tapes
105 - CDs
20 -- other media (inlcuding JAZ, ZIP and Exabytes)
8 -- floppies
14 -- 100' reels of 35mm film
17 -- accompanying notebooks or logs

Alvin -- 12 dive series

745 -- hi-8 video tapes
34 -- 100' reels 35mm film
24 -- CDs
28 -- floppies

Approximately 35 requests for deep submergence data of various types have been made during the current year

Museum and other Outreach Activities

WHOI-BBH *"Extreme Deep"* Exhibit

"Extreme Deep" is an exhibit that includes: models of and displays about deep sea vehicles including Alvin, Jason, ABE, and REMUS; a full-scale diorama of a hydrothermal vent community and extensive video presentations as well as samples and models of vent animals and geology; a section on shipwrecks; and other displays related to deep sea exploration.

"Extreme Deep" has been on display at:
Boston Museum of Science, (Sept. '99 to Jan. '00)
The Children's Museum of Indianapolis, (Feb.-May '00)
Oregon Museum of Sci. & Industry, Portland, (May-Sept. '00)

Over 700,000 people have viewed *"Extreme Deep"* at the abovethree venues

Liberty Science Center, Jersey City, (Oct. '00-Jan. 01)

Next venue is the Museum of Natural Science in Raleigh, NC.
**(see other sheets for upcoming venues)

Museum and other Outreach Activities (cont'd)

WHOI Exhibit Center

WHOI maintains an Exhibit Center dedicated to providing information and displays of oceanographic and deep submergence science and research technologies.

Each year approximately 30,000 people visit the WHOI Exhibit Center, many of them during the spring, summer and fall months.

The Exhibit Center staff responds to about 7000-8000 requests of various types per year with the majority being the following: walk-in requests, phone requests, guided tours and email requests.

WHOI Media Relations Office

WHOI maintains a media relations office to assist in the distribution of oceanographic and deep submergence related imagery and visual materials that are both in the public domain as part of the National Deep Submergence Archives, and which WHOI holds the rights. This office also helps notify the media of important scientific findings carried out by scientists using WHOI oceanographic facilities, or researchers at WHOI.

The WHOI Media Relations Office handles ~2,000-3000 requests per year for visual and other materials related to deep submergence. In addition, they distribute ~1,000 press kits or information packets per year as part of their ongoing media-relations program.

Museum and other Outreach Activities (cont'd)

WHOI Media Relations Office (cont'd)

Printed articles in newspapers and magazines number ~500 per year and are primarily handled through this office. National Geographic Magazine had on article by R. Lutz on hydrothermal vents this past year, and another one is expected in early 2001 by R. Ballard on his Black Sea work.

This office also coordinates use of deep submergence archive footage for educational television programming and film and TV specials. Several TV specials are in progress and will be aired in 2001 including: "The Ultimate 10 Modern Machines" and "Ultimate Underwater Machines", both feature Alvin and Jason.

The total number of requests to the WHOI Media Relations Office for imagery during this year was 248. They break down as follows:

179 still image requests
48 video image requests
21 combination requests

WHOI Archiving and Outreach
Annual Expenses & Revenues
CY - 2000

Approximate Annual Expenses Related to WHOI Exhibit Center and Media Relations Office: ~$400,000.

Maintenance of Deep Submergence Archives ~$ 75,000.
(as a percentage of the WHOI-MBL library system)

Approximate Revenues from Various Sources: ~ $ 55,000.

*Note that no licensing fees are charged for news, non-commercial and educational production uses.

Future Outreach Efforts

These efforts include:

1) Continuing national tour of "Extreme Deep" exhibit
2) Collaboration with National Geographic Television on weekly science news programming
3) Assisting S. Lowe and R. Lutz with an IMAX movie on hydrothermal vents partly funded by NSF to be filmed next summer on MAR using Alvin
4) Continued efforts at contacting various media organizations to encourage highlighting of deep submergence and oceanographic science and technology

December 11, 2000

WHOI-BBH *"Extreme Deep"* Exhibit
Planning in Progress

Dates	Venue
September 9, 1999 - January 9, 2000	Science Museum, Boston Boston, MA
February 5, 2000 -May 7, 2000	Children's Museum of Indianapolis Indianapolis, IN
May 26, 2000 - September 10, 2000	OMSI Portland, OR
September 29, 2000 - January 7, 2001	Liberty Science Center Jersey City, NJ
February 17, 2001 - May 6, 2001	NC State Museum of Nat. Sciences Raleigh, NC
June 1, 2001 - September 16, 2001	Omniplex Oklahoma City, OK
October 5, 2001 - January 13, 2002	Lawrence Hall of Science Berkeley, CA
February 1, 2002 - May 5, 2002	Philadelphia Academy of Science Philadelphia, PA

December 11, 2000

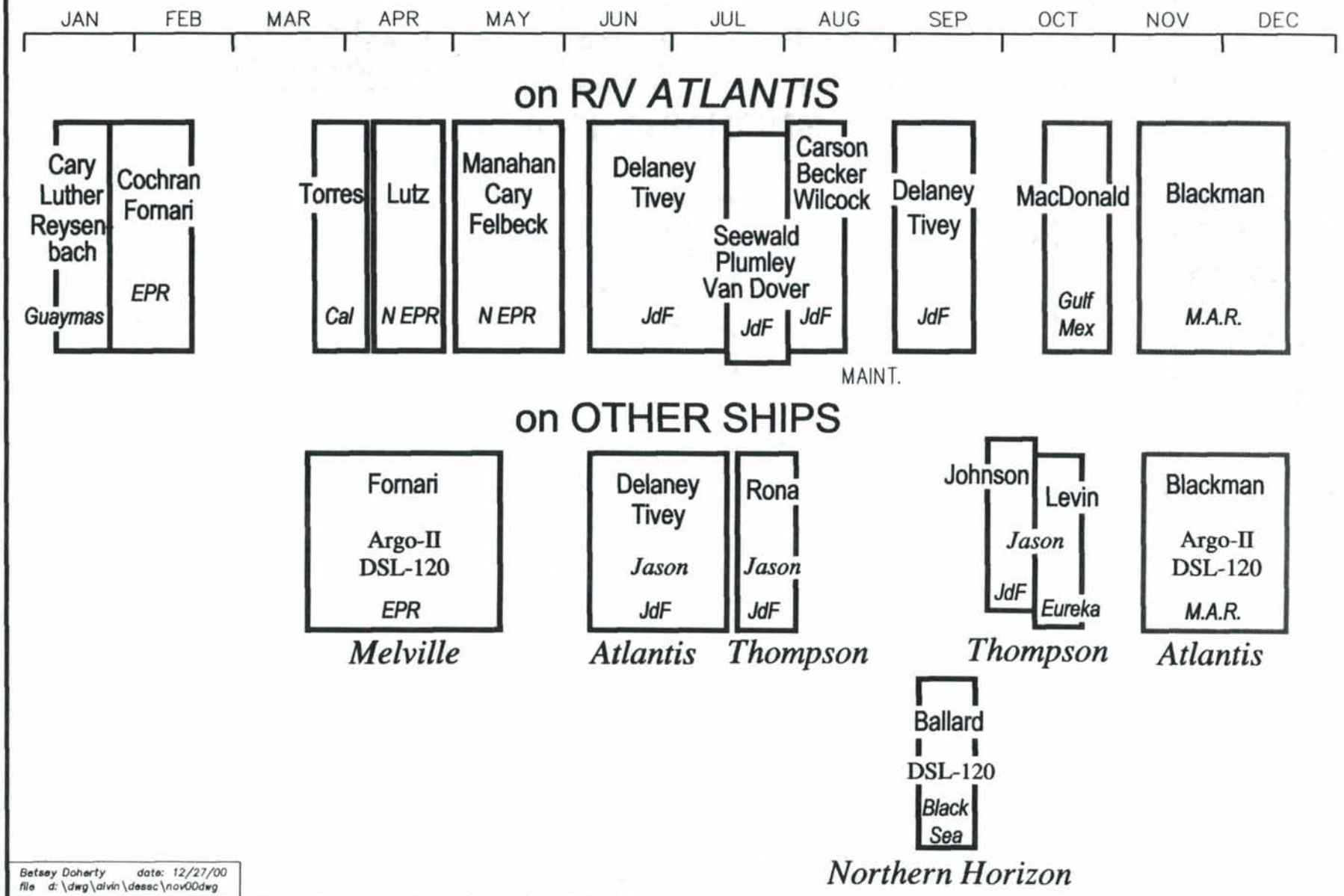
WHOI-BBH *"Extreme Deep"* Exhibit
Planning in Progress

Dates	Venue
May 24, 2002 - September 22, 2002	Open
October 12, 2002 - January 12, 2003	Space Center Houston Houston, TX
February 8, 2003 - May 10, 2003	St. Louis Science Center St. Louis, MO
June 6, 2003 - September 13, 2003	Great Lakes Science Center Cleveland, OH
	ScienceCity Kansas City, MO
October 3, 2003 - January 11, 2004	Museum of Science Buffalo, NY
	Great Lakes Science Center Cleveland, OH
January 30, 2004 - May 2, 2004	Open
May 22, 2004 - September 6, 2004	New York Hall of Sciences Queens, NY

Appendix XV

Scheduled 2000 *Alvin* & ROV Operations

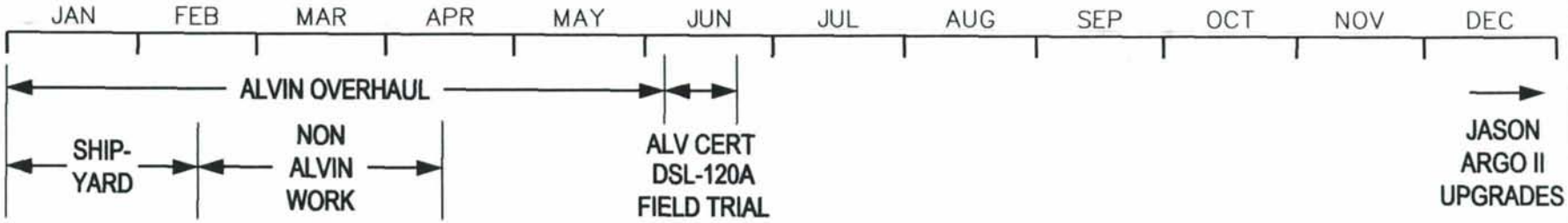
Deep Submergence Group
Woods Hole Oceanographic Institution



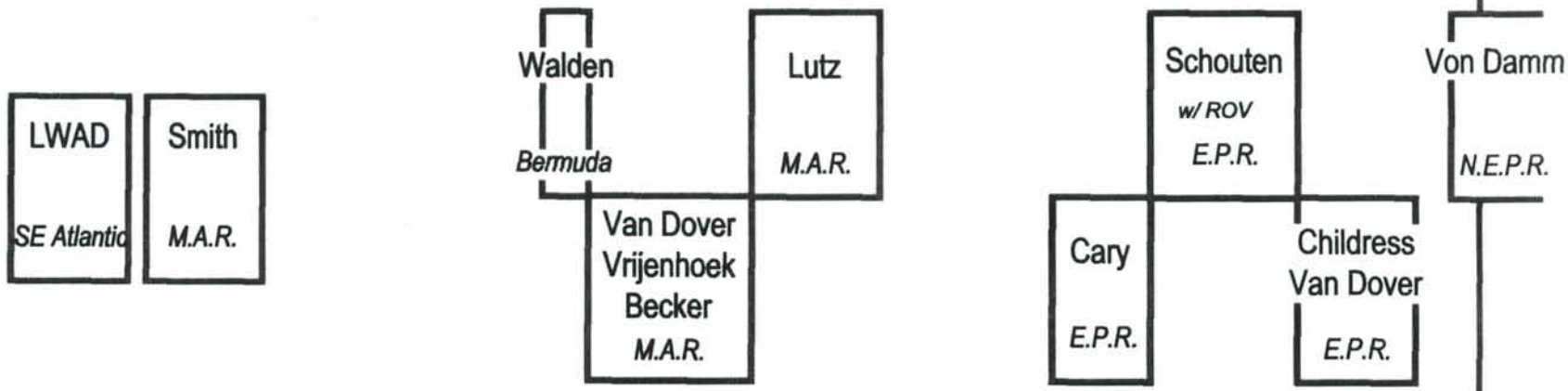
Betsey Doherty date: 12/27/00
file d:\dwg\alvin\dessc\nov00dwg

2001 Alvin & ROV Scheduled Operations

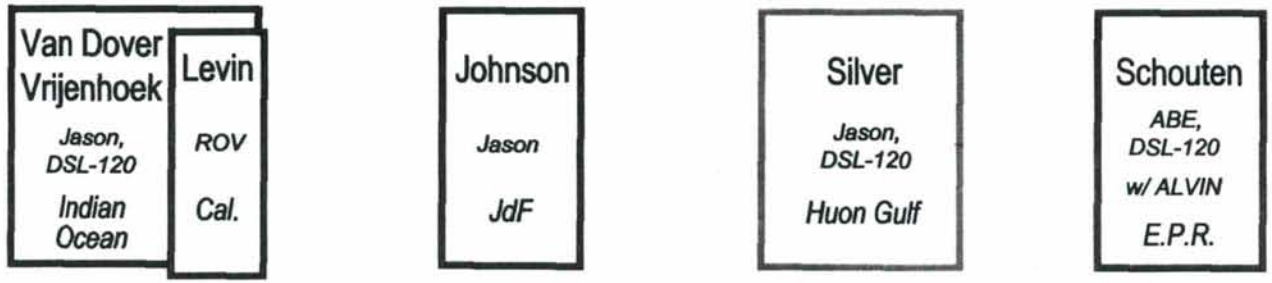
Deep Submergence Group
Woods Hole Oceanographic Institution



ALVIN & ATLANTIS OPERATIONS



ROV OPERATIONS



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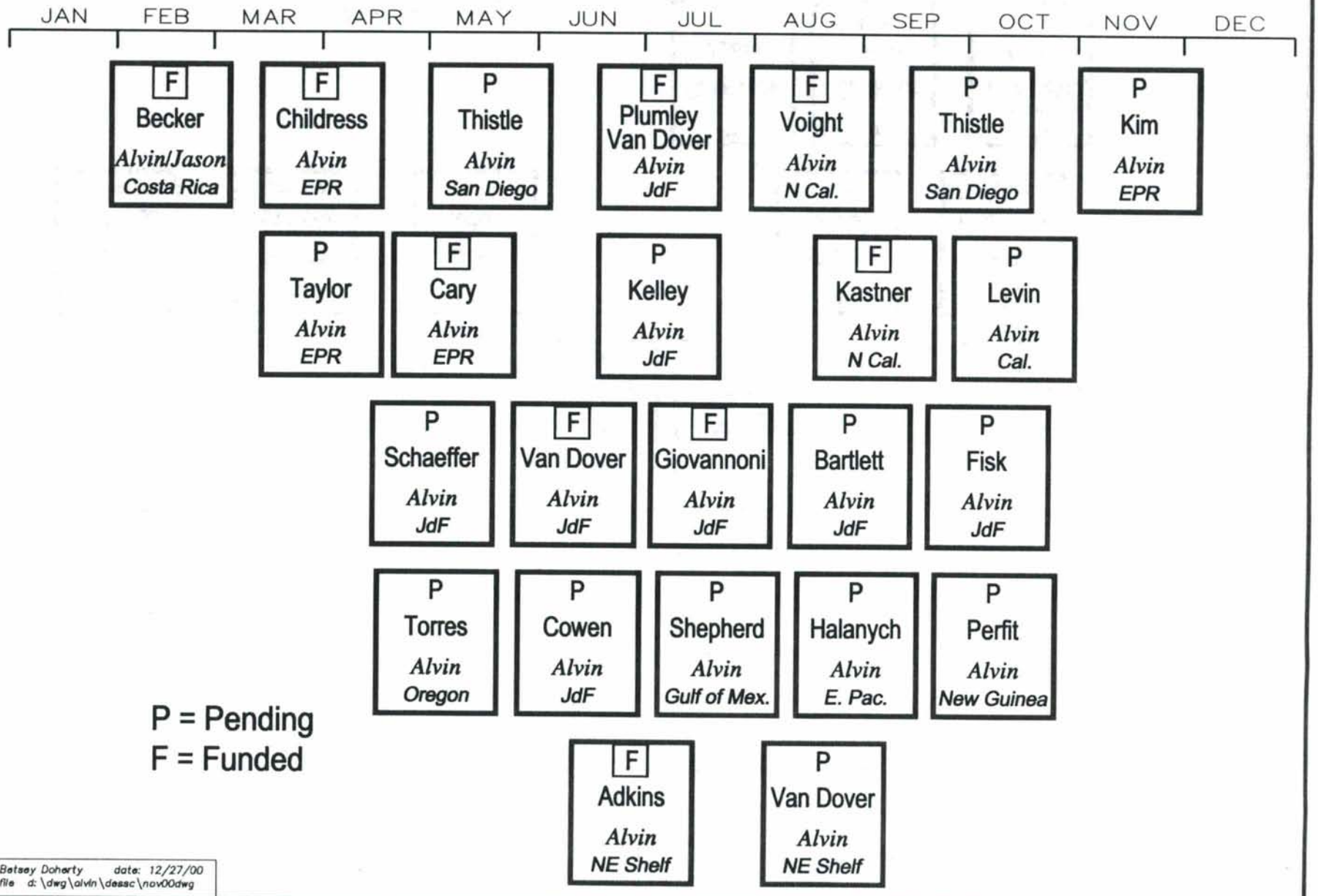
2002 Requests for Alvin Operations

Deep Submergence Group, Woods Hole Oceanographic Institution



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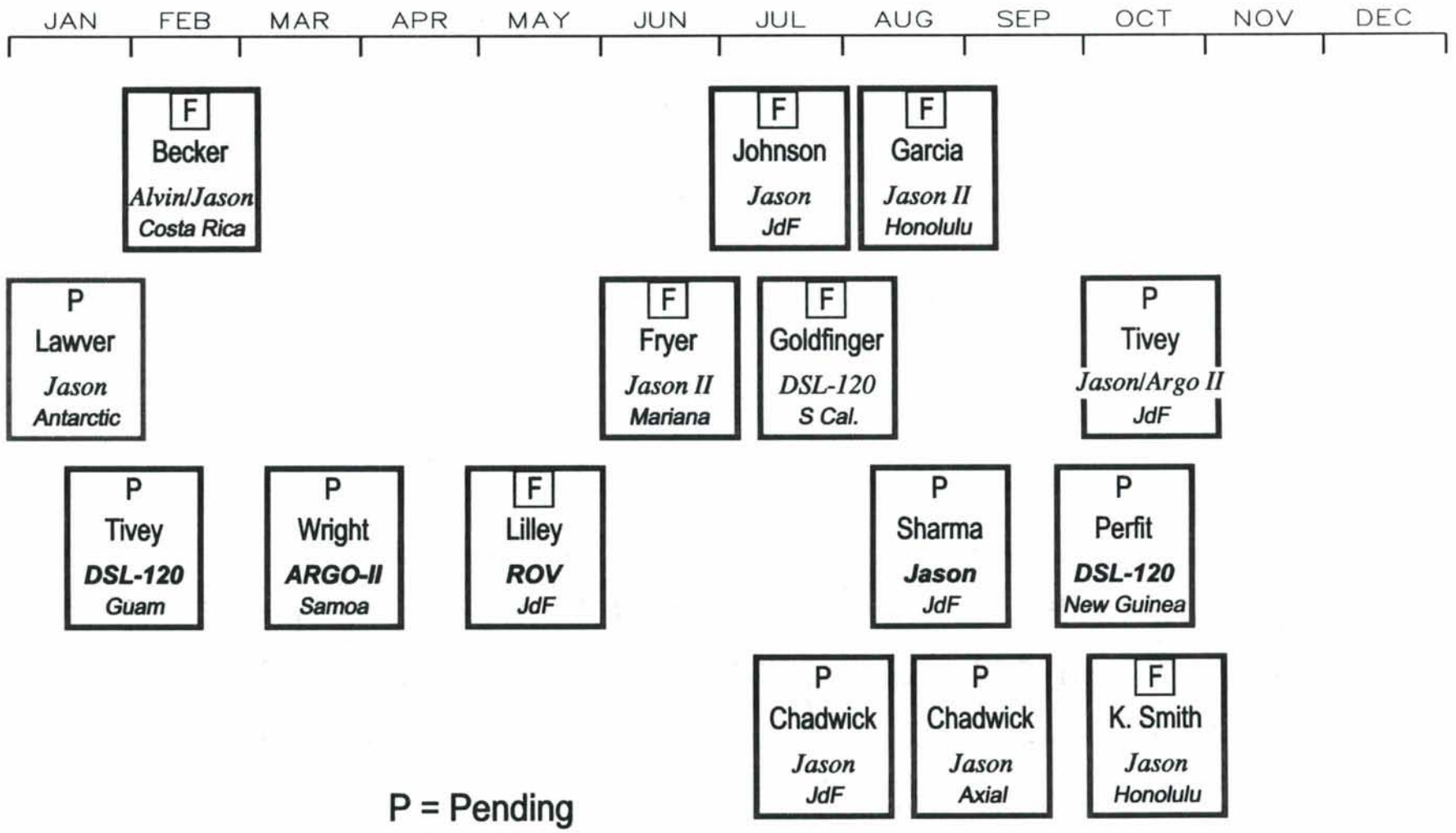
2002 Requests for ROV Operations

Deep Submergence Group
Woods Hole Oceanographic Institution



P = Pending
F = Funded

Betsey Doherty date: 12/27/00
file d:\dwg\alvin\dessc\nov00dwg

2003 Requests for Alvin Operations

Deep Submergence Group
Woods Hole Oceanographic Institution

P
Cowen
Alvin
JdF

F
Van Dover
Alvin
EPR

P
Fisher
Alvin
Gulf of Mex.

P
Kim
Alvin
EPR

P = Pending
F = Funded

Betsey Doherty date: 12/27/00
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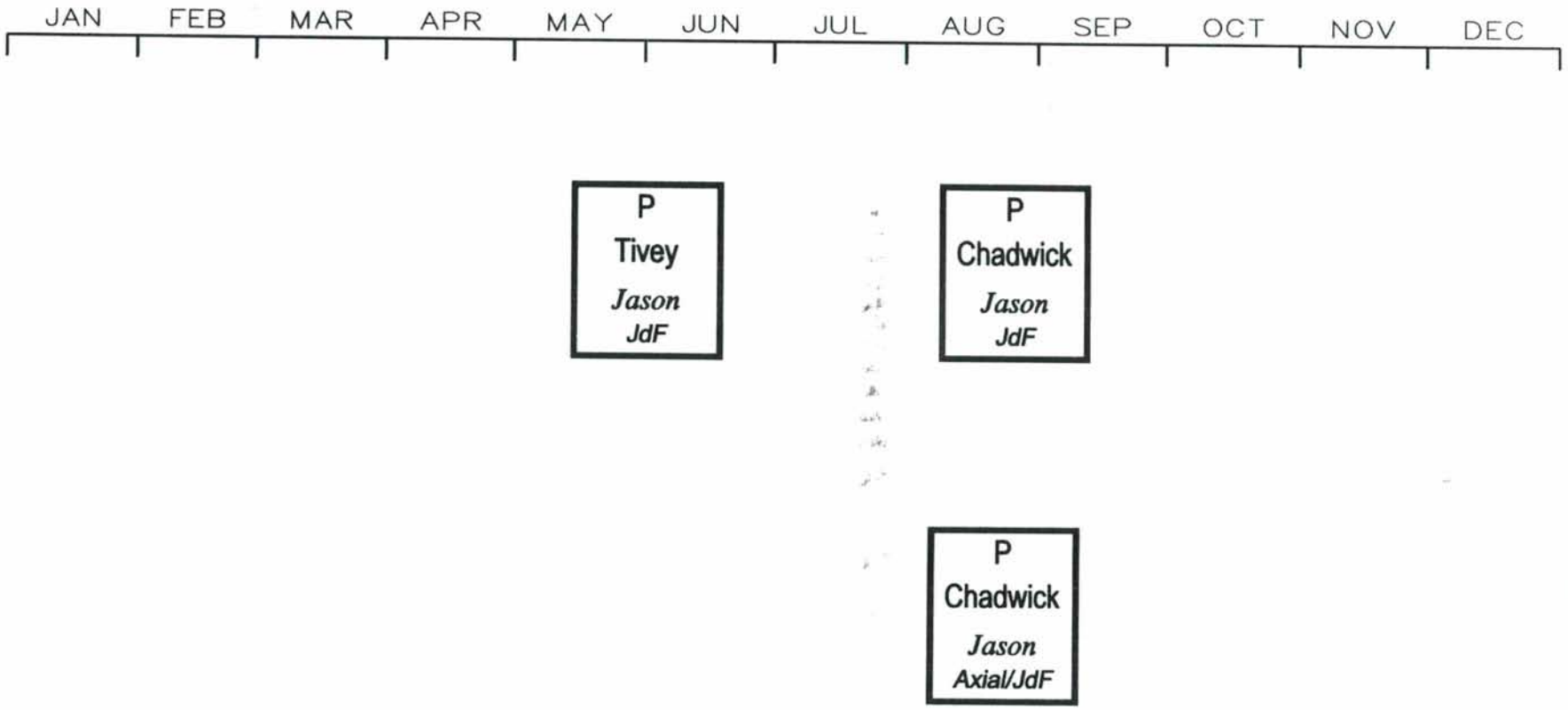
2003 Requests for ROV Operations

Deep Submergence Group
Woods Hole Oceanographic Institution



P = Pending
F = Funded

Betsey Doherty date: 12/27/00
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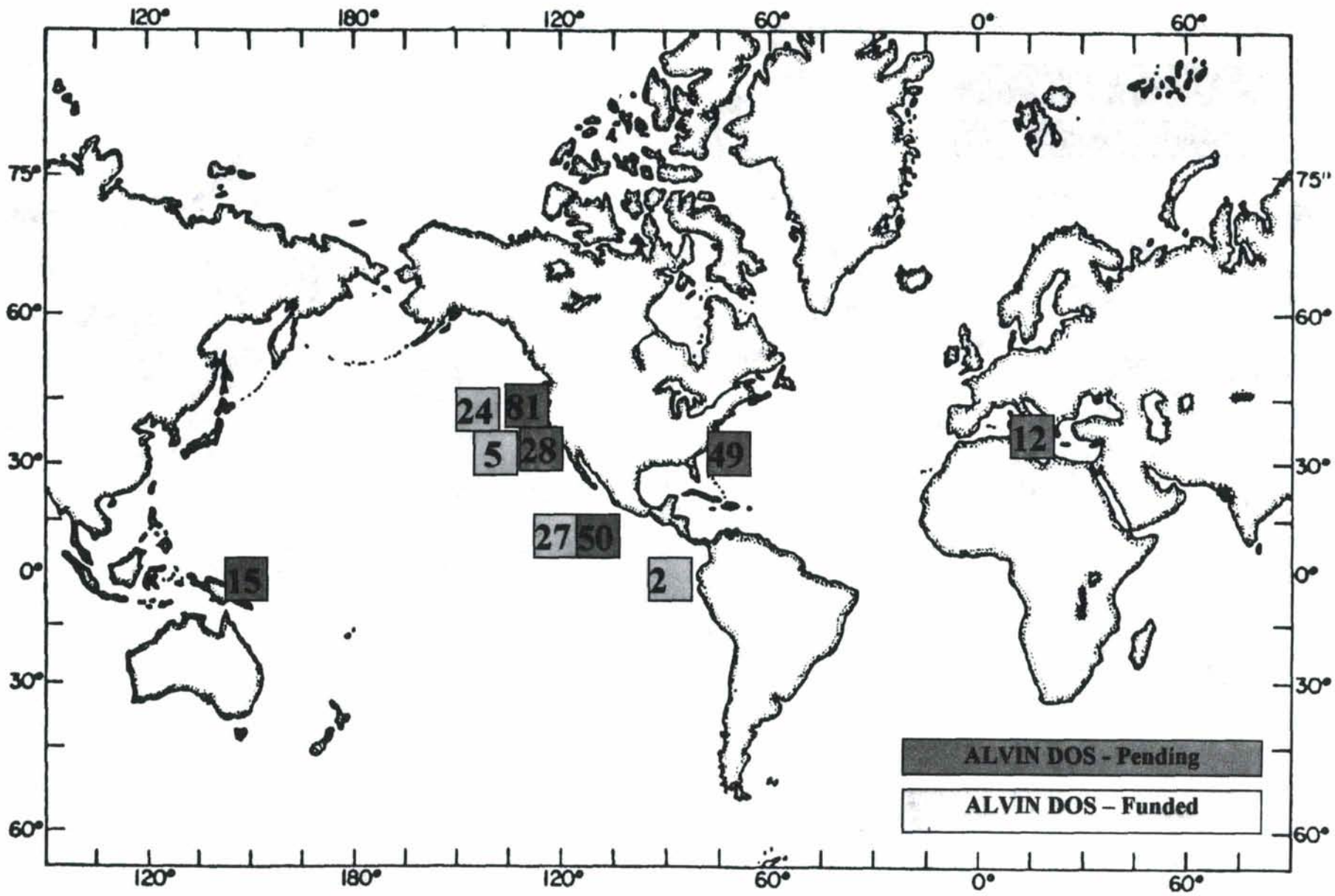
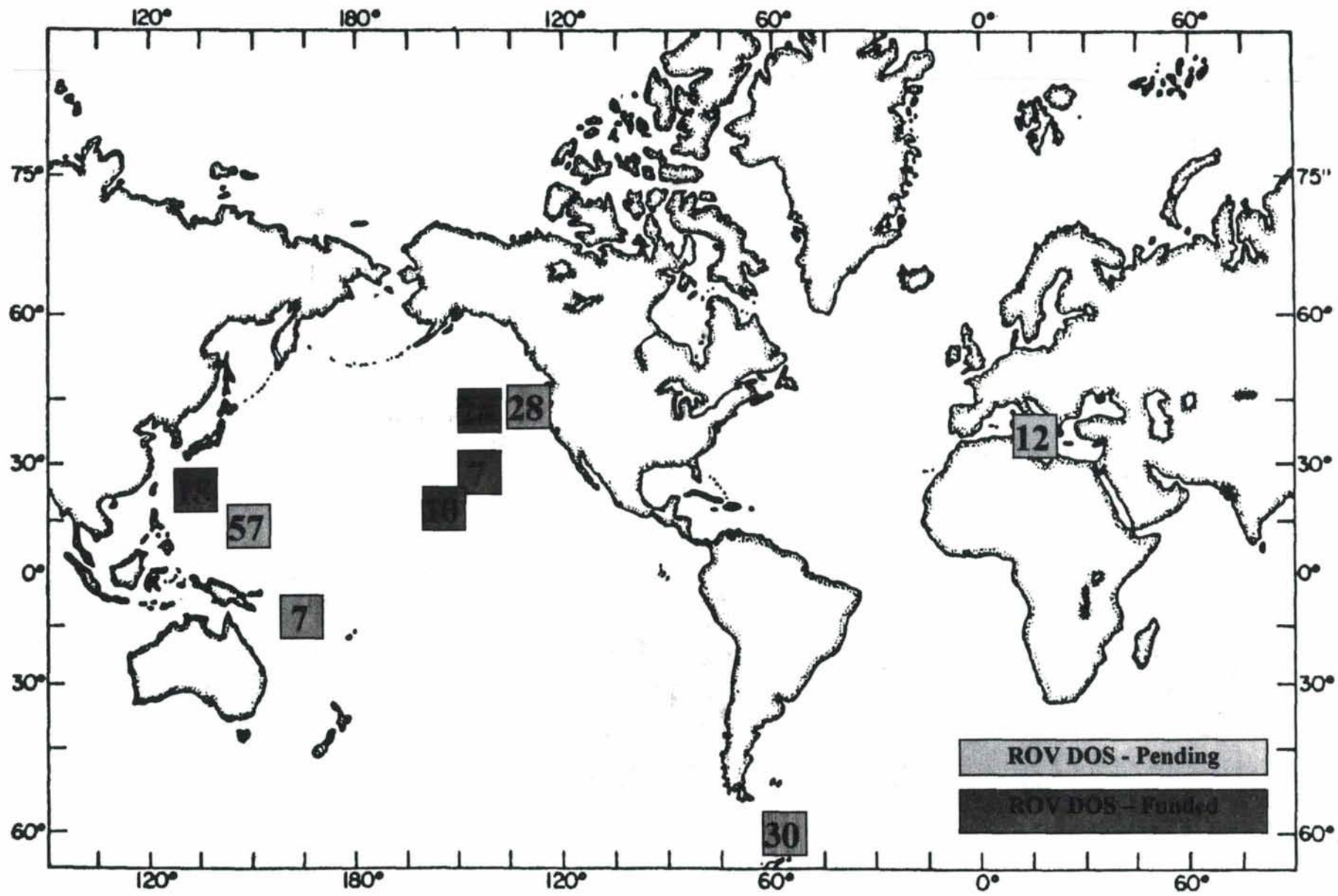
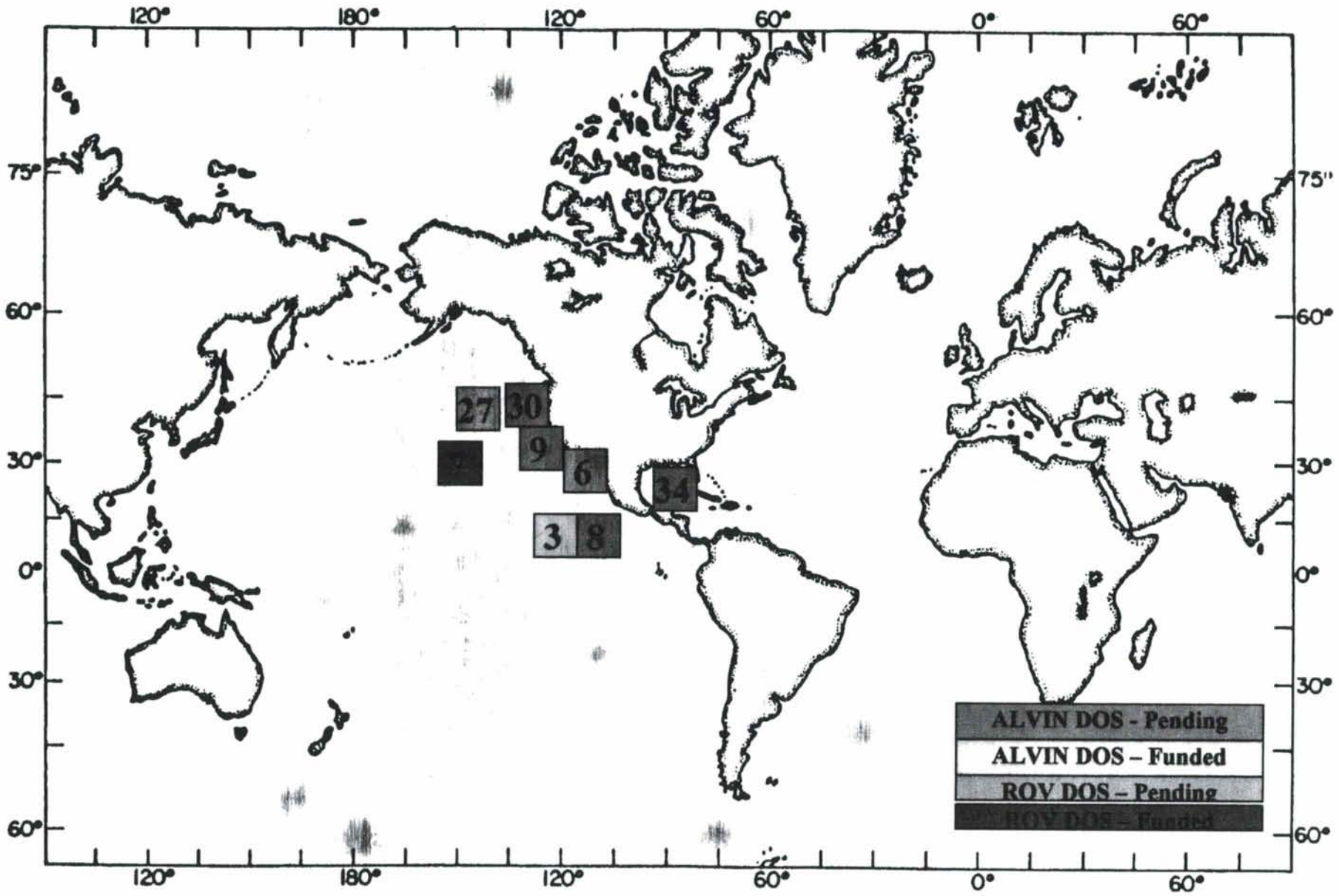
SUMMARY OF ALVIN REQUESTS: 2002



SUMMARY OF ROV REQUESTS: 2002

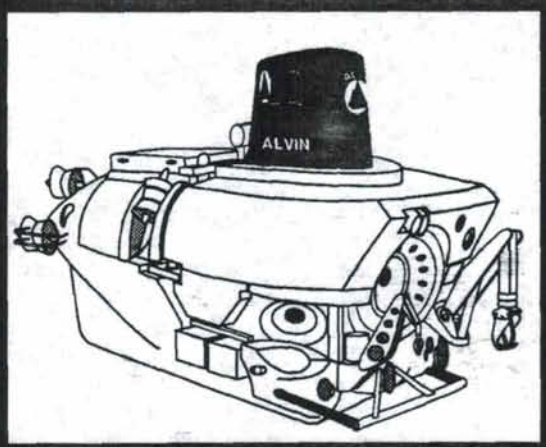


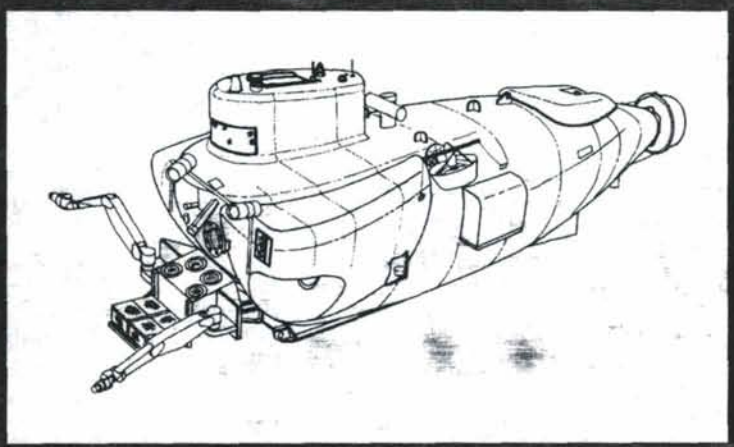
SUMMARY OF ALVIN and ROV REQUESTS: 2003



Appendix XVI

Comparison of Options for an Improved Manned Deep Submersible Vehicle for Research





Background

- Availability of SEA CLIFF
- Desire to maintain U.S. 6000 meter manned capability

Opportunity

- Review sphere size, viewport arrangement
- Improve battery capacity and access
- Improve ascent/descent times
- Review other options to produce a 6000 meter manned capability

Method of Study

- Assess SEA CLIFF equipment
- Survey other 6000 meter submersibles
- Survey current technologies
- Survey users and operators
- Develop desired vehicle functional specifications
- Evaluate possible modification to ALVIN and / or SEA CLIFF
- Investigate hull replacement / modification possibilities
- Conduct cost analysis on design and construction of new submersible
- Evaluate options

Improved Submersible Capabilities Survey

Concentrating Efforts

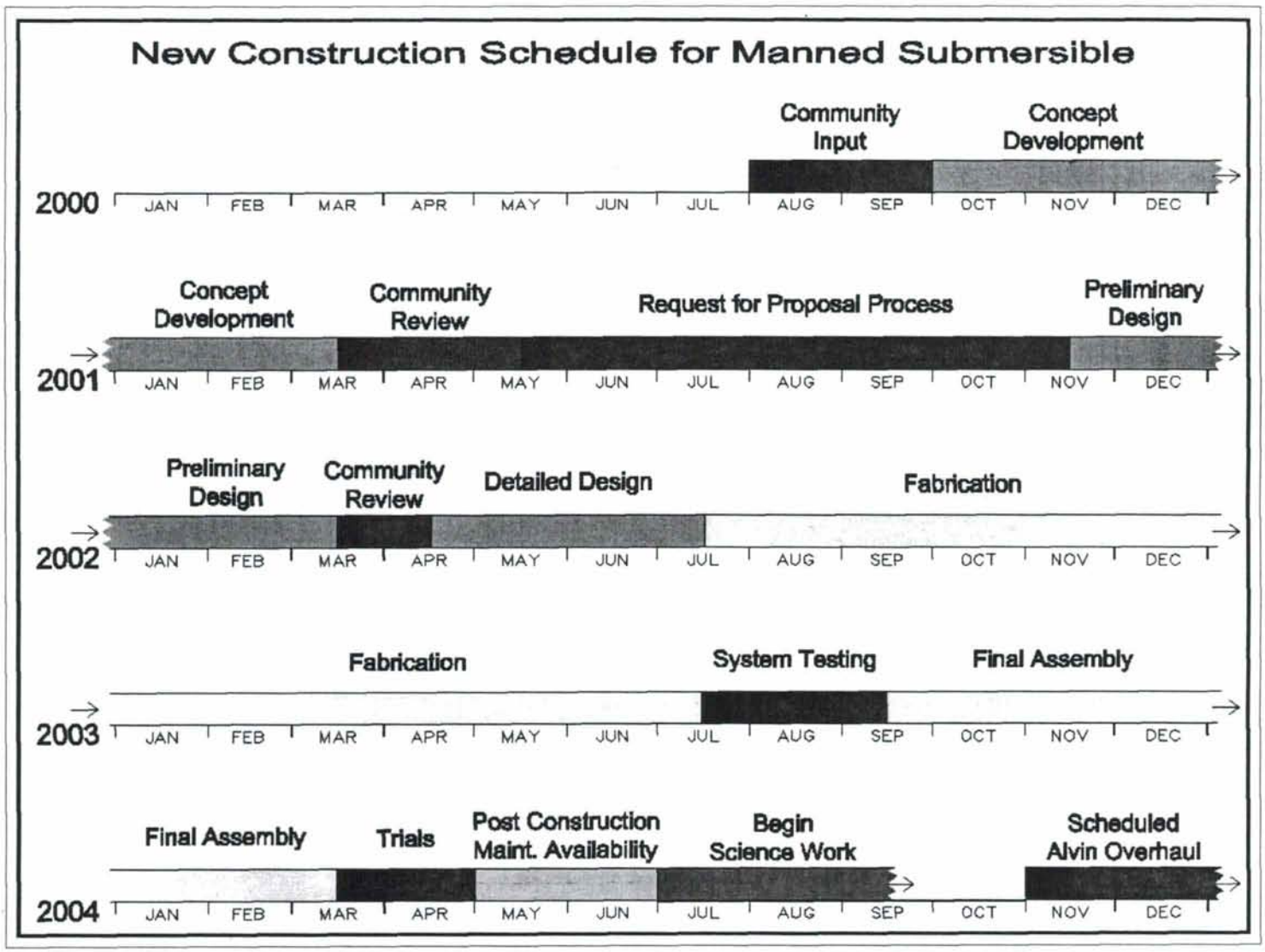
- Rearrange viewports
- Imaging
- Power capacity
- Bottom time
- Manipulative capabilities

Conclusions

- A new submersible will provide the best opportunity for the US to regain its 6000 meter manned capability and to achieve significant improvements in other areas.

Major Submersible Capability Improvements

- Depth capability
- Available power
- Bottom time
- Viewport locations
- Video imaging
- External and internal payload
- Manipulator performance
- Navigation accuracy/reliability


New Construction Schedule for Manned Submersible
Community Input
Concept Development
2000
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Concept Development
Community Review
Request for Proposal Process
Preliminary Design
2001
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Preliminary Design
Community Review
Detailed Design
Fabrication
2002
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Fabrication
System Testing
Final Assembly
2003
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Final Assembly
Trials
Post Construction Maint. Availability
Begin Science Work
Scheduled Alvin Overhaul
2004
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