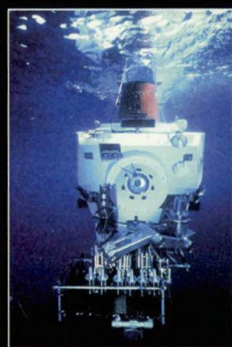
THE ACADEMIC RESEARCH FLEET



A REPORT TO THE ASSISTANT DIRECTOR FOR GEOSCIENCES
BY THE FLEET REVIEW COMMITTEE

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Under the auspices of the Advisory Committee for Geosciences, National Science Foundation

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EXECUTIVE SUMMARY

Oceans cover nearly three-quarters of the globe, and consist of nearly 1.4 billion cubic kilometers of saltwater, or about 97 percent of the free water on Earth. This volume of water strongly influences Earth's climate by transporting heat and energy around the globe, and exchanging gases with the atmosphere. The oceans host complex food webs that cycle energy and carbon, and provide the daily sustenance for millions. They are the highways of global commerce. Ocean processes operate at a variety of scales, ranging from global patterns of ocean circulation to localized processes occurring at scales of a few kilometers or less. The ocean floor also records 200 million years of climate history in its sediment blanket, in some places in great detail. The ocean floor's mountain chains—its mid-ocean ridges—provide laboratories for studies ranging from the origin of life to the chemical evolution of our planet. Long-term seafloor observatories are providing new information related to water and heat transport, and fault slippage that may result in large earthquakes. Oceanography, the science of the seas, explores these critical processes worldwide.

The U.S. Academic Research Fleet provides essential support to enable productive basic research in oceanography. Over the past four decades, the National Science Foundation (NSF) and other federal agencies have worked with universities and academic research institutions to provide the broadest possible access to the sea for the nation's oceanographic community. The current system for managing the Academic Research Fleet gets high marks from the scientific community and the federal agencies that participate in the system, which can be summarized as follows:

- **THE FLEET.** Ships of the Academic Research Fleet are both privately and federally owned. They are all operated by academic institutions. The fleet consists of large ships for ocean-wide investigations, intermediate size ships for regional investigations, small ships for coastal and estuarine work, and platforms with special capabilities such as the submersible *Alvin*. NSF provides a majority of the support for the operation, maintenance, and upgrade of the Academic Research Fleet. The U.S. Navy and the National Oceanic and Atmospheric Administration (NOAA) are the other major users of the Academic Research Fleet.

- **OVERSIGHT.** NSF, in partnership with the Office of Naval Research (ONR), supports and manages a ship inspection program to oversee safety practices, crew training, maintenance, operational procedures, and shipboard science laboratory facilities. The federal agencies maintain oversight on scheduling and operation of the Academic Research Fleet with respect to the federal programs they sponsor. As part of this oversight, goals for optimum annual vessel usage have been established, with recognition that geographic region, maintenance cycles, and other unique circumstances are a factor in usage.

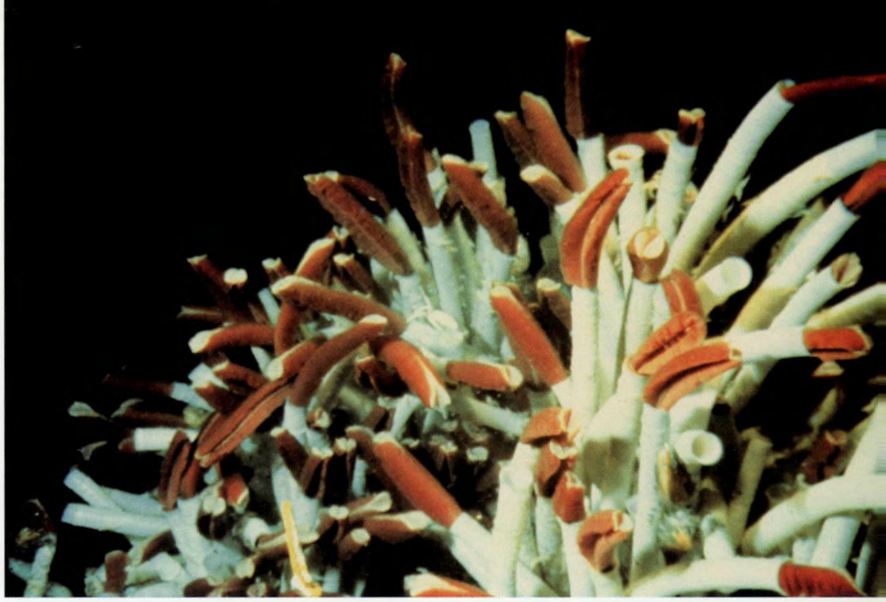
- **COORDINATION OF ACTIVITIES.** Ship operations are coordinated through the University-National Oceanographic Laboratory System (UNOLS), a consortium of 57 institutions, 20 of which currently operate ships. UNOLS ensures community-wide ship access, cooperative ship scheduling, standards for operations and safety, and uniform funding and cost accounting procedures, among other activities.

- **FLEET ACCESS BY OTHER FEDERAL AGENCIES.** Other federal agencies using vessels of the U.S. Academic Research Fleet coordinate scheduling and operator oversight through NSF and UNOLS, while policy issues at the interagency level are managed through the Federal Oceanographic Fleet Coordinating Council (FOFCC).

- **COMPETITION.** For ships of the Academic Research Fleet constructed and owned by the government, selection of operating institution is made via competition and review of proposals responding to a formal solicitation or request-for-proposal process. Selection of the host institution for the UNOLS Office is also made through a competitive process. Selection of scientific programs to be carried out on Academic Research Fleet ships is handled independent of the facilities through normal merit review of research proposals within NSF (or other agencies through their own standard procedures).

- **TECHNOLOGY AND SERVICES.** Most research vessels carry a sophisticated array of instruments tailored to a vessel's operating profile. NSF is the lead agency responsible for shipboard equipment replacement and upgrades, technical services awards and managing the operational and maintenance awards to all institutions on behalf of most research sponsors.

This report is the culmination of a comprehensive external review of the U.S. Academic Research Fleet requested by NSF's National Science Board (NSB). A Fleet Review Committee (the "Committee") formed by the Assistant Director for Geosciences and which operated under the auspices of the Advisory Committee for Geosciences, was asked to report on two principal aspects of the Academic Research Fleet. The first was to evaluate the current and future vessel requirements that are necessary to effectively support NSF-sponsored oceanographic research, and research of other federal agencies, state and local governments and private sources. The second was to



evaluate the overall structure currently in place to manage the myriad aspects of the research fleet, and to recommend any changes to the structure that would further optimize operations.

The Committee met four times between June 1998 and March 1999. It received input from NSF and ONR managers; UNOLS managers, ship operators and members; and the scientific user community. Findings were augmented by cost analysis of UNOLS vessel operations and those of other operators provided by an independent contractor (Tecolote Research, Inc.). In addition, UNOLS provided post-cruise reports where both Chief Scientists and Vessel Masters provide independent evaluations of past research cruises.

There are eight principal findings and recommendations of the Committee:

CURRENT AND PROJECTED RESEARCH FLEET REQUIREMENTS

1. The potential for near-term decrease in utilization of ocean-going research facilities is real. It may represent a transient condition, as new planning for ocean programs identifies the next cycle of field efforts. This provides an opportunity to respond to some management issues in fleet operation and to continue to improve the capability, productivity, and quality of fleet operations as a means of achieving NSF research and educational objectives in ocean sciences.

2. NSF must accelerate and expand efforts within the oceanographic research community to articulate a broadly based vision for the future of ocean science and technology requirements. This will provide a much needed foundation on which to plan and procure major facilities for research.

MANAGEMENT STRUCTURE AND CAPABILITIES

3. The UNOLS system should be retained. The NSF-UNOLS current practices, using institutional operators funded by NSF and other federal agencies with centralized scheduling through UNOLS, seems to provide excellent access to the sea for US investigators. To the extent the committee can assess, costs appear comparable to or better than government operators, and not evidently different from costs of contracting commercial platforms.

4. The funding agencies and UNOLS need to support fleet improvements by enhancing quality control, expanding training of personnel in technical and safety procedures, and developing even higher standards for shared use facilities.

5. NSF should continue the practice of periodically competing the management of the UNOLS office, and should consider funding it by a cooperative agreement rather than a grant to ensure necessary management oversight.

6. We ask NSF to consider a trial which includes some commercial operators participating as UNOLS non-member operators to provide unique capabilities not otherwise available.

7. There is a need for a strong, continuing program of new technology introduction; steady improvement of existing facilities and technologies; greater, continuing attention to quality control and safety; and a more systematic, standard approach to maintenance, renovation, upgrading, and replacement.

8. The Federal agencies funding research in oceanography should prepare and maintain a long range plan for the modernization and composition of the oceanographic research fleet which reaches well into the 21st century. This will avoid the high cost of obsolescent facilities and provide the Congress with a unified roadmap for out-year allocations for vessels to support oceanographic research.

1. COMMITTEE CHARGE AND PROCEDURES

Although annual administrative, management, and financial analyses and review of institutional ship operators are routinely conducted, the National Science Board (NSB) requested a comprehensive review of the overall system for providing access to the sea via oceanographic research vessels. A review of this kind had not been conducted since the formation of the current support system in the early 1970s. An additional impetus for a review of the fleet was the establishment of major principles and key issues for 'Competition, Recompetition and Renewal of NSF Awards' (NSB 97-224) by the National Science Board (NSB) in November, 1997. The supporting statement notes that even in cases where facility management has been explicitly and vigorously reviewed and found to be effective, NSF must evaluate periodically if there is a better management approach.

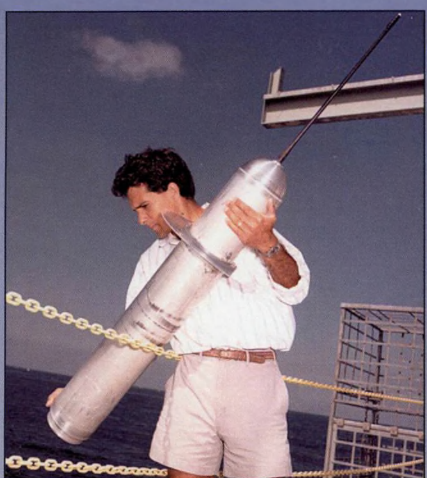
In response to this request by the NSB, the Assistant Director for Geosciences formed a Fleet Review Committee (the "Committee") which operated under the auspices of the Advisory Committee for Geosciences and reported to the Assistant Director for Geosciences (Appendix A). The Committee was asked to:

1. Review and evaluate the current and projected research vessel fleet required for research sponsored by the National Science Foundation within a national framework that includes research requirements of other federal agencies, state and local governments, and private sources.

2. Review and evaluate overall management structure of the Academic Research Fleet; review and evaluate existing capabilities and services provided by the operating organizations; and review and evaluate possible future changes in academic fleet operations to ensure optimal operations of the academic fleet to support research requirements.

3. Provide recommended actions by NSF to improve the organization, management, and cost effective operation of the Academic Research Fleet in support of scientific capabilities required to maintain world leadership in ocean and environmental science research.

The Committee met four times between June 1998 and March 1999 (Appendix B). During that time, NSF presented information on fleet management and support. UNOLS management, ship operators and members, together with other operators of oceanographic research vessels in the U.S. and abroad, addressed existing models for vessel support of oceanographic research. An independent contractor (Tecolote Research, Inc.) augmented the UNOLS presentation by providing an independent cost analysis of UNOLS and other vessel operators. NSF and ONR research program managers, and external community representatives, provided an assessment of trends and opportunities in ocean science research with a focus on sea-going requirements. A number of users of the Academic Research Fleet— from different subdisciplines, from both large and small oceanographic institutions, and from other programs which use the fleet but do not operate ships— presented their views on academic research vessel support. In addition, the oceanographic community provided written comments on the management, operation and future needs of the Academic Research Fleet. Finally, UNOLS provided post-cruise reports where both Chief Scientists and Vessel Masters provide independent evaluations of past research cruises.



WOCE: World Ocean Circulation Experiment

WOCE is a 30-nation research program whose goal is to better understand the role of ocean circulation in long-term climate change and to develop models for predicting such change.

- Work is conducted from large UNOLS vessels
- Used several satellites, dozens of ships, and thousands of instruments during its field program
- Acquired physical, chemical, and ocean current data along an extensive grid of transects in all the major ocean basins
- Used over 2200 days of ship time between 1990 and 1999
- Field programs concluded in 1999; program entering a five-year modeling and data synthesis phase

How does the ocean affect climate?

The upper layer of the ocean contains as much heat as the whole atmosphere. Interaction between the two results in changes in weather, sea level, and more. The ocean also absorbs trace gases implicated in global warming (e.g., carbon dioxide), mitigating their immediate effects. More importantly, however, the ocean mixes and moves water away from the surface and redistributes it to deeper layers around the globe as part of large-scale ocean circulation. Thus, the ocean acts as a buffer to reduce some of the potential climate shifts. Knowledge of the global ocean and its circulation is essential to understanding and predicting Earth's climate variability, long-term change, and ultimately its impact on humankind.

2. ACADEMIC RESEARCH FLEET

The International Geophysical Year (IGY; 1957-58) brought to the international ocean science community a recognition that large-scale, multinational research initiatives could be conducted that offered a new way to observe and understand the Earth on a truly global scale. The experience of implementing the IGY led to a realization that global initiatives would require better national and international coordination of both the programmatic and logistical elements of ocean science research. The International Decade of Ocean Exploration (IDOE) in the 1970s stemmed from the success of IGY, and provided a substantial additional increase in requirements for research and oceanographic facilities. This initiated the development of the present academic fleet.

Several conditions must be met if the Academic Research Fleet is to be operated in an effective manner in support of NSF-sponsored science. First, the capabilities, operating modes, and geographic distribution of the fleet must meet research requirements. For NSF-sponsored research, this means that the fleet profile must include large ships with global range, intermediate ships for regional or ocean basin scale studies, and smaller ships for local, near-shore studies including the Great Lakes. Specialized capabilities to meet research priorities that cannot be met by general purpose ships must be maintained as needed. The submersible *Alvin* and associated support is an example of such a unique facility. Second, an effective science support infrastructure is required to ensure that shipboard equipment and technicians can support research needs. To achieve these goals, each operator within the fleet must maintain a shipboard technical support group and an inventory of shared-use instruments. Third, an effective and efficient management structure is required to ensure community-wide access to the ships and instrumentation, safe operating procedures, and uniform cost accounting.

A. THE FLEET

The overall U.S. oceanographic fleet includes research, survey, fisheries and other mission-related vessels of the federal agencies, of which the Academic Research Fleet (the "UNOLS Fleet") is the largest single component, and virtually all of the research component (Figure 1). In 1999, the Academic Research Fleet consists of 28 research vessels, broadly divided into four categories, with operating modes responsive to different components of national research requirements (Figure 2).

U.S. OCEANOGRAPHIC FLEET - 2000

(operator by color)

Mission / Owner	NAVY	NOAA	NSF	Other FED	University
MULTI-PURPOSE RESEARCH	Knorr 279' Melville 279' Thompson 274' Atlantis 274' Revelle 274'	Brown 274' Ka'imimoana 224' Ferrel 133'	Ewing 239' Point Sur 135' Wecoma 184' Alpha Helix 133' Endeavor 184' Barnes 66' Oceanus 177' Cape Hatteras 135'	Andersen 165' Lake Guardian 168' Lake Explore 82' Clean Waters 85' Urraca 96'	S Johnson 204' Weatherbird 115' Gyre 182' Sea Diver 113' New Horizon 170' Longhorn 105' Edwin Link 168' Pelican 105' Samul 125' Laurentian 80' Henlopen 120' Blue Fin 72' Calanus 69'
SURVEY	Pathfinder 328' Heezen 328' Sumner 328' Kane 285' Bowditch 328' Littlehales 208' Henson 328' McDonnell 208'	Rainier 231' Whiting 163' Rude 90'			
FISHERIES		Gunter 228' Delaware II 171' Freeman 215' Oregon II 170' Albatross IV 187' Cromwell 163' Jordan 155' MacArthur 175' Cobb 93'			
SPECIAL PURPOSE: Polar			Palmer* 308' Gould* 230' *Contracted by NSF	Healy 420' Polar Star 399' Polar Sea 399'	
Submersible	Manned: Alvin 4500m Sea Cliff 6000m ROV: ATV 6100m AUV: AUSS 6000m				Manned: Pisces V 2000m ROV: Jason / Medea 6000m Ventana 1850m Tiburon 4000m Focus 6000m AUV: ABE 6000m Odyssey II 6000m Sea Floor Rover 6000m
Other	FLIP 355'		JOIDES Resolution* 471'		

Fig. 1: U.S. National Oceanographic Fleet projected for 2000. NSF and Navy ships operated as UNOLS vessels are color-coded "University Ships."

	NAME	OWNER	SIZE
LARGE EXPEDITIONARY SHIPS			
Scripps Institution of Oceanography	MELVILLE	Navy	279 ft.
Woods Hole Oceanographic Institution	KNORR	Navy	279 ft.
Scripps Institution of Oceanography	ROGER REVELLE	Navy	274 ft.
Woods Hole Oceanographic Institution	ATLANTIS	Navy	274 ft.
University of Washington	THOMPSON	Navy	274 ft.
Lamont-Doherty Earth Observatory	MAURICE EWING	NSF	239 ft.
INTERMEDIATE SHIPS			
University of Hawaii	MOANA WAVE*	Navy	210 ft.
Harbor Branch Oceanographic Institution	SEWARD JOHNSON	HBOI	204 ft.
Oregon State University	WECOMA	NSF	185 ft.
University of Rhode Island	ENDEAVOR	NSF	184 ft.
Texas A&M University	GYRE	TAMU	182 ft.
Woods Hole Oceanographic Institution	OCEANUS	NSF	177 ft.
Scripps Institution of Oceanography	NEW HORIZON	SIO	170 ft.
Harbor Branch Oceanographic Institution	EDWIN LINK	HBOI	168 ft.
REGIONAL SHIPS			
Moss Landing Marine Laboratories	POINT SUR	NSF	135 ft.
Duke University/University of North Carolina	CAPE HATTERAS	NSF	135 ft.
University of Alaska	ALPHA HELIX	NSF	133 ft.
Scripps Institution of Oceanography	ROBERT G. SPROUL	SIO	125 ft.
University of Delaware	CAPE HENLOPEN	UD	120 ft.
Bermuda Biological Station for Research	WEATHERBIRD II	BBSR	115 ft.
Harbor Branch Oceanographic Institution	SEA DIVER	HBOI	113 ft.
Louisiana Universities Marine Consortium	PELICAN	LUMCON	105 ft.
University of Texas	LONGHORN	UT	105 ft.
LOCAL NEAR-SHORE SHIPS			
Smithsonian Institution	URRACA	SI	96 ft.
University of Michigan	LAURENTIAN	UMICH	80 ft.
University System of Georgia	BLUE FIN	UG	72 ft.
University of Miami	CALANUS	UM	68 ft.
University of Washington	BARNES	NSF	66 ft.

Moana Wave is being retired in July 1999.

Fig. 2: U.S. Academic Research Fleet (1999).

- Six large ships with capabilities for extended, global research cruises to regions distant from home port. Five are Navy-owned, one NSF-owned.
- Eight intermediate and large coastal ships with capabilities for multidisciplinary and single investigator studies throughout U.S. waters and adjoining regions. One is Navy-owned, three are NSF-owned, and four are institution-owned.
- Nine regional, or "Cape Class" research ships with capabilities for smaller projects in coastal and near-shore regions. Six are institution-owned, three NSF-owned.
- Five local ships, with capabilities for small projects close to home port and in near-shore waters. Four are institution-owned, one NSF-owned. Operating Institution

In general, the large expeditionary ships are new and highly capable, and carry the most extensive and advanced scientific instrumentation in the fleet. In the 1990s, the Navy constructed three large ships, NSF acquired and converted an industry multi-channel seismic ship, and the Navy extensively refitted two large, existing academic research ships. In contrast, many of the intermediate and regional ships built in the 1960s and early 1970s will require replacement in the next decade or so, and several of the local ships need to be replaced immediately (Figure 3). The University of Miami and the University System of Georgia, operators of two of the older local vessels, have indicated their intentions to replace their institution-owned vessels with internal funds in the next two years.

In addition to general oceanographic and environmental studies supported by the Academic Research Fleet, NSF sponsors specialized studies for Antarctic research and scientific ocean drilling through separate programs. The required facilities for both of these programs are provided by private companies through contracts with NSF for integrated scientist support, logistics and facilities operations.

B. Science Support Infrastructure

NSF maintains programs totaling about $5 million annually for upgrading and replacing scientific instrumentation and shipboard equipment throughout the fleet. Most vessels carry a sophisticated array of instruments tailored to a vessel's operating profile. This research instrumentation falls in four basic categories:

- Installed systems which sail permanently with the vessel. This includes items such as winches of varying capability, standard oceanographic cables, advanced navigation equipment, meteorological sensor suites, single-beam (all) and multi-beam (6 ships) echosounder systems, acoustic doppler current profilers, and both voice and Internet communications systems.

- Widely-used shared-use instrumentation, which are common to most or all ships in the fleet. This includes CTD systems and related water samplers and sensors,

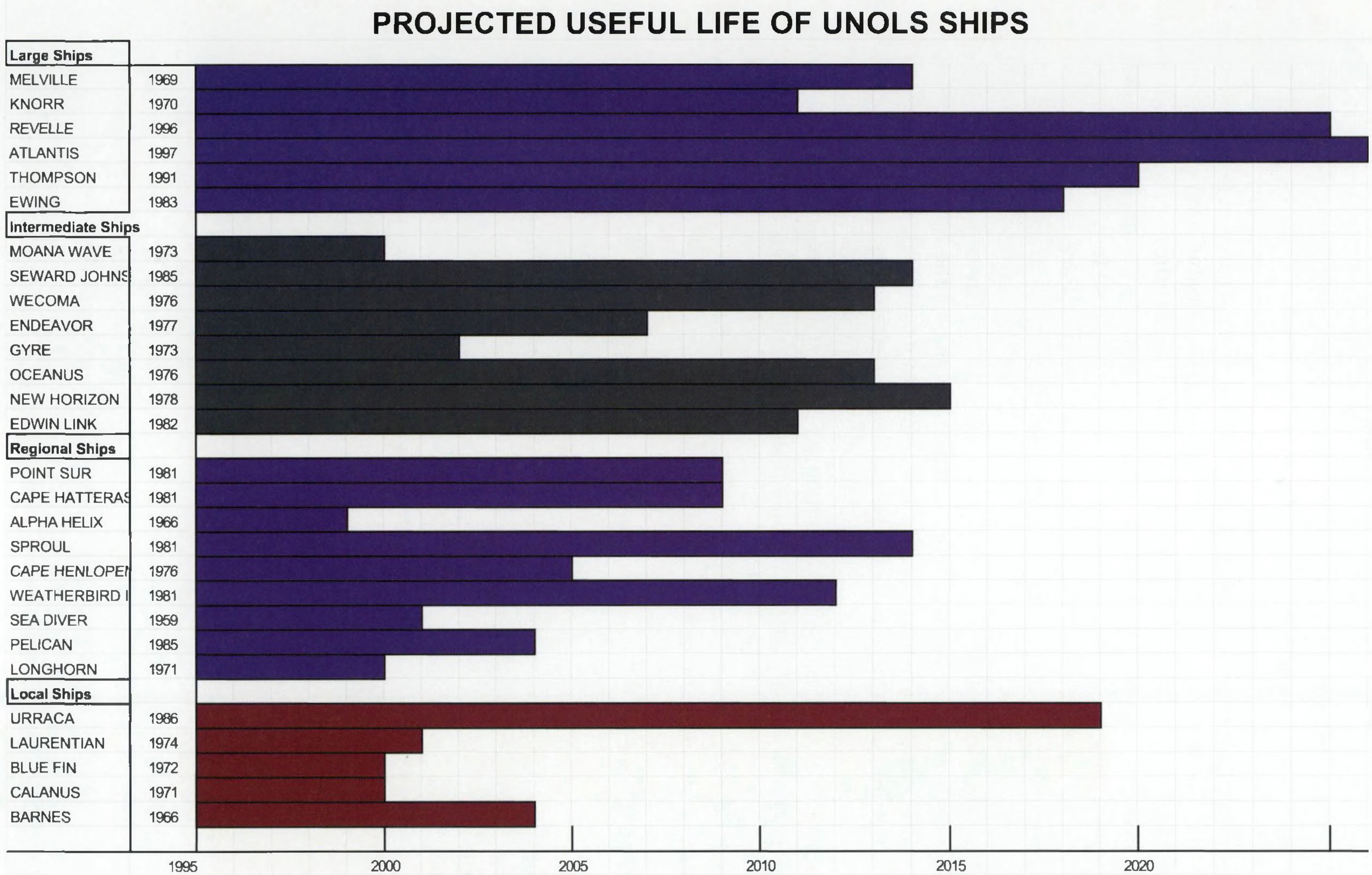


Fig. 3: Projected replacement/retirement dates for existing UNOLS ships. Based on 20 to 30-year service life modified to reflect mid-life refits and other service upgrades (UNOLS Fleet Improvement Committee data).

surface water underway analysis systems (most commonly for temperature, salinity and some nutrients), biological sampling nets of various types, corers, dredges and trawls, as well as a number of other tools.

- Specialized shared-use instrumentation, of which only one or a few systems are available to the fleet, which can be moved from one ship to another as needed. This includes such items as remotely-operated vehicles (ROVs), large piston coring systems, towed side-scan sonar systems, "clean" CTD systems, and undulating profiler systems, among others.

- Instruments provided by the scientific user.

In addition to these instruments, all ships in the UNOLS fleet carry computers for onboard research. Most ships have local-area networks on board, some of which are very sophisticated, allowing scientists access to computer resources required in their research, or to attach their own set of computers to the existing network.

Each operator maintains a group of shipboard technicians to support the shared-use instrumentation, and one or two of these technicians (depending on vessel size) always sail on research cruises to assist the scientific user. These technical support groups have responsibility for maintaining and calibrating their pool of shared-use scientific instruments as well as operating them at sea.

C. MANAGEMENT

UNOLS

The basic organizational structure for the operation of the Academic Research Fleet was established in 1972 with the formation of the 17-member University-National Oceanographic Laboratory System. Two key elements of the UNOLS structure are that UNOLS is not a ship operating organization, i.e., ship operations remain the responsibility of the individual research institutions; and federal agencies and other research sponsors continue to provide facilities support directly to the operating institutions.

Prior to establishing UNOLS, 33 research vessels were operated under rules and procedures of the individual institutions. Vessel access was primarily under the direction of institution scientists and managers. The federal and university administrators who established UNOLS saw the need to develop a system that made ships accessible to a broader community of investigators, established standards for operations and safety, and had uniform funding and cost accounting procedures.

Initial UNOLS efforts focused on ship scheduling and investigator placement procedures. This was followed by uniform cost accounting, cruise reporting, ship operations data and information services. Other UNOLS developments included stan-

Alabama Marine Environmental Sciences Consortium	Moss Landing Marine Laboratories
University of Alaska	Naval Postgraduate School
Bermuda Biological Station for Research	University of New Hampshire
Bigelow Laboratory for Ocean Sciences	State University of New York at Stony Brook
Brookhaven National Laboratory	University of North Carolina at Wilmington
University of California, San Diego, Scripps Institution of Oceanography	Nova University
University of California, Santa Barbara	Occidental College
Cape Fear Community College	Old Dominion University
Columbia University, Lamont-Doherty Earth Observatory	Oregon State University
University of Connecticut	University of Puerto Rico
University of Delaware	University of Rhode Island
Duke University/University of North Carolina	Rutgers University
Florida Institute of Technology	San Diego State University
Florida State University	Sea Education Association
Harbor Branch Oceanographic Institution	Smithsonian Tropical Research Institute
Harvard University	University of South Carolina
University of Hawaii	University of South Florida
Hobart & William Smith Colleges	University of Southern California
The Johns Hopkins University	University of Southern Mississippi
Lehigh University	University System of Georgia, Skidaway Institute of Oceanography
Louisiana Universities Marine Consortium	University of Texas
University of Maine	Texas A&M University
The Marine Science Consortium	Virginia Institute of Marine Science
University of Maryland	University of Washington
Massachusetts Institute of Technology	University of Wisconsin at Madison
University of Miami, Rosenstiel School of Marine and Atmospheric Sciences	University of Wisconsin at Milwaukee
University of Michigan, Center for Great Lakes and Aquatic Sciences	University of Wisconsin at Superior
Monterey Bay Aquarium Research Institute	Woods Hole Oceanographic Institution

Fig. 4: UNOLS member institutions. Ship operating institutions in blue.

dards for shipboard equipment and technical services, foreign research clearance procedures, science mission requirements for new ship planning, shipboard safety standards and community plans for ship replacements for aging and obsolete research vessels. UNOLS has a number of working committees which handle topics from ship scheduling and vessel operation to technical improvement and the use of specialized facilities (Appendix C).

All institutions with academic programs that use the research vessels may join UNOLS. Currently UNOLS has 57 member institutions, 20 of which operate UNOLS fleet vessels (Figure 4). Since the beginning of UNOLS, five institutions ceased being ship operators and eight new operators joined, bringing to UNOLS institution-owned ships.

CONTRACTUAL MECHANISMS FOR FLEET OPERATIONS SUPPORT BY NSF

NSF uses two fiscal instruments, grants and cooperative agreements, to support different aspects of the UNOLS fleet operations. Grants, the most commonly used instrument by NSF, are used to support the UNOLS office, technical services awards, acquisition of shared-use equipment and instrumentation, and research projects which are carried out on the ships. The cooperative agreement is used to support each operator's vessel operations costs. The cooperative agreements used by the Division of Ocean Sciences contain common provisions sharing responsibility for ship operation management between the operator and NSF, and have reporting requirements related to a number of operational factors, including accidents, maintenance, and safety. They require regular (every two years) vessel inspections, and they also require proposals in a common format which detail individual cost components for four years (two past, current and upcoming), to keep NSF informed of cost history and assist with "best practices" management procedures. Cost and data trends compiled for the last six years (1993-1998) show that the total funding ranged from $42.9 to $52.0 million annually from all research sponsors (Figure 5). The average cost per day (in constant 1998 dollars) to operate ships of the Academic Research Fleet ranges from about $16,000 for the large ships to about $4,000 for the local ships. Operating costs for all ship classes have remained nearly constant over this time and indicate costs are under control within the range of the ship utilization factors (Figure 6).

FACILITIES PLACEMENT

For the research vessels constructed by NSF and the Navy, agencies follow federal procurement regulations in making construction awards. To select ship operating institutions, calls for operating proposals are made via open competition. Selection of operator institutions is made based on terms outlined in the solicitation. Charter party agreements with the selected institutions are then negotiated. These agreements vary in length (usually five years) and are reviewed periodically. They may be extended by consent of both parties. During the period the charter party agreement is in force, the operating institution must agree to maintain the vessel to the U.S. Coast Guard (USCG) and the American Bureau of Shipping (ABS) standards and be subject to Navy or NSF inspections.

The ship-operating institution is responsible for the safety of all crew and scientific parties and is not guaranteed operational funds by virtue of selection as a vessel operator. The operator must meet all UNOLS access, operations and safety standards.

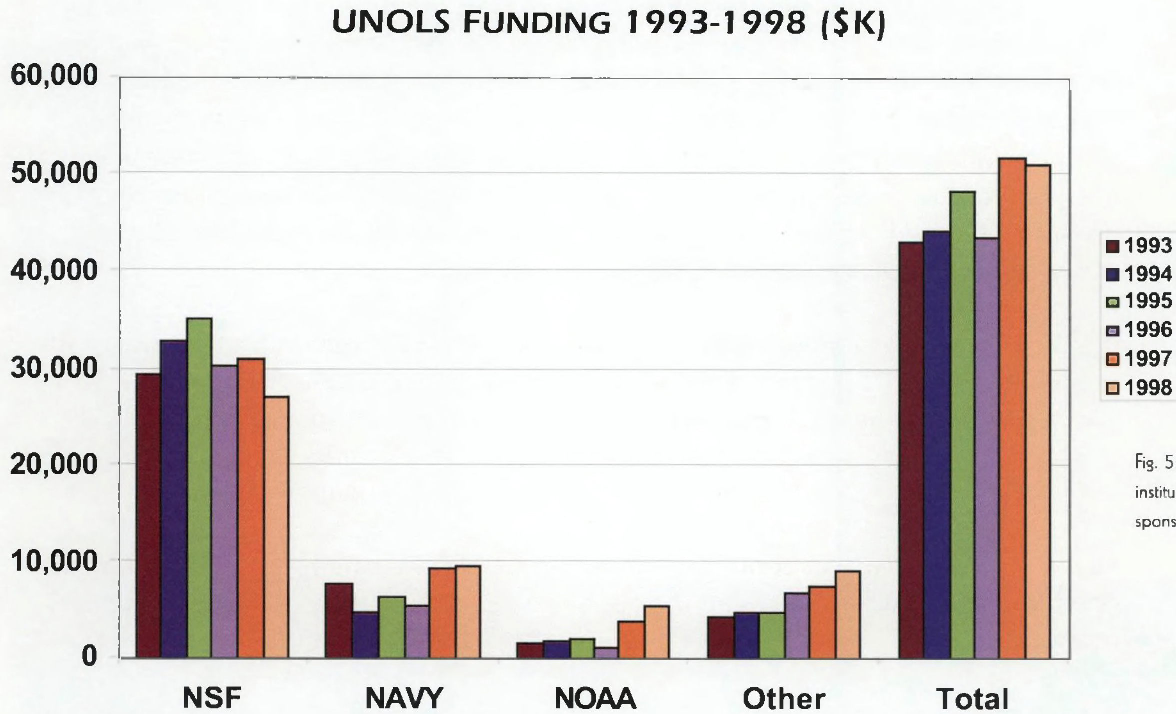


Fig. 5: Funding for UNOLS institutions ship operations by research sponsor.

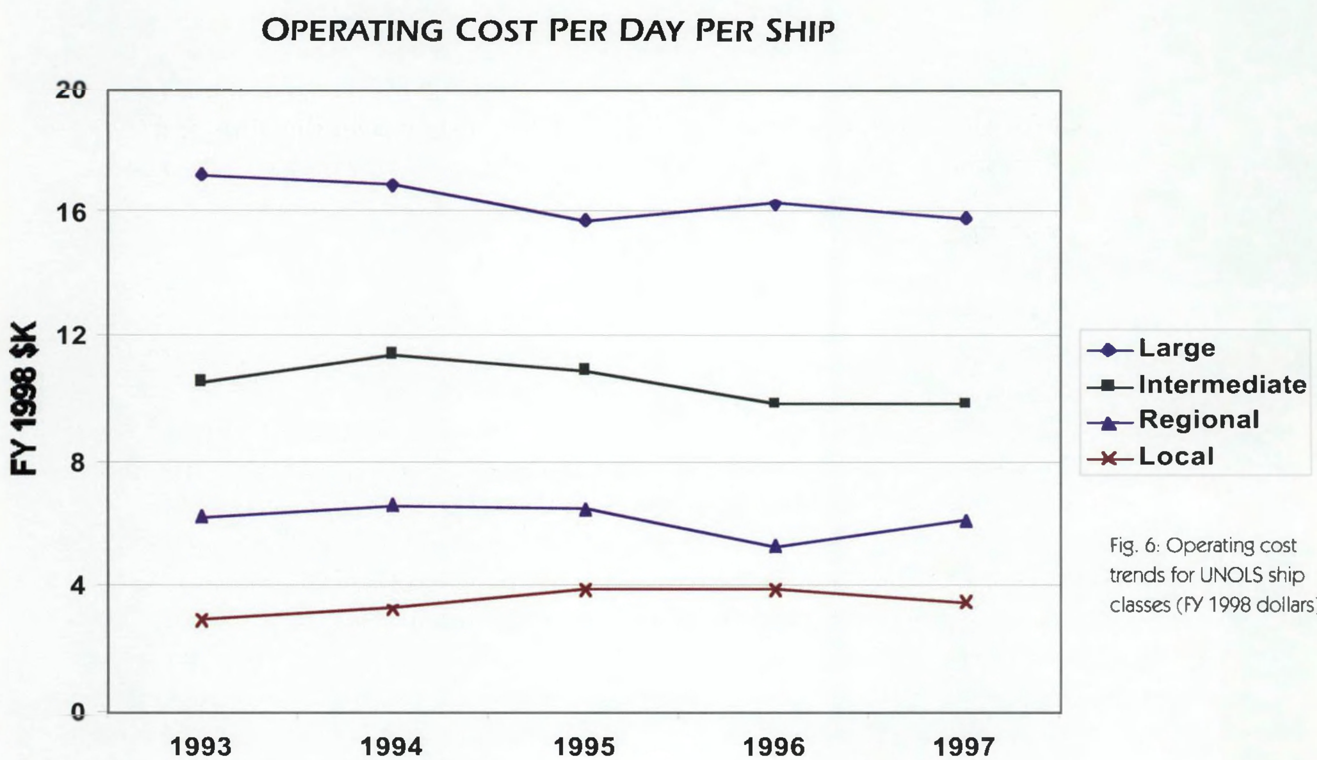


Fig. 6: Operating cost trends for UNOLS ship classes (FY 1998 dollars).

As an operator, the institution may propose to NSF, ONR or other agencies for support of scheduled scientific cruises using a negotiated day rate. It may also submit proposals for ship technician support, ship scientific support equipment and oceanographic instruments for shared use. The proposal regime, charter party agreements, UNOLS membership, and safety inspections provide strong fiscal and management oversight of the vessel operators. Five-year agreements with provision for extension provide the longevity needed for the operator to establish and maintain effective crews and technical personnel in support of science.

U.S. institutions with non-federally owned oceanographic research ships can apply to become UNOLS operating institutions. Once linked to UNOLS and abiding by UNOLS operational and scheduling constraints, these institutions can propose to

GLOBEC: U.S. GLOBAL ECOSYSTEM DYNAMICS

U.S. GLOBEC is a research program organized to investigate how global climate change may affect the abundance and production of animals in the sea.

- Majority of ship usage is intermediate and smaller vessels
- Used over 1000 days of ship time between 1992 and 1999
- Specialized biological sampling systems, chemical sensors and high precision navigation for 3-D volumetric studies of biology and environmental properties.

THE OCEAN FOOD WEB

The capacity of marine ecosystems to sustain fish and other animal populations depends on the growth of phytoplankton, tiny drifting plants that convert carbon dioxide into living organic matter. In ocean systems, nutrient availability often sets limits on this production. Therefore, changes in upwelling circulation, increasing or decreasing mixing of ocean waters, or changes in freshwater runoff patterns could reduce or shift nutrient inputs, in turn causing changes in phytoplankton productivity at both regional and larger scales. Fluctuations in this productivity would ultimately affect larger marine animals-such as fish, whales, and seabirds-throughout the ocean's food web, starting with the tiny zooplankton upon which they directly or indirectly feed. Changes in food availability may result in changes in species abundance and shifts in their distribution. Such changes may cascade throughout the food web, ultimately altering population stability in economically important fish species.

NSF annually for ship operations funding, as well as technician support and shared use equipment, in the same manner as a federally constructed research vessel. Often operational costs are partly supported by state or private foundation funding. Many of the smaller vessels in the UNOLS fleet are state owned, and a few intermediate vessels are partly supported by foundation resources.

Situations do arise when limits to available resources, the introduction of more modern vessels or geographic imbalance of assets cause ships in the Academic Research Fleet to be either laid up, retired, or relocated to new operators. These decisions have high local impact. This type of situation has often proved difficult for UNOLS to plan or mediate, and these decisions normally require coordination and agreement at the federal level, primarily through NSF and ONR. Such decisions can require direct coordination with congressional representatives.

OCEANOGRAPHIC RESEARCH SCHEDULING

Research proposals submitted from academic institutions around the U.S. and selected for support via merit review drive facilities' support. In 1998, over 150 individual NSF research projects required 2651 days of UNOLS ship time on 323 separate cruises ranging from 1 day to almost 50 days at sea, and involved all but one of the 28 UNOLS vessels. Ship operations support is based on merit review of research proposals having ship requirements, not on separate merit review of the operations proposals per se. Proposals for ship operations support are evaluated by the NSF Ship Operations Program Director in consultation with other agencies. Criteria are cost, operational capability and quality of operations, and support is provided to operators through cooperative agreements with strict reporting requirements.

While the basic approach and concept is straightforward, the actual assignment of funded research projects to fleet platforms involves a multi-stage process that considers ship and researcher schedules, maximizes ship utilization and incorporates the needs of researchers funded by all federal agencies. The NSF portion of this process is outlined in Appendix D. Scheduling of platforms and scientists is managed by UNOLS, with fiscal oversight by federal agency representatives. This process allows for the scheduling of researchers and platforms supported by all federal and state agencies into a coordinated national framework.

3. Current and Projected Fleet Requirements

The Committee reviewed recent use of the Academic Research Fleet in support of NSF-sponsored research projects. In addition, NSF and ONR research program managers and external community representatives provided an assessment of trends and opportunities in ocean science research with a focus on sea-going requirements.

A. Current Ship Use

NSF assembled detailed data on the use of the UNOLS vessels in support of sea-going science projects for 1988 through 1999. During this period, total Academic Research Fleet ship days used annually by all sponsors has fluctuated between about 4000 and 5400, and has remained between 5200 and 5400 for the past three years (Figure 7). NSF-sponsored ship-days, which are a subset of the total fleet days used, declined somewhat during this same period, from about 3500 days in 1988 to about 2600 for each of the past two years (Figure 8).

For the large vessels, use by all sponsors has gradually increased from about 900 days in 1989 to over 1500 days in 1999. NSF use of the large vessels has varied during that same period, increasing from about 500 days in 1989 to a peak of 1300 in 1995, before steadily declining to about 850 days in 1999. In part, this increase in total use by all sponsors corresponds to an increased number of available days as new vessel construction and midlife refits of these large ships have been completed. (The fleet had four large vessels available in 1990, increasing to six in 1999). When plotted as utilization rate (Figure 9), a measure of actual use versus recommended or target use levels, the large vessels have a >80% utilization rate for all but two of the twelve years (1989, 1990). A utilization rate of 90 to 100% for all ship classes is desired.

Overall use of intermediate vessels declined over the period illustrated from an average of about 1900 days prior to 1993 to an average of about 1500 days since then. Use of intermediate class vessels for NSF-sponsored research mirrors this decline, decreasing from an average of 1100 days prior to 1993 to 800 days more recently. In addition, the utilization rate for the intermediate class is the lowest of all groups, averaging only about 70%. Similar to the large vessels, midlife refits of this vessel class

TOTAL DAYS BY CLASS

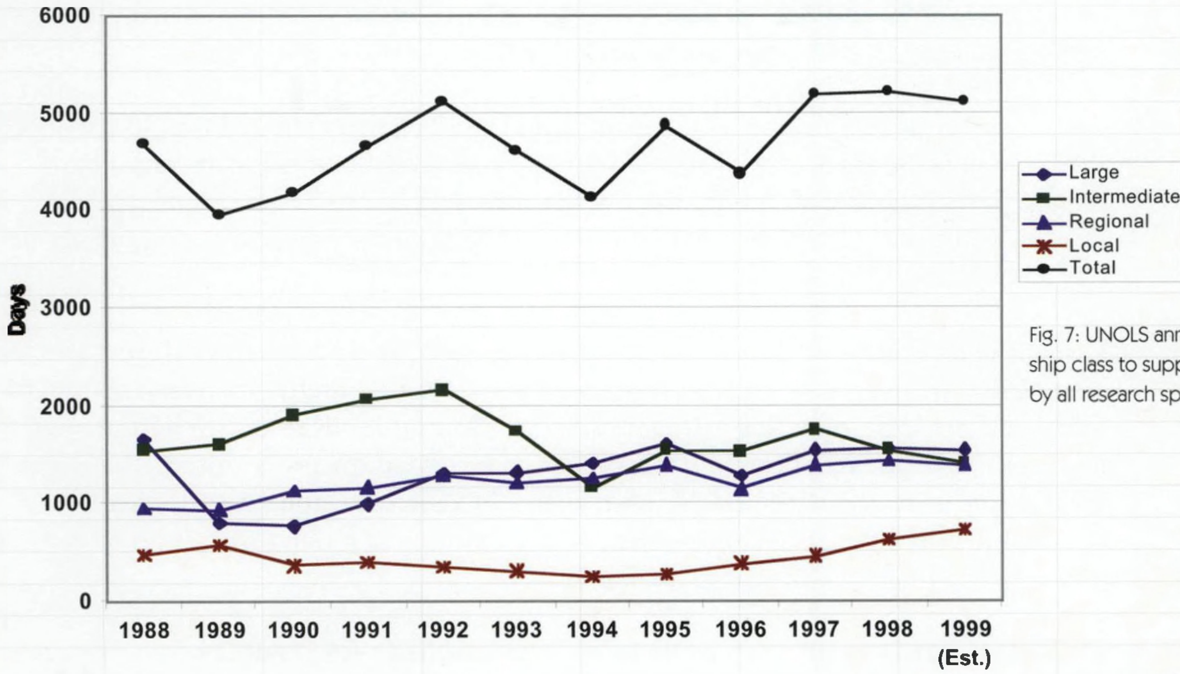


Fig. 7: UNOLS annual operating days by ship class to support sea-going projects by all research sponsors.

NSF TOTAL SHIP DAYS BY CLASS

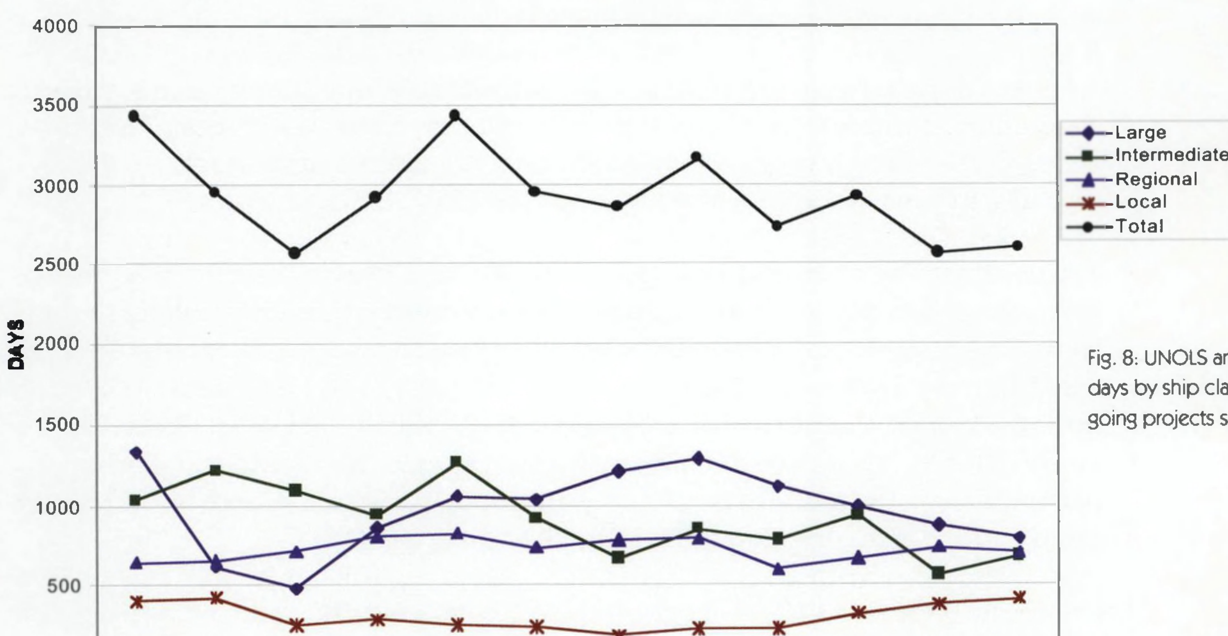


Fig. 8: UNOLS annual operating days by ship class to support sea-going projects sponsored by NSF.

and changes in fleet composition, including both ship retirements and fleet additions has had an impact on the number of available ship days. The R/V *Moana Wave* will be retired in 1999 and her replacement will not be completed for about two years, further reducing the number of available ship days in this vessel class.

Use of the regional ships by all sponsors over the 12 years evaluated has, like that of the large vessels, gradually increased, although utilization rates for the period are only slightly higher than for the intermediate vessels (about 75%). Use of regional vessels in support of NSF-sponsored research has been very steady, averaging about 700 days during this period.

Use of the local class of ships has fluctuated between 300 and 800 days during the 12-year period evaluated, with NSF-sponsored program use ranging between about 200 and 400 days. With only five available vessels, all of which are very limited in operating area, the impact of a single multi-year program can be pronounced. The rise in local ship use in 1998-1999, clearly seen as the spike in utilization rate of local vessels, is a result of Great Lakes research, which requires as much time as can be provided by the one UNOLS vessel available.

B. Projected Ship Use for NSF-Sponsored Research

There are two principal user components to NSF-sponsored ocean-going field programs: individual-investigator projects and major ocean science initiatives. Ship use for both components is driven by merit review of individual proposals by the various research programs at NSF, thus projections of ship use can have substantial uncertainty. However, when viewed historically, field programs using the Academic Research Fleet have made up about 30% of the awards in the Division of Ocean Sciences in the past decade. The ship use for individual-investigator science is projected to continue at current levels or increase slightly in response to a modest, 7.8% increase in the research program budgets in 1999. Additional support for multidisciplinary research is also requested for 2000.

The development of several major ocean science initiatives in the 1990s has greatly influenced NSF-sponsored use of the Academic Research Fleet, particularly the large ships. The major ocean science initiatives accounted for about 20% of the NSF-sponsored ship use during the decade, but was as high as 40% in 1995 (Figure 10). At that time, the World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Study (JGOFS), Ridge Interdisciplinary Global Experiments (RIDGE) and other initiatives were in the midst of their data acquisition phases (see science boxes throughout report for more information on individual programs).

Currently, WOCE and JGOFS have completed data acquisition and are focusing resources on data analysis and synthesis. RIDGE is still executing field programs, as are other initiatives such as Global Ocean Ecosystem Dynamics (GLOBEC) and

SHIP UTILIZATION RATES

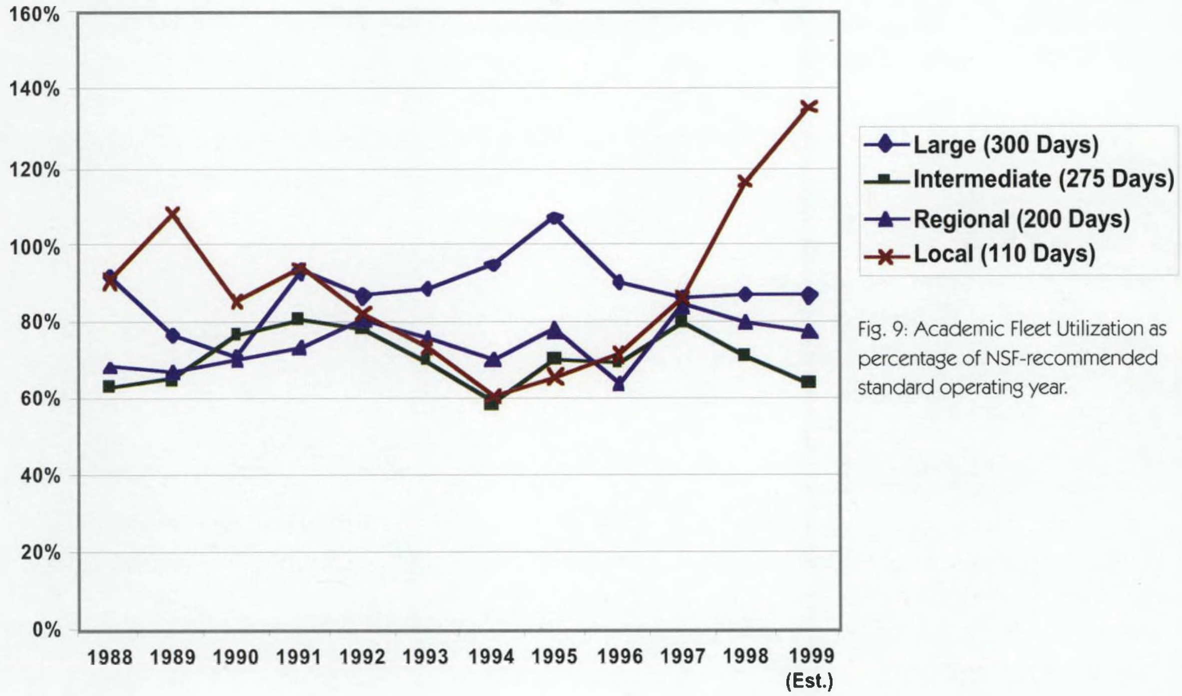


Fig. 9: Academic Fleet Utilization as percentage of NSF-recommended standard operating year.

UNOLS SHIP USE BY MAJOR OCEANOGRAPHIC PROGRAM

Fig. 10: Total UNOLS ship use by major oceanographic programs (from Global Ocean Science, NAS/NRC, 1999). Lower data points for 1999 and 2000 as shown in that report; upper points for those two years updated by NSF.

JGOFS: JOINT GLOBAL OCEAN FLUX STUDY

JGOFS is a research program whose goal is to understand on a global scale the processes controlling the time-varying fluxes of carbon and associated biogenic elements in the oceans, and to evaluate the related exchanges with the atmosphere, sea floor and the continental boundaries. Another goal is to develop a capability to predict on a global scale the response of oceanic biogeochemical processes to anthropogenic perturbations, in particular those related to climate change.

- From 1987 through 1999, 222 principal investigators from 66 institutions have been funded to carry out JGOFS research
- Used over 2200 days of ship time between 1988 and 1997
- Used large UNOLS ships
- "Clean" sampling systems, sediment traps, buoyed air-sea interaction instrumentation.
- Over 30 nations participate in the program

THE MARINE CARBON CYCLE:

The oceans contain about 50 times as much carbon dioxide as the atmosphere, and small changes in the marine carbon cycle can therefore have large atmospheric consequences. Such changes are believed to have had important feedback effects on climate during the transitions to and from ice ages; they may also have important consequences during the climate changes that are predicted to occur in the next 50-100 years, as a result of rapidly rising levels of atmospheric carbon dioxide and other greenhouse gases. Models indicate that the oceans are currently taking up at least a third of the anthropogenic carbon dioxide, by dissolving it in water that then loses contact with the atmosphere because of sinking or vertical mixing. Biological processes complicate the oceanic carbon cycle, although they probably do not affect the current uptake of anthropogenic carbon dioxide.

Coastal Ocean Processes (CoOP). MARGINS, a new program to study the geological structure of continental margins, begins field programs in 1999. In addition, increased survey efforts related to ocean drilling are expected during this period in anticipation of a new, international program in ocean drilling beginning after 2003. As a result, the projections for NSF-funded ship time for the major ocean programs remain flat for the next 2-3 years at about 800-1000 days/year.

Beyond about 2001, specific plans for major ocean initiative field programs are still being developed. However, there are planning efforts in the community and at NSF in two thematic areas – climate variability and carbon systems science – which are likely to develop into initiatives requiring substantial ship use beginning after 2001. In addition, the Division recently sponsored discipline-based workshops to identify future trends in ocean science. Workshops were held in Biological Oceanography, Chemical Oceanography, Marine Geosciences, and Physical Oceanography. Each community identified major research areas for the future (Appendix E). A fifth activity on future directions, which is an interdisciplinary synthesis, is currently underway, with report expected in late 1999. Past experience indicates that multidisciplinary or regional efforts will emerge as drivers for future requirements of the Academic Research Fleet. There is a suite of environmentally and socially relevant ocean science topics for the future.

It is worth noting that "intermediate-scale" programs, involving coordinated groups of investigators but smaller than major initiatives, are an active area of growth at NSF. This scale of project was specifically identified in the National Research Council's 1999 report, "Global Ocean Science: Toward an Integrated Approach," which emphasizes meeting evolving research requirements. Community response to the report's recommendation is already evident in proposals to NSF, particularly in the area of physical oceanography, and least one or two such projects involving 100-200 days of ship use are expected beginning in 2000.

Even under the most optimistic projections, however, there appears to be a near-term period of two or three years during which use of the academic oceanographic fleet will remain below existing capacity before the impact of new ocean sciences initiatives is felt.

C. Technology and Facilities Support Requirements

As merit-reviewed science programs progress, they introduce new instrumentation and facility support requirements to the Academic Research Fleet. New physical, chemical, geophysical, optical, and biological sensors all collect data at rates and densities which challenge the capacity of existing shipboard computer systems. Along with this increase in data rate is an increased need to communicate broadband data at high-speeds from ship to ship, ship to fixed or mobile platforms and to shorebased labs. Rapid two-way data transmission between platforms at sea and shore can optimize data acquisition during cruises that sample ocean structures and ecosystems. AUVs and ROVs extend the reach and efficiency of shipboard systems. Already emerging is the technology to tap into deep-ocean telephone cables and place long-term sensor systems on the seafloor at great depth with constant communication ashore. These new technologies require special handling systems, hull mounted navigation systems, and platforms with reduced self-noise.

Tomorrow's research platform may function both as delivery systems for special vehicles and moorings and as nodes on a complex web of sensors communicating with laboratories and computer centers ashore. Near-shore ocean observatories which mesh AUV and satellite technologies are being developed. Preparing the present Academic Research Fleet to be a part of these emerging technologies and to use them effectively is an important task which merits continued NSF investment with federal and institutional partners. Clearly, the need for technical support will change (and has, substantially, over the past decade), with much greater reliance on computer technology and communication. The impact on oceanography of new technology is clearly demonstrated by the advent of satellite remote sensing. Global views of sea surface temperature, ocean color, wind speed, rainfall and sea ice have been instrumental in the formulation of new research efforts. Radar altimetry has provided new insights on patterns of global circulation and earth structure. Modern oceanographers plan and modify sampling designs based on remotely sensed imagery even as cruises progress. These new data sets are having a broad impact on science and modify patterns of the use of research vessels. As with the advent of remotely sensed oceanographic data, the role and need for ocean research vessels will evolve, and certainly will not disappear.

NSF is currently addressing new technology issues on several fronts. It has an active Oceanographic Technology program in Division of Ocean Sciences that has been addressing issues of computation, communication, and emerging ocean technology. This program is very interactive with ONR, and numerous emerging technology efforts have been jointly funded. NSF is also part of the National Ocean Partnership Program (NOPP), a multi-agency effort with congressional support, which is supporting a significant effort in new technologies and measurement systems.

4. USER INPUT

The Committee used several methods to sample opinions of operators and users of research ships. Formal presentations were made by vessel operating institutions, and scientists from several institutions and disciplines gave briefings. NSF requested input from the scientific community via the Division of Ocean Sciences newsletter and by web sites and e-mail announcements, and UNOLS provided a sample of cruise reports written by masters and chief scientists. A summary of user comments in response to NSF is in Appendix F and a tabular summary of cruise reports to UNOLS is provided in Appendix G.

A. GENERAL USER SATISFACTION

The Committee assessed the satisfaction of the user community with the Academic Research Fleet by obtaining comments from users at major operating institutions, non-operating institutions, and non-academic agencies and organizations. It is clear from the responses that user satisfaction with the current system is very high. Praise for the UNOLS system focused on the high quality and flexibility of the ships' crews and support staff, which was attributed to the distributed nature of the UNOLS management structure and the operational responsibility that this system invests in the user community. To quote from one of the respondents:

> *"Routinely, the crew and officers go beyond their duties to assist the science operations and I feel that the UNOLS fleet has directly contributed to many of the achievements in marine research. I feel that the success of the fleet operations is generally promoted by the present organizational structure. Individual, distributed operators encourage crew stability and pride of ship operations; scheduling coordination by the UNOLS office optimizes the efficient utilization of fleet assets. As a frequent long-time user, I am very satisfied with the operations of the UNOLS fleet."*

Perhaps even more compelling were the responses from those who have had experience using both UNOLS and non-UNOLS vessels.

Comments from scientists working for the Naval Oceanographic Office (who typically work with Military Sealift Command-operated vessels) and the U.S. Geological Survey were very complimentary of the UNOLS fleet operations, particularly with respect to the competence and flexibility of the UNOLS crews and the condition of the ships. Scientists who have worked on commercial vessels also commented on the general lack of enthusiasm and flexibility of commercial crews (when compared to UNOLS crews) though there are notable exceptions where commercial arrangements have provided excellent service and value (e.g., the German system, in which government-sponsored research is conducted from vessels on long-term charter from commercial operators).

INDIVIDUAL INVESTIGATOR SCIENCE

TESTING THE LINK BETWEEN ENVIRONMENTAL CONDITIONS AND HARMFUL ALGAL BLOOMS

Quay Dortch (Louisiana Universities Marine Consortium)

This research project, which is to test whether there is a link between Harmful Algal Blooms and eutrophication, was carried out as "individual investigator science" and not as part of a larger scientific research initiative.

- Work was conducted mainly from small UNOLS ship (R/V Pelican)
- Collected data over three years at both estuarine and shelf sites, ca. one day per month
- Collaboration between academic and government researchers and private industry

Understanding the relationship between environmental conditions and Harmful Algal Blooms (HABs) in coastal areas is essential for predicting blooms, protecting human health, and preventing economic losses. Recently, considerable interest has focused on Pseudo-nitzschia, a diatom genus in which some species produce domoic acid, a potent neurotoxin, causing, among other things, death or short-term memory loss (Amnesic Shellfish Poisoning; ASP). Preliminary data from the Louisiana coastal zone show that Pseudo-nitzschia spp. (including potentially toxic species) reach very high abundances every spring in the plumes of the Mississippi and Atchafalya Rivers, and high abundances occur frequently, but less predictably in a Louisiana estuary. The hypothesized link between HABs and eutrophication was tested by 1) comparing the highly eutrophic shelf environment with the less eutrophic estuary and 2) examining changes in Pseudo-nitzschia preserved in cores taken from the shelf where increasing eutrophication over time is well documented.

Another theme that emerged from the user satisfaction survey was the complexity of the scheduling procedure and in particular the desire to see schedules finalized earlier. Over the past decade, ship scheduling has become increasingly challenging as more research projects have become interdisciplinary. Scheduling must take into account groups from different disciplines, often from different universities, who use equipment that must be shipped from different places. Investigators note that frequent or last minute changes in schedules present problems such as additional shipping costs and disruptions in teaching schedules. Equally disruptive to investigators are schedule shifts that make arrangements to use critical equipment or technicians no longer viable. The shift of families to the two wage-earning model, with carefully orchestrated schedules to cover child rearing, is becoming a norm in scientific research. Unplanned shifts in cruise schedules are highly disruptive and can threaten career and family stability.

B. Distributed Operations

A frequent comment made by those responding to the NSF informal survey was that they strongly support the current system of distributing ship operations to oceanographic institutions. The clear message from users was that this system leads to better service. The distributed nature of the ship support provides a degree of direct access for scientists planning cruises or analyzing their data afterwards; when not at sea both the ship's crew and the technical personnel are often working on shore at one of the oceanographic institutions. This gives scientists access even when not on board the vessel, and it keeps the scientists abreast of new developments which might affect a future project, particularly for those who use their own institutions' vessels (and they are still a large plurality of users, if not the majority). Other important factors cited by users for the high-quality service provided by this system is the interest of the institutions in vessel operations and their ability to attract crew and technical personnel to work and remain in the academic environment, which is highly unusual for most seafaring employees. These individuals also tend to be interested at some level in the science of oceanography.

The very positive sentiments expressed above were by far the most common thread throughout the user responses and are supported by both the analysis of the post-cruise assessment forms and the reports made to the committee during its meetings. Nonetheless, a number of issues were raised, particularly from those users further removed from the operating institutions, and these need to be addressed. First, is the question of accountability. What recourse does a scientist have when a ship, its equipment, or its technical staff fails to deliver the level of service necessary to meet the scientific objectives of the cruise? While major incidents of this sort are apparently rare, there was clear indication of minor situations that have led to frustration on the part of users. Second, some users were dismayed at the lack of consistency of the shared-use equipment and technical capabilities available across the fleet. There was a clear desire by many respondents for ships to have uniform shared equipment on almost every UNOLS vessel with equal standards of technical support and common charges, if any, to the investigator. Third, there was some frustration that certain types of equipment that can have a wide variety of applications, such as specialized navigation systems, must be provided by the users. This creates duplication within the community and puts users from small institutions at a disadvantage. Fourth, there were concerns about the universal accessibility and cost of some of the major geophysical systems (or the data they collect) aboard some of the larger vessels, specifically multibeam soundings and multichannel seismic data.

C. Quality Control, Shipboard Equipment, and Technical Support

The reliability of shared-use shipboard systems emerged as a major concern through the review of user responses, discussions with UNOLS operators, and NSF management. This seems to be the result of the increasing technological complexity and quantity of shipboard systems, which has increased the potential for problems, as well as limits to both funding and berths for the number of technical personnel who can sail on a cruise. The continued trend toward increased complexity of systems has a clear impact on the need for shore-side and onboard technical help with increasing skills. The community relies heavily upon this pool of expertise and shared-use equipment, and major cruise goals can be lost when crucial systems fail without adequate backup.

The Committee feels that NSF and UNOLS should examine equipment issues to see if a list of shared-use equipment for each vessel and class can be identified and a quality-based system adopted fleet-wide to ensure that this equipment gets proper logistical and technical support at each operating institution. While adequate funding to optimize repairs and technician performance and availability are part of this problem, the Committee discussed the possible fleet-wide adoption of modern quality control efforts, including increased education and training of personnel and rigorous evaluations. The Committee feels that the NSF budget should support this program and evaluate operator performance on a regular basis as part of the quality program. UNOLS appears to be a well-suited vehicle to institute and evaluate such an effort in conjunction with the federal agencies. It is clear, however, that accommodation will need to be made to address employment contracts, state and federal workplace regulations, and similar unique employee factors at the various private and public institutions involved in vessel operation.

5. Consideration of Options

A research vessel is a major capital investment and expensive to operate. Most ships have a 20- to 30-year service life when modernized by mid-life refits and other service upgrades. The need for estimates of long-term requirements for ship resources is clear. Presentations and data that the Committee reviewed indicate that the Academic Research Fleet has more capacity than is projected to be used in the near term by the community of scientists being funded by U.S. agencies and scheduled by UNOLS (See Chapter 3). However, emerging needs and opportunities for sea-going ocean research are large for future years. Programs for for new construction or modernization of ships and facilities can easily span a decade or more and require considerable financial resources. The committee examined several options to meet short-term operational issues and provide cost effective and optimal scientific capabilities for longer-term research requirements.

A. Strategies for Dealing with Excess Ship Capacity

An effective way to promote full use of the UNOLS fleet when excess capacity is relatively small and short-term is to make agreements for ship use with non-academic users such as those in Navy applied oceanography programs and industry. UNOLS has done this in recent years, and plans to continue this practice in the future. Use of the fleet by outside groups preserves the full capacity of the fleet for future increases in academic use while providing needed services for other users. Navy scientists who have participated in this program view it as a success. However, continuation of support by such sponsors is difficult to predict.

When the level of funded programs requiring ship time or the dollars available to support facilities falls below that needed to support the operation of the research fleet, one or more other options must be implemented. Consideration must be given to the age and engineering history of the vessels, the geographic distribution of assets and the placement of special purpose technologies (like DSV *Alvin*).

One way to manage excess ship capacity, suitable to relatively new vessels of good engineering condition, is to reduce the schedule of several ships. Some crew and technicians can be cycled into other tasks at the operating institutions or participate in training. Ships are retained in good working order and there is only a minimal im-

RIDGE: RIDGE INTER-DISCIPLINARY GLOBAL EXPERIMENTS

The goal of the RIDGE Program is to promote an improved understanding of the geophysical, geochemical, and geobiological causes and consequences of energy and material transfer within and through the global mid-ocean ridge system.

- Work is conducted from large UNOLS ships
- Work is heavily concentrated on using specialized facilities (e.g., ROV's, submersibles, multibeam echosounding)
- Multidisciplinary and international collaborations
- Used over 1000 days of ship time between 1993 and 1997

THE MID-OCEAN RIDGE SYSTEM

The mid-ocean ridge system extends more than 30,000 miles around the globe. It is a dynamic expression of internal convection processes, which strongly influences the shapes of the oceans and continents. The mid-ocean ridge system dominates Earth's volcanic activity, driving much of our planet's physical and chemical evolution. Five cubic miles of new oceanic crust are created every year, resurfacing more than 70 percent of the Earth's surface during the last 100 million years (a time span that is less than five percent of the planet's age).

Massive amounts of energy and material move from Earth's mantle into the mid-ocean ridge system to form new crust. "Hydrothermal" circulation of heated seawater through fractures in this young ocean crust promotes chemical exchange and acts as a long-term regulator of ocean water chemistry, strongly influencing the long-term chemical evolution of the planet. At high-temperature hydrothermal vents, unique biological systems, that derive both energy and nutrients from these fluids, in the complete absence of sunlight, may hold the key to understanding the origin of life, both here and on other planets.

pact on crews and technicians. Some maintenance can be performed during these periods if plans exist and funds are available. The impact on ship operations is low, but cost savings are minimal.

If the excess ship capacity is large and is projected to remain for a protracted period, the vessel, if modern and in good shape, may be a candidate for long-term lay-up with expected return to the fleet at some future date. There are several consequences of this management option. One can anticipate a costly yard period to return the ship to operational status, plus recruitment and training of lost personnel. Savings accrue if the lay-up lasts one or more years. Contracting ships to industry is also a possibility, depending on economic conditions and industry needs.

UNOLS has recognized the necessity for occasional or rotating lay-ups, but there has been little formal advance planning to implement them. Ships have been considered for lay-up only if they present a weak schedule, and generally the decision is not finalized until after the fall scheduling meeting immediately preceding the operating (calendar) year. A schedule is considered weak if it falls substantially below the guidelines for the number of operating days appropriate for each class of vessel. An established program of regular maintenance and upgrade periods, properly planned and funded, would benefit the fleet. Major projects, which require naval architects and shipyard bid packages, take well over a year to prepare and thus are not done during lay-up periods. If a defined rotation schedule for taking ships out of service is established for each class of ship or region, then operators and crews can make productive use of the lay-up time. This could increase short-term costs as projects are completed during lay-ups, but in the long term the need and cost of major midlife overhauls could be reduced or eliminated.

Another strategy is to remove older and less capable platforms from the academic fleet and reallocate one or more of the remaining vessels to new operators. This can achieve better geographic distributions of resources and if refit with new instrument systems, better quality vessels for operations in an area. Such reallocations of assets between operators are expectedly controversial at the local level where crewing and technical support staff are impacted. This type of fleet realignment is usually coordinated at the interagency level in the Federal Oceanographic Fleet Coordinating Committee (FOFCC). Changes in vessels operators can also be a subject of Congressional interest.

B. Review of Other Research Vessel Operating Systems

The committee reviewed several other research ship operating systems to place NSF/UNOLS procedures in context. These included the National Oceanic and Atmospheric Administration (NOAA) and Naval Oceanographic Office (NAVOCEANO) systems from the U.S., and comparable systems in the United Kingdom and Canada. They cover a range of both management and operational models, including centralized and decentralized systems. The various operational and management models were compared keeping in mind the research tasks to be performed. A detailed look at each system is provided in Appendix H.

Comparative cost data for academic research ship operations and analogous operations of research vessels by NOAA, NAVOCEANO, and the Canadian Coast Guard were compiled by Tecolote Research, Inc (Appendix I). A complication in analyzing comparative costs is that differences exist among the rate structures and accounting systems of the various ship operating systems. The NSF/UNOLS operating system uses a standardized accounting system for all operating costs of the research ships, with technical support, new instrumentation and equipment, and research costs of the scientific projects provided separately. NOAA and NAVOCEANO operating systems include as part of ship operations some instrument systems, deployment costs and general management functions not included within UNOLS. The Canadian Coast Guard operating system uses a different crewing system than most U.S. operations.

In general, the data show that UNOLS, NOAA and Canadian Coast Guard operations costs for comparable research ships are similar, with differences reflecting utilization, specific operating conditions, and ship age and condition. NAVOCEANO costs are significantly greater, reflecting both larger ships than the largest academic research ships and expenses for "forward-based" or remote operations support that is not provided for UNOLS operations.

C. USE OF COMMERCIAL SHIPS

The Committee reviewed the effectiveness of contracting vessels from industry, giving consideration to costs, services, and safety. NSF and ONR managers provided information about how costs for the various aspects of UNOLS fleet operations are supported, the contractor's report provided a basic comparison of operational costs of UNOLS vessels and commercial charters.

As a result of partnerships with private and public institutions and with the U.S. Navy, the bulk of vessel capitalization and a large portion of major equipment purchased for oceanographic research vessels has been borne outside of NSF. Since 1990, the Navy has spent about $190 million to build R/Vs *Thompson*, *Atlantis* and *Revelle* and extensively refit *Knorr* and *Melville*, all of which are large ships. The Navy has committed $45 million to replace one intermediate research vessel, R/V *Moana Wave*. The Navy has also funded expensive multibeam sonar systems, winches and fiber optic oceanographic cables for the large ships, and has provided the bulk of the support for the development of remotely operated vehicles and autonomous underwater vehicles. In the past decade, private institutions have capitalized five new vessels for the Academic Research Fleet without cost to the government. Such institutional support continues. This new construction is providing state-of-the-art platforms that are specifically designed to support oceanographic research. In addition, because of the distributed nature of vessel operations, state and institutional funds offset operational costs in some cases. These partnerships continue to be highly cost effective for all.

As the ability of the UNOLS fleet to support more sophisticated and demanding oceanographic research has increased significantly in recent years, so has the gap between what UNOLS ships and industry vessels can provide. A key drawback of contracting industry vessels is that there are few platforms available which are configured and equipped to support the diversity of oceanographic research without significant additional outfitting costs. Commercial ships suitable for general purpose oceanographic research often have spartan lab facilities, if any at all. The independent contractor even noted that "clean" power, a staple on UNOLS ships, and a basic requirement for operating computers and other equipment, may be unavailable, even unknown on commercial vessels.

However, where industry does present significant capabilities not available within the UNOLS fleet (e.g., special 3-D geophysical systems), NSF has in the past provided funds to make such capabilities available to individual research projects. In these few cases, the arrangements have fallen to the principal investigator of the project. The Committee is concerned that such arrangements put a heavy burden on the investigator's ability to provide due diligence and ensure high standards of safety. After considerable discussion, the Committee decided to encourage NSF to consider an experiment where an industry contractor could participate as a non-member operator of UNOLS for the purpose of arranging for unique capabilities when needed. This would ensure the use of UNOLS standards for operation, safety, and reporting and obtain a benchmark for the cost of such operations.

There was a special discussion of the use of "bare boat" (no food, fuel, equipment and limited daily hours of operation) charters. There are cases where the research being supported requires no additional installed equipment other than that which can be brought aboard by the investigator. The independent contractor's report provided bare boat estimates for four operators and ten vessels. When the average daily costs of food and fuel were added to these estimates, the costs were comparable to or slightly higher than equivalent UNOLS operating costs (Appendix I). These estimates were provided in a market with the lowest costs seen in several years. The Committee was concerned that a proliferation of this type of charter arrangement through individual investigators could lack in due diligence and compromise safety standards.

For ocean research platforms other than the general purpose platforms discussed above, NSF has made effective use of commercial arrangements. The special element of these arrangements is either a unique operational mission (e.g., deep ocean drilling) or unique long-term deployment to a specific unique environment (e.g., Antarctic ocean research). In both instances very specific modifications to the vessel under contract were required to make the vessels suitable for scientific research.

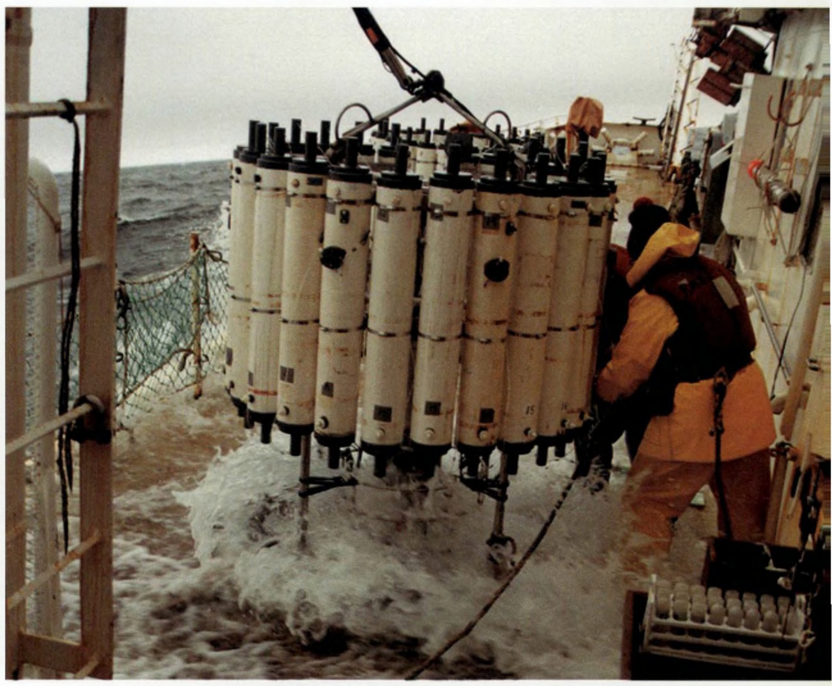
In addition to the obviously beneficial capital investment and operational support from Navy and other operating institutions, the Committee concluded that the true strength of the NSF/ UNOLS system, beyond the scheduling process and high safety and operating standards, lies in operator interest in science and provision of the well trained and motivated crews which support research at sea. Given the diversity of science supported by the general oceanographic ships, this appears to be the most difficult challenge for the commercial operator to duplicate except when the capabilities provided are unique and the contractual relationship is long-term.

6. FINDINGS AND RECOMMENDATIONS

CURRENT AND PROJECTED RESEARCH FLEET REQUIREMENTS

The Academic Fleet is emerging from an era of intense utilization. During the last decade, several major programs of oceanographic research have completed their field efforts. Currently these data are being processed, analyzed and used to better understand the oceans. Projections for fleet use for the next few years may decline, falling to less than the current capacity. Federal agencies with responsibilities for funding of the oceanographic fleet have been evaluating courses of action ranging from lay-up of some platforms to expanded use of UNOLS assets by more applied oceanographic programs.

Emerging needs and opportunities for fleet-based ocean research are large. Current issues centered on global climate change and marine ecosystems cannot be resolved without a significant increase in our understanding of the oceans, their exchanges with the atmosphere and the impact of anthropogenic stresses. Such understanding requires collection of large amounts of high quality data, and will require substantial use of research vessels, moored sensors and satellites. Further, more and more human demands are being placed on the resources of the sea (especially in the coastal regions of the world and by fisheries) without fully understanding their long-term impact. Thus many global and international issues of high importance depend on knowing more about the oceans. The ocean research community, at many levels, needs to accelerate planning for this future need.



The potential for near-term decrease in utilization of ocean-going research facilities is real. It may represent a transient condition, as new planning for ocean programs identifies the next cycle of field efforts. This provides an opportunity to respond to some management issues in fleet operation and to continue to improve the capability, productivity, and quality of fleet operations as a means of achieving NSF research and educational objectives in ocean sciences.

The community of ocean scientists must assess the future needs and opportunities of the field to establish priorities for future work, and to clarify the balance between coordinated programs and individual investigator efforts. Several recent workshops have addressed the goals of individual disciplines, and a National Research Council report, "Global Ocean Science," has examined the major oceanographic programs. There now needs to be an integration of these various efforts into a broad, coherent vision that can guide future directions, of small, intermediate, and major programs. Ocean science, like astronomy, space science, and high energy physics, all requiring major, shared facilities, cannot address every important need and opportunity by relying solely on proposals of independently working investigators. A broad vision is essential to anticipate future fleet requirements.

Additionally, a separate, but closely related, effort should be made to identify emerging and future technologies that can have a great impact on future research efforts. Many opportunities exist for significant advances in instrumentation, equipment and techniques that do not emerge automatically from presently identified research needs. As new capabilities arise, new research ideas can emerge and vice versa. Neither, alone, should be relied upon to identify all of the promising avenues of future research.

> ***NSF must accelerate and expand efforts within the oceanographic research community to articulate a broadly based vision for the future of ocean science and technology requirements. This will provide a much needed foundation on which to plan and procure major facilities for research.***

MANAGEMENT STRUCTURE AND CAPABILITIES

Overall, the UNOLS system of planning and allocating the resources of the Academic Research Fleet gets high marks from the scientific community and from other agencies that participate or cooperate with it. Several recurrent issues such as improvement in the scheduling process (especially abrupt changes), equal support of non-operator researchers, quality of shore support, and maintenance/support of installed and pool equipment need to be worked on and improved. The orientation towards a continuous improvement program and a formal quality control program (looking toward the best industry training and practices) needs to be infused into the entire UNOLS and operator system.

NSF, on the behalf of the committee, engaged an independent contractor to conduct a review and cost analysis for support of oceanographic research. Findings indicated that the NSF-UNOLS system, with institutional vessel operators and centralized scheduling of scientific parties, is on par with costs for operation of like vessels by other federal agencies and international organizations. UNOLS operating costs are comparable to estimates provided by several commercial contractors when adjusted from their "bare-boat" estimates. Even with this analysis, however, the committee finds that it is very difficult to get fully comparable estimates of cost between UNOLS and commercial operations.

The goal of any research facility should be to find the optimum path to satisfy the needs of the research enterprise. In this context, for support of oceanography, this may require going outside the present UNOLS fleet for specific capabilities. We believe a case can be made to include some commercial charter operations that meet UNOLS standards as part of UNOLS operations, to provide capabilities unavailable within the UNOLS fleet. We note that in special circumstances, the federal funding agencies already go outside the UNOLS system for specialized capabilities; we recommend here that this might be better done inside the UNOLS system. We do not recommend "bare-boat" chartering due to complex issues of safety, mobilization and technical support. We expect the use of commercial vessels to be only a small fraction of total usage, but expanding UNOLS' scope in this manner would have at least two important advantages: greater ability and flexibility to meet science needs, and outside benchmarks.

> *The UNOLS system should be retained. The NSF-UNOLS current practices, using institutional operators funded by NSF and other federal agencies with centralized scheduling through UNOLS, seems to provide excellent access to the sea for US investigators. To the extent the committee can assess, costs appear comparable to or better than government operators, and not evidently different from costs of contracting commercial platforms.*
>
> *The funding agencies and UNOLS need to support fleet improvements by enhancing quality control, expanding training of personnel in technical and safety procedures, and developing even higher standards for shared use facilities.*
>
> *NSF should continue the practice of periodically competing the management of the UNOLS office, and should consider funding it by a cooperative agreement rather than a grant to ensure necessary management oversight.*
>
> *We ask NSF to consider a trial which includes some commercial operators participating as UNOLS non-member operators to provide unique capabilities not otherwise available.*

The current system of ownership and operation of ships works well. While there is general satisfaction with ship operations in the UNOLS fleet, there are opportunities for improvement. This is the right time to launch a significant campaign to upgrade and strengthen the fleet, not only to prepare it for increasing technological sophistication, but also to improve the future productivity and quality of fleet operations. For the owners, operators and crew there should be programs implemented for continuous improvement and high standards of safety and quality control. To this end, appropriate programs of education and training for all participants should be a regular and ongoing activity.

Improvements are needed in the strategies and practices of planning and managing "common" shipboard equipment. Owners and operators, working through UNOLS and in conjunction with NSF and other federal agencies, should develop policies and practices for managing shared-use, technical support in the Academic Research Fleet.

> *There is a need for a strong, continuing program of new technology introduction; steady improvement of existing facilities and technologies; greater, continuing attention to quality control and safety; and a more systematic, standard approach to maintenance, renovation, upgrading, and replacement.*

It is clear from the projections of the service life of all ships supporting oceanographic research that continuous planning is needed to prevent obsolescent facilities. In past years, individual agencies initiated construction efforts as need and budget opportunity presented. In addition, new ships have been brought into the UNOLS fleet without the guidance of a comprehensive long-range plan. With such a plan, research requirements can be directly addressed even in circumstances where external political processes modulate vessel allocation.

Nationally, the federal agencies can and should do a better job of coordinating long range planning for facilities with twenty to thirty year life spans. More commonality of design will provide cost savings. Joint planning can keep average fleet age relatively low in each major class and provide the latest in technology to support research. Any such plan should be robust enough to accommodate both adding and removing vessels from the fleet. This is clearly beyond the scope of NSF and UNOLS acting independently. However, by virtue of its dominant funding role for the Academic Research Fleet, NSF should lead the effort with strong support from the Navy and NOAA.

> *The Federal agencies funding research in oceanography should prepare and maintain a long range plan for the modernization and composition of the oceanographic research fleet which reaches well into the 21st century. This will avoid the high cost of obsolescent facilities and provide the Congress with a unified roadmap for out-year allocations for vessels to support oceanographic research.*

APPENDIX A: TERMS OF REFERENCE

The Academic Research Fleet Review Panel is charged to provide a comprehensive and balanced evaluation of science support services and capabilities, ship operations, and organizational structure for the support of the Academic Research Fleet and to recommend actions by NSF to ensure the most cost-effective means of organizing and managing the academic fleet for support of research requirements. The review procedures will follow the principles outlined in the NSB Resolution concerning Competition, Recompetition, and Renewal of NSF Awards for facilities operations (NSB 97-224).

1) Review and evaluate the current and projected research vessel fleet required for research sponsored by the National Science Foundation within a national framework that includes research requirements of other federal agencies, state and local governments, and private sources.

   This review should be done in the context of environmental and geoscience research, in general, and the specific contributions the Academic Research Fleet provides to the research enterprise as a whole.

   Specific issues include:
   - Do the capabilities and operating modes of the academic ships meet research requirements?
   - Is the number of ships overall, and distribution within size categories, consistent with the level of research support and type of seagoing research projects expected in the future?
   - Are specialized capabilities required to meet research priorities adequately included in the overall fleet profile?

2) Review and evaluate overall management structure of the Academic Research Fleet; review and evaluate existing capabilities and services provided by the operating organizations; and review and evaluate possible future changes in academic fleet operations to ensure optimal operations of the academic fleet to support research requirements.

   The review context should include consideration of the distributed ownership of the fleet, cost sharing for both capital acquisition and operations and requirements of multiple research sponsors who participate in scientific, operational and financial support.

Specific issues include:

- Are organizational arrangements and structures appropriate?
- Can the Academic Research Fleet system be managed in a more cost-effective manner?
- Should elements of the research fleet or its operation be recompeted?

3) Provide recommended actions by NSF to improve the organization, management, and cost-effective operation of the Academic Research Fleet in support of scientific capabilities required to maintain world leadership in ocean and environmental science research.

   The recommendations should be formulated in the context of the results of the review and evaluations of the first two terms of reference. Key elements include providing a perspective on Academic Research Fleet operations within a national context, relevance and quality of scientific, educational, and technical support; and benefits and added value of any recommended actions for peer reviewed competition or recompetition of research fleet components.

APPENDIX B: COMMITTEE MEETINGS

The committee met four times to obtain information on U.S. Academic Research Fleet operations, science program requirements and financial and management data. The second meeting included a site visit to the marine facilities at Scripps Institution of Oceanography, including three ships in port there – R/V *Melville* and R/V *Sproul* operated by Scripps, and R/V *Atlantis* (with the submersible *Alvin*), operated by Woods Hole Oceanographic Institution.

Meetings were held as follows:

Meeting 1: National Science Foundation, Arlington, VA, 8-10 June 1998
Meeting 2: Scripps Institution of Oceanography, La Jolla, CA, 1-3 September 1998
Meeting 3: Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 2-3 December 1998
Meeting 4: National Science Foundation, Arlington, VA, 3-4 March 1999

Meeting agendas were as follows:

MEETING 1

<u>June 8, 1998</u>

Committee review
- Charge, Introductions

NSF Programs and Procedures
- Overview, Dr. Donald Heinrichs, NSF
- Ship Operations Program, Ms. E.R. Dieter, NSF
- Instrumentation and Technical Services, Dr. Alexander Shor, NSF
- Oceanographic Facilities, Dr. Richard West, NSF

UNOLS Executive Summary, Dr. Kenneth S. Johnson, UNOLS Chair
- UNOLS Functions
    1. Science Facility Support
    2. Access to the Sea
    3. Safety at Sea
    4. Operating Efficiency and Science Efficiency
    5. Planning the Fleet of the Future
- UNOLS Structure

Committee Executive Session
- Review Goals, Dr. Robert Corell, NSF

<u>June 9, 1998</u>

History and Evolution of UNOLS, Capt. Robertson Dinsmore, WHOI (Ret.)

Science Facility Support
- General Purpose Ships
    - Global/Expeditionary Ships, Dr. Robert Knox, SIO
    - Intermediate/Regional Ships, Dr. Michael Roman, U MD
    - Local/Near-shore Ships, Dr. Richard Jahnke, SkIO
- Specialized Capabilities

Submersible Science, Mr. Richard Pittenger, WHOI; Dr. Karen Von Damm, UNH
Multichannel Seismics, Dr. Dennis Hayes, LDEO
What Needs Are Not Being Met?, Dr. Kenneth S. Johnson, UNOLS Chair
UNOLS Support for Science at Sea
Ship Operations: Science/Facility Integration, Mr. Steve Rabalais, LUMCON
Role of the Ship Operator
Research Vessel Operators' Committee (RVOC)
Research Suppport Services: Research Vessel Technical Enhancement Committee's (RVTEC) Role, Mr. Steve Rabalais, LUMCON
Customer Feedback, Dr. Kenneth S. Johnson, UNOLS Chair
Access to the Sea, Mr. John Bash, UNOLS Executive Secretary
The UNOLS Scheduling Process
Safety at Sea, Mr. John Bash, UNOLS Executive Secretary
Inspection Program
RVOC Safety Standards, Safety Training Manual, Safety Video
Operating Efficiency and Science Efficiency
UNOLS Management, Dr. Kenneth S. Johnson, UNOLS Chair
Institutional Operations: Contributions/Benefits, Dr. Robert Knox, SIO

June 10, 1998
UNOLS Sponsor History and Trends
Sponsorship, Dr. Robert Knox, SIO
NSF, ONR, NOAA
Other Federal, State, Institution
Private, Industry, International
Science Trend Summary, Dr. Kenneth S. Johnson, UNOLS Chair
UNOLS Wrap-Up, Dr. Kenneth S. Johnson, UNOLS Chair
Committee Executive Session
Meeting Review

MEETING 2:

September 1, 1998
Site Visit to Marine Facilities, Including Research Ships Melville, Atlantis with Submersible Alvin, and Sproul.

September 2, 1998
First Meeting Review
Intersessional Items
Science Trends and Opportunities: Community Views
Ocean Studies Board and other Community Reports, Dr. Kenneth Brink, WHOI (and OSB Chair)
NSF Futures Workshops: Synopsis and Recommendations, Dr. Donald Heinrichs,NSF
Institutional Perspectives on Future Ocean Science Plans, Dr. John Orcutt, CORE
Scientist Survey: Responses to Request for Community Input, Dr. Donald Heinrichs
Comparative Operations: National and International

NOAA, Adm. William Stubblefield
NAVO, CDR James Trees
UK/NERC, Mr. Paul Stone
Canada, Mr. Stephen Peck
UNOLS, Dr. Kenneth S. Johnson

September 3, 1998
NSF Antarctic Program: Systems Integration Contractor, Mr. Al Sutherland, NSF OPP
Science Trends: Budgets and Priorities
National Science Foundation, Dr. Michael Reeve, NSF
Office of Naval Research, Dr. Steven Ramberg, ONR
Naval Oceanographic Office, CDR James Trees and Mr. Gordon Wilkes, NAVO
National Ocean Partnership Program, Dr. Steven Ramberg, ONR (and Chair, IWG)
Financial Management and Economic Analysis
Introduction of External Contractor
Discussion of Scope, Content and Issues for Financial Management and Economic Analyses, Mr. William Humphrey, Tecolote Research.
Committee Deliberations

MEETING 3:

December 2, 1998
Science Trends and Research Ship Capabilities: Scientist Views
Biological Oceanography: Present and Future Directions and Implications for the Academic research Fleet, Dr. Karen Wishner, URI
Marine Geology and Geophysics: Perspectives from a Non-Ship Operating Institution, Dr. Donald Forsyth, Brown University
New Oceanographic Observation Platforms: Implications for the Fleet, Dr. James Bellingham, MIT
Site Visit to UNOLS Office
Cruise Assessment Summaries: UNOLS, Mr. John Bash, UNOLS Executive Secretary
Preliminary Financial/Management Report, Mr. William Humphrey, Tecolote Research.

December 3, 1998
Committee Working Session
Findings and Recommendations
Preliminary Text/Content

MEETING 4:

March 3-4, 1999
Committee Working Session
Report Review.
Revised Text and Content.
Approved Findings and Recommendations.

APPENDIX C: DESCRIPTION OF UNOLS

The University-National Oceanographic Laboratory System (UNOLS) is a consortium of 57 academic institutions with significant programs in marine science that either operate or use the U.S. Academic Research Fleet. UNOLS is governed by an elective body, the UNOLS Council, and operates through six standing committees. The UNOLS office, with three staff members, provides organizational support.

UNOLS COUNCIL

The UNOLS Council includes seagoing scientists, vessel operators and marine technicians, and is charged to provide policy guidance and monitor committee activities. The focus is to ensure effective use of available oceanographic facilities and assure access to the federally supported facilities for scientists from other institutions. The Council, as the executive body, develops long range projections for operational support, identifies capital needs, and advises the federal agencies on fleet issues.

SHIP SCHEDULING COMMITTEE (SSC)

All ship operating institutions are members of the scheduling committee. The committee task is to work with the seagoing scientists, research sponsors and each other to provide an integrated set of ship schedules. They are to ensure the research ship fills science requirements, provide access to all scientists, minimize non-working transits, and accommodate geographic and seasonal research requirements.

RESEARCH VESSEL OPERATORS COMMITTEE (RVOC)

The RVOC addresses regulatory issues, crew training, medical standards, insurance and safety issues. The members are marine superintendents from UNOLS member institutions with representatives from other international research ship operators, commercial operators, regulatory bodies and inspection societies. The focus is on ship operating issues per se, meeting compliance with the complex of national and international laws and regulations, and ensuring reliable and safe ship operations.

RESEARCH VESSEL TECHNICAL ENHANCEMENT COMMITTEE (RVTEC)

Committee participation is open to technical and scientific personnel from all UNOLS member institutions and interested non-UNOLS organizations. The purpose is to promote the scientific productivity of research programs by improving technical support for at-sea operations. The focus is on the exchange of practical information on scientific instrumentation operations, standards and calibration, identification of latest technologies and developing data and operations standards for consistent information exchange.

FLEET IMPROVEMENT COMMITTEE (FIC)

The primary responsibility of the committee is to review the scientific capabilities of the present research fleet, identify future scientific trends and needed seagoing capabilities, and recommend facilities plans to meet science requirements. The members are research scientists with liaison representatives from the research vessel operators. Products include a periodic fleet assessment and recommendations, identification of scientific mission requirements for various ship categories and ad hoc assistance to ongoing construction projects.

ARCTIC ICEBREAKER COORDINATING COMMITTEE (AICC) AND DEEP SUBMERGENCE SCIENCE COMMITTEE (DESSC)

These two committees are special focus groups to specifically assist NSF and the U.S. Coast Guard with supporting research on USCG icebreakers in the Arctic and assisting NSF, ONR and NOAA in operating the submersible *Alvin* and related unmanned tethered vehicles respectively. In both cases, the committee members are research scientists with interest in the specialized facilities, and provide communication with the broader research community, oversight of facilities operations, and advice to the operators and federal sponsors.

APPENDIX D: NSF MANAGEMENT

This appendix details the mechanism for review of proposals within NSF which lead to scheduling oceanographic research projects on vessels of the U.S. Academic Research Fleet.

The first stage is the submission of research proposals to study ocean phenomena to any scientific program office in NSF. While the Division of Ocean Sciences is the primary NSF sponsor of research using the Academic Research Fleet, programs in earth and atmospheric sciences, biological sciences, education, polar programs, engineering, physics and chemistry have all sponsored projects in recent years. The research proposal must provide a compelling case for the science project, as for all proposals to NSF. As part of the proposal, a cruise plan must be included, outlining the sampling strategy, time required, location, and other pertinent data needed by an external reviewer to evaluate the seagoing phase of the project. The investigator may request a specific ship or simply general ship requirements. To simplify the process, and to ensure all required data is provided, a one-page ship time request form (NSF Form 831) is required in the proposal.

All NSF research proposals that request ship time from the U.S. Academic Research Fleet must be submitted in time for award decisions by July or August of the year before the cruise, i.e., July 1998 for all cruises in calendar year 1999. The merit review process for research proposals submitted to most NSF program offices takes about 6 months, thus proposals are submitted no later than February of the year preceding sea time. The final logistics plans, coordination of research projects, and assignment of specific research ships and cruise dates can only be done after the full mix of science projects is known.

At this point (July) in the process, the NSF projects requiring ship time in the following year are established and the schedule coordination begins. This expands the process from a NSF-internal proposal process to an interagency and community coordination activity. The academic research fleet is a national capability with multiple research sponsors, multiple operations, and ships of differing sizes and operating areas. During the time that NSF was reviewing potential projects, the other federal, state and private sponsors were conducting their 'science reviews.' By July, the ship operators have the general specifications for most cruises, and they identify projects they believe are suitable for their ships. Tentative schedules designed to match project requirements with ship capabilities, integrate seasonal and weather requirements, and minimize unproductive transits between project sites are prepared.

There is extensive communication among the ship operators, funded research scientists and agency program directors to ensure project requirements will be met, and that cost-effective and suitable ships are assigned when the scheduling is complete. The process is intense and iterative for most of the larger ships, as they compete for projects, and adjustments to one schedule can 'cascade' onto several other schedules. The scheduling of the local and regional ships is generally simpler, since science teams are smaller and most operating areas do not overlap. The challenge for the system as a whole is to match about 550 science projects for 5000 days at sea around the world for studies in many science fields, involving over 2000 researchers and students with 28 research ships.

THE SHIP OPERATIONS PROGRAM at NSF is the central element for the overall management and support of the research vessels and submersible of the fleet. Each ship operator must submit a 'master' proposal to NSF for operations in the following calendar year. These research ship and submersible operations proposals are exempt from external merit review as a service function in support of merit reviewed research projects. Guidelines for uniform project and cost accounting procedures are provided in 'Instructions for Preparation of Proposals Requesting Support for Oceanographic Facilities," NSF 94-124, which covers all the facilities support programs in Division of Ocean Sciences. The operations proposals request support for direct and indirect costs arising from the actual maintenance and operation of research vessels. Support for research science teams, including shipboard technicians, scientific instrumentation and major equipment, must be obtained separately based on merit reviewed proposals to other programs. Allowable ship operation costs include salaries and related expenses of crew members and marine operations staff; acquisition of minor or expendable equipment; maintenance, overhaul and repair; insurance; and direct operating costs such as fuel, food, supplies and pilot and agent fees. Shore facilities costs are provided only to the extent that they directly relate to the ship operations.

The guidelines require identification of each research project and the number of days at sea so that facilities costs can be directly allocated to the project and supporting agency. The specific source of funding is identified. The NSF Ship Operations Program conducts the annual administrative, management and financial analyses of the institutional proposals for all sponsors, i.e. a single negotiation is done with the institutions. All proposals are examined concurrently by the program to evaluate operating costs on a comparative basis and establish 'best practices' procedures. All costs must be fully justified. The NSF review and negotiated budget is used to calculate proportional costs, based on days of use, for all sponsors. Each research project sponsor is responsible for the ship operations costs of their projects. The NSF award to each institution aggregates all NSF-sponsored projects for the year in a single award based on the total days required.

NSF ship operations support for a given ship may vary significantly from year to year. Support depends on the number and size of NSF projects compared to other sponsors, which changes annually. Thus, precise NSF ship operation award levels for specific ships cannot be projected in advance. Most federal agencies and all other sponsors provide their share of operating funds directly to the operating institutions. NSF will, if asked, manage interagency transfers for other federal agencies for a small management fee. These funds, appropriately identified, are included in the NSF master award. Annual interagency transfers managed by NSF have ranged from $1 to $2 million in recent years.

THE TECHNICAL SERVICES PROGRAM at NSF operates in parallel with the Ship Operations Program, i.e., each research ship operator must submit a 'master' proposal to NSF for basic technical support for all users and sponsors in the following year. Each research project and days at sea must be identified, so that costs can be directly attributed to the science proposed and the research sponsor. These proposals undergo an external merit review every three years, with administrative budget and management reviews annually to respond to the changing research project balance between sponsors.

Support provided through the NSF Technical Services Program is principally for operating and maintaining basic, shared-use equipment and scientific instruments which are available to all vessel users. This includes such things as winches, wires, navigation systems, biological and geological sampling systems, CTDs for measuring water properties, and a variety of acoustic tools for geophysical, physical and biological oceanographic study. Some of these tools are provided as part of the basic technical services rate charged to all vessel users; some carry extra charges for operation, since (for instance) they are used for only a small portion of the projects, or they require several extra personnel for operation.

Changes implemented by NSF for CY1999 require that the full, annual cost of specialized shared-use systems offered for use by operating institutions must be included in the NSF Technical Services proposal, and that cost allocations to each user must be indicated. This provides budget and management oversight which was lacking previously. Costs can now be based on known schedules and reasonable (1-year) cost projections; previously they needed to be estimated much further in advance and without knowledge of funding status, since most specialized system usage fees were part of research awards rather than facilities awards.

NSF works with other federal agencies through the Federal Oceanographic Fleet Coordination Committee to ensure an appropriate match of ship size and capabilities, overall fleet size, and availability of research and operating funds to meet national requirements. All federal agencies are invited to actively participate in the ship scheduling process to ensure their interests are considered. ONR and NOAA are the primary other sponsors of research using the academic ships and provide 15 – 20 percent of operations support in comparison with 60 – 65 percent from NSF. The remaining support, about 20 percent, comes from a number of other federal agencies, Navy laboratories, industrial projects, and state and local sources.

ONR, in particular, as owner of six of the academic research ships works closely with NSF on operational, maintenance and technical support issues. A formal Memorandum of Agreement provides for consultation and cooperative efforts on academic fleet management issues. They participate as an active partner with NSF on most significant management decisions. The other federal agencies primarily participate in the scheduling process, and defer to NSF and ONR on operational decisions.

Appendix E: NSF Future Research Directions

NSF has recently sponsored discipline-based workshops in Biological, Chemical, Physical and Geological Oceanography to open a community dialogue which will lead to plans for future oceanographic research. Workshop titles and broad themes are listed below. Detailed workshop reports and community comments can be found on the World Wide Web at: http://www.joss.ucar.edu/joss_psg/project/oce_workshop

Future of Marine Geosciences (FUMAGES)

- mid-ocean ridges
- role of water in the lithosphere,
- formation and aging of oceanic plates,
- paleoclimate studies,
- converging and passive margins, and
- shelf sediments and transport and nearshore marine geology.

Future of Ocean Chemistry (FOCUS)

- role of important nutrients in community structure in the euphotic zone and relationship between photosynthesis and export of materials out of upper ocean,
- how ocean margins process materials exchanged with land and sea,
- define and identify controls of organic matter in seawater,
- effects of advective flow through ocean ridge systems, ocean margin sediments and through coastal aquifers,
- characteristics and forecast anthropogenic changes in ocean chemical and consequences
- document air/sea exchange rate of gases, and
- controls on the accumulation of sedimentary phases.

Ocean Ecology: Understanding and Vision for Research (OEUVRE)

- deep-sea hydrothermal vent community,
- biodiversity,
- human impacts on marine ecosystems,
- importance of nanoplankton for ocean productivity,
- dominant influences of fluid motions on populations and ecosystems,

- stewardship of marine resources and ecosystems,
- understanding causes and consequences of change on scales from hours to
- millennia, and
- understanding and forecasting of biological change, and restoration of damaged communities and the ecosystem services that they provide,

ADVANCES AND PRIMARY RESEARCH OPPORTUNITIES IN PHYSICAL OCEANOGRAPHIC STUDIES (APROPOS)

- ocean's role in climate,
- the hydrologic cycle,
- observing the ocean,
- coastal regions,
- inland waters and environmental fluid dynamics,
- turbulent mixing and unexplored scales, and
- numerical modeling as an integrative tool.

APPENDIX F: NSF USER SURVEY SUMMARY

NSF invited comments from the general community of marine scientists with experience on research vessels. The invitation was publicized in the Division of Ocean Sciences newsletter, science community electronic bulletin boards, and by the UNOLS office web site. The general terms of the Academic Fleet Review study were provided to help those who chose to reply make relevant comments. Forty-five replies were sent in over a period of 6 months. The replies represented scientists from twenty-four institutions and included researchers from oceanographic institutions, government agencies and private contractors. Replies came both from investigators at small and large UNOLS vessel operating institutions and from investigators from non-vessel operating universities. The data cover a wide range of users of all classes of UNOLS vessels and from a wide spread geographic region (all U.S. coasts plus Alaska and Hawaii).

The vast majority of respondents (84%) directly addressed satisfaction with the present NSF/UNOLS system as it applied to their personal research experience. A majority of these replies stressed the importance of vessel operation by academic centers with active oceanographic programs and the role of the vessel crews and technicians in the conduct of field work. The trend was to consider the vessel, crew and technicians as a system with high value on experience, training and long term involvement in the science. Of those responding, only a limited number had experience with both UNOLS vessels and those managed by other systems, including others nations. Most in that category discussed differences in management, facilities, and most importantly crew longevity, training , communication and dedication to the mission. The UNOLS vessels rated highly in these comparisons. It is clear in the replies that, given a working platform, it is the interaction with a talented helpful crew and technical staff which makes or breaks the research experience.

While investigators from most academic disciplines were included in the replies, the spread was skewed in the direction of marine geology and geophysics (MG&G) and those investigators who utilize multi-beam bottom mapping array sonars. Their comments appeared to assume a continuation of the UNOLS system, and pressed other discipline-oriented issues such as the availability and operation of MG&G equipment and the future availability of vessels and technical support to host such large fixed systems. A second bias in the responses was the large percentage with concern for having adequate small vessels for coastal and estuary work. Physical Oceanographers (PO), a significant portion of the ocean science community, may have been underrepresented.

The following major issues were identified in the comments:

1. There is a fear, real or perceived, that there will be a push to contract for oceanographic vessel services as a cost measure. Most discussing this issue were strongly against such a practice.
2. Experienced crew, technician and shoreside support of the science party is what makes the UNOLS system better than other current operational methods.
3. There is a perception that pending lay-ups will hurt crew and technicians with long term impact.
4. While an overwhelming majority like the UNOLS system, the scheduling process is a concern and perceived to be getting worse. This is impacting personnel and possibly increasing costs.
5. Technical and engineering support for onboard equipment is critical and must be a priority.
6. Some MG&G installed systems have fleet wide problems, with a parallel issue that multibeam data should be continuously taken and made available.
7. There is a fear, real or perceived, that the intermediate class vessels will disappear.
8. The current coastal/estuary research fleet is taxed to it's limit and should be augmented (West Coast)
9. UNOLS represents the ship operators better than the research user.

The following excerpts were taken from the replies to demonstrate the range and flavor of comments.

1. Whatever the conclusions of this review may be, I sincerely hope that they will include maintaining the strength of the concept that operational responsibility must reside within the immediate user community.... I worry about the possibility that there could be a recommendation that ship assignments MUST be rotated every 4 or 5 years.... There are so many decisions about manning, maintenance and improvements that have long time constants that this would be disastrous....
2. The UNOLS fleet, especially the smaller vessels, suffers in that it is completely devoid of any shallow and intermediate water swath mapping system....
3. I am writing primarily to express my concern that one of the options that the review committee is considering is that NSF charter commercial or industry vessels to conduct academic research cruises....
4. NSF must be concerned about and monitor the MCS [multi-channel seismic reflection] capability closely. Perhaps an "oversight" committee of some sort should be instituted to 1) project our MCS needs into the future and 2) develop a plan to respond to those needs....
5. I would like to advocate that the US ship operation remain in the university community and not be transferred to a private contractor....
6. The system has worked very well for me. I have found the crews, scientific liaisons, and computer techs to be highly professional and dedicated to making my experience successful scientifically. The specialized equipment like multi-beam

echosounding and precision gravimeters simply would not be available without a central-facility system like UNOLS....

7. It is my experience that on the whole the UNOLS vessels and other U.S. Academic Fleet Vessels were the best outfitted for and had crew most familiar with and competent at the types of operations required in the conduct of oceanographic research....
8. All of track and survey objectives were met....
9. The constitution, operation, and management of the UNOLS fleet is admirable. The USGS Coastal and Marine Program has made important and successful use of the UNOLS fleet on many occasions....
10. The single biggest problem that affects me as a scientist in using UNOLS vessels in the last 18 months has been equipment failure or poor performance.... I'm sure you are aware of the numerous problems being encountered on the AGOR vessels now equipped with SeaBeam 2100 systems. I have had occasion to use the systems on Revelle, Brown and Atlantis, and essentially they all suffer from similar problems.... The larger issue that has been mentioned regarding privatization of the fleet, seems to be quite unbelievable that such a thing would even be considered. These ships are quite different from any others operating on the worlds oceans, and are not at all suited to operations by a ship operator not involved in the science itself....
11. NSF proposal success rates are going down; the same is true at other agencies. Therefore, until funding decisions are settled, "draft" or "preliminary" schedules that incorporate many or all "pending" proposals are becoming increasingly less credible – there are simply too many schedule entries that will not in fact happen. This is not anyone's fault, it is just a mathematical fact of life as success rates decline....
12. I give high praise to the UNOLS system... I am very concerned about the future of intermediate-size ships, i.e., around 200 feet.... I see several huge new ships now in the field and I see the end of life for several mid-size ships....
13. First, I think that UNOLS is an extremely effective operation, and I strongly endorse the concept of many institutions operating ships rather than putting all fleet operations under the umbrella of one or a small handful of large oceanographic institutions....
14. I have been using ships for almost 30 years and am a frequent UNOLS ship user. My comments about the UNOLS fleet are in the "Everything is Fine" category.... My biggest concern here is not the local pinch on the ships but the potential loss of crew. I have had bad experiences on ships with non-oceanographic research crews.... Lay ups put the crews at risk...
15. While my experiences on non-UNOLS vessels were generally favorable, I can also state from first-hand experience that these vessels offered no research advantages over the UNOLS vessels and several disadvantages (crew and operators that answer to company, union or agency officials and not to the science users). Thus, I believe that the UNOLS fleet provides state-of-the-art platforms for U.S. marine research, no small accomplishment given the size and distribution of the fleet... I am very satisfied with the UNOLS fleet. Routinely, the crew and officers

go beyond their duties to assist the science operations and I feel that the UNOLS fleet has directly contributed to many of the achievements in marine research....

16. UNOLS has virtually no estuarine or nearshore operational capabilities on the West Coast...
17. I would like to see all UNOLS vessels provide the same services on a cruise....
18. I think it is in the best interest of the NSF to have the multibeam systems on the UNOLS fleet more freely available for scientists to use... The UNOLS ships should keep the multibeam systems up and running as part of their normal operating expenses....
19. For me, a physical oceanographer, the biggest drawback of the existing system is a lack of consistent marine technical support....
20. Nonetheless, from the perspective of the end user, the rapidly and significantly changing [ship scheduling] scenarios are incredibly frustrating. The logistics of organizing multi-institution programs with various technicians and students and faculty adhering to their own academic schedules is a nightmare when cruise dates and/or ports are changing from month-to-month (or even, week-to-week, a little over two years ago).... we got more science done than was planned because of good channels of communication pre-cruise and excellent communication at-sea with the ship's officers and technician staff... Time after time in my career, I've seen the benefits of the vast experience which the various operators of the academic vessels have brought to the sea-going projects....
21. In the realm of pre-cruise support my UNOLS experiences stand out (positively). The other end of that spectrum is probably ASA, although the Canadian Coast Guard does not score well there, either... The work SIO scientists do at sea is not cut-and-dry assembly line stuff (although occasionally some work is that way), but more let's-try-it-out-and-sea experimentalism. The fact that we are so closely tied with our operators has provided the best opportunity for us to do our science... I can think of no more effective scheme to provide vessel support for science excellence than is now provided to us by the interactions between the UNOLS organization, UNOLS operators, scientists, and funding agencies (primarily NSF)....
22. These problems arise because the current system provides no effective feedback to control the operators of the ships in these cases since they are active participants in the one organization that should be controlling them, i.e. UNOLS. Clearly we have a case of the foxes guarding the hen house.... On the other hand I have also seen a similar system operate on a US navy ship (Lynch) run by a civilian contractor. In this case the result was almost exactly the opposite, indifferent crew, no support despite massive overcrewing.... UNOLS recently asked for input regarding their charter and I wrote at that time that I believed that the problem was mainly a result of the fact that UNOLS as it currently operates represents ship operators rather than ship users...
23. I want to say what a pleasure it has been interacting with the different operators, Captains and crew, and scientific support staff at the different institutions. They all wanted to make things work and have us, the scientists, be a satisfied customer....

24. The present system of ship scheduling too often creates a situation where the cost of logistics supported by the science program (i.e., travel, shipping, etc.) cannot be determined far enough in advance....
25. I have used the academic fleet now for 25 years and am fairly well acquainted with its capabilities as well as limitations. Overall, I have been very satisfied with the fleet and it has served me well in many trips to sea... The ships in the academic fleet are literally the experimental tools needed to sustain the field, our telescopes or accelerators.... I personally do not believe that there is a long-term imbalance in the composition of the fleet and that the vitality of the large ship portion of the fleet should be maintained. Many programs we envision in the future, including the establishment and maintenance of a global observatory or observing system, will require all the capabilities we have and probably more...
26. Many of the members of the MG&G [marine geology and geophysics] community would be better served by having a greater number of intermediate-sized ships that are fully capable of doing blue water oceanography on a global basis....
27. The recent tendency to build larger ships has no advantage for marine G and G [geology and geophysics] – added running cost is a disadvantage.... The present system has many advantages for science operations, the most significant being that it retains good corporate memory and a pool of dedicated personnel. Management tends to understand and support science operations....
28. Three classes of research vessels are emerging today. The first and best .... is manned by highly knowledgable crews.... The second class of vessel is manned by crews willing to help but generally clueless.... The third class is the "bareboat" charter where the vessel's crew operates the ship but provides no help with science.... I strongly encourage the support/promotion of the first (vessel manning by knowledgable and helpful crews) and less focus on the daily rate....
29. The long-term need can only be addressed by planning for timely replacement and enhancement of UNOLS vessel capabilities for estuarine and coastal research, the needs for which were generally (although still with a coastal, open-ocean bias) represented in the 1994 UNOLS report....
30. Very high marks and grateful that the US has UNOLS and very capable ship operators to help organize, plan and provide equipment for fair and unfettered access to the world ocean and seafloor... Given my knowledge of the ship operations and facilities of other nations, primarily France and UK. I would unquestionably rate US academic research facilities and UNOLS as head and shoulders above them, both in terms of productivity, cost-effectiveness, and ease of access.... In recent years, scheduling decisions have been made very late in the process much to the consternation of the science community, the result being a general lack of confidence (at a certain level) of the process, UNOLS (with a trickle down of sentiment towards the various ship operators), and the federal agencies charged with this responsibility.... The cadre of well-trained and dedicated people, who understand how important it is to deliver on science at sea, even in challenging circumstances, is not large. Each time we lay up a ship at a UNOLS institution on a rotational basis we impact the lives of people and families who provide essential support to oceanography....

31. The two improvements that I would recommend at this time would be to assure that the vessel has a 150, 75 or 38 kHz ADCP available.... and to seriously consider enlarging the vessel to be able to handle additional deck loads....
32. We are frequent users of UNOLS vessels and offer the following comments regarding the desirable attributes of UNOLS. Overall we think the present system is highly effective and would be concerned about the future of our science in the absence of the present system.... Safety and performance are the big issues here. UNOLS is continually on top of this and we think it has been very successful in these efforts. We have never been on non-UNOLS vessels that measure up to the safety and performance standards of UNOLS vessels. UNOLS crews tend not to have as high a turnover as non-UNOLS vessels (in our experience). This is essential to getting the work done quickly and safely....
33. Cooperation was excellent. The entire crew as involved in seeing that survey plan was executed to our satisfaction....
34. I have been Chief Scientist on four UNOLS cruises since February 1997. I have experienced nothing but splendid cooperation in planning and executing the cruises....
35. An experience aboard an oceanographic research vessel adds immeasurably to the quality of the educational experience we provide for our graduate and undergraduate students....
36. I can see little to criticize in the present system, except that perhaps budgets ought to be increased to bring optimal ship usage....
37. Henlopen has been very good about providing the technical support that is required and my understanding is that NSF and Henlopen will try to extend the technical assistance services in the future, which I see as critical, especially for those of us from relatively small marine institutions without major engineering or technical support capabilities....
38. UNOLS seems to serve the community well and I can't think of any improvements....
39. Specifically, in situ access to the upper 1000 m of the marine realm seems to me to be a serious omission to the capabilities of the fleet. UNOLS would be enhanced by providing the opportunity for a counterpart to the ALVIN deep submergence facility. I think this option for crewed or robotic intervention would be welcomed by a wide variety of oceanographers....
40. I am unable to come up with any bad experiences that concern the operation of the BLUE FIN that were not acts of nature and, in my cases, unavoidable. Even then, the captain and crew usually were able to improvise. I will continue to be an enthusiastic user of the BLUE FIN....
41. Having staff who've been working for the SIO shipboard technical operations groups for anywhere up to 25-30 years means that a huge amount of expereince and expertise is already onboard....
42. I have found the administration and operation of the vessel [R/V Pelican] to be efficient, cooperative, and professional. The vessel met most of our research needs and we plan to continue to use it in the future....
43. My experience with using contractors who run programs for profit is not good.

While UNOLS has its problems, a private contractor may well have other, unforeseen problems, and I doubt it will be as cost-effective in the long run. UNOLS may well need adjustment. I have no specific suggestions here. As a starting point, it probably needs to be reviewed more frequently than every 25 years. Incremental changes as needs evolve are usually easier....

44. The problem is that every PI has to reinvent such a system [transponder navigation system], at great expense and hassle, when the capability could be built in ... with the rest of most ship operations...
45. I have always thought that the system has worked well in providing platforms for the scientific community.

APPENDIX G: UNOLS CRUISE REPORT SURVEY

SCIENTISTS CRUISE ASSESSMENT SUMMARY

SHIP	DAYS	REPORT RECV'D	REPORTED LOST TIME (days) WEA.	SHIP	SCI.	TOTAL%	SUCCESS FULL	PART.	UNSAT.	COMMENTS PRAISE	IMPROVE
MELVILLE	213	6	0.00	6.00	0.00	2.8	5	1	0	4	4
KNORR	258	12	2.50	1.50	1.00	1.9	11	1	0	11	6
REVELLE	163	7	1.00	0.75	1.00	2.0	6	1	0	7	5
ATLANTIS	177	13	4.00	0.00	0.00	2.8	13	0	0	10	3
THOMPSON	136	2	5.25	10.50	0.00	11.6	1	1	0	2	2
EWING	139	3	1.00	0.00	0.00	1.0	3	0	0	2	0
MOANA WAVE	0	0	0.00	0.00	0.00	N/A	0	0	0	0	0
SEWARD JOHNSON	254	9	1.00	5.50	0.50	2.8	8	1	0	9	7
WECOMA	199	18	12.00	0.00	7.75	9.9	12	5	1	16	7
ENDEAVOR	35	2	7.00	0.00	1.00	23.0	2	0	0	2	0
GYRE	181	13	5.25	1.25	11.25	9.8	12	1	0	12	3
OCEANUS	199	19	18.00	1.00	8.25	13.7	14	5	0	15	3
NEW HORIZON	180	9	4.00	3.00	1.00	4.4	7	2	0	9	2
EDWIN LINK	199	18	10.25	3.75	1.00	7.5	13	5	0	17	5
POINT SUR	97	14	0.50	5.00	0.50	6.2	14	0	0	14	4
CAPE HATTERAS	204	21	11.75	0.5	2.25	7.1	16	5	0	19	1
ALPHA HELIX	107	7	7.50	2.00	0.00	9.0	5	2	0	7	0
R. G. SPROUL	106	25	1.00	0.00	0.00	1.0	19	5	1	16	3
CAPE HENLOPEN	169	21	4.25	0.00	1.50	3.4	21	0	0	17	4
WEATHERBIRD II	140	46	4.50	0.00	2.00	4.6	42	4	0	29	7
SEA DIVER	67	7	2.00	0.50	0.00	3.7	5	1	0	6	0
PELICAN	133	20	3.25	0.25	0.00	3.5	18	1	0	18	4
LONGHORN	46	20	1	0.50	0.25	4	14	3	0	15	3
URRACA	58	3	0.00	1.00	0.00	1.7	3	0	0	2	2
LAURENTIAN	0	0	0.00	0.00	0.00	N/A	0	0	0		
BLUE FIN	31	38	0.00	0.00	0.00	0.0	16	3	0	7	0
CALANUS	111	13	0.00	0.00	0.00	0.0	13	0	0	11	0
BARNES	0	0	0	0	0	N/A	0	0	0	0	0
TOTALS	3602	366	107.00	43.00	39.25	5.2	293	47	2	277	75

SHIP CAPTAIN POST-CRUISE REPORTS

KEY:
E = EXCELLENT
G = GOOD
A = AVERAGE
B = BELOW AVERAGE
P = POOR

SHIP	ASSESS. REPORTS RECV'D	OBJECTIVES MET		ORGANIZATION					COMMUNICATIONS				
		YES	NO	E	G	A	B	P	E	G	A	B	P
MELVILLE	6	6	0	0	6	0	0	0	0	5	1	0	0
KNORR	14	12	1	2	9	1	1	0	2	10	1	0	0
ROGER REVELLE	0	0	0	0	0	0	0	0	0	0	0	0	0
ATLANTIS	15	15	0	1	12	2	0	0	1	12	2	0	0
THOMPSON	1	1	0	0	0	0	0	0	0	0	0	0	0
EWING	0	0	0	0	0	0	0	0	0	0	0	0	0
MOANA WAVE	21	15	5	5	13	2	0	0	5	13	2	0	0
SEWARD JOHNSON	5	5	0	1	4	0	0	0	0	5	0	0	0
WECOMA	18	15	3	3	8	5	2	0	4	11	2	1	0
ENDEAVOR	18	18	0	4	6	8	0	0	5	5	7	1	0
GYRE	13	13	0	3	6	3	1	0	6	4	1	1	1
OCEANUS	20	20	0	4	10	6	0	0	5	9	6	0	0
NEW HORIZON	9	8	1	3	3	1	0	0	2	4	1	0	0
EDWIN LINK	18	16	2	10	7	1	0	0	10	7	1	0	0
POINT SUR	35	35	0	11	20	3	1	0	7	25	3	0	0
CAPE HATTERAS	21	21	0	10	9	2	0	0	11	9	0	0	0
ALPHA HELIX	8	8	0	4	3	1	0	0	5	2	0	1	0
R. G. SPROUL	33	30	3	18	11	4	0	0	21	10	1	1	0
CAPE HENLOPEN	27	27	0	5	2	0	0	0	24	2	0	0	0
WEATHERBIRD II	52	52	0	50	1	1	0	0	50	2	0	0	0
SEA DIVER	8	7	1	3	4	1	0	0	2	5	1	0	0
PELICAN	1	1	0	1	0	0	0	0	1	0	0	0	0
LONGHORN	20	18	1	1	18	0	0	0	0	18	0	0	0
URRACA	0	0	0	0	0	0	0	0	0	0	0	0	0
LAURENTIAN	0	0	0	0	0	0	0	0	0	0	0	0	0
BLUE FIN	38	37	1	1	36	1	0	0	1	36	1	0	0
CALANUS	13	13	0	7	4	2	0	0	9	3	1	0	0
BARNES	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	414	393	18	147	192	44	5	0	171	197	31	5	1

APPENDIX H: COMPARISON OF RESEARCH SHIP OPERATING MODELS

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

NOAA owns and operates 15 research ships in support of the agency missions for charting, fisheries monitoring and research, oceanographic research and environmental assessment. The NOAA fleet profile has significant differences from UNOLS. Most of the ships are "special purpose" ships outfitted to meet specific mission requirements for fisheries assessment, monitoring and research (11 ships) and charting (2 ships). Only two ships are general purpose research ships, and one of these ships is dedicated to support of a tropical Pacific buoy array for climate studies. The fisheries ships also are generally assigned to a region and support NOAA centers and laboratories in that area.

The NOAA scheduling process, with the partial exception of the R/V Ronald Brown, their major general purpose research ship, is an internal agency process. The NOAA laboratories and centers submit requests for ship time to their management offices. After management review and prioritization, the requests from the major line organizations, Office of Oceanic and Atmospheric Research (OAR), National Oceanic Service (NOS) and National Marine Fisheries Research (NMFS), are submitted to the NOAA Fleet Allocation Council. A working group examines all requests for scheduling and time conflicts, days available, ship capabilities and repair/maintenance requirements for the ships. The working group develops an integrated operating plan for all 15 ships which undergoes final review and approval by the Fleet Allocation Council.

NOAA fleet operations are similar in most aspects to academic fleet operations. The 15 ships are dispersed and operate out of 6 home ports on both coasts and in the Gulf of Mexico. Technical support and shared-use instrumentation are provided to users. A safety inspection program, ship equipment upgrades, and maintenance and repair plans are similar in concept to the NSF programs for the academic fleet. The major difference is in the general management structure. NOAA operates their fleet through headquarters oversight by the Office of NOAA Corps Operations (ONCO) and two marine centers in Seattle and Norfolk. Purchasing, engineering, personnel support, and technical services and instrumentation systems are centrally managed. In contrast, each academic ship operator provides all services locally with coordination through UNOLS committees and the NSF program offices.

Crewing for the research ships is also distinctive. The academic fleet is staffed by licensed officers and crew who are university employees. NOAA ships are staffed by NOAA Corps officers, a uniform service similar to the Coast Guard, and government marine wage employees for crew.

NAVAL OCEANOGRAPHIC OFFICE (NAVOCEANO)

NAVOCEANO owns and operates 8 survey ships to provide oceanographic military surveys for the operational Navy fleet. All of the ships are "special purpose" ships outfitted to meet classified, and occasionally unclassified, military surveys. The specialized measurement systems focus on geophysical mapping, acoustic surveys and hydrographic measurements. Seven of the eight ships are "forward deployed" and operate in distant offshore or littoral areas where data are sparse or non-existent.

The NAVOCEANO scheduling process is requirements-driven to meet specific needs of operational and system commands. Currently 240 ship years of requirements are identified and an extensive internal Navy process establishes the timing and location priorities. In essence, the NAVOCEANO survey fleet has a single sponsor and single client – the operational Navy.

NAVOCEANO ships are operated by the Military Sealift Command with civilian crews. The data collection team or scientific party consists of 10-15 NAVOCEANO oceanographers and contractors. Although the ships have a single nominal homeport in Gulfport, Mississippi, they do not operate from this port, but use military bases and commercial ports worldwide. The shipboard equipment and data collection technical teams are supported through a centralized office at the Stennis Space Center in Mississippi. Personnel are rotated between at-sea duties and shore-based data analysis activities. Approximately 300,000 pounds of sensor and support equipment and supplies are organized at Stennis and sent to the ships annually. Technical support is provided for onboard equipment. Technicians are assigned to vessels and periodically rotate to Mississippi for shore assignments.

RESEARCH VESSEL SERVICES (RVS), UNITED KINGDOM

Research Vessel Services (RVS) owns and operates 3 research vessels equivalent to one large expeditionary vessel, one intermediate and one Cape-class vessel to support university and research institution scientists. These ships are the United Kingdom's equivalent of the U.S. academic research fleet. The RVS is technically a division of the Natural Environment Research Council (NERC), the primary research sponsor, and "commissioned" to operate the research fleet and provide technical and instrumentation support. RVS fleet operations provides equivalent services to a U.S. academic ship operator in response to variable research project requirements in all oceanographic disciplines. The home port for all three ships is at the Southampton Oceanography Centre which is a joint venture between the University of Southampton and NERC. The university Geology and Oceanography Departments, four NERC ocean sciences research institutes, and Research Vessel Services are co-located in a single complex in the port of Southampton.

The RVS scheduling process has many similarities to the UNOLS ship scheduling procedure. Research projects from university scientists are merit reviewed through the NERC research councils. Research projects from the NERC research institutes at times directly compete with university projects through the research councils and sometimes are reviewed separately in context of the institute's mission responsibilities. Following review of the sea-going research projects, a "Sea Time Assessment Panel" meets to establish a priority order and general schedule. This framework is then refined into an operations schedule for the following year by RVS staff. With 3 ships instead of 28 ships, the system is less complex but based on the same principle – science drives ship operations. Due to the scale of the operation, a single operational site is sufficient to service the fleet.

The financial management model for the RVS fleet is evolving to be similar to the U.S. academic fleet with modest differences. The ship funding is divided into two accounts – infrastructure and superstructure. Infrastructure funding provides for base costs for ships and their operations to exist for the benefit of UK scientists. It includes facility management and building costs along with ship and shore-based staff and currently covers about 50 percent of total annual costs. This funding comes directly to RVS from NERC. Superstructure funding provides for a merit reviewed project to actually use a ship. These funds are included in the research project award and are calculated as a "day rate" for each vessel and the level of technical and instrumentation support required. Fuel, maintenance, sea-pay overtime, expendable supplies, food and all general operations cost are included. If a sufficient number of research projects to fully use the three ships are supported, then the system is in balance. If not, then a vessel or vessels must be laid-up or taken out of service for all or part of a year.

In recent years, RVS has had to lay-up individual vessels for as much as 5 months and does not project that sustained funding from NERC for infrastructure and superstructure will increase to fully use the ships. The RVS is investigating links to expand their sponsor base from NERC to agriculture and fisheries research organizations, defense research agencies and commercial environmental assessment work. The "new sponsors" are expected to cover full costs, i.e. infrastructure and superstructure. If successful in attracting new sponsors, the RVS operations will increasingly resemble the multiple sponsor, multiple mission support model for the U.S. academic fleet. However, with only 3 ships, a single operator and owner will remain in contrast to the multiple ownership and operations model in the U.S.

CANADIAN COAST GUARD (CCG), CANADA

In 1996, Canada reorganized and consolidated its marine operations into a single national fleet operated by the Canadian Coast Guard, a civilian organization. The CCG identifies 132 ships and tenders in the national fleet that range from heavy icebreakers (6) to small search and rescue lifeboats (41). The national fleet is multipurpose and covers activities ranging from icebreaking; marine navigation services; rescue, safety and environmental response; fisheries conservation and protection; and marine science. In the U.S., responsibility for the various tasks are distributed among the U.S. Coast Guard, NOAA, EPA, FEMA, USGS and research agencies such as NSF and ONR. The large majority of vessels in the CCG fleet are equivalents of the U.S. Coast Guard operations and navigation aids ships (108 ships) followed by NOAA-type fisheries vessels (12 ships), academic/government survey and research vessels (9 ships) and maritime training vessels (3 ships).

The larger ships operate out of 5 regional bases on both coasts with a number of smaller ships at about 60 coastal stations. All personnel are government employees. A small headquarters staff provides policy guidance, overall coordination of facilities and fleet services, communications support and cost accounting. Operational support is provided by the five regional bases similar to an academic or NOAA operations center.

The CCG fleet is funded by two methods and from several sources. The first method, or formula funding based on levels of service, applies to the "coast guard" functions for navigation, search and rescue, spill response, etc. and includes most of the ships (111 ships). The second method, buying ship days per project, applies to the fisheries and marine sciences ships (21 ships) and is functionally similar to the U.S. academic fleet support model where costs are tied to specific projects.

Scheduling for science or research projects is done on a three region basis – Atlantic zone, Central and Arctic region, and Pacific zone. Research sponsors include the Department of Fisheries and Oceans (DFO), Environment Canada, and the Canadian universities with NSERC support. The review process is variable with most university-based projects undergoing merit review, but agency projects may be submitted based on internal administrative and management review only. DFO projects have a scheduling priority but conflicts with other programs are rare.

Technical and instrumentation support is limited. The CCG provides ships and crew including support for operating heavy ships gear, e.g. winches, mooring deployment, etc. However, all specialized deck equipment and instrumentation is the responsibility of the scientific complements. In brief, the science projects are expected to provide most of the science systems in contrast to the shared-use instrumentation and technical services approach used for the U.S. academic research fleet.

Within the Canadian academic community marine science proposals are peer reviewed and rated by NSERC's standard grant selection committees. Investigators that require ship time include a ship-time request form that specifies the operating area, nature of operations, number of days needed and the type of vessel required. Funding for ship time may come from directed science programs or from a general ship time fund established by NSERC. All successful proposals are then reviewed by the ship time selection committee that:

1. Ensures that the program outlined is manageable on the type of vessel requested;
2. Sees where programs can be combined for more cost-effective use of ship time; and
3. Distributes the available ship time funds to those not funded through other sources.

While users are encouraged to use CCG vessels, NSERC does not require this. NSERC has, and will allow users to use their funding for any vessel (commercial, foreign, etc.) if the case can be made that it is the most cost effective and efficient use of funding.

APPENDIX I: CONSULTANT REPORT

Analysis of
University-National Oceanographic
Laboratory System (UNOLS)
Ship Operations

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1.0 INTRODUCTION

The University–National Oceanographic Laboratory System (UNOLS) is a consortium of academic institutions that either operate or use the U.S. academic research fleet. The goal of UNOLS is to optimize the scientific and economic efficiency of the fleet and to support national planning for new ships.

The purpose of this task is to provide financial management and economic analysis support for the NSF Academic Research Fleet Review. To assist in this evaluation, other government and commercial benchmark cost data was gathered. These rates were compared with UNOLS costs to evaluate the cost effectiveness of UNOLS services.

The data for the cost analysis, utilization rates, and sponsor history were collected from the National Science Foundation (NSF) cooperative agreements and cost data for operations of the ships. Data for 1993 through 1997, the last year with complete actual cost data, is shown in constant CY 1998 dollars.

2.0 PROCEDURES AND ASSUMPTIONS

The study focused on 29 ships, the 1997/98 UNOLS fleet. Table 2.1 lists these ships.

Expeditionary Ships:

Operator	Ship	Owner	Ship Length
Scripps Institution of Oceanography	Melville	Navy	279
Woods Hole Oceanographic	InstitutionKnorr	Navy	279
Scripps Institution of Oceanography	Roger Revelle	Navy	274
Woods Hole Oceanographic Institution	Atlantis	Navy	274
University of Washington	Thomas Thompson	Navy	274
Lamont-Doherty Earth Observator	Maurice Ewing	NSF	239
Woods Hole Oceanographic Institution	Atlantis II	WHOI	210

* Atlantis II was retired in 1996 and replaced by Atlantis, which began operations in 1997.

Intermediate Ships:

Operator	Ship	Owner	Ship Length
University of Hawaii	Moana Wave	Navy	210
Harbor Branch Oceanographic Institution	Seward Johnson	HBOI	204
Oregon State University	Wecoma	NSF	185
University of Rhode Island	Endeavor	NSF	184
Texas A&M University	Gyre	TAMU	182
Woods Hole Oceanographic Institution	Oceanus	NSF	177
Scripps Institution of Oceanography	New Horizon	SIO	170
Harbor Branch Oceanographic Institution	Edwin Link	HBOI	168

Regional Ships:

Operator	Ship	Owner	Ship length
Moss Landing Marine Laboratories	Point Sur	NSF	135
Duke University/University North Carolina	Cape Hatteras	NSF	135
University of Alaska	Alpha Helix	NSF	133
Scripps Institution of Oceanography	Robert G. Sproul	SIO	125
University of Delaware	Cape Henlopen	UD	120
Bermuda Biological Station for Research	Weatherbird II	BBSR	115
Harbor Branch Oceanographic Institution	Sea Diver	HBOI	113
Louisiana Universities Marine Consortium	Pelican	LUMCON	105
University of Texas	Longhorn	UT	105

Local Ships:

Operator	Ship	Owner	Ship length
Smithsonian Institution	Urraca	SI	96
University of Michigan	Laurentian	UMich	80
University System of Georgia	Blue Fin	UG	72
University of Miami	Calanus	UM	68
University of Washington	Clifford A. Barnes	NSF	66

Table 2.1 UNOLS Academic Research Vessels

The major study objective was to develop a cost structure to support, evaluate and financially analyze the fleet in terms of operations, maintenance, acquisition, and the modification of ship capability. The chosen structure allows for an in-depth cost comparison between various approaches or alternatives designed to meet the needs of the members of UNOLS. In addition, the data structure allows for the identification and study of fixed and variable costs.

Cost Element Structure

The costs were broken down into eleven major cost element categories. The elements of Salaries and Wages (both crew and shore) and Other Direct Costs were further broken down. Indirect costs were identified separately.

The UNOLS daily operating costs presented in this report cover a standardized complement of cost elements. They include:

- Vessel and crew costs
- Fuel and lube, provisions, port and customs fees
- Shore support, headquarters overhead and overhead support
- Procurement office support and augmentation support
- Docking fees and cellular communications

- An additional Captain or Mate (if needed for 24 hour operations)
- Crew travel (transportation of relief crews to distant ports and the return)
- Faculty visitations and travel, per diem and berthing (not including scientific party wages)

Data Sources Include:

- NSF Co-operative Agreements and Proposals
- Ship Operator Institutions
- Office of Naval Research
- Federal Oceanographic Fleet Coordination Committee
- Industry and other sources

3.0 DATA COLLECTION

Budget projections and actual costs were collected for all UNOLS ships for 1993 through 1997. Budgeted data, where available, was used where cost data was unavailable.

3.1 Average Cost per Day and Ship Length

There is a statistical relationship between the size of the ships within the fleet and the cost of operation. The average cost of operating Expeditionary ships with an average length of 270 feet was $15,757 a day. The range of costs was between $12,574 to $16,906. The smallest Expeditionary ship, the Maurice Ewing (239 ft), had an operating cost of $16,637, while the largest, Melville and Knorr (both at 279 feet), were $16,582 and $16,906, respectively. Figure 3.1 displays the relationship between ship length and operating cost per day while Figure 3.2 compares each ship to class averages.

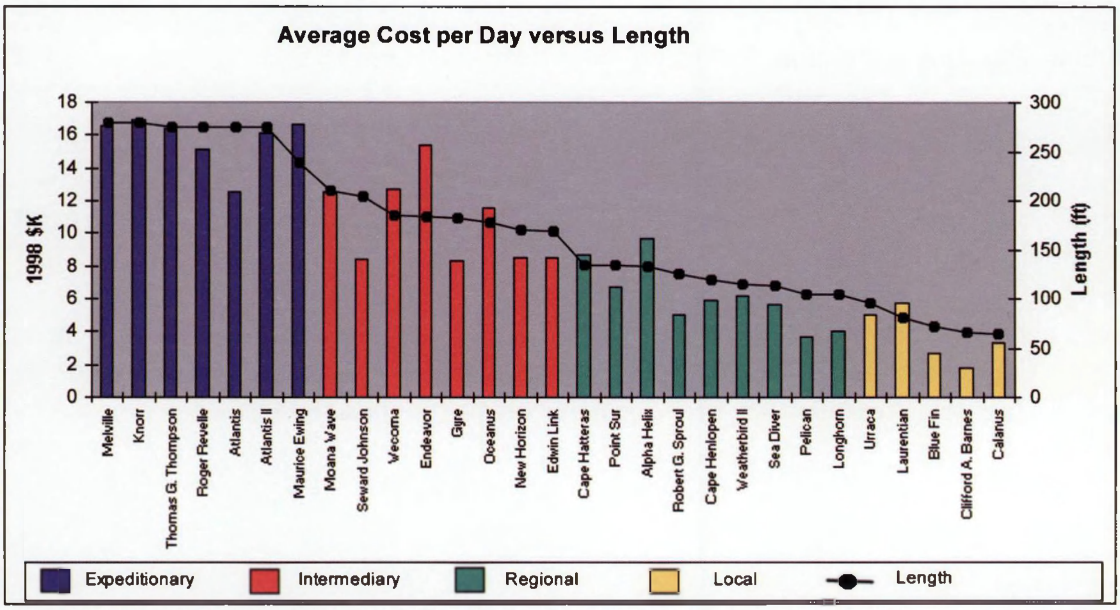


Figure 3.1 Ship Average Cost/Day and Individual Ship Lenghts

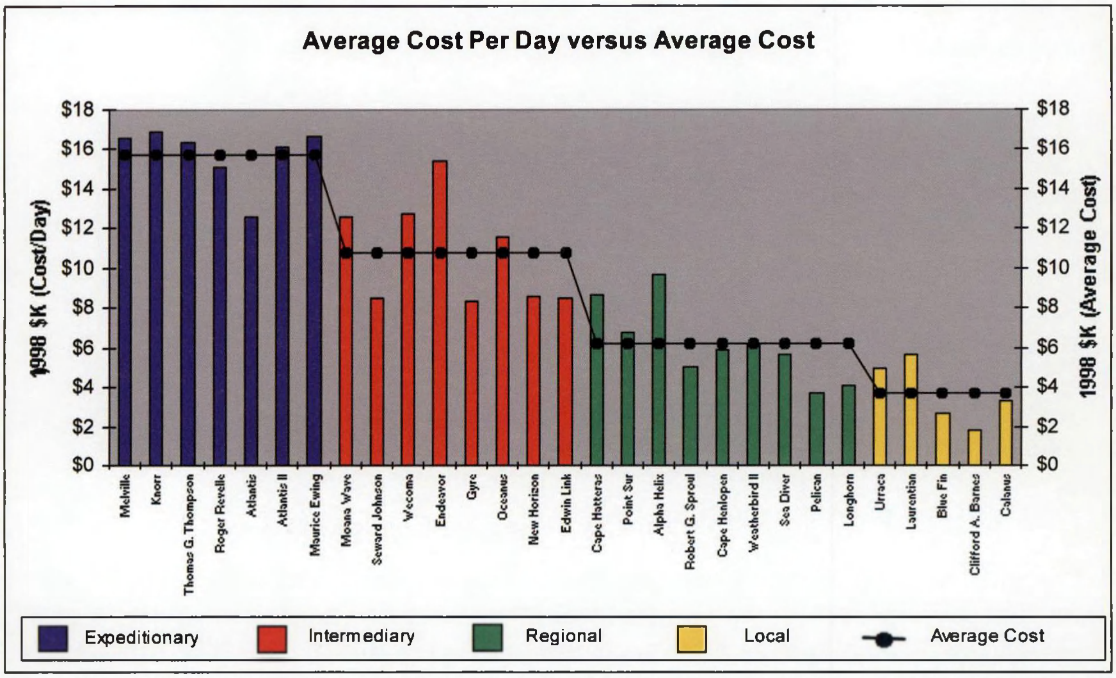


Figure 3.2 Ship Average Cost per Day and Class Average Ship Costs

3.2 Operating Cost Trends

Average cost data provides a frame of reference for comparing individual ships with their respective class average. Some variability of costs is attributed to differing research missions, ship utilization days per year, and special customer requirements and practices. The trend of data is most important, and costs have remained fairly constant between 1993 and 1997. Expeditionary ship operating costs decreased by 8.21% over the five-year period. This is approximately a two percent decline per annum. The average local ship cost per day increased from $2,910 in 1993 to $3,520 in 1997 (21%). It was the only class of ship that the cost per day increased. Figure 3.3 displays the class average cost per day for 1993 to 1997.

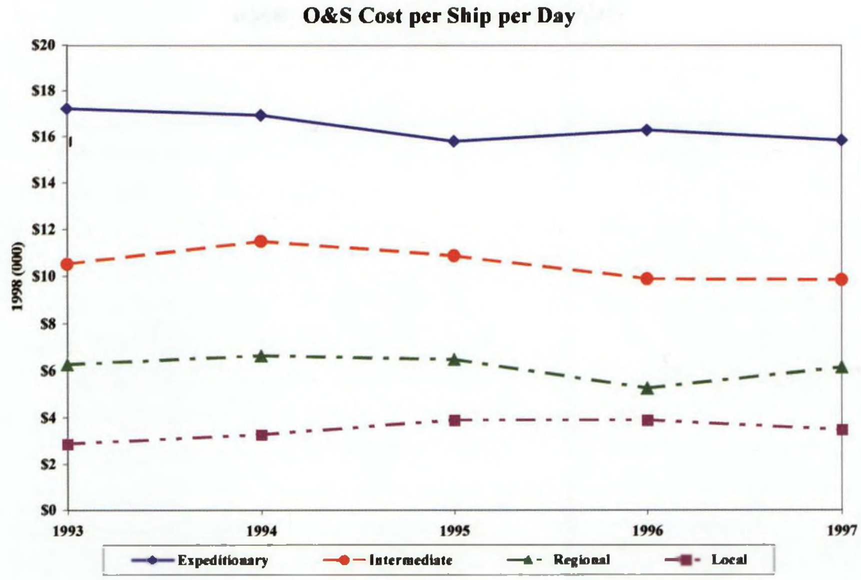


Figure 3.3 Ship Class Average Cost per Day

3.3 Utilization by Class

An analysis of the trend of operating costs is considered in respect to utilization levels. Utilization levels directly correlate with operating costs. The higher the number of days a ship is utilized the lower the cost per day, as there are more operational days to spread the fixed costs. The standard is the planning rate for the last five years. The average utilization rate and NSF standards for the fleet are:

Class	NSF Standard	Average
Expeditionary	300	285
Intermediate	275	188
Regional	180	152
Local	110	83

Although the five year averages are below the standard, the trend of the number of operating days per year has increased in all classes except for Regional ships. This is very positive. The Expeditionary class of ships has the highest utilization rate at 95% of the standard followed by Regional (84%), Local (75%) and Intermediate (68%). The Intermediate rate had increased to 77% by 1997. Figure 3.4 compares the operating days to the NSF Standard.

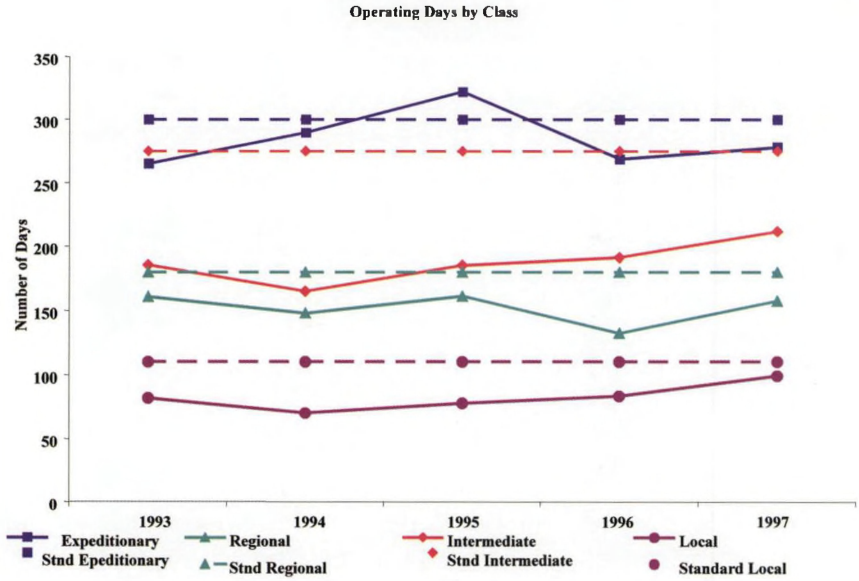
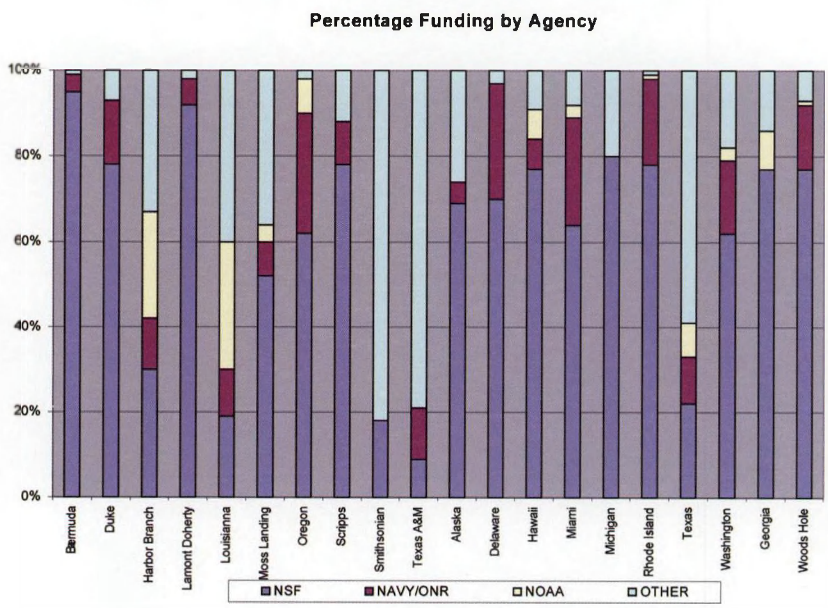


Figure 3.4 Operating Days to Standard

3.4 Funding Sources

Educational institutions conducting oceanographic research are funded from three major sources; NSF, Office of Naval Research (ONR), and National Oceanic and Atmospheric Administration (NOAA). Additional sources of funding include the Department of the Interior, National Institutes of Health, Environmental Protection Agency and a number of other federal agencies, state and local sponsors. Figure 3.5 shows the percent of each institution funding from the major sources.

Figure 3.5 Percentage of Funding by Agency



3.5 Cost Drivers

The major cost elements in the UNOLS daily rate are: Salaries & Wages (crew), Salaries & Wages (Shore Staff), Repair, Maintenance, and Overhaul, Other Direct Costs, and Indirect costs. Labor costs account for 48 percent (crew and shore staff combined) of the rate with Other Direct Costs being a distant second at 27 percent. Repair, Maintenance, and Overhaul costs are 13 percent while Indirect costs are 11 percent. Figure 3.6 depicts this data.

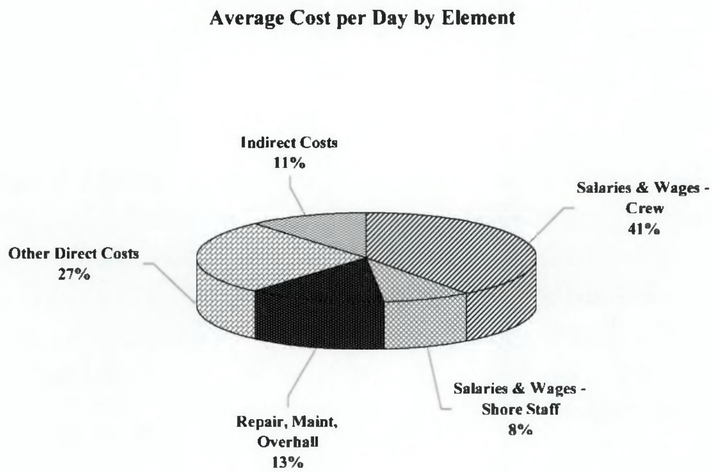


Figure 3.6 Costs per Day Cost Drivers

4.0 LAY-UP COSTS

Lay-up is the temporary removal of a ship from service. The removal may be for maintenance or to reduce operating costs. There are several management scenarios dictated by the lay-up duration. Lay-ups lasting several years reduce operating costs, due to decreased maintenance cost and no labor costs. No multi-year lay-ups occured in the academic fleet for 1993-1998. For periods of a year or less, there are a variety of costs incurred including dockage, preservation actions, insurance, security, shore support, and partial retention of the ships crew.

Short term lay-ups of three months or less are often done while retaining the crew. This is an institutional policy that has a major impact on lay-up costs, and is a critical factor in retaining scarce maritime skills. Short lay-ups do not typically result in significant cost savings.

Actual lay-up costs were available for the Endeavor (Intermediate) and the Cape Hatteras (Regional). Both were laid-up for one year. In both cases, approximately half the crew was retained to provide maintenance, security and some refurbishment of the ship. No Expeditionary ships were laid-up during the period of this report.

	Endeavor	Cape Hatteras
Crew Costs	$277,000	$317,000
Shore Staff	128,000	104,000
Insurance	32,000	25,000
Miscellaneous	57,000	13,000
Total	$494,000	$459,000

Lay-up scheduling among the operators is optimized to utilize anticipated down-time for maintenance. It would be beneficial to establish a more common criteria and procedure for placing vessels in lay-up. Nonetheless, the present system is working.

5.0 COMPARATIVE COSTS

The UNOLS daily costs presented in this report cover a standardized complement of costs including: vessel and crew costs, fuel and lube oil, per diem, provisions, port and custom fees, shore support, headquarters overhead, other overhead, procurement office support, docking fees, communications, an additional Captain or Mate (if needed for 24 hour operations), crew travel (to transport relief crews to distant ports and original crew to home port) and faculty visitations and travel. Per diem, berthing, but not wages, are paid for the complement of the scientific crew; scientists, technicians and students.

UNOLS rates are turnkey costs, encompassing vessel and crew costs as well as other factors not typically included in commercial rates. Although standardized, differences exist between the rate structures and accounting systems of different UNOLS institutions, ships performing different missions, and government-owned ships and academic-owned ships. A full assessment of these differences would require significant additional research. Comparative data is provided, however, to provide a preliminary comparison of UNOLS operating costs with governmental and commercially operated ships.

5.1 UNOLS and Naval Oceanographic Office Ships

Daily rates for the large UNOLS oceanographic research ships and similar Naval Oceanographic Office (NAVOCEANO) ships are shown below:

	NAVOCEANO	UNOLS
Cost per day	$22,000	$15,757

Several reasons explain the cost differences: 1) NAVOCEANO ships are larger and consequently have higher fuel and operating costs; 2) NAVOCEANO lifetime maintenance and overhaul and projected upgrade costs are included in the cost schedules; 3) Military Sealift Command (MSC) operation of NAVOCEANO ships provides forward-based support which is unavailable for

UNOLS ships; and 4) Some overhead costs for UNOLS ships are not included in the daily rates, because they are borne by the ship owner (universities).

5.2 National Oceanographic and Atmospheric Administration (NOAA) Operations

NOAA daily operating costs include items not in the UNOLS rate. Those cost items are: general management and coordinating, some scientific equipment, safety inspections, fleet-wide computer systems, professional medical personnel, and limited technician support. Table 5.1 compares three NOAA ships with the UNOLS class average rates.

Ship	Length	Cost/Day	UNOLS Class Average
Ferrel	133	$ 6,033	$6,178
Oregon II	170	10,582	$10,753
Ronald Brown	274	13,513	$15,757

Table 5.1 Daily Rates for NOAA Ships

At a presentation held at the Scripps Oceanographic Institution during the fall of 1998, RADM William Stubblefield, head of the NOAA Corps, cited an operating cost for the Ronald Brown of $15,700 per day. These costs also included the costs associated with one survey technician. Updated cost data obtained from NOAA in early 1999 are shown below. According to NOAA, the Ronald Brown cost figure includes all the standard UNOLS cost elements. Like the UNOLS ship, this excludes scientists and technicians.

Table 5.2 shows a detailed comparison between the UNOLS ship Atlantis and the NOAA ship Ronald Brown on a per day basis. Atlantis and Ronald Brown are "sister ships" constructed to the same basic design and delivered for use starting in 1997 and 1998.

Cost Element	Atlantis	Ronald Brown
Salaries & Wages (crew)	$1,066	$1,780
Salaries & Wages (shore)	117	307
Repair, Maintenance, Overhaul	47	495
Fuel and Lube Oil	330	969
Food	71	99
Insurance	45	
Supplies and Minor Equipment	98	99
Travel	54	40
Shore Facilities Support	31	173
Miscellaneous	137	203
Total Direct	$ 1,997	$4,164
Indirect Cost	284	485
Total Costs	$ 2,281	$4,648
Operating Days	185	344
Daily Rate	$12,330	$13,513

Table 5.2 Atlantis/ Ronald Brown Comparison

It is important to note that the salaries for the scientists on Atlantis that support the manned submersible ALVIN are not included in the UNOLS rates. The berthing and per diem for those personnel are included. The above analysis shows how the number of operating days impacts the daily rate. The Ronald Brown annual operating cost was twice (204%) the cost for the Atlantis, but the daily rate was only nine percent higher. The Ronald Brown operated 159 more days than did the Atlantis.

5.3 Canadian Coast Guard/Department of Fisheries and Oceans

Table 5.3 shows the operating costs for 1998/1999 of selected Canadian Coast Guard/ Department of Fisheries and Oceans vessels. Supplemental data is provided to aid in the comparison with approximately comparable UNOLS ships.

Many ships are operated on a Lay Day system, usually on a 28-day on/off cycle, although others are operated on 14-day cycle. The complement refers to only one of the two crews - the TELEOST has a complement of 20 officers and crew, but in fact 40 people (plus relief) are assigned to the ship - 20 "on" and 20 "off."

The personnel costs are broken out into three subcategories: 1) salary and wages; 2) overtime; and 3) other personnel costs (which include bilingual bonuses, armed boarding training and allowance, search and rescue specialist training and allowance). Operating Costs are captured in the subcategories of Fuel and Lubricants, Provisions; Crew Changes (for example, the crew rotation taking place in a port other than the home port); and Voyage Repairs and Maintenance Consumables. The more current UNOLS ships have more scientists than crew, whereas most Canadian ships are older and more labor-intensive, and require larger crews.

UNOLS CLASS	CANADIAN VESSEL	TYPE	LENGTH	COST($K/day)
EXPEDITIONARY				
	HUDSON	Ocean Research	275	$16.4 (CDN)
	Average Canadian Cost			$11.5 (US)
	Average UNOLS Cost			$15.8 (US)
INTERMEDIATE				
	JOHN P. TULLY	Ocean Research	210	$11.6(CDN)
	PARIZEAU	Ocean Research	197	$11.0 (CDN)
	TELEOST	Research Trawler	192	$16.1(CDN)
	W.E. RICKER	Research Trawler	177	$ 9.3 (CDN)
	Average Canadian Cost			$ 8.0 (US)
	Average UNOLS Cost			$10.8 (US)
REGIONAL				
	WILFRED TEMPLEMAN	Research Trawler	153	$14.0 (CDN)
	ALFRED NEEDLER	Research Trawler	153	$10.5 (CDN)
	VECTOR	Ocean Research	121	$ 6.3 (CDN)
	Average Canadian Cost			$ 7.2 (US)
	Average UNOLS Cost			$ 6.2 (US)
LOCAL				
	SHAMOOK	Research Trawler	7	$ 5.1 (CDN)
	CALANUS II	Research Trawler	61	$ 3.0 (CDN)
	OPILIO	Research Trawler	55	$ 1.1 (CDN)
	CALIGUS	Research Trawler	51	$ 1.0 (CDN)
	Average Canadian Cost			$ 1.8 (US)
	Average UNOLS Cost			$ 3.7 (US)

Table 5.3: Operating Costs for UNOLS and Canadian Research Vessels, 1998/1999

5.4 Charter/Contract Operated Ships

Costs for commercially chartered ships were compared to operating costs of UNOLS ships to a first order of magnitude. Many of the commercial rates as provided by industry appear competitive, but closer scrutiny reveals that commercial rates are not comparably calculated. Direct comparison of UNOLS and commercial rates is difficult, since commercial rates must be supplemented with mission specific costs such as fuel, crew travel, port fees, and other operating costs not included in "base rates."

Ship	Length	Commercial Base Daily Rate*	UNOLS Adjusted Rate**
R/V Ocean Ranger	242	$13,000	$9,837 - Expeditionary
R/V Atlantic Explorer	205	9,550	$9,181 - Intermediate
R/V Independence	200	9,500	
R/V Fox	190	8,950	
R/V Pacific Star	180	5,500	
R/V Davidson	175	6,500	
R/V McGraw	106	3,800	$4,894 - Regional
R/V Beacon	100	3,495	$3,232 - Local
R/V Heck	90	3,490	
R/V Southland	66	1,850	

* Does not include fuel, lube, customs, or dockage
** UNOLS rate without crew overtime, crew shore leave, fuel and lube oil, food, travel and miscellaneous

Table 5.4 Comparison between Commercial and UNOLS Rates

In summary, some quoted commercial rates do appear lower than those of comparable UNOLS ships, but the commercial rates omit the full complement of costs contained in the UNOLS rates.

While this analysis focuses on operating costs of UNOLS ships, ships operated by other institutions, and the commercial sector, additional considerations include research capabilities available on various ships. UNOLS ships come well equipped with laboratory equipment that has been optimized through years of experimental work. While many commercial ships have been chartered for scientific research, most have spartan laboratory facilities, if any at all. "Clean" power, a staple on research ships, may be unavailable, even unknown, on commercial, or even Navy, vessels. Furthermore, the crews on commercial vessels may not equal UNOLS fleet experience with scientific research missions.

6.0 CLOSING COMMENTS

This report is a short general summary of cost data for UNOLS ships and data provided by operators of similar research ships from government, commercial and international organizations for use by the Academic Fleet Review committee. Significant differences exist between the rate structures used by different institutions, ships performing different missions, and commercial, government and institution-owned ships. The comparative data, however, provides a preliminary comparison of UNOLS operating costs with governmental and commercially operated ships.

ACADEMIC FLEET REVIEW REPORTS

Oceanography in the Next Decade: Building New Partnerships National Research Council (NRC), 1992
Opportunities in Ocean Science: Challenges on the Horizon National Research Council (NRC), 1998
The Ocean's Role in Global Change National Research Council (NRC), 1994
Global Ocean Science: Toward an Integrated Approach National Research Council (NRC), 1999
Projections for UNOLS' Future: Substantial Financial Challenges, University National Oceanographic Laboratory System (UNOLS), 1995
The UNOLS Fleet, Sea Technology Journal, 1998
The Academic Fleet: Past, Present and Future Marine Technology Society Journal 1998
UNOLS Fleet Improvement Plan Update: 1995, University National Oceanographic Laboratory System (UNOLS), 1995

GLOSSARY

ABS .... American Bureau of Shipping
ADCP .... Acoustic Doppler Current Profiler (instrument)
AGOR .... Auxiliary General Oceanographic Research (vessel designation, USN)
AICC .... Arctic Icebreaker Coordinating Committee (UNOLS)
Alvin .... Manned Research Submersible named after Alan Vine
APROPOS .... Advances and Primary Research Opportunities in Physical Oceanographic Studies
ASA .... Antarctic Science Associates
AUV .... Autonomous Underwater Vehicle
BBSR .... Bermuda Biological Station for Research
CCG .... Canadian Coast Guard
CoOP .... Coastal Ocean Processes
CORE .... Consortium for Oceanographic Research and Education
CTD .... Conductivity, Temperature and Depth (an instrument)
CY .... Calendar Year
DESSC .... Deep Submergence Science Committee (UNOLS)
DFO .... Department of Fisheries and Oceans, Environment Canada
DSV .... Deep Submergence Vessel
EPA .... Environmental Protection Agency (US)
FEMA .... Federal Energy Emergency Management Agency
FIC .... Fleet Improvement Committee (UNOLS)
FOCUS .... Future of Ocean Chemistry in the U.S.
FOFCC .... Federal Oceanographic Fleet Coordinating Council
FUMAGES .... Future of Marine Geosciences
FY .... Fiscal Year
GLOBEC .... Global Ocean Ecosystem Dynamics
HBOI .... Harbor Branch Oceanographic Institution
IDOE .... International Decade of Ocean Exploration
IGY .... International Geophysical Year
IWG .... Interagency Working Group
JGOFS .... Joint Ocean Global Flux Study
JOI .... Joint Oceanographic Institutions, Inc

LDEO .... Lamont-Doherty Earth Observatory
LUMCON .... Louisiana Universities Marine Consortium
MARGINS .... A major geological and geophysics program in the continental margins
MC&G .... Mapping Charting and Geodesy
MCS .... Multi-Channel Seismic Reflection
MIT .... Massachusetts Institute of Technology
MOP .... Major Ocean Program
MSC .... Military Sealift Command
NAS .... National Academy of Sciences
NASA .... National Aeronautics and Space Administration
NAVOCEANO ... U.S. Naval Oceanographic Office (or NAVO)
NERC .... National Environmental Research Council (UK)
NMFS .... National Marine Fisheries Service
NOAA .... National Oceanic and Atmospheric Administration
NOPP .... National Ocean Partnership Program
NOS .... National Ocean Service
NRC .... National Research Council
NSB .... National Science Board
NSERC .... National Science and Environmental Research Council, Canada
NSF .... National Science Foundation
OAR .... Office of Office of Oceanic and Atmospheric Research
ODP .... Ocean Drilling Program
OEUVRE .... Ocean Ecology: Understanding and Vision for Research
ONCO .... Office of NOAA Corps Operations
ONR .... Office of Naval Research
OPP .... Office of Polar Programs
OSU .... Oregon State University
PI .... Principal Investigator
PO .... Physical Oceanography
RIDGE .... Ridge Interdisciplinary Global Experiment
ROV .... Remotely Operated Vehicle
RSMAS .... Rosenstiel School of Marine and Atmospheric Sciences (University of Miami)
RVOC .... Research Vessel Operators Committee (UNOLS)
R/V .... Research Vessel

RVS .... Research Vessel Services (UK)
RVTEC .... Research Vessel Technical Enhancement Committee (UNOLS)
SSC .... Ship Scheduling Committee (of UNOLS)
SI .... Smithsonian Institution
SIO .... Scripps Institution of Oceanography
SkIO .... Skidaway Institution of Oceanography
TAMU .... Texas A&M University
UCSC .... University of California, Santa Cruz
UD .... University of Delaware
UG .... University of Georgia
UK .... United Kingdom
UM .... University of Miami
U MD .... University of Maryland
UMICH .... University of Michigan
UNH .... University of New Hampshire
UNC .... University of North Carolina
UNOLS .... University-National Oceanographic Laboratory
URI .... University of Rhode Island
USCG .... US Coast Guard
USGS .... US Geological Survey
UT .... University of Texas (at Austin)
UW .... University of Washington
WHOI .... Woods Hole Oceanographic Institution
WOCE .... World Ocean Circulation Experiment

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