UNOLS Fleet Improvement Plan

A Report of the
UNOLS Fleet Improvement Committee

May 1, 1990

FOREWORD

A primary objective of the University-National Oceanographic Laboratory System (UNOLS) is to develop plans for vessel replacement with the assurance that the fleet will meet the needs of tomorrow's research. The aging of the UNOLS fleet has provided added impetus to such planning. The UNOLS Fleet Improvement Committee (FIC), as a successor to the Fleet Replacement Committee, has the responsibility for continually upgrading the status report on the current fleet, as well as developing and documenting the scientific mission requirements to be met by our future research vessels.

As a follow up to defining scientific mission requirements, UNOLS, through the FIC, has commissioned a number of concept designs for new classes of vessels and a preliminary design for a large, medium-endurance, general-purpose research ship; a considerable segment of the research community and related federal funding agencies have been involved. These and related efforts are summarized in this plan for the organized modification and replacement of the aging fleet, as well as defining the capabilities required of research vessels to meet the future needs of oceanographic research in this country.

The members of the FIC are to be commended for their efforts on behalf of the academic oceanographic community in preparing this UNOLS Fleet Improvement Plan of 1990. Funding for the FIC effort by the National Science Foundation and the Office of Naval Research is acknowledged with much appreciation.

George H. Keller
UNOLS Chairman

TABLE OF CONTENTS

LIST OF TABLES

Executive Summary

One objective of the University-National Oceanographic Laboratory System (UNOLS) is to coordinate and review the match of oceanographic facilities with the needs of the U.S. academic research programs. UNOLS recommends priorities for replacing, modifying, or improving the number and mix of facilities for this user community. Another UNOLS objective is to foster federal and other support for academic oceanography, with emphasis on ships and other seagoing facilities.

In 1987 the revised Long-range Plan for the Division of Ocean Sciences of the National Sciences Foundation set objectives for increased funding of major ocean initiatives. These objectives were not met due to constraints on the federal budget. This year (1990), the Division has initiated a new plan for increasing research funding for both global change studies and the core research program. UNOLS and its Fleet Improvement Committee (FIC) note that the national program in ocean sciences is presently faced with declining rates of approval of good science projects, declining student enrollments in science and technology, particularly in the ocean sciences, and aging facilities.

The national resources in manpower and facilities for ocean sciences are stressed and urgently require increased funding to maintain the U.S. position of leadership in oceanography.

In exercising its responsibility for the overview of facilities, and following the successful work of its earlier ad hoc Fleet Replacement Committee (FRC), whose recommendations to federal funding agencies resulted in some significant upgrades to the oceanographic research fleet, UNOLS in 1986 established a standing Fleet Improvement Committee. This committee's purpose is to assure the continuing excellence of the UNOLS fleet by developing plans to improve the capability of ships to match the changing science requirements of academic oceanography. This version of the UNOLS Fleet Improvement Plan, an update of the original 1986 plan, recommends changes necessary to carry the fleet well past the 1990s. The "fleet" considered in this plan consists of the designated UNOLS ships over 100 feet long that are operated by U.S. academic institutions. The size of the operational fleet varies somewhat, but in recent years it has averaged 20 such vessels; in 1988, there were 20 such UNOLS ships operated by 15 institutions.

It should be noted that there is potential for the UNOLS fleet to become significantly larger than the size recommended in this updated improvement plan. The new UNOLS charter makes it possible for the UNOLS Council to add an unspecified number of ships as UNOLS vessels so long as they are operated generally in support of national oceanographic research programs by academic (UNOLS) institutions, receive significant funding from the federal government, permit periodic inspections, participate in UNOLS scheduling procedures, and meet certain criteria for safety, performance, and cruise and cost reporting. It is important to understand, however, that designation as a UNOLS vessel does not carry with it any commitment for funding or replacement by federal agencies. Generally, most federal funding support has been provided for the UNOLS ships owned or built by the federal agencies. Nine UNOLS ships over 100 feet in length were built under grants from the National Science Foundation; seven others were built by the Navy.

The updated Fleet Improvement Plan calls for:

- **Six large research ships that meet the UNOLS scientific mission requirements for high- or medium-endurance, general-purpose large vessels; one or more of these ships should be capable of supporting a deep-diving submersible.**

This requirement is based on historical fleet usage, modified by the projected needs of global change research and core research programs for improved capabilities and global coverage.

By 1991, new construction, conversion, and refit projects under way should result in four vessels in the U.S. academic fleet that nearly meet the UNOLS scientific mission requirements for a new generation of high-endurance or medium-endurance, large, general-purpose vessels: THOMAS THOMPSON (AGOR-23), KNORR, MELVILLE, and MAURICE EWING (formerly BERNIER). It is assumed that these will be operated as UNOLS vessels. Two more vessels meeting those requirements are sought, at least one with the capability of supporting a deep-diving submersible.

Two other large UNOLS vessels are active; the WASHINGTON (AGOR-10) and MOANA WAVE. It is assumed that UNOLS accreditation will be requested for the 219-ft VICKERS (formerly OSPREY) when conversion is completed in mid-1990 and that the WASHINGTON will be retired in the early 1990s. These large vessels are assumed not to meet the UNOLS scientific mission requirements for medium- or high-endurance large, general-purpose vessels. If full utilization of the large, general-purpose vessels does not materialize because of lack of adequate science support, options must be weighed.

ATLANTIS II is still operating as a submersible-support vessel but is recommended for retirement in 1997, at which time a new large, medium-endurance vessel equipped for submersible support will be needed. This vessel should be designed in anticipation of operation of 6,000- to 10,000-m submersibles.

This plan urges the Navy to move forward with the construction of the AGOR-24 and to consider building it as a large, medium-endurance vessel incorporating features of the preliminary design developed for UNOLS by the Glosten Associates. Plans for new vessels should include at least one new ship capable of accommodating a 6,000- to 10,000-m submersible. Provision should include more space and equipment for scientific support on extended cruises than the ATLANTIS II.

- **Ice-worthy research vessel capability for both polar regions.**

U.S. ice-worthy ships in both northern and southern hemispheres are essential if U.S. scientists are to remain competitive in ocean research. The study of many global research problems requires ocean measurements in high latitudes. The needed capability is not now available, but could be provided with coordination between federal agencies.

The plan recommends that required ice-breaking research vessel capability in the Southern Ocean be provided by the NSF Division of Polar Programs (DPP), supplemented by U.S. Coast Guard ice breakers. The DPP is leasing for a 10-year period a ship approximately 290 feet long with berths for 37 scientists. Although this ship is needed by scientists in the academic community, it is not included in this plan's UNOLS fleet profile because it will not be operated as a UNOLS vessel by an academic institution. *For the western Arctic, the plan recommends that a concept design study be undertaken now for an intermediate size, ice-capable vessel. That ship is included in the planned UNOLS fleet profile.* A second ship is needed in the eastern Arctic because no single ship of the capability envisioned can be expected to transit the Arctic safely between the two areas. The Navy has plans to construct an ice-worthy oceanographic research ship for operation in the eastern Arctic, particularly the Greenland and Norwegian Seas. Tentative plans include use by the U.S. academic community, but the ship is not included in the UNOLS fleet profile because it is expected to be operated by the Military Sealift Command.

- **Six intermediate general-purpose research vessels with improved capability.**

Systematic replacements of intermediate ships should occur by their 30th year, or sooner if they are not refit at mid-life.

The plan recommends that the existing general-purpose intermediate ships ENDEAVOR, GYRE, ISELIN, NEW HORIZON, OCEANUS, and WECOMA be replaced on an individual basis depending on fleet needs and adequacy of federal support for ocean research. The first such replacement is recommended in 1998.

Proposed refits for federally-owned vessels are for GYRE (partial in 1991), OCEANUS and WECOMA (1992), and ENDEAVOR (1995). Two privately-owned intermediate vessels with special submersible-support capability, EDWIN LINK and SEWARD JOHNSON, are just now entering the UNOLS fleet, and it is not clear whether the need will exist for their replacement, nor what impact their operation will have on the intermediate ship schedules.

It is evident from ship-use data for the period 1982-89 that the largest impact of the ocean science research ship "market" falls on the intermediate vessels. Their use-days per ship has declined through 1989 and will be dependent on the success of the present bids by federal agencies for increased funding. We therefore have taken a conservative view of their replacement through the end of the century.

The plan also recommends that a concept design for an intermediate SWATH ship having one strut per submerged hull be undertaken to compare potential performance with the recently completed four-strut concept design. Tank tests should be undertaken and serious consideration given to including an intermediate SWATH research vessel in the future UNOLS fleet.

- **No recommendation on the required number of small UNOLS ships.**

A number of small vessels, funded by private and state sources, are entering the UNOLS fleet. In the immediate future, the supply of small ships may exceed the demand. Some of these receive operational support largely from sources that have not traditionally provided large measures of support for UNOLS vessels. Thus, until the operational funding pattern of this expanded small vessel fleet is better understood, it would be only speculation to specify the number of small UNOLS vessels needed in the future.

The existing small UNOLS ships (all general-purpose) are ALPHA HELIX, CAPE HATTERAS, CAPE HENLOPEN, LONGHORN, PELICAN, POINT SUR, SPROUL, and WARFIELD. The only proposed change is construction of the ice-capable vessel mentioned earlier as a replacement (of different size) for ALPHA HELIX. Generally, it is recommended that small vessels can be effectively operated for about 25 years and should be refit at mid-life.

A summary listing of the plan's proposed schedule of UNOLS vessel refits and retirements, given by year from 1989 to 2012, is found in Table 7 on page 39. Cost estimates are given (Table 8, page 41) for the refit and replacement of federally-procured ships.

The UNOLS Fleet Improvement Plan

I. Background

One purpose of the University-National Oceanographic Laboratory System is to assess the match between facilities to support academic oceanographic research and the oceanographic research program needs, and then to make recommendations for replacing, modifying, or improving the number and mix of facilities. It has long been recognized that maintenance of a fleet of modern, capable research vessels is essential to the outstanding success of the U.S. program in academic oceanographic research.

The operation of the UNOLS fleet and its composition are ultimately defined by the research demands of the national oceanographic research programs supported by funds from the various contributing agencies. Two previous long-range plans had a significant impact on the development during the 1960s and 1970s of university oceanographic facilities. One of these was the 1959 National Academy of Sciences Committee on Oceanography (NASCO) Report "Oceanography 1960 - 1970". The other was the U.S. Navy's first long-range oceanographic planning document "Ten Years of Oceanography (TENOC)".

Over the past decade several reports have dealt with the role of UNOLS vessels either as a separate fleet or part of the more encompassing Federal Oceanographic Fleet. These reports include, but are not limited to:

- Capital Structure for Ocean Science – 1975 (Center for Naval Analysis)
- Ocean Services for the Nation (NACOA, January 1981)
- Technology and Oceanography (Office of Technology Assessment , June 1981)
- Academic Research Vessels, 1985-1990 (Ocean Sciences Board, National Research Council, 1982)
- Composition, Distribution, and Management of the UNOLS Fleet (UNOLS Advisory Council, 1984)
- Secretary of the Navy Initiatives for Naval Oceanography (1984)
- Federal Oceanographic Fleet Study (Federal Oceanographic Fleet Coordinating Council, 1984)
- Emergence of a Unified Ocean Science: Long-range Plan for the Ocean Sciences Program of the National Sciences Foundation (Advisory Committee on Ocean Sciences, May 1985)

- A Unified Plan for Ocean Science: A Long-Range Plan for the Division of Ocean Sciences of the National Science Foundation (Advisory Committee on Ocean Services, revised August 1987)
- Scientific Requirements for the UNOLS Fleet (UNOLS Fleet Improvement Committee, 1988)

Many additional ocean science planning documents have been prepared by the scientific community under the aegis of the various global science initiatives, such as Tropical Ocean Global Atmosphere program (TOGA), World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Study (JGOFS), and Ridge InterDisciplinary Global Experiments (RIDGE).

These reports present past views of oceanographic directions. The National Science Foundation (NSF) Ocean Sciences Advisory Committee recommended, in addition to a strengthening of ongoing discipline oriented programs, large-scale new interdisciplinary initiatives in global studies of the ocean and the underlying lithosphere. The 1984 Navy document expressed the intent of that organization to regain its position of leadership in oceanography, in order to undergird its ability to carry out the Navy's mission more effectively.

As of 1990, the NSF Ocean Sciences Division staff and their advisory councils envision growth of research funding by 10–15% annually over the next five years. New funds will support the Global Change Research Program (Committee on Earth Sciences, 1990, "Our Changing Planet: the FY 1991 U.S. Global Change Program") and research sponsored with core funds. Core funds are those reserved for the traditional individual research proposals that historically have constituted the major fraction of the Ocean Sciences Division sponsored research program. In fiscal year 1990, the support of Global Change Programs (such major initiatives as WOCE, JGOFS, TOGA, etc.) utilized about 15% of the Ocean Science funds; the core projects composed about 85% of the total. In future years, NSF anticipates an overall increase in funding in both categories, but the large increase anticipated in Global Change Research would bring about a shift in proportion to about 65% core and 35% Global Change.

The proposed interagency Global Change Program for FY 1991 represents an increase over FY 1990 of about 57% (an additional $375 million). If this increase is realized there will be a proportional increase in ship use for all agency programs. The UNOLS fleet provides support for most of the academic sector work on Global Change and thus will participate in this increased program. It is clear from the above short review that the future growth and composition of the UNOLS fleet will depend in large measure on the success of the national Global Change Program.

In 1984, based on recommendations of its Advisory Council, UNOLS established an ad hoc Fleet Replacement Committee (FRC) charged with planning for the orderly replacement of the UNOLS Fleet. The charges to the FRC were to:

"1) Make an immediate start on planning for replacement of [200 ft or greater LOA] ships (large, long-range vessels, some with special purposes). Some of these must be retired by the 1990s. Such ships are essential to our capability for modern oceanography. Planning for replacement must begin. The committee will prepare and propose mechanisms for drawing specific plans for new platforms.

2) A full schedule for replacement of intermediate and coastal vessels [150 to 199 ft LOA and 100 to 149 LOA, respectively] must be prepared. Planning must begin for at least one replacement in the late 1980s.

3) Detailed consideration is required of new means to promote greater cost efficiency, particularly fuel efficiency. Needed is specific anticipation to meet the needs of oceanography in the 1990s."

The FRC formulated scientific mission requirement for six classes of oceanographic vessels: three large, one intermediate, and two small. That committee concentrated its efforts on the preparation of plans for refitting the KNORR and MELVILLE and for construction of additional new large vessels with improved scientific capabilities. It commissioned and supervised six new concept designs, worked with the U.S. Navy in the preparation of two others by Naval Sea Systems Command (NAVSEA), and published in 1986 summaries of ten concept designs (including two commissioned by the University of Texas) for large oceanographic research vessels in three sub-classes; SWATH, high-endurance monohull, and medium-endurance monohull. Finally, before dissolving, the FRC prepared "A Plan for Improved Capability of the University Oceanographic Research Fleet" dated June 1986. This plan included by reference a "Summary of Concept Designs", "Science Mission Requirements for New Oceanographic Ships", and six reports of individual new ship design studies.

So successful was the FRC, that in November 1986, UNOLS established a standing Fleet Improvement Committee. The purpose and organization of that committee, as adopted by UNOLS in October 1988 as an Annex to its Charter, follow.

"*Purpose.* The Fleet Improvement Committee works to assure the continuing excellence of the UNOLS fleet, to improve the capability and effectiveness of individual ships and to assure that the number, mix and overall capability of ships in the UNOLS fleet match the science requirements of academic oceanography in the U.S. To that purpose, the Committee maintains the currency of a dynamic *UNOLS Fleet Improvement Plan.* The plan, updated periodically, includes:

> Assessment of the number and mix of ship capabilities needed in the UNOLS fleet,
>
> Development of science mission requirements for all size- and capability-classes of ships,
>
> Definition of roles and the need for innovative research platforms,
>
> Consideration of means for acquiring the needed vessels, including new construction, modification to existing UNOLS ships, conversions, private acquisition and leasing,
>
> Development of conceptual or preliminary plans for ships to fill the needs identified, and
>
> Development of a schedule for improvement and replacement of vessels so as to assure continuing fleet excellence.

The Fleet Improvement Committee will serve as a *liaison and planning activity as well as an information source* for federal agency representatives concerning long range planning, and funding for design, construction, or renovation of vessels for the UNOLS fleet.

Organization. The Chair and seven additional members of the Fleet Improvement Committee are appointed by the UNOLS Chair with approval of the UNOLS Council. Those appointed should be experienced in ship operations and from institutions which are either operators or users of UNOLS research vessels. The Chair and at least three other members will be from UNOLS operator institutions, at least two members will be from institutions other than operators, and two members may be from any UNOLS institution. The FIC Chair is, ex-officio, a member of the UNOLS Council. Terms for all members are three years, for no more than two consecutive terms.

Demands on the Fleet Improvement Committee may be intense, and the development of ship plans may require significant financial management. With the approval of the UNOLS Chair and UNOLS Council, the FIC may arrange for staff and financial support for their activities. Proposals and grants for such support may be through the UNOLS Office or a UNOLS institution, as appropriate."

The UNOLS "fleet" considered in this plan is comprised of the UNOLS ships over 100 feet in length operated by U.S. academic institutions. The size of the operational fleet thus defined varies somewhat, but in recent years it has remained within 10% of 20 vessels. In 1988, UNOLS ships comprised a 20-ship fleet operated by 15 institutions, as shown in Table 1. Although vessels constructed or converted with federal funds are owned by whoever holds title to them, they are here designated as federally-procured. Several special arrangements have been made in this regard; most recently, NSF is amortizing over a period of seven years loans made by Columbia University to purchase and refit the MAURICE EWING (formerly BERNIER).

Table 1, and those to follow in this report, have been organized by size for general-purpose research vessels plus special ships. There are three large ship classes: the classes of high-endurance and medium-endurance ships as defined by the UNOLS Scientific Mission Requirements (UNOLS FIC, 1990) and other general-purpose research vessels ≥ 200 ft length overall. None of the large UNOLS vessels operating in 1988 could meet the high- or medium-endurance standards.

The UNOLS fleet is getting larger by definition of the UNOLS Council under the terms of its new charter. According to the UNOLS charter, "UNOLS vessels are those so designated by the UNOLS Council. They are those United States research vessels generally operated in support of national oceanographic research programs, by academic [UNOLS member] institutions and are significantly funded by the federal government. They are operated in accordance with UNOLS safety standards, subject to regular, recognized ship inspection programs, scheduled by established UNOLS procedures and meet cruise reporting, cruise assessment, cost accounting and

Table 1. The UNOLS Fleet – 1988

SHIP NAME	LOA (Feet)	DATE BUILT	DISPL. TONS	OWNER	OPERATOR
LARGE HIGH-ENDURANCE SHIPS					
None					
LARGE MEDIUM-ENDURANCE SHIPS					
None					
LARGE SHIPS > 200 Feet					
MELVILLE (AGOR-14)	245	1969	2,300	U. S. Navy	Scripps
KNORR (AGOR-15)	245	1969	2,300	U. S. Navy	Woods Hole
T. WASHINGTON (AGOR-10)	209	1965	1,362	U. S. Navy	Scripps
T. G. THOMPSON (AGOR-9)**	209	1965	1,302	U. S. Navy	U. of Washington
CONRAD (AGOR-3)	209	1962	1,425	U. S. Navy	Lamont-Doherty
MOANA WAVE (AGOR-22)	210	1973	1,403	U. S. Navy	U. of Hawaii
INTERMEDIATE SHIPS 150-199 Feet					
OCEANUS	177	1975	960	NSF	Woods Hole
WECOMA	177	1975	1,015	NSF	Oregon State U.
ENDEAVOR	177	1976	962	NSF	U. Rhode Island
GYRE (AGOR-21)	182	1973	980	U. S. Navy	Texas A & M
ISELIN	170	1971	830	NSF*	U. of Miami
NEW HORIZON	170	1978	1090	U. of California	Scripps
FRED MOORE **	165	1967	992	U. of Texas	U. of Texas
SMALL SHIPS 100-149 Feet					
POINT SUR	135	1981	539	NSF	Moss Landing Marine Lab.
CAPE HATTERAS	135	1981	539	NSF	Duke U.
ALPHA HELIX	133	1965	554	NSF	U. of Alaska
CAPE HENLOPEN	120	1975	179	U. of Delaware	U. of Delaware
R. WARFIELD	106	1967	162	NSF*	CBI
R. G. SPROUL	125	1981	520	U. of California	Scripps
SPECIAL SHIPS Submersible-Support					
ATLANTIS II	210	1963	2,300	NSF*	Woods Hole
Ice-Worthy					
None					

* Title resides with operator so long as ship is operated as research vessel for community; considered here as federally-procured vessel.

** Retired in 1988

performance standards according to UNOLS uniform practices. UNOLS vessels... are regularly available to users outside of the operator institution provided that funding is available...."

A useful comment on this definition (George Keller, UNOLS President) follows: "Being a UNOLS vessel does not carry with it any commitment for funding [or replacement] by federal agencies.... Certainly in many cases the funding pattern will not change from when the vessel was not part of the UNOLS fleet.... One might say UNOLS has become a certifier of academic research vessel operations to ensure that the research community has quality facilities from which to operate.... Being designated a UNOLS vessel will mean that it is basically certified to safely and effectively carry out academic research as well as being available to the community for scheduling."

Most of the basic research projects of the Federal oceanographic program are carried out by ships of the UNOLS fleet, although basic research also is carried out from vessels owned and operated by the Environmental Protection Agency, National Oceanic and Atmospheric Administration, U. S. Coast Guard, U. S. Geological Survey, and U. S. Navy. Chief sponsors for the utilization of UNOLS ships are the National Science Foundation and the Office of Naval Research. However, UNOLS ships receive some utilization and support by oceanographic projects of many other Federal agencies. Nine of the nineteen UNOLS ships were built under grants from NSF and six are owned outright. Seven, including all of the large general-purpose UNOLS vessels, were built and are owned by the Navy and chartered by the Office of Naval Research.

If the size of the UNOLS fleet grows beyond needed levels, as additional ships are accepted then only the more capable vessels which best meet the needs should be supported. In effect, the fleet's composition is driven by the economic forces of the ocean research "market". The remainder of the fleet may not receive levels of support adequate to maintain them in good working condition. Another factor to consider is that the NSF and ONR have generally agreed to provide maintenance support levels only for vessels they own. Retirement of ships can be expected if they are consistently underutilized.

In section II of this document, a review is presented of the factors that make continuing improvement of the UNOLS fleet necessary. Then, a summary of the development of this plan is given. Section IV summarizes the work of the UNOLS Fleet Replacement and Fleet Improvement Committees to develop a complete, self-consistent, and realistic suite of UNOLS ship capabilities. These recommendations include scientific mission requirements for each class of research vessel, special capabilities needed by some scientific disciplines or in some environments, concept designs, and preliminary designs.

A plan for UNOLS fleet improvements comprises the final section V of this report. There are presented the precepts which have guided the formulation of this plan, the recommended fleet profile, and a suggested schedule for refits and replacements (with estimated costs) which would transform the existing fleet into the recommended improved fleet.

II. Need for Continuing Fleet Improvement

The need to plan for new, more capable research ships to conduct scientific programs at sea has become virtually self evident. Numerous studies have demonstrated that our ships, mostly constructed in the 1960s and early 1970s using both private and federal funds, are becoming obsolete in their capability to support oceanography for the 1990s and beyond. This is a concern to federal research ship operators as well as UNOLS; the 1984 Federal Oceanographic Fleet Study (FOFCC) reported that two of its major findings give cause for concern:

- "Within the next fifteen years over 70% of the federal fleet will have become overage and obsolete."
- "No agency has an approved plan for the replacement of ships as they become obsolete."

The issue of fleet improvement is thus a matter of urgency; it is one of the priority matters resulting from the Federal Fleet Study.

The 1982 NAS/OSB study on the needs for academic research vessels examined the growing demands being placed upon these ships. It noted the following: "Much scientific equipment, especially that going onto or into the bottom, has increased in weight, bulk, and complexity, therefore requiring deployment from large, stable ships. Increasing complexity of electronic sensors and shipboard computers often result in an increase in the number of technicians who must go to sea, rather than a reduction in their number. The nature of new interdisciplinary ocean science research projects requires that several scientists from different disciplines be able to work on the same ship at the same time. This increases the demand for laboratory, storage and other working spaces aboard ship. Larger high-performance overside handling arrangements and modern state-of-the-art shipboard laboratories will be needed to support major ongoing ocean programs. In addition, a high-quality working and living environment is essential in order to attract competent seagoing personnel."

Such studies illustrate that oceanographic ships are subject to two distinct forms of obsolescence:

> **Platform Obsolescence.** Like any ship, an oceanographic vessel ages, eventually becoming either so mechanically outdated or so physically "worn out" that it is no longer economical to operate, repair, or upgrade.

Mission Obsolescence. Due to scientific and technical progress an oceanographic vessel may become unable to perform efficiently a useful oceanographic mission, not because it is obsolete or worn out as a ship, but because the mission itself has evolved out of reach. For example, a ship that was satisfactory when built may be inefficient today because it is too noisy, too small, too slow, not seakindly enough for today's oceanographic mission, or simply because it cannot successfully support modern oceanographic equipment.

The factors which define platform obsolescence have no set value. They include material condition, maintenance costs, habitability, and the capability to "keep up" with the changing needs of scientific requirements. The most commonly used measure is age. In time, conditions will deteriorate to a point where the platform is no longer tolerable. The life span of a contemporary research ship can vary from 20 to 40 years, depending on ship construction, maintenance, and service. We will consider the average life times of intermediate and larger ships to be 30 years, if refit at mid-life; an average life time for small ships with mid-life refits is taken as 25 years. Likewise, mission obsolescence results because requirements evolve in time beyond the capability of the ship to respond. Here the time scale is often shorter than in the case of platform obsolescence.

In addition to planning for fleet improvement by refits and replacements of conventional ships, it is important that UNOLS planners maintain a current awareness of special facilities and innovations that could improve the fleet. For that reason, the Fleet Replacement and Improvement Committees have developed scientific mission requirements for Small Waterplane Area Twin Hull (SWATH) research ships in three size classes and have published concept designs on large and medium SWATH general-purpose research ships. The FIC has developed scientific mission requirements for a manned spar buoy laboratory and an intermediate ice-capable research vessel. Further, mission profiles are under development for a research submarine and plans are to develop mission requirements for a large submersible-support ship.

The UNOLS Fleet Replacement Committee (FRC) considered the UNOLS fleet as of 1985. At that time, the average age of the fleet was 14 years and the median age was 13 years. Actual ages ranged from 5 to 24 years. However, considering the larger ships as a separate asset, the average and median ages were 20 years. On this basis, the case was made in 1984-1986 by the FRC that planning for replacement of the larger ships was the most pressing issue. Actions taken during the past five years by the Federal agencies supporting oceanography have gone far to redress this need by conversion, mid-life refits, and new construction of a total of four research vessels from 239 to 279 ft in length. (See section V for details.)

Even so, study of Table 1 indicates strongly the need for long-term planning for the refit and replacement of the academic fleet. As one example, 5 of the 6 intermediate ships (FRED MOORE is retired) will be eligible for mid-life refit within a 6-year period; later, they will all reach retirement age within an equal time interval. During these same periods, one large and one small vessel will reach refit and retirement ages. It probably is not realistic to anticipate 7 new ships during a 6-year span. Instead, new ship replacements must be planned to occur over a longer time period. Some ships will be expected to operate past a nominal 30-year retirement age. If fleet capability is not to be jeopardized however, replacement should begin as early as budget planning allows.

Moreover, examination of Table 1 reveals that no ice-capable vessels exist in the UNOLS fleet — nor are such vessels available to U.S. scientists from other U.S. operators (with the exception of the limited capabilities represented by U. S. Coast Guard ice breakers). There is the need for such capability in both polar regions (as discussed later). Also evident is the advanced age of our submersible-support vessel, the ATLANTIS II.

Beyond the needs for improving our existing fleet, as individual ships move into obsolescence, the programs and concepts embraced by the science planning documents clearly indicate a need to acquire ships having new and increased capabilities. This implies ships of somewhat larger size but probably no increase in numbers of ships.

Table 2 details the actual use of UNOLS ships from 1982 through 1989 with breakdown by length class. Science funding affects the total size of the fleet but does not absolve us of the need to constantly review and improve the components of the fleet and make use of evolving technologies. A complete analysis of the ship-use data is dependent on establishing realistic expected ship days per year of usage for each class of vessels. For example, if cost-efficient operation of large vessels should average 250 days, then over the 1982-1989 period, that class operated at just over 100% of full expected utilization; but, if a large vessel should operate for 275 days per year, then the utilization was 92%. In the coming year, the Fleet Improvement Committee will attempt to refine the estimates for "full operation years" for all three classes of vessels.

Table 2: UNOLS Fleet Operating Days, 1982-1989

Large vessels are > 200 feet in length, intermediate ships are 150-199 feet, and small ships are 100-140 feet. Number of ships in each class is in parenthesis.

YEAR	TOTAL DAYS	LARGE	INTERMEDIATE	SMALL
1982	3643	(5) 1226	(6) 1379	(6) 1038
1983	3697	(5) 1117	(7) 1703	(6) 877
1984	4250	(6) 1599	(8) 1652	(7) 999
1985	4203	(7) 1916	(7) 1177	(7) 1110
1986	3766	(7) 1612	(6) 1191	(6) 963
1987	4158	(7) 1771	(7) 1499	(6) 888
1988	4162	(7) 1693	(7) 1272	(6) 865
1989	3386	(5) 1091	(7) 1303	(7) 992

YEAR	LARGE AVG.	INTERMEDIATE AVG.	SMALL AVG.
1982	245	230	173
1983	223	243	146
1984	266	206	143
1985	274	181	158
1986	230	198	160
1987	253	214	148
1988	242	181	144
1989	218 *	186	142
Averages ± S.D.	244 ± 20	207 ± 26	152 ± 10

* Figure does not include CONRAD, which operated only 103 days before being retired.

In summary, at this time both the composition of the fleet with regard to age and scientific mission requirements indicate that, though we should maintain attention on the completion of construction, conversion and refitting of the large ships, we must begin now preparing studies (comparable in detail to those prepared for large vessels) for upgrading our intermediate and coastal components. And, we should give due attention to special facilities and capabilities as we plan our fleet of the future. As noted earlier, the primary constraint on fleet composition is science funding.

III. Development of a Plan

A goal of UNOLS — and one of the objectives for which UNOLS was established — is to develop and update a long-range plan for university oceanographic facilities. The importance of such a plan cannot be overstated. Because most oceanographic facilities, especially ships, are built with federal funds, all new acquisition must compete in an increasingly rigorous manner for support. Unless requests for new ships and other facilities are accompanied by substantive, credible, and approved plans showing how such new facilities fit into the needs for future oceanographic research, those requests will have little likelihood of succeeding.

The UNOLS process of planning for an improved fleet was initiated with:

- Preliminary Report, UNOLS Long Range Planning Meeting, May 1975.
- a UNOLS Advisory Council report "On the Orderly Replacement of the Academic Research Fleet", July 1978.

These were followed by the final report of the UNOLS ad hoc Fleet Replacement Committee, "A Plan for Improved Capability of the University Oceanographic Research Fleet", June 1986.

The goals of the FRC study were to:

- Develop the requirements for new research ships based on the best possible projections of ocean science and engineering,
- Produce concept designs of new classes of research ships which meet the stated requirements in terms of size, science capabilities, and other characteristics, and
- Develop a plan for the orderly replacement of the existing UNOLS Fleet incorporating a recommended mix of ship sizes and types along with priorities, time frame, and construction costs.

The Fleet Improvement Committee has furthered these goals of the FRC and in addition has initiated the pursuit of preliminary design studies (with that of a large, medium-endurance monohull ship). Beginning with the FRC fleet improvement plan, and incorporating its studies and new developments in ocean sciences, the Fleet Improvement Committee has prepared a revised plan for the continued improvement of the UNOLS fleet.

This proposed UNOLS fleet improvement plan is based upon needs envisioned through the year 2000. Overall numbers and mix of ships probably will not differ significantly from current inventories. Changes are anticipated in areas of special capabilities such as geophysics, submersible handling, and polar research. Most important, however, is the capability of new ships to successfully do the kinds of science which our present ships cannot now do, and to do them in places, times, and sea states in which our present ships are prohibited.

Basic criteria of the plan are:

- To be responsive to the anticipated future trends and needs of oceanographic research and engineering,
- To be realistic in terms of the national economy,
- To bear the general approval of the academic research community,
- To be sufficiently credible to compete in the Federal funding infrastructure,
- To provide a logical implementation scheme bridging the current and projected time frame, and
- To provide for periodic updating.

The time frame for retiring of existing ships should be based upon:

- Age and material condition of existing ships,
- Deficiencies in capability of existing ships, and
- The needs of ongoing and projected science irrespective of existing ships.

IV. Recommended UNOLS Ship Capabilities

A. Scientific Mission Requirements

The beginning point for any facility planning is an orderly statement of the mission requirements. In the case of research vessels, it is the science requirements which define the type of ship along with the size, speed, endurance arrangements, and overall capability. Habitability, safety, and cost are important aspects and can have a significant impact on ship design, but these are either mandatory or statutory and usually are defined elsewhere. One of the major accomplishments of the Fleet Improvement Committee and its predecessor Fleet Replacement Committee has been the compilation of a standard set of scientific mission requirements for a variety of research vessel types. These requirements already have proven to be valuable references for actual vessel design criteria established by the Navy and are also being used in the procurement of the NSF's research vessel with icebreaking capability for Antarctic use and in the current NOAA evaluation of their fleet. The sets of requirements have been developed by the user community of sea-going scientists and the variety of types reflect their evaluation of potential future needs. These requirements provide standards for future vessel designs, and also provide a means for evaluation of the vessels in the present fleet (see Appendix II).

Work to date has compiled ten sets of mission requirements:

- Large, high-endurance, general-purpose research ship—size range 250-300 ft
- Large, medium-endurance, general-purpose research ship—size range 200-249 ft
- Large, general-purpose, SWATH, research ship—size range over 200 ft
- Intermediate general-purpose research ship—size range 150-199 ft
- Intermediate, ice-capable, general-purpose research ship—size range 150-199 ft
- Intermediate, general-purpose, SWATH research ship—size approximately 150 ft
- Small, general-purpose, SWATH research ship—size approximately 100 ft
- Small, general-purpose, research ship—size range 100-149 ft
- Manned spar buoy
- Research submarine

Scientific mission requirements for a research submarine are under review. There are plans for development of requirements for a submersible-support ship.

Concept and preliminary designs for large SWATH research vessels to meet the original UNOLS scientific mission requirements for that class have not evidenced significant improvements or fewer disadvantages relative to large monohulls. This could have resulted because those scientific mission requirements placed too stringent requirements on a large SWATH. Consequently, the requirements have been reconsidered, and the November 1989 version calls for reduced capabilities for some criteria.

These scientific mission requirements define needs for operational capabilities, working environment, science accommodations, and outfitting of the kinds of ships which the UNOLS Fleet Improvement Plan has identified.

Each set of requirements defines the general-purpose (multidisciplinary) science role for which that ship type is intended. Requirements for enhanced capabilities or "options" such as multichannel seismic capability may be added to the basic requirements as dictated by specific ship planning. (see section IV.B.)

Current editions of requirements are published separately. These have been developed by working groups of practicing, seagoing scientists. As much as possible they have been, and continue to be, reviewed and revised throughout the community. The final design, construction, and outfitting of future new ships will be based on the contents of these requirements. It is important that all seagoing scientists give serious attention to their content.

In any statement of requirements, an ordering of priorities is important for the guidance of follow-up activities leading to the design and construction of the facility. In the case of research vessels the following factors have been ranked by groups of practicing investigators from all disciplines. (Refer to "A plan for Improved Capability of the University Oceanographic Research Fleet," UNOLS Fleet Replacement Committee, June 1986, p. 49. Reviewed by a UNOLS National Workshop in Miami, Florida, 6–7 January 1986.) As with any set of priorities, interpretations will differ between ship sizes and areas of use. The following table summarizes the majority viewpoint:

Table 3. Priorities for Research Ship Requirements

- Seakeeping
  - Station Keeping
- Work Environment
  - Lab Spaces and Arrangements
  - Deck Working Area: overside handling; winches and wire
  - Flexibility
- Endurance
  - Range
  - Days at Sea
- Science Complement
- Operating Economy
- Acoustical Characteristics
- Speed
  - Ship Control
- Pay Load
  - Science Storage
  - Weight Handling

Most respondents agreed that seakeeping, particularly on station, and work environment were the two top priorities. But the remaining requirements were ranked so closely together that they become of equal importance. The stated scientific mission requirements which are set for each of these areas then become threshold levels, and any characteristic which falls below the threshold becomes a high priority. For example, speed, which is ranked relatively low in Table 3, would become a matter of concern if a proposed ship showed a design speed below the required, or threshold, level.

This emphasizes the importance of assigning genuine, realistic requirements. The acceptance of a design characteristic less than the original requirement signifies either that the original requirement was not well established, or that the ship may not measure up to its intended service.

B. Special Capabilities

The needs of some scientific disciplines and of operating environments dictate that special capabilities must be incorporated in some vessels of the UNOLS fleet. These are briefly described here.

Special geophysical and geological sampling equipment. According to the Federal Oceanographic Fleet Study (1984), Marine Geology and Geophysics (MG&G) ship time requirements amounted to over 21% of the total ship needs for all Federal Agencies in the years 1983-85. Within the UNOLS Fleet component, which is concerned with basic research, the MG&G requirements were

34% of total ship needs. Only a small fraction of this ship time is required for multi-channel seismic work — probably less than one ship year annually at present.

Multichannel seismic capability. Perhaps the most demanding design aspect for ships enhanced for seafloor studies is the requirement for a multichannel seismic profiling (MCS) system. These MCS systems are the essential tool for probing the deep geologic structure beneath the seafloor. In fact, no other shipborne geophysical technique can provide the scientist with such detailed, structural images and direct measurements of mechanical properties of seafloor materials.

Major components of an advanced multichannel seismic system for academic research are:

- Streamer—A 3600-6000 m seismic streamer with reel. The reel is mounted near the stern, is 5 m high, has a 6-m x 6-m footprint, and weighs 15 to 20 tons.
- Acoustic sources—An array of up to 24 airguns towed from booms in strings or paravanes mounted on the stern. Deck equipment for handling airgun arrays and a close-by shop for maintenance are required.
- Compressors—Compressors that can supply up to 3000 SCFM at 2500 psi. Some of the compressors could be in vans.
- Storage Space—Ample storage space for streamer accessories such as tail buoys and spare sections is required.

Acoustic characteristics. In planning for any research vessel particular attention should be given to acoustic characteristics. Earlier ship planning provided "quiet ship generators" that operated limited ship's equipment for short periods in order to reduce radiated noise. Present operations involve continuously operating equipment such as multichannel seismic systems, multibeam echo sounders, sub-bottom profilers, side scan imagery, acoustic navigation, and Doppler current profilers. All of these have increased sensitivity to underwater radiated noise, sonar self noise, and shipboard airborne noise.

Analyses have shown that the most active acoustic frequencies, at which interference should be minimized are from 1 to 15 kHz for echo sounders; 4 to 500 kHz for seismics; and 50 to 300 kHz for Doppler profiling. Of these, the multibeam echo sounder "Sea Beam" has proved to be the most critical, and thus becomes the target for primary acoustic control. The current recognized limits for underwater radiated noise is 50 dB relative to $1\mu Pa^2/Hz$ @ 1m, 12.5 kHz.

The dominant underwater noise source is the propulsor. Special consideration should be given to provide acoustically quiet propellers. Propulsion machinery should have two stage mountings for the attenuation of low frequency structureborne noise. Likewise, auxiliary machinery should be provided with resilient mountings for the suppression of radiated noise. The prevention of bubble formation and sweepdown paths should be included in hull designs. Measures to minimize structureborne noise transmission should be included in ship structure specifications. In general, acoustics should become an essential element at the outset of new ship planning.

Submersible Handling. The research usefulness of the Deep Submergence Vehicle ALVIN is a matter of record. According to the 1982 NSF-ONR-NOAA Submersible Science Study, the most outstanding requirement to further the effectiveness of ALVIN was an adequate support vessel. In 1983 the ATLANTIS II was converted to handle the ALVIN by a single-point-lift, stern A-frame. The conversion entailed the installation of the A-frame and associated machinery, hangar, deck modifications, and shops. Some loss of laboratory space and science berthing resulted, but the overall effect has been to drastically increase the utility of the submersible and make it a partner in other scientific investigations from the ship. It has become evident that a replacement vessel should provide additional deck working area and science berthing. Such a vessel, even upgraded from the present, should remain within the medium-endurance, large size range.

Although it is not the task of this report to include manned submersible requirements, it can be stated with some confidence that the requirement for at least one such vehicle will continue into the next generation of research vessels and bring about the need for a replacement submersible handling vessel on the occasion of the ATLANTIS II retirement. Furthermore, it can be forecast that the next generation of deep submersible probably will be a 6,000- to 10,000-m depth vehicle. Judging from DSV SEACLIFF such a submersible would weigh 25-tons compared with ALVIN at 16-tons. The ATLANTIS II is not capable of handling such a submersible and continue to serve as a research vessel.

Based on current projections, it seems clear that remotely operated vehicles (ROVs) will play an increasingly important role in oceanographic research. This rapidly evolving technology will serve for instrument deployment, sample collection, and observations in the water column and on the sea floor. As the size and complexity of ROVs decrease, the shipboard characteristics necessary to deploy them become less demanding. Planning for refits and replacement ships should incorporate the minimal requirements to install equipment necessary for ROV operations. Shipboard capabilities required for the operation of large (2 ton) ROVs include:

- launch and recovery gear (cranes or A-frames),

- tether handling gear (winches and power sheaves),
- navigation and vehicle tracking capability,
- vehicle control station (van or interior lab space),
- surface ship maneuverability and positioning, and
- clean, uninterrupted power supply.

Ice-worthy vessels. The subject of a Polar Research Vessel has attracted a great deal of attention over past years along with no little controversy. According to a recent interagency report, "Polar Icebreaker Requirement Study" (Department of Transportation, 1984), issues surrounding the Polar Research Vessel include:

1. What *is* a Polar Research Vessel? The perception of what it is varies between agencies and even individuals.
2. Is there justifiable need for a research-dedicated vessel(s) for arctic and antarctic service?
3. If yes, what level of capability for breaking ice and penetrating pressure ridges should be required?
4. If a vessel were to be acquired, what agency would be responsible for its operation, and in what manner and to what standards?

The 1984 study proposed the following definitions be applied to the various ice-worthy types of vessels.

- **Ice strengthened -** A vessel able to operate in very open pack (<3/10 concentration), first-year thin ice (or earlier stage of development), which is less than 1.4 feet thick. The vessel is structurally strengthened around the waterline and has a conventional bow form. Safe navigation through sea ice is possible only under ice escort. The strengthening around the waterline is designed to minimize damage from the hull hitting sea ice at slow speed.

- **Ice capable -** A vessel able to operate in open pack (4/10 to 6/10 concentration), first-year thin/medium level ice, which is 1.5-4.0 feet thick. The vessel is structurally strengthened around the waterline, has an ice-breaking bow form, and has more horsepower than required for transit through ice-free waters. Safer navigation can be accomplished independently in very open pack; however, in open pack (or greater concentration), it is prudent to navigate with an ice escort. For independent operations, the vessel must navigate at slow speed using available leads in the pack ice and/or by pushing the ice out of its path. An example of this vessel type is the former ELTANIN.

• **Icebreaker** - A vessel able to operate independently in close pack (or greater), first-year thick to multi-year ice, which is greater than 4.0 feet in thickness. The vessel is structurally strengthened around the waterline, has an ice-breaking bow form, and has added horsepower and displacement to continuously break level first-year pack ice without risk of hull damage. Vessel endurance, facilities and berthing are dependent upon the design mission needs. Examples of this vessel type are USCGS POLAR STAR (1.8 m of level ice at 3 knots), the LEONID BRESHNEV (1.8 m of level ice at 2 knots), and the Federal Republic of Germany's icebreaking research vessel POLARSTERN (1 m of level ice at 3 knots).

The need for a polar research vessel which meets one or more of these criteria has been reaffirmed consistently. In 1984 the Federal Oceanographic Fleet Coordination Council (FOFCC) undertook a study on the need for a Polar Research Vessel. Its findings showed shiptime requirements of 573 days about evenly divided between icebreakers and ice-capable ships. It was recommended that an ice-capable vessel in the 250-275 ft range be acquired and operated by the National Science Foundation as a national facility. Earlier studies within the National Research Council identified the needs for ice worthy vessels in both arctic and antarctic regions.

More recently, the UNOLS Fleet Improvement Committee reports "Arctic Science Requirements for Ice-worthy Research Vessels" (Vera Alexander et al., 1988) and "Scientific Mission for an Intermediate Ice-Capable Research Vessel" (Thomas Royer et al., 1989) have documented special needs for ice-worthy research vessels in the Arctic. Selected UNOLS vessels should be prepared to operate in these regions. In many instances they will be the only ships available. In order to prepare for this, at least two ships in separate size classes — one large and one intermediate — should be ice-capable.

Twice in recent years the ALPHA HELIX (ABS Ice Class C) operating in northern Alaska waters sustained ice damage and failed to accomplish its scientific mission. Numerous other instances exist where relatively light ice has constrained UNOLS (and other) research ships from intended areas of investigation.

Polar research can and should be accomplished both from ice-breakers and from lesser ice-worthy but ice-capable vessels dedicated to polar research. The Coast Guard is including a significant oceanographic capability in the design of a new replacement icebreaker.

In 1984 following an intensive search, NSF chartered the 219-ft Norwegian-built (1983), Canadian flag vessel POLAR DUKE. This ship, designed to Arctic Sealer specifications as an off-shore survey vessel, is ABS Ice Class 1AA and DNV-1A1-Sealer and meets the "ice-capable definition" above. Its primary mission is logistic support for the Palmer Antarctic research station, but vessel time is available for oceanographic research assignments in that region.

Ice-capable UNOLS ships should be built to ABS Arctic Standard A1 or higher. Special provisions should be included for overside and deck work in cold regions. Seakeeping, as well as ice worthiness, should receive important consideration in the design of these ships.

C. Concept Designs

An important step in the planning process is the "concept design" of new ships to meet the intended scientific mission requirements.

The classic design spiral begins with the Concept Design phase, continues with the Preliminary Design phase, and ends with the Contract Design phase leading to construction. The sequence of steps may vary with the individual design problem and with individual design practice.

The concept design stage proposed here is the first step in translating the stated requirements for a ship into the actual design process. It is a technical and engineering effort by a qualified naval architect to develop a hull form, machinery system, and general arrangements which integrates the various scientific requirements, combining laboratory arrangements, deck handling, storage and ship control into a single shipboard system. Here the requirements of the regulatory agencies, principally the Coast Guard and the American Bureau of Shipping (ABS), are defined. From this the community of oceanographers can evaluate whether the ship thus described is what they really had in mind.

The scope of a concept design includes:

- Technical description of the vessel design
- Discussion of the vessel design and its responsiveness to the scientific requirements and ship characteristics stated
- Summary of ship specifications
- General arrangements plans
- Inboard profile and outboard profile plans
- Scientific arrangement
- Machinery arrangement
- Operating characteristics, including costs
- Estimated construction cost
- Artist's conception drawing

The concept design review provides the opportunity for feedback into the requirements and the testing of the many comments and suggestions which ought to be available at this stage. It is doubtful whether the next stage of the design process, the preliminary design, will closely resemble the conceptual design. But the concept design will have served its purpose if it permits the next stage to start with any reasonable degree of confidence.

Concept designs completed for UNOLS which should be considered as part of this revised fleet improvement plan are referenced in Table 4. These designs have been printed and distributed as separate UNOLS reports of the Fleet Replacement and Fleet Improvement Committees.

Table 4. Concept Designs Completed

Large, SWATH research ships

- 2,500-ton SWATH Oceanographic Research Ship; SSS Corp.; February 1985
- Semi-submerged Research Ship; Blue Sea; April 1985
- Large Oceanographic Research Ship; SWATH AG(X); Naval Sea Systems Command, Preliminary Design Div.; August 1985

Large, high-endurance research ships

- Large Oceanographic Research Ship; MONOHULL AG(X); Naval Sea Systems Command, Preliminary Design Div.; August 1985
- High Endurance Oceanographic Research Ship; J. Leiby, Woods Hole Oceanographic Institution; December 1985
- Large Oceanographic Research Vessel; Rodney E. Lay & Associates; October 1985
- General Purpose Oceanographic Research Ship with Enhanced Marine Geology and Geophysics Capability; John W. Gilbert Associates; October 1985

Large, medium-endurance research ship

- "MG&G Friendly" Oceanographic Research Ship; Marinette Marine Corp.; May 1985
- Large Oceanographic Research Ship; M. Rosenblatt & Son, Inc.; October 1985
- Medium Endurance General Purpose Oceanographic Research Ship; Glosten Associates; November 1985

Intermediate research ships

- General Purpose SWATH Oceanographic Research Ship; SEACO; September 1988
- Tandem Strut Design Modifications for the UNOLS 150-foot, General-Purpose SWATH Oceanographic Research Vessel; SEACO; November 1989

The concept design for an intermediate four-strut SWATH ship was for a vessel with two struts per submerged hull. It has been modified in an attempt to improve station-keeping performance, and a second report has been issued. A concept design for a small, general-purpose SWATH research vessel is underway. It is strongly urged that concept designs be undertaken now for:

- a two-strut (one strut per submerged hull) intermediate SWATH ship, to compare potential performance with the four-strut concept design and
- an intermediate ice-capable general-purpose vessel for use in the western Arctic.

D. Preliminary Designs

Based on requirements for support of scientific missions aboard general-purpose oceanographic research ships, the UNOLS Fleet Replacement Committee initiated and oversaw concept design studies for three distinct large, medium-endurance monohull ships. The potential inherent in these designs was so great that UNOLS instructed its Fleet Improvement Committee to initiate and provide scientific guidance for a preliminary design of a large, medium-endurance, general-purpose oceanographic research ship combining the best features of the concept designs. The Committee selected for the preliminary design work the Glosten Associates, Inc., whose concept design was judged to have the most potential.

This study was funded by a grant from the National Science Foundation. The Scripps Institution of Oceanography was the prime contractor. Dr. Fred Spiess was the contractor's representative. A subcommittee of the UNOLS Fleet Improvement Committee consisting of Marcus Langseth, James Murray, and Fred Spiess (chairman) provided scientific guidance to Glosten Associates, Inc. during the study. The report from Glosten Associates, Inc., issued as a UNOLS FIC report, presents the preliminary design. The FIC believes this study should receive serious, thorough consideration as a candidate for any new UNOLS research vessel having those general mission requirements.

V. A Plan for UNOLS Fleet Improvement

A. Guiding Precepts

Several precepts have guided the development of a plan for improving the UNOLS fleet. The major ones are:

1. Many of the existing ships (and particularly the large ones) are not capable of meeting the present requirements of science at sea, and with the increased requirements foreseen for the future, these shortcomings will be exacerbated. The average age of the large ships at the start of 1989 was 23 years. The acquisition of EWING and THOMPSON (AGOR-23), as well as renovations of the KNORR and MELVILLE, and the retirement of CONRAD and THOMPSON (AGOR-9) will improve this. At the beginning of 1990, the average age of the fleet of large and intermediate vessels will be 15 years (the nominal half life for vessels of these sizes); the average age of the small-size vessels also will be 15 years, somewhat more than a desirable mid life for the smaller vessels. *Two programs should be initiated and go forward in parallel: a long-term plan for construction of new hulls to replace the oldest ones; and a short-term plan for mid-life refits and upgradings to improve the remainder.*

2. New ships should have improved seakeeping and station keeping characteristics; and should have upgraded laboratories, overside handling capability, and scientific outfitting. It is likely that this will lead to increased average size. To the extent possible, these improvements also should be made to existing ships during their mid-life refits; this may require stretches to accommodate improved equipment. [Note that stretching a ship may jump that vessel to the next class which may already be crowded and so, again, the total fleet composition and requirements must be considered in decisions to refit.]

3. The numbers of future large and intermediate ships needed to support scientific requirements are not expected to be significantly different from the existing fleet. An analysis of the summary ship use data for 1982–1989 (Table 2) shows for example that the total number of ship days in 1988 was 4162 distributed over 20 individual vessels. This was a fleet average of 208 days per vessel. Average use of the 7 large vessels was 242 days/year; average use of 7 intermediate vessels was 181 days/year; average use of 6 small vessels was 144 days/year. The summary data show that the large vessel class is working close to capacity at 244 days per year. This is a significantly higher utilization rate than for the intermediate vessels (207 days per year). We have made no recommendations for the small research vessels (100-149 feet), but we note on average that they

were operating below their potential full working-year capabilities. If additional vessels are accepted into the UNOLS fleet, it may contain more ships than can be supported by traditional funding sources for academic oceanography.

4. The mix of ships is about evenly divided between the size classes, i. e., large, intermediate and small ships. However, the size of ships in all classes necessarily increases to fulfill the UNOLS scientific mission requirements. Note also that vessels in the large size class now fall into two categories: those meeting the scientific mission requirements for high-endurance, general-purpose vessels, and those meeting the requirements for medium-endurance, general-purpose vessels.

5. Particular attention should be given to making both new and upgraded ships more economical to operate. While this will likely make the initial investment costs somewhat larger, it must be remembered that the cumulative life-time costs of operation are very large compared to the one-time costs of construction or modernization. Consideration should be given not only to more efficient equipment, such as fuel-efficient engines and improved anti-fouling and anti-corrosion systems, but also to lowered personnel costs through the use of unattended engine rooms and modern overside handling systems.

6. Several of the new or upgraded ships should have, in addition to multidisciplinary general purpose capabilities, the capability, or option, for a particular discipline or field of work. These include multichannel seismic capability, the handling of submersibles or extremely large pieces of equipment, or high-latitude work.

7. Reviews of UNOLS fleet capability, and planning for additions or replacements to the fleet, must also consider alternatives such as cooperative use or charter of both foreign and domestic non-UNOLS vessels. The current major reviews by FOFCC and of the NOAA fleet will have future impact on UNOLS fleet planning and the progress of those reviews will be closely watched by the Fleet Improvement Committee. Both FOFCC and NOAA committees are exchanging information and papers with the FIC.

8. Necessary improvements to the UNOLS fleet are ongoing and must continue. Replacements should continue to be planned in a systematic manner to permit replacing small ships by their 25th year, and those of intermediate and large size by their 30th year. These lifetimes are meant as guidelines, and they are predicated on the assumption that all vessels will be refit at mid-life — otherwise useful lifetimes likely will be shorter. It is often mission obsolescence and not platform obsolescence which determines the optimum vessel lifetime.

9. Major refits or upgrades should be made to all ships at about their mid life. These refits must be planned well in advance to optimize fleet utilization.

B. Profile of Planned UNOLS Fleet

The recommended UNOLS fleet profile is summarized in Table 5. Note that the "existing fleet" is that expected for 1991 (as shown in Table 6 on p. 35). It will be noted that for some classes, the number of ships in the recommended fleet differs from those in the 1991 fleet. This results because we sized the recommended fleet to meet the projected needs of academic oceanographic research as traditionally supported in the United States. The needs for special-purpose intermediate size vessels and for large vessels not meeting the UNOLS scientific mission requirements for medium- or high-endurance large vessels are not clearly demonstrated at this time, so such vessels are not included in the recommended UNOLS fleet profile. The size of the existing UNOLS fleet, on the other hand, is determined by the UNOLS Council based on a different set of criteria. A schedule for achieving this recommended fleet is shown in Table 7.

Table 5. Recommended UNOLS Fleet Profile

	1991 Fleet	Recommended Fleet
LARGE, HIGH-ENDURANCE GENERAL-PURPOSE SHIPS (≥250 ft)	**3 †**	**3**
LARGE, MEDIUM-ENDURANCE GENERAL-PURPOSE SHIPS (≥200 ft)	**1 ††**	**2**
LARGE, GENERAL-PURPOSE SHIPS (≥ 200 ft)	**2**	**0**
INTERMEDIATE, GENERAL-PURPOSE SHIPS (150–199 ft)	**6**	**6**
SMALL, GENERAL-PURPOSE SHIPS (100–149 ft)	**8**	*****
SPECIAL SHIPS		
SUBMERSIBLE-SUPPORT (> 200 ft)	**1**	**1**
ICE-WORTHY	**0 ****	**1 ****

† Assumes inclusion of THOMPSON (AGOR-23) into the UNOLS fleet.
†† Assumes inclusion of EWING into UNOLS fleet.
* See subsection V.B.iii (p. 36).
** See subsection V.B.v (p. 37) for a discussion of U.S. academic community needs for non-UNOLS ice-worthy ships.

Table 6 lists the fleet which is expected to be in service in 1991. Also shown is when each ship should be (or was) refit and when it should be retired. The age of the ship is in parentheses following the year for each action. [We note that the University of Southern California is converting the VICKERS (previously named OSPREY) as a 219-ft general-purpose research vessel which should be in service in 1990. They likely will apply for UNOLS status upon completion of the conversion in mid-1990, but application has not been made and it is not included here.]

i. *Large, general-purpose vessel needs in the UNOLS fleet.*

At present, refits, new construction, and conversion of large academic research vessels are ongoing. When these projects are complete (in 1991) there should be four vessels in the U.S. academic fleet that come close to meeting the UNOLS scientific mission requirements for a new generation of high-endurance or medium-endurance, large, general-purpose vessels: THOMPSON (AGOR-23), KNORR, MELVILLE, and EWING. The recommendation of the FIC, and of the Fleet Replacement Committee before it, is that the UNOLS fleet should include six modern large vessels, including one ship capable of deep submersible support, that meet the scientific mission requirements for high-endurance or medium-endurance. That recommendation is based on the historical makeup and usage of an academic fleet that has included six large vessels modified by the projected requirements of the global change programs for improved capabilities and global coverage. It is possible that these projections are somewhat optimistic considering the modest increases in science funding during the past few years, but in the view of the FIC the U.S. academic community should strive to obtain a fleet which will meet the projected requirements. These large vessels might be capable of serving as a submersible-support ship as a replacement for ATLANTIS II. A FIC subcommittee is looking at this alternative in association with a general study of submersible-support ship requirements. The large vessels appear to have maintained a good use profile (Table 2).

We strongly urge the Navy to move forward with the construction of the AGOR-24 to bring on line a state-of-the-art vessel to increase the effectiveness of the UNOLS fleet in support of the needs of the nation's academic oceanographic research program. Moreover, we recommend that the Navy consider as an alternate to the AGOR-23 design the preliminary design recently completed for UNOLS by the Glosten Associates. This would add a large, medium-endurance vessel to the fleet.

Table 6. UNOLS ships, classed by decreasing size within class, expected to be in service in 1991

LARGE HIGH-ENDURANCE SHIPS

SHIP	INST.	LOA (FT)	IN SERVICE	REFIT	RETIRE
KNORR	WHOI	245 (279)	1969	1989 (20)	2009 (40)
MELVILLE	SIO	245 (279)	1969	1990 (21)	2010 (41)
THOMPSON (AGOR-23)*	U. Wash.	274	1991	2006 (15)	2021 (30)

LARGE MEDIUM-ENDURANCE SHIPS

SHIP	INST.	LOA (FT)	IN SERVICE	REFIT	RETIRE
EWING*	LDGO	239	1990	2004 (14)	2020 (30)

LARGE SHIPS
≥ 200 Feet

SHIP	INST.	LOA (FT)	IN SERVICE	REFIT	RETIRE
WASHINGTON	SIO	209	1965	---	1993 (28)
MOANA WAVE	U. Hawaii	209	1973	1985 (12)	2005 (32)

INTERMEDIATE
150-199 Feet

SHIP	INST.	LOA (FT)	IN SERVICE	REFIT	RETIRE
OCEANUS	WHOI	177	1975	1992 (17)	2004 (29)
WECOMA	OSU	177	1975	1992 (17)	2004 (29)
ENDEAVOR	URI	177	1976	1995 (19)	2006 (30)
GYRE	TAMU	174	1973	1980-84 (11)	2003 (30)
ISELIN	U. Miami	170	1971	1985 (14)	1998 (27)
NEW HORIZON	SIO	170	1978	1995 (17)	2008 (30)

SMALL
100-149 Feet

SHIP	INST.	LOA (FT)	IN SERVICE	REFIT	RETIRE
CAPE HATTERAS	DUKE	135	1981	1994 (13)	2011 (30)
POINT SUR	MLML	135	1981	1994 (13)	2010 (29)
ALPHA HELIX	U. Alaska	133	1965	~ 1978 (13)	1993 (28)
SPROUL **	SIO	125	1984	1993 (13)	2007 (26)
CAPE HENLOPEN ***	U. Del	120	1975	---	1999 (24)
WARFIELD †	CBI	106	1967	1991 (24)	2007 (40)
PELICAN	LUMCON	105	1986	1999 (13)	2012 (26)
LONGHORN	U. Texas	105	1971	1986 (15)	2000 (29)

SPECIAL SHIPS
Submersible-Support

SHIP	INST.	LOA (FT)	IN SERVICE	REFIT	RETIRE
ATLANTIS II	WHOI	209	1963	1982 (19)	1997 (34)
SEWARD JOHNSON ††	Harbor Branch	176	1985	---	
EDWIN LINK ††	Harbor Branch	168	1982	1988	

Ice-Worthy

None

* Not part of UNOLS fleet at this time, but expected to be so when in operation.
** Built in 1981; partial refit 1983-84 before service as oceanographic vessel.
*** Schedule is weak and future status is not clear at this date.
† CBI plans to discontinue oceanographic research. The WARFIELD will be operated by the Center for Environmental and Estuarine Studies, U. Maryland beginning in 1991.
†† Provisionally designated as UNOLS vessels pending satisfactory inspections.

In addition to THOMPSON (AGOR-23), KNORR, MELVILLE, and EWING, the large vessels WASHINGTON (AGOR-10) and MOANA WAVE are presently part of the UNOLS fleet. The VICKERS, when completed, will undoubtedly be nominated for inclusion in the UNOLS fleet. Large ship use appears to be strong as of this time; if full utilization of this number of large general-purpose vessels does not materialize because of a lack of adequate science support or delay in construction, two options should be weighed. First, one of the existing general-purpose large vessels could be utilized as a submersible-support vessel. Such a ship will be needed in the near-to-intermediate term because the ATLANTIS II is not a young vessel. Second, support could be suspended for the least capable of the other large vessels, raising the capability of a somewhat smaller fleet. The Navy's capability now to construct AGOR-24 represents a significant opportunity to add a state-of-the-art research vessel to the fleet and retire less functional vessels. We should not lose this opportunity.

Table 5 is based on the assumptions that THOMPSON (AGOR-23), KNORR, and MELVILLE will come close to meeting the mission requirements for large, high-endurance vessels, that EWING will meet many requirements for a medium, high-endurance vessel, and that the AGOR-24 be built as a large, medium-endurance vessel with submersible-support capabilities. Available characteristics for THOMPSON (AGOR-23), MELVILLE, KNORR, and EWING are compared with UNOLS scientific mission requirements for large, medium- and high-endurance ships in Appendix II.

ii. *Intermediate, general-purpose vessel needs in the UNOLS fleet.*

It is proposed that the existing general-purpose intermediate ships ISELIN, GYRE, OCEANUS, WECOMA, ENDEAVOR, and NEW HORIZON be replaced on an individual basis depending on fleet needs and adequacy of federal support for research at the time of consideration. Two privately-owned intermediate vessels with special submersible-support capability, EDWIN LINK and SEWARD JOHNSON, are just now entering the UNOLS fleet. The role of these vessels in the fleet is not yet clear, nor is it clear whether the need will exist for their replacements. We note that data (Table 2) suggest a weakness in intermediate ship use which may improve if research funding increased.

iii. *Small, general-purpose vessel needs in the UNOLS fleet.*

The existing small UNOLS ships (all general-purpose) are ALPHA HELIX, CAPE HENLOPEN, WARFIELD, CAPE HATTERAS, SPROUL, PELICAN, LONGHORN, and

POINT SUR. The number of small vessels now in the UNOLS fleet is much larger than the number of such vessels traditionally in this fleet or the number likely needed for work significantly supported by ONR and NSF at academic institutions. The additional vessels, with other funding sources, have been added recently to the UNOLS fleet; they were procured with non-federal funds and some receive significant private or state support. Other institutions have pending requests to add vessels to the fleet. It seems likely that the supply of such vessels will be greater than demand. However, it does not seem feasible at this time of great change in numbers, ownership, and sources of support for small UNOLS vessels, to recommend realistically the number of such ships needed in the UNOLS fleet. Refits and replacements of only the CAPE HATTERAS and POINT SUR, as federally-constructed vessels, have been included in Tables 7 and 8. The only change proposed is construction of an ice-capable vessel as a numerical replacement for ALPHA HELIX, probably by an intermediate size ship.

iv. *Submersible-support ship.*

Planning should begin for the next submersible-support ship to replace the ATLANTIS II. The FIC recommends that preparation should be for a 6,000- to 10,000-m submersible and that the next support vessel has more capability for scientific support on extended cruises than does the ATLANTIS II.

v. *Ice-worthy ships.*

In no area should more integration of facilities be forthcoming than in polar research vessels. They are special, expensive facilities. Coordination between the Federal agencies is essential. At present, plans for ice-capable oceanographic research ships are being made and followed by the Coast Guard, Navy, and NSF. As discussed in section IV.B., U.S. ice-worthy ships in both northern and southern hemispheres are essential if U.S. scientists are to remain competitive in ocean research. The needed capability is not now available.

The U.S. academic community needs ice-capable vessels in the Arctic and in the Southern Ocean. Because of the long transit times between these two polar regions and because of the need to sample in the Southern Ocean in all seasons, it is not feasible for *one* vessel to meet requirements in the Southern Ocean and in the Arctic.

It is recommended that the required ice-breaking capability in the Southern Ocean be provided by the NSF Division of Polar Programs (DPP), supplemented by U.S. Coast Guard ice breakers. The DPP is expected to lease a ship about 290 feet long—a 11,000-horsepower vessel capable of breaking three feet of level ice at three knots. It will have accommodations for 37 scientists, 4000 square feet of laboratory space, and 3000 square feet of working area at the fantail. Government furnished equipment on the vessel will include multi-channel seismic and SWATH mapping systems. The RFP included a set of technical requirements based on the UNOLS scientific mission requirements; bidders proposed their own designs to meet them. The winning bidder is Edison Chovest Offshore of Galliano, LA. The vessel is to be leased for a 10-year period; an arrangement similar to the existing contract for the POLAR DUKE. This ship was not included in the planned UNOLS fleet profile, because it will not be operated by an academic institution, but it is needed by the UNOLS community.

U.S. oceanographic research needs will then be for ice-capable vessel operations in both east and west Arctic regions. It seems unlikely that we will have a single vessel capable of regular, safe Arctic transit between these two areas. The need for an ice-worthy ship in the western Arctic Basin is for 175-200 days per year (Royer et al., 1989). The FIC recommends that a concept design study be undertaken based on the provisional scientific mission requirements for an intermediate size vessel included in the report by Royer et al. That study should identify trade-offs between functional requirements and size. That ship is included in the recommended UNOLS fleet profile.

A second U.S. ice-worthy oceanographic research ship is needed in the eastern Arctic—for operation in the Greenland and Norwegian Seas and contiguous areas, as documented by the report of Alexander et al. (1988). The Navy has plans to procure such a ship to be operated by the MSC. So, although tentative plans include use by the U.S. academic community, it is not included in the UNOLS fleet profile.

C. Suggested Improvement Schedule With Costs

A plan for improvement of the fleet should take into account a meld of the following factors:

1. The needs of ongoing and foreseen science.
2. The material condition and scientific capability of existing ships.
3. The national economy and support available for research in general, and oceanography specifically.

The first factor should be periodically updated to reflect the changing research interests of the community, and the plans of sponsoring agencies such as NSF and ONR. These needs are translated into ship capabilities in the Scientific Mission Requirements for the various types of research vessels, developed and periodically updated by the UNOLS Fleet Improvement Committee.

The second group of factors should be regularly reviewed. This is now based on the ship inspection programs of NSF and ONR and user assessments.

While the last factor is impossible to predict over the long term, this plan is based on the hope for some improvement relative to the funding climate of the 1980s.

In Table 7 is presented a proposed schedule for refits and retirements. It is emphasized that the "desirable" dates for upgrading and constructions have, in some cases, been modified to spread budget costs in a more realistic manner. Even so, the simultaneous maturing of many of the intermediate ships leads to the need for concentrations of upgrading and replacements.

Table 7. Proposed Schedule of Refits and Retirements by Year
(Federally-procured vessels are in bold type.)

Year	Ships Refitted	Ships Retired
1989	**KNORR**	**CONRAD**
1990	**MELVILLE**	---
1991	**GYRE** (partial), **WARFIELD**	---
1992	**OCEANUS, WECOMA**	---
1993	SPROUL	**WASHINGTON, ALPHA HELIX**
1994	**HATTERAS, SUR**	---
1995	NEW HORIZON, **ENDEAVOR**	---
1996	---	---
1997	---	**ATLANTIS II**
1998	---	**ISELIN**
1999	PELICAN	HENLOPEN
2000	---	LONGHORN
2001	---	---
2002	---	---
2003	---	**GYRE**
2004	**EWING**	**WECOMA, OCEANUS**
2005	---	**MOANA WAVE**
2006	**THOMPSON (AGOR-23)**	**ENDEAVOR**
2007	**Ice-Capable Replacement**	SPROUL, **WARFIELD**
2008	**AGOR-24**	NEW HORIZON
2009	---	**KNORR**
2010	---	**MELVILLE, SUR**
2011	---	**HATTERAS**
2012	**New Submersible-support**	PELICAN

In Table 8 are given cost estimates, by 5-year increments for 25 years, to refit and replace (according to the schedule of Table 6) the federally-procured component of the UNOLS fleet. The purpose here is to provide budget estimates for use by NSF and ONR in advance planning. No estimates have been included for the costs of improvements to the privately-procured ships in the fleet. Estimated costs are in millions of 1989 dollars and were made by the Fleet Improvement Committee. This committee has commissioned a study by The Glosten Associates, Inc. to estimate the present value of the UNOLS fleet, and then revise replacement and refit costs, based on real costs of construction and modifications.

Clearly some privately-procured vessels may be replaced with federal dollars, some federally-procured vessels with private funds, and some vessels not replaced one-for-one. It is also possible that conversions, rather than new construction, may be undertaken as a more cost-effective method of replacing some of these vessels. These options have been considered by the UNOLS Fleet Improvement Committee; a discussion and summary of past methods of ship acquisition is included in the UNOLS FIC report, "History of the U.S. Academic Oceanographic Research Fleet and the Sources of Research Ships", by Treadwell, Gorsline, and West (1988).

Table 8. Cost Estimates for Improvement of Federally-procured Component of UNOLS Fleet by 5-year Increments for 25 Years

TIME FRAME	LARGE SHIPS	INTERMEDIATE	SMALL SHIPS
1990-1994	3 new ($ 83) (EWING, AGOR-23, AGOR-24) 1 refit ($ 16) (MELVILLE)	1 new ($ 50) (Ice-capable) 3 refits ($ 10.5) (GYRE, OCEANUS, WECOMA)	3 refits ($ 5) (HATTERAS, SUR, WARFIELD)
1995-1999	1 new ($ 33) (Submersible-support)	1 new ($ 17) (ISELIN) 1 refit ($ 3.5) (ENDEAVOR)	
2000-2004	1 refit ($ 9) (EWING)	3 new ($ 51) (GYRE, WECOMA, and OCEANUS replacements)	
2005-2009	1 new ($ 40) (KNORR replacement) 2 refits ($ 20) (AGOR-23, AGOR-24)	1 new ($ 17) (ENDEAVOR) 1 refits ($ 5) (Ice capable)	1 new ($ 5) (WARFIELD)
2010-2014	1 new ($ 40) (MELVILLE replacement) 1 refit ($ 9) (Submersible-support)		2 new ($ 20) (HATTERAS, SUR replacements)
TOTALS:	6 new 5 refits	6 new 5 refits	3 new 3 refits

* ALPHA HELIX may be replaced by a vessel of intermediate size.

Epilogue

This edition of the UNOLS Fleet Improvement Plan represents a snapshot of the present status and plans for the future academic research fleet as seen in early 1990. This plan is an evolving document as was its predecessor, "A Plan for Improved Capability of the University Oceanographic Research Fleet," published in 1986, and revisions are planned every three to four years.

As we complete this version of the document, comments have been received from interested parties outside of the Committee pointing out that there are issues relative to the size, composition and maintenance of the fleet that were not fully addressed in recent drafts of this Plan. We have tried to address some of these issues in the final version, but the FIC recognizes that omissions and unresolved issues remain. These issues, some of which are longstanding, deserve serious consideration in any future plan, and will no doubt provoke considerable discussion among UNOLS members, supporting agencies, the UNOLS Council and the Fleet Improvement Committee in the years ahead. Some of these issues are briefly reviewed below.

Admission of research vessels to the UNOLS Fleet is decided by the UNOLS Council. During the past year, the Council has admitted two additional special-purpose intermediate vessels and two more small vessels to the fleet; additional vessels have been nominated and are or will be under consideration. It is not yet clear whether available scientific research funding will be adequate to support this expansion of the fleet. Review of the data presented in this plan on ship-use versus ship-availability indicates that over the past eight years the existing ships in the intermediate and small classes have not been fully utilized. Firm criteria for admission of vessels into the fleet (taking into account the total fleet requirements) must be established and applied.

It has been the policy of federal sponsoring agencies (NSF and ONR) to provide support for the expenses of temporary lay-up periods for the intermediate and large ships in the UNOLS fleet when availability exceeds demands. This policy will become untenable or the criteria of support will have to be redefined if the fleet expands without bound. On the other hand, the high standards of safety and effectiveness required of ships in the UNOLS fleet makes it highly desirable to have all U. S. ships that carry a significant number of academic scientific programs be included.

Other questions regarding the significance of being in the UNOLS fleet should be considered as well. Should there be two or more grades of membership with different weighting of financial responsibility between the operator and the sponsoring agencies? Should the federally-procured ships be treated differently (i.e., be the only ship supported during lay-up periods)?

Traditionally, classification of research vessels has been based on length. However, we know that such factors as scientific berthing space; deck, lab and storage space; equipment; endurance; and range are not simply a function of length. UNOLS has defined ship capabilities in terms of a suite of mission requirements ("Scientific Mission Requirements for Oceanographic Research Vessels", 1989) that can provide a more rational basis for classification. These requirements also provide a reference against which the capability of existing or planned vessels can be compared. One of the tasks that the FIC has set for itself in 1990 is to make such a comparison between the large and intermediate research vessels now in the Fleet and the UNOLS scientific mission requirements, and compare the results to a similar analysis for the fleet as of 1981, thus providing a means for evaluating fleet evolution over a decade.

A reasonable definition of what constitutes a "full working year" for research ships in different classes is still unresolved. This definition is important because it is the basis for estimating the available shiptime in the Fleet, and consequently the utilization of the Fleet. It is clear that the optimum number of shipdays in a "full working year" is not a fixed number, but will depend on mode of operation (whether from a home port or from foreign ports), the operating area (seasonal or year-round accessibility), and maintenance schedule. Experience over the past 25 years suggests that for "large" vessels, 250 to 275 working days per year is a reasonable range; for "intermediate" ships, 225 to 250 days; and for "small" ships, 160 to 200 days. These estimates should be verified and refined.

It is evident that the bulk of the UNOLS Council and Fleet Improvement Committee attention is focused on the large and intermediate ships that carry the largest fraction of the deep ocean research load. These will also be the main platforms for much of the expanding Global Change studies. There could be an increase in the needs for small vessels in that plan or in new initiatives for coastal studies being planned by several funding agencies for the next few years. We should remember that the problems or successes of any single class of vessels cannot be evaluated in isolation from the other classes. We also recognize that there will be impacts on UNOLS Fleet composition from other sources of ship time that are non-UNOLS (both foreign and domestic). And last, we repeat a statement from the report, that the primary criterion for fleet composition and direction is the science funding.

Appendix I: Reports of the UNOLS Fleet Improvement Committee

Alexander, Vera, *et al.*, Arctic Science Requirements for Ice-Worthy Research Vessels, UNOLS Fleet Improvement Committee Report, 21 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1988.

Barber, Richard and T. K. Treadwell, Report of a Workshop on Mid-Life Refits and Improvements of Intermediate-Size Ships, UNOLS Fleet Improvement Committee Report, 19 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1989.

Fisher, F.H., and F.N. Spiess, Draft Science Support Requirements for a Manned Spar Buoy Laboratory, UNOLS Fleet Improvement Committee Letter Report, 6 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1989.

The Glosten Associates, Inc., Preliminary Design for Medium Endurance General Purpose Oceanographic Research Vessel, Final Report, File No. 8808, for the UNOLS Fleet Improvement Committee, 130 pp + 3 Appendices, UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1989.

Johnson, Thomas C., Report on a Workshop on Improvement to the CAPE-Class Research Vessels, UNOLS Fleet Improvement Committee Report, 23 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1989.

Murray, James W., Richard Barber, and Marcus Langseth, Scientific Requirements for the UNOLS Fleet, UNOLS Fleet Improvement Committee Report, 25 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1988.

Royer, Thomas, *et al.*, Scientific Mission for an Intermediate Ice-Capable Research Vessel, UNOLS Fleet Improvement Committee Report, 17 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1989.

SEACO, Concept Design for a General Purpose SWATH Oceanographic Research Ship, UNOLS Fleet Improvement Committee Report, 86 pp. + 3 Appendices, UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146.

SEACO, Tandem Strut Design Modifications for the UNOLS 150 foot General-Purpose SWATH Oceanographic Research Vessel, UNOLS Fleet Improvement Committee Report, 68 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146.

Treadwell, T. K., D. S. Gorsline, and R. West, History of the U.S. Academic Oceanographic Research Fleet and the Sources of Research Ships, UNOLS Fleet Improvement Committee Report, 55 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1988.

UNOLS Fleet Improvement Committee, Scientific Mission Requirements for Oceanographic Research Vessels, UNOLS Fleet Improvement Committee Report, 36 pp., UNOLS Fleet Improvement Committee Office, Texas A&M University, College Station, TX 77843-3146, 1988.

Appendix II: Comparison of Existing UNOLS Ships with Scientific Mission Requirements

The comparison of intermediate ships was prepared using data from the UNOLS FIC Report of a Workshop on Mid-life Refits (1989), cruise planning manuals for ISELIN, GYRE, WECOMA, and NEW HORIZON on file at the UNOLS Office. No data were available on operations in different sea states; problems noted are from comments in the cited workshop report. For OCEANUS class, we have no data on positioning precision and thrusters. Working deck areas were estimated from ship plans.

Information regarding large ships under construction, refit, or conversion was taken from informal status reports dealing with constructions, conversion, and refits. This information is subjective and likely somewhat speculative. Information regarding ATLANTIS II, WASHINGTON, and MOANA WAVE was taken from cruise planning manuals on file at the UNOLS Office, as was information for the small vessels CAPE HATTERAS, POINT SUR, and ALPHA HELIX.

SHIP NAME	YEAR BUILT/REFIT	LENGTH/ BEAM	ENDURANCE (DAYS)	ENDURANCE (MILES)	SCIENCE BERTHS	CREW BERTHS	CRUISING SPEED	MAX. SPEED
UNOLS Large, High-Endurance Ship	---	250–300 ft.	60	15,000	30–35	?	15 kts @ sea state 4	15 kts
AGOR-23	1991	274/52	33 @ 14.5 kts + 29 @ 3 kts	12,000	30	20	14.5 kts.	15 kts.?
MELVILLE	1969/1990	279/46	60	14,100	34	24	12 kts.	14 kts.
KNORR	1969/1989	279/46	60	14,100	34	24	12 kts.	14 kts.
UNOLS Large, Medium-Endurance Ship	---	>200 ft.	50	12,000 @ 14 kts.	20-25	?	14 kts.	not specified
BERNIER	1983/1990	239/45	60 @ 12 kts 45 @ 14 kts	15,000 @ 12 kts. 12,000 @ 14 kts.	31	19	14 kts.	14
ATLANTIS II	1963**	210	35	8,800	20	?	10.5	12
WASHINGTON	1965	209	36	8,300	22	23	10	11.5
MOANA WAVE	1973	210	50	14,000	19	13	10	11

SHIP NAME	SEAKEEPING	STATION KEEPING	ICE CLASS	DECK WORK AREA	A-FRAMES	CRANES	WINCHES
UNOLS Large, High-Endurance Ship	13 kts. @ SS 5 6 kts. @ SS 7	Work through SS 5 Limited work in SS 7	ABS 1A	3,000 ft^2	1^+ †	see SMRs	3^+
AGOR-23	?	?, dynamic positioning	?	3,800 ft^2	1; 1 J-Frame	4	3^+
MELVILLE	12 kts to SS 4	work through SS 4	None	3,764 ft^2	2	3	3^+
KNORR	12 kts to SS 4	work through SS 4	None	3,764 ft^2	None	3	3^+
UNOLS Large, Medium-Endurance Ship	14 to SS 5; 12 to SS 6 8 to SS 7; 6 to SS 8	Work through SS 5 Limited work in SS 6	ABS 1C	≥ 2000 ft^2	1^+ †	see SMRs	3^+
BERNIER	14 kts. through SS 4; survey @ 6 kts to SS 6		ABS A1 LR-1A	2,950 ft^2	2	3	3 + streamer winches
ATLANTIS II	?	?	?	?	1+1 §	1	2^+
WASHINGTON	?	?	?	1,600 ft^2	1	2	3
MOANA WAVE	?	?	?	1,400 ft^2	1	1	2

† See SMRs

** converted as submersible-support vessel in 1982 and now in special category.

§ special frame for ALVIN

SHIP NAME	NUMBER OF LABS	LAB AREA	VANS	WORK BOATS	SCIENCE STORAGE	ACOUSTICAL SYSTEMS
UNOLS Large, High-Endurance Ship	5 + special labs	≈4,000 ft^2	4-8x20 + up to 4 portables	two 16 ft inflatable 25–30 ft. scientific boat	20,000 ft^3	3.5, 12 kHz, wells, multibeam
AGOR-23	5 + climate control & freezer	3,858 ft^2	2- 8x20 + up to 2 portables	19 ft. inflatable 26 ft. workboat	15,000 ft^3	3.5, 12 kHz, 150 kHz, multibeam, wells
MELVILLE	5 + special labs	3,680 ft^2	2-8x20 + others	several 16–20ft.	9,900 ft^3	3.5, 12 kHz, multibeam, wells
KNORR	5 + special labs	3,680 ft^2	2-8x20 + others	several 16–20ft.	9,900 ft^3	3.5, 12 kHz, multibeam, wells
UNOLS Large, Medium-Endurance Ship	5 + special labs	3,000 ft^2	4-8x20 + up to 3 portables	19 ft. inflatable 26 ft. workboat	15,000 ft^3	3.5, 12 kHz, wells, multibeam
BERNIER	5 + office	2,800 ft^2	2 vans as needed space for additional 2	workboat	11,732 ft^3 (5,700 ft^3 climate control)	multichannel seismic system
ATLANTIS II	5	2,000+ ft^2	?	1	?	3.5, 12 kHz, ?
WASHINGTON	4	1,350 ft^2	?	1	?	3.5, 12 kHz, multibeam
MOANA WAVE	5+	1,850 ft^2	?	?	?	3.5, 12 kHz, ?

SHIP NAME	NAVIGATION COMMUNICATIONS	EXTERNAL COMMUNICATIONS	SAT. DATA ACQUISITION	SHIP CONTROL	PROBLEMS
UNOLS Large, High-Endurance Ship	GPS & Short Baseline Navigation	Sat., VHF, UHF, Fax	yes	pilot house midships or extra control stations	
AGOR-23	GPS, SN, O, LC	HF, VHF, Inmarsat	yes	bridge wing, engine room, & lab. control stations	
MELVILLE	GPS, SN, O, LC	VHF, UHF, SATCOM	?	bridge wing, engine room, & lab. control stations	
KNORR	GPS, SN, O, LC	VHF, UHF, SATCOM	?	bridge wing, engine room, & lab. control stations	
UNOLS Large, Medium-Endurance Ship	GPS §	Sat., VHF, UHF, Fax	yes	pilot house midships or extra control stations	
BERNIER	integrated navigation system	MF (SSB and telegraphy), VHF, Sat	Transmission	bow thruster, aft control station, Becker rudder	
ATLANTIS II	GPS, SN, LC	CW, VFS, ATS	yes	?	
WASHINGTON	GPS, SN, LC	HF, VHF, SSB, ATS	yes	?	
MOANA WAVE	GPS, SN, LC	HF, VHF, ?	yes	?	

§ selected vessels have dynamic positioning capability

SHIP NAME	YEAR BUILT	LENGTH FEET	ENDURANCE DAYS	ENDURANCE MILES	SCIENCE BERTHS	CREW	SPEED CRUISING	SPEED MAX
UNOLS Intermediate General-purpose	----	177	30	8000	15–20	10–12	14kt	15kt
OCEANUS*	1975	177	25	7200	12	10	12kt	14.5kt
WECOMA	1975	177	25	7200	20	13	12kt	14.5kt
ENDEAVOR**	1975	177	25	7200	16	10	12kt	14.5kt
GYRE	1973	182	21	8000	21	10	9.5kt	11.5kt
ISELIN	1972	170	30	9500	24	12	13kt	14.5kt
NEW HORIZON	1978	170	33	7500	13	12	11kt	13.2kt

SHIP NAME	SEAKEEPING To SEA STATE 4	STATION KEEPING	ICE CLASS	DECK WORK AREA	A-FRAMES	CRANES	WINCHES
UNOLS Intermediate General-purpose	12kts	SS5/+/-150ft	1C	$1500ft^2$	see notes	see notes	see notes
OCEANUS*	?	?	?	$1000ft^2$	1	1	3
WECOMA	?	?	?	$1000ft^2$	1	1	3
ENDEAVOR**	?	?	?	$1000ft^2$	1	1	3
GYRE	?	?	?	$1500ft^2$	2	2	3
ISELIN	?	?	?	$1500ft^2$	2	2	3
NEW HORIZON	?	?	?	$2000ft^2$	1	2	3

SHIP NAME	LABS NUMBER	LABS AREA	VANS	WORK BOATS	SCIENCE STORAGE	ACOUSTICAL SYSTEMS
UNOLS Intermediate General-purpose	—	2000ft^2	2	1	10,000ft^3	3.5, 12 kHz
OCEANUS*	2	900ft^2	1	1	In Labs ?	3.5, 12 kHz
WECOMA	2	900ft^2	1	1	Van, 80 ft^2	3.5, 12 kHz
ENDEAVOR**	2	900ft^2	1	1	In Labs ?	3.5, 12 kHz
GYRE	3	1000ft^2?	1	1	In Labs ?	3.5, 12 kHz
ISELIN	3	880ft^2	1?	1	In Labs?	3.5, 12 kHz
NEW HORIZON	3	990ft^2	4	1	In Labs?	3.5, 12 kHz

SHIP NAME	NAVIGATION COMM	EXTERNAL COMM	SAT. DATA ACQUISITION	DATA HANDLING	SHIP CONTROL	PROBLEMS
UNOLS Intermediate General-purpose	GPS	VHF, UHF, Sat	Yes	SAIL	See Sta. Keep	—
OCEANUS*	GPS, SN, O, LC	HF, VHF, ATS	No	SAIL	?	?
WECOMA	GPS, SN, O, LC	HF, VHF, ATS	No	SAIL	?	Stability?
ENDEAVOR**	GPS, SN, O, LC	HF, VHF, ATS	No	SAIL	?	?
GYRE	GPS, SN, O, LC	HF, VHF, ATS	No	SAIL	Bow Thruster	?
ISELIN	GPS, SN, LC	HF, VHF, Sat	No	SAIL	Bow Thruster	?
NEW HORIZON	GPS, SN, LC	HF, VHS, ATS	No	SAIL	Bow Thruster	Stability

* Data assumed to be same as for WECOMA, if not known to differ.
** Has been altered; but probably is similar to other ships in class.

SHIP NAME	YEAR BUILT/REFIT	LENGTH/ BEAM	ENDURANCE (DAYS)	ENDURANCE (MILES)	SCIENCE BERTHS	CREW BERTHS	CRUISING SPEED	MAX. SPEED
UNOLS Small, General-Purpose	—	<150	21	5,000	12–16	<10	12 kts	?
CAPE HATTERAS	1981	135	24	5,800	11	10	10 kts	12 kts
POINT SUR	1981	135	21	5,000	12	9	10 kts	11.5 kts
ALPHA HELIX	1965	133	30	6,500	15	8	10 kts	11 kts

SHIP NAME	SEAKEEPING	STATION KEEPING	ICE CLASS	DECK WORK AREA	A-FRAMES	CRANES	WINCHES
UNOLS Small, General-Purpose	9 kts to SS 4 4 kts to SS 6	Normal thru SS 4	C	1,500 ft^2	1	2	2
CAPE HATTERAS	?	?	?	1,000 ft^2	1	2	3
POINT SUR	9 to SS 4, Sta in SS 6	Normal thru SS 5	?	1,100 ft^2	1	2	3
ALPHA HELIX	10 to SS 5, 4 to SS 6	Normal thru SS 4	C	1,280 ft^2	1	1	2

SHIP NAME	NUMBER OF LABS	LAB AREA	VANS	WORK BOATS	SCIENCE STORAGE	ACOUSTICAL SYSTEMS
UNOLS Small, General-Purpose	2–3	1,000 ft^2	1	1	1,250 ft^3	3.5, 12 kHz
CAPE HATTERAS	3	700 ft^2	?	1	?	3.5, 12 kHz
POINT SUR	3	700 ft^2	?	1	?	3.5, 12, 28 kHz
ALPHA HELIX	3	708 ft^2	none	2	1,120 ft^3	3-40 kHz, 28 kHz

SHIP NAME	NAVIGATION COMMUNICATIONS	EXTERNAL COMMUNICATIONS	SAT. DATA ACQUISITION	SHIP CONTROL	PROBLEMS
UNOLS Small, General-Purpose		GPS, LC	VHF, UHF, Fax	Yes	see SMRs
CAPE HATTERAS	GPS, LC	Sat, VHF, HF	Yes	?	
POINT SUR	GPS, LC	Sat, HF, VHF	Yes	?	
ALPHA HELIX	GPS, LC	Sat, HF, VHF	VHF	Bow Thruster, Auto Pilot	