UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

Scientific Requirements for the UNOLS Fleet

A Report of the
UNOLS Fleet Improvement Committee

Prepared as Part of an
Overall Fleet Planning Study

UNOLS Fleet Improvement Committee

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James W. Murray,
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PREFACE

One objective of the UNOLS Fleet Improvement Committee is to maintain a current assessment of the scientific requirements for the UNOLS fleet. In 1987, a subcommittee was appointed to reassess these requirements.

This report is the result of their analysis completed in late 1987. We hope that it will be of use in continued overall fleet planning. We thank the subcommittee members, and especially the chairman James Murray, who drafted this report.

UNOLS Fleet Improvement Committee
February 1988

Scientific Requirements for the UNOLS Fleet

I. Background

One of the main objectives of the UNOLS Fleet Improvement Committee (FIC) is to amplify and update the UNOLS Fleet Improvement Plan. This requires a continued reassessment of the number and mix of ships and their science mission requirements.

At present (11/87) the UNOLS fleet consists of 7 large ships (class II: 200-250 ft), 7 intermediate ships (class III: 150-199 ft) and 6 small ships (class IV:100-149 ft). UNOLS also supports 4 ships that are smaller than class IV. The only recent new construction was two general purpose class IV ships built in 1981.

The number of ships in the core academic fleet from 1970 to 1985 is shown in Figure 1 and the average age is shown in Figure 2. These charts do not include the FRED MOORE (1984 and 1985) or the LAURENTIAN (1985) which were in the UNOLS fleet for a short time.

The situation for the large ships is most crucial since 4 of these ships were built before 1965. Plans for their replacement need special attention. Two of the large ships (class II), the R/V KNORR and R/V MELVILLE, may be stretched and refit over a two-year period beginning in the fall of 1988. The construction of a new AGOR 23 with ONR funds is scheduled for 1990 or 1991 and will be compensated by the layup of an AGOR-3 hull (CONRAD, WASHINGTON, or THOMPSON). ONR funds are also budgeted for the construction of an AGX sometime after 1990; an expected result is the retirement of the two remaining AGOR-3 vessels. In the next 5 or 6 years, NSF plans to acquire a research ship with ice breaking capability through the Division of Polar Programs (DPP) and three new research vessels (2 large general purpose and 1 smaller ice strengthened) through the Division of Ocean Sciences. The new DPP ship will probably not be part of the UNOLS fleet.

Figure 1. The number of ships in the core academic fleet, 1970-1985.

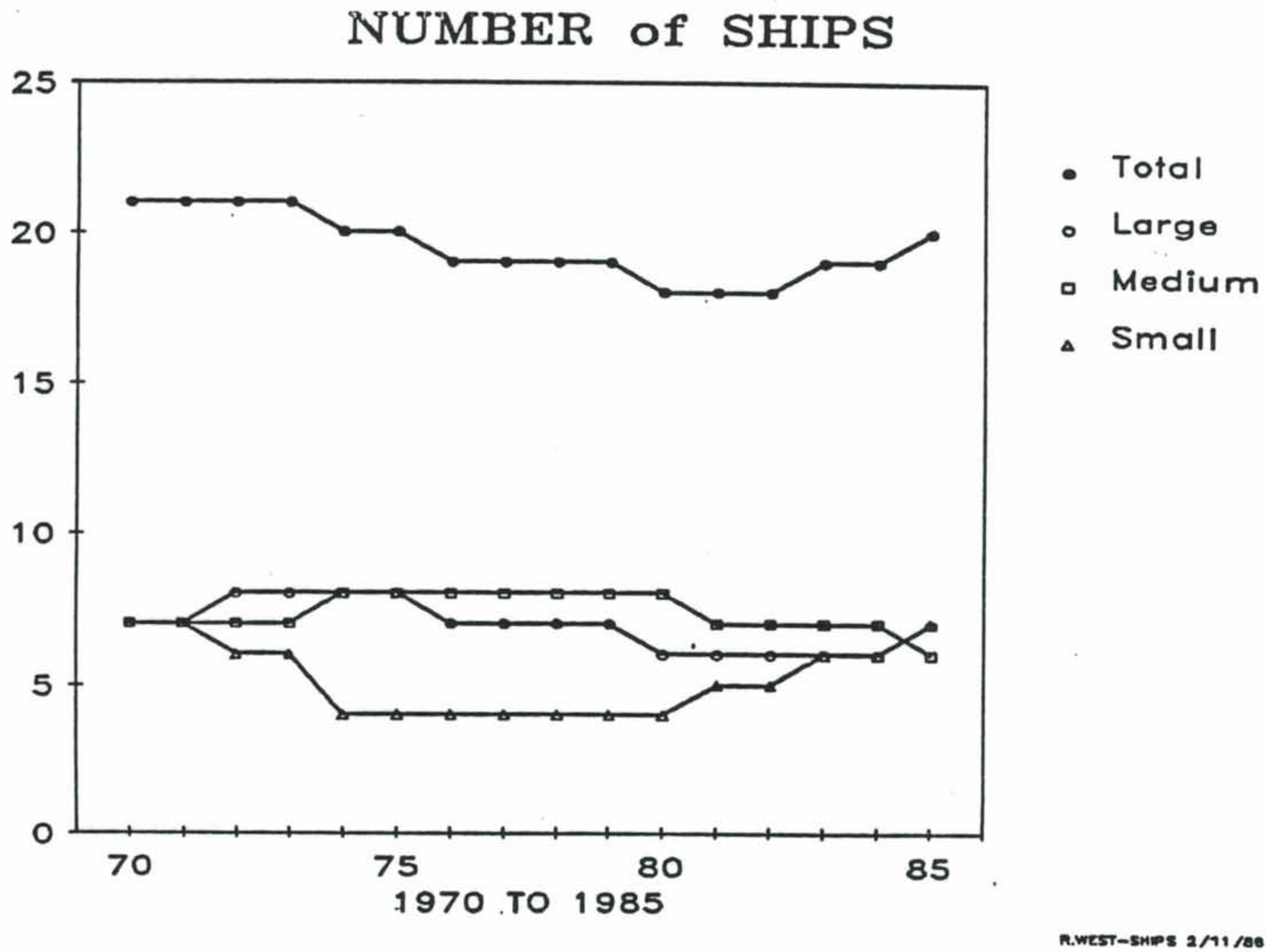
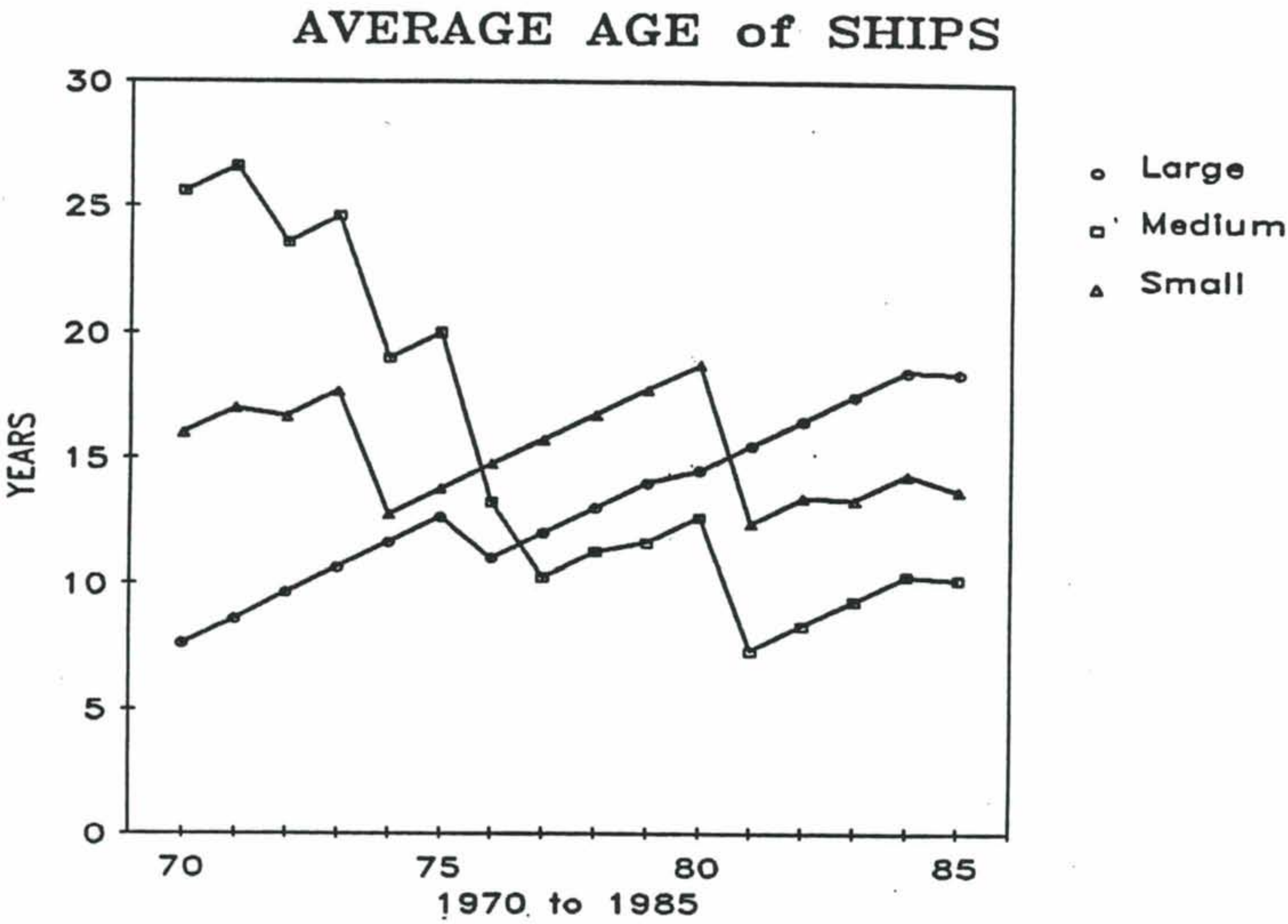


Figure 2. The average age of ships in the core academic fleet, 1970-1985.



As new ships are coming on line and older ships are being retired, a restructuring is occurring in oceanographic research. Large scale initiatives are planned that will tackle problems of global scale (for example, global climate change). These global programs call principally for larger vessels although we anticipate that the need for smaller vessels will remain strong. NSF has responded to these plans by projecting significant increases in research and ship support, and other funding agencies may follow their lead. This suggests a potential problem: plans are being prepared to lay up large research vessels just as the demand for large ship time could increase dramatically.

Therefore, the FIC appointed a subcommittee of R.T. Barber, M.G. Langseth and J.W. Murray (chairman) to examine the demands of oceanographic science for ship use. Two approaches were taken: first, to evaluate the needs of new large research initiatives; second, to examine funding agency plans for current and projected budgets. The objective is to determine whether the fleet capability projected in the UNOLS plan is adequate for the scientific research planned. Will our fleet meet the demands of the next two decades?

II. The Ocean Sciences: Core Research Program

The core research program in ocean sciences consists of individual projects supported primarily by NSF, ONR and to a lesser extent by DOE, NOAA, NASA and USGS. Long range projections of NSF support have been made in the NSF Long Range Plan. The new initiatives that are included in the Global Geosciences Program are the featured part of that plan. Nevertheless, the NSF long range plan recognizes that the core programs in biological, chemical and physical oceanography, and marine geology and geophysics will continue to support relatively small projects by individual investigators.

NSF anticipates that after 1988 the increases in support will be due largely to the new initiatives. Because these initiatives have not yet influenced UNOLS ship usage, the summary of UNOLS fleet statistics as prepared by the UNOLS office is the best estimate of the present demand by the core programs. Appendix A presents UNOLS fleet statistics. Table 1 gives a detailed five-year summary; Table 2 presents the short-term projection for 1987-1988. Table 3 is the five-year fleet history for all ships in the UNOLS fleet. Figures 1, 2, and 3 in the text are based on these tables. The condensed summary in Table 1 below shows the number of ships involved and the total number of days supported (class II, III and IV ships only). The UNOLS summary breaks this down further into the class sizes of ships and the funding sources.

Table 1. UNOLS Fleet condensed summary.

Year	Number of ships	Total days	Average days/ship
1982	17	3,643	214
1983	18	3,697	205
1984	21	4,250	202
1985	21	4,203	200
1986	19	3,766	198
1987(projected)	20	4,250	212
1988(estimated)	19	4,569	240

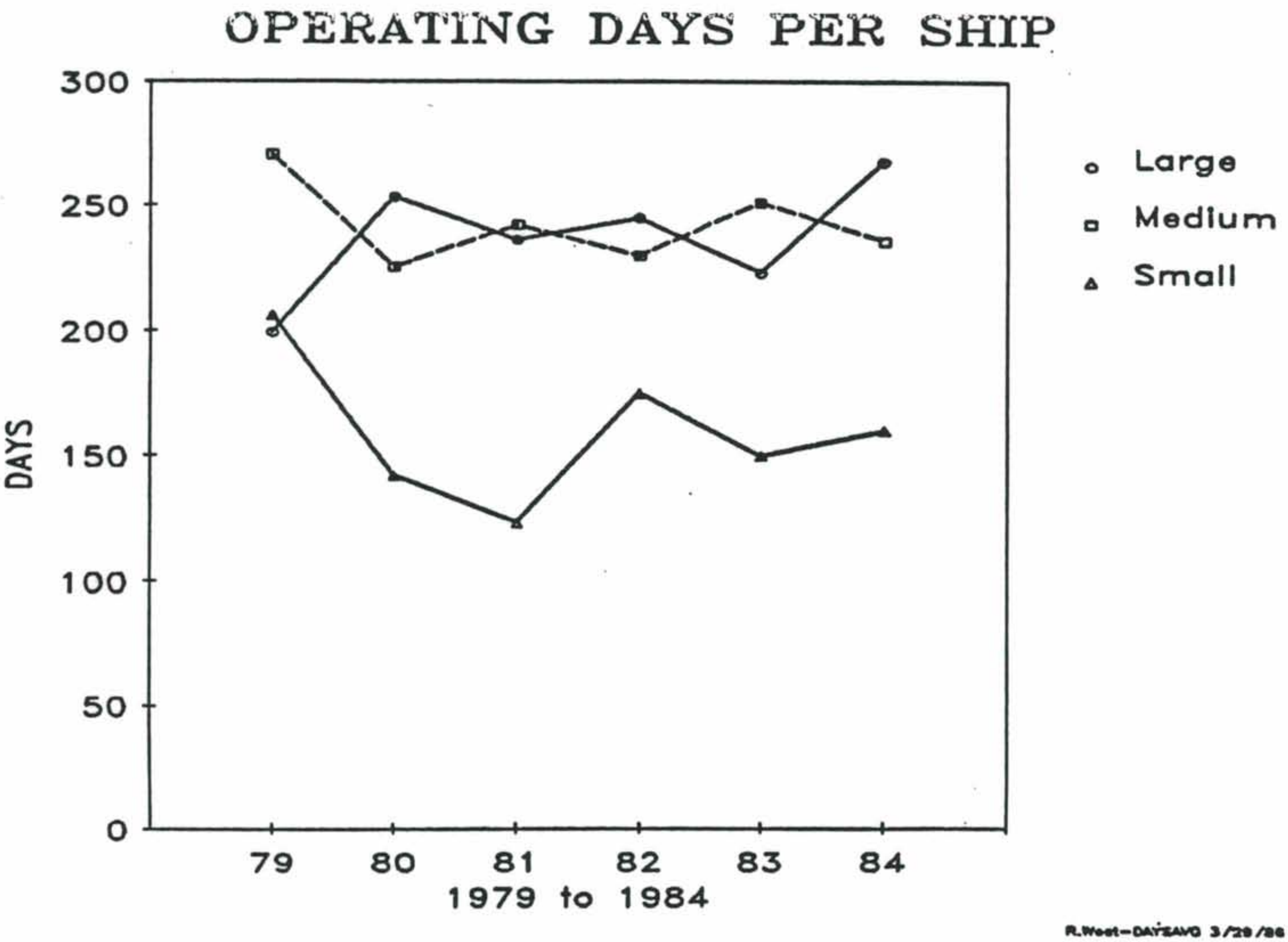
See also Appendix A.

The average days of operation per ship has been about 200 days/ship for all 3 classes. The average for the larger class II and class III vessels has been about 250 days/year (Figure 3).

For the past 4 or 5 years we have had a submersible support ship (ATLANTIS II) in the UNOLS fleet. We can project this need into the 1990's. For our purposes this is considered part of the core program.

The biggest uncertainty in estimating future demands of the core research programs on ship time is evaluating the impact of the initiatives on the core program. The most generous prediction is that the core program demand will remain at its present level or at about 4,000 days per year. The actual usage will probably be less as the initiatives siphon off scientists and program emphasis continues to shift toward the initiatives.

Figure 3. The average number of operating days per ship in the UNOLS fleet, 1979-1984.



III. The Global Ocean Science Program (Science Initiatives)

Natural scientists have increasingly realized there are major environmental questions that need to be addressed on a global scale. Examples include the influence of the ocean on global climate, and the results of the increase in fossil fuel CO_2 and other radiatively important trace gases (e.g. methane, fluorocarbons) in the atmosphere. These concerns have led to the development of several international programs endorsed by the International Council of Scientific Unions (ICSU), the Intergovernmental Oceanographic Commission (IOC), the World Meteorological Organization (WMO), and other scientific and international organizations.

The oceanographic community has responded by planning several scientific initiatives. Federal ocean funding agencies in the U.S. have, in turn, begun programs to address these global initiatives. These initiatives require significant ship time and specific platform types. In this section we review those needs by individual scientific program. We are at an early stage in the planning process and some of these initiatives are further along than others. Nevertheless, this is a logical starting point because, in principle, it is the science that drives the funding support that drives the ships.

This report will follow the organization of A Unified Plan for Ocean Science: A Long-Range Plan for the Division of the Ocean Sciences of the National Science Foundation (Advisory Committee on Ocean Sciences, August, 1987); this NSF report will be cited as Long-Range Plan. Two new broad initiatives are recognized: Global Ocean Studies and Ocean Lithosphere Studies. Each of these initiatives comprises sub-initiatives or components. Together these initiatives have been included in the NSF FY 1987 budget as the Global Geosciences Program. The following discussion references the organizational framework of "Section IV. Budgets" within the Long-Range Plan.

Initiative 1: GLOBAL OCEAN STUDIES

1.A. *Climate, Circulation and Productivity*

1.A.(1) *World Ocean Circulation Experiment (WOCE)*

The fundamental rationale for WOCE is to understand the role of the ocean in climate. The primary scientific objective is to understand the general circulation of the global ocean well enough to be able to model its present state and predict its evolution in relation to long-term changes in the atmosphere. Nine specific scientific objectives are discussed in detail in U.S. WOCE Planning Report Number 3 (1986). The primary practical objective is to provide the scientific background for designing an observing system for long-term measurement of the large scale circulation of the ocean. A key element of the scientific plan is, for the first time, to survey the ocean circulation globally for a brief period and collect a data base that will support the development of global eddy-resolving ocean circulation models. The planning for WOCE has been ongoing since 1980.

As currently envisioned, there are two aspects of WOCE requiring ship time.

a) WOCE Hydrographic Program

A hydrographic survey will extend from about 1991 to 1997. Tracers to be measured include salinity, nutrients, tritium, helium 3 and fluorocarbons. The one-time survey will require about 7 ship years. Repeated survey work may require another 2-4 ship years.

The research vessel requirements were discussed at a U.S. WOCE meeting held at Scripps in January, 1987. These include:

- Approximately 30 berths for scientific personnel
- 2000-3000 sq. ft. of lab space
- 4 specialized 20 ft. lab vans
- Extensive deck space for 18 Gerard bottles and 50-60 drifters
- Wet lab/rosette sampling room
- CTD winch with motion compensation or cable tensioning device and coaxial cable
- Articulated crane
- Extended duration (92% of the legs are less than 45 days but some are as long as 75 days)

The nature of these requirements implies that the largest research vessels will be needed. The hydrographic legs will require a dedicated ship because of the extensive laboratory set up. The KNORR or MELVILLE will be suitable after their stretch and refit. However, it appears at present that only 2 or 3 of the 7 years needed for the basic hydrographic survey and about half of the time required for the repeated surveys (1-2) years will be conducted on U.S. UNOLS vessels. Among the foreign research vessels which might be suitable are:

DISCOVERY (UK, being considered for a refit)
NEW HAKUHO MARU (Japan)
RAPUHIA (converted METEOR) (New Zealand)
METEOR II (FRG)
POLARSTERN (FRG)
MARION DUFRESNE (France)
AFRICANA (R. South Africa)
AGULHAS (R. South Africa)

Proposed track lines for the WOCE Hydrographic Program are shown in Figure 4.

b) Process Studies

Special studies of processes or detailed studies of special regions will also be conducted as part of WOCE. Although the planning is in early stages, these projects will probably require about 4-5 ship years during 1990-1997. Present vessels of the UNOLS fleet will probably meet U.S. ship needs; intermediate size vessels will suffice for much of the work.

1.A.(2) _Tropical Ocean/Global Atmosphere (TOGA)_

The primary scientific objective of TOGA is to describe the tropical oceans and the global atmosphere as a time dependent system to determine the predictability of the system on time scales of months to years.

TOGA is organized and coordinated by an International Scientific Steering Group. In the U.S., an NRC/NAS TOGA Review Panel provides oversight of the U.S. component of TOGA. The NOAA laboratories play a significant role in the U.S. component although NSF provides major funding to academic scientists through the Tropic Heat Program. TOGA has a strong international aspect with much sharing of research vessels and utilization of ships of opportunity. In recent years, foreign research vessels from China, France, Australia and Peru have been utilized. TOGA ship use can be classified as either "monitoring" or "special projects."

a) Monitoring

One 40- to 60-day cruise is conducted each spring and fall on NOAA Class A vessels in the eastern tropical Pacific. Continuing NOAA cruises are projected for the duration of the study (through 1995).

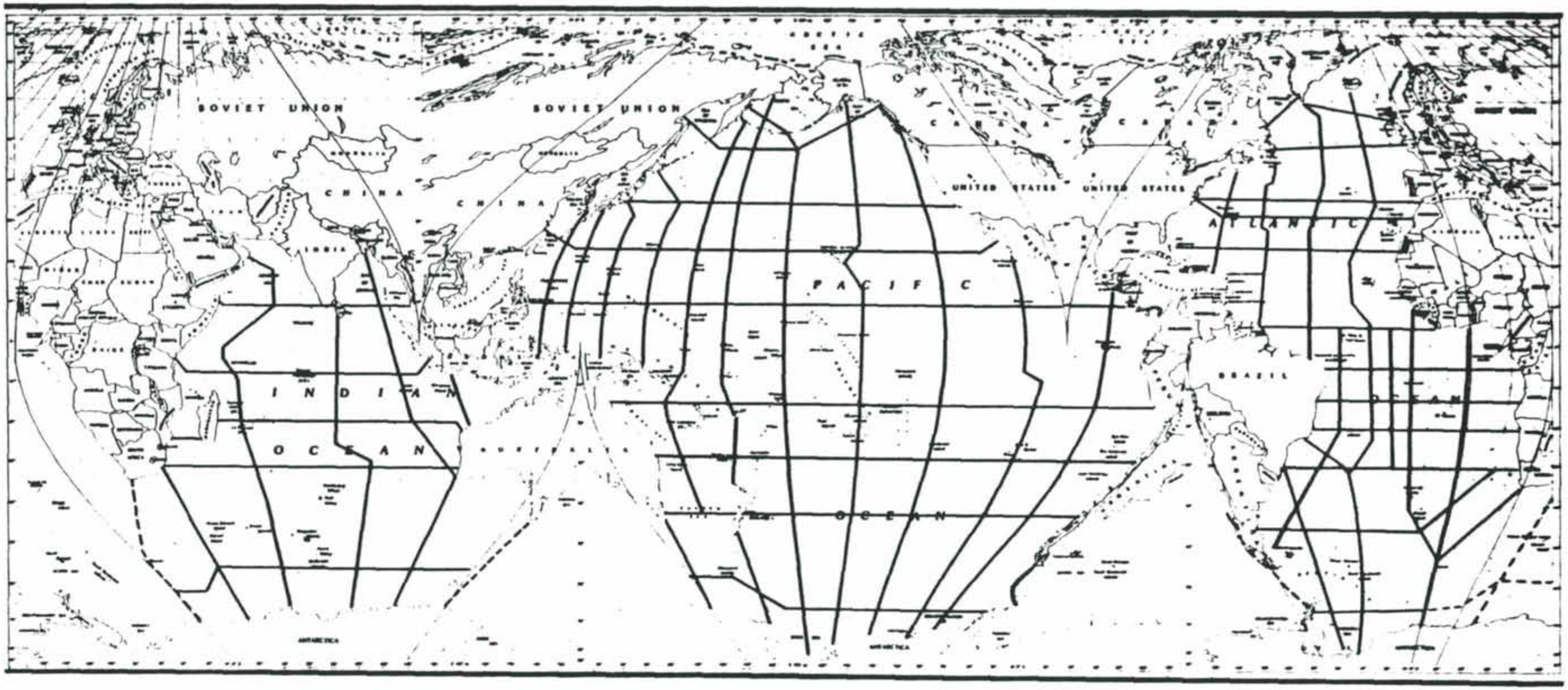


Figure 4. Location of the tentative track lines of the WOCE Hydrographic Program.

b) Special Projects

One or two process-oriented field projects per year use 2 to 4 months of UNOLS ship time.

1.B. *Open Ocean Fluxes or Global Flux Study (GOFS)*

GOFS was born out of a desire to understand how to predict the fate of fossil fuel CO_2 in the ocean. Its main goal is to determine on a global scale the physical, chemical and biological processes controlling the time-varying fluxes of carbon and associated biogenic elements in the ocean and to evaluate the exchanges with the atmosphere, seafloor and continental boundaries. The aim is to understand the processes governing the production and fate of biogenic materials in the sea well enough to predict their influence on and responses to, global scale perturbations. GOFS will be the U.S. component of an internationally coordinated decade-long Joint Global Ocean Flux Study (JGOFS). GOFS planning began with a scientific meeting at Woods Hole in September, 1984.

Present plans are for three parts to the field program.

1) Global Survey

A global survey of the oceanic CO_2 system will be conducted in cooperation with WOCE. Small volume samples for total CO_2 and either pCO_2 or alkalinity will be collected during the WOCE global survey. It has been agreed that GOFS work on CO_2 parameters will utilize 2 of the 25 to 30 berths required by WOCE. A third WOCE berth has been requested by GOFS for a pigment analysis program for satellite color calibration.

In addition, GOFS will probably require 1 to 2 additional ship years on UNOLS vessels over the span of the global survey.

2) Time Series Stations

Data sets are needed to describe seasonal and interannual time scales which may be obtained in part by establishing time series stations at diagnostic locations. Ease of access is also an important factor for locating such stations and the preliminary plan is to establish these stations near islands (for example, stations off Bermuda and Hawaii). Local non-UNOLS ships could be used at each location, and it is unclear whether any of this work will be done from UNOLS vessels.

3) Process-Oriented Studies

Research cruises (perhaps multiship) will be conducted in key oceanographic areas to study the numerous processes that control the dynamics of biogeochemical cycling in the ocean. International cooperation in these projects will be through JGOFS. Planning is moving rapidly at present and it looks like the demand for the U.S. UNOLS fleet will be for 9 months of ship time per year for about 10 years. The initial plan is for a North Atlantic program that will involve 1) transect studies, 2) time series studies, and 3) process studies. A North Pacific planning meeting will be held in February, 1988. Coordination with WOCE is being explored. Because most of these studies will be multi-investigator interdisciplinary projects, large research vessels will receive most of the use. The minimum suite of measurements (defined as level 1) will require approximately 13 investigators. Level 1 measurements include hydrography, nutrients, oxygen, CO_2, DOC, pigments, ^{14}C productivity, net tows, epifluorescence microbiology, sediment traps and benthic landers. The process studies (level 2) could easily add another 17. Level 2 activities include more microbiology, photosynthesis, isotope geochemistry, upper layer physics, shallow sediment traps, zooplankton, optics, deep water biology, benthos, nanomolar nutrients and organic geochemistry. The only U.S. UNOLS ships in the current fleet adequate for this study will be the KNORR or MELVILLE after their stretch/refit.

1.C. *Coastal Dynamics and Fluxes*

A major component of global ocean fluxes is a scientific understanding of coastal oceanography. A workshop was held at Boulder, Colorado, in March, 1987, to consider plans for U.S. research on the physical oceanography of the continental regions. The participants recommended that a major Coastal Physical Oceanography (CoPo) program be undertaken. Another workshop will be held following the Ocean Sciences Meeting in January, 1988. Present plans include only physical oceanography. No effort has been made to organize equivalent CoChem, CoGeo, or CoBio programs. Though the organization of this program has begun, there has not been sufficient progress to indicate its impact on the UNOLS fleet.

1.D. *Ecosystems Dynamics and Recruitment*

The objectives of this program will be to understand the climate, physical factors and variability in primary production, secondary production and predation that regulate agecohort class success and therefore variability of biological populations. Six working groups have been set up to prepare white papers that will provide the focus for a general meeting in the spring of 1988. At present there is no formal steering committee, but a proposal for planning money has been written by JOI Inc. In this sense it is 3 or more years behind GOFS.

Recruitment research may begin in 1989 or 1990. It will probably not have as many long or regularly spaced cruises as WOCE or GOFS, but probably it will combine biological studies in a framework of good chemical and physical measurements. Ships with large scientific complements and laboratories will be needed because of the interdisciplinary nature of the projects, but they will probably not require a dedicated ship. Some projects may require multi-ship cruises, perhaps in which one large (class II) ship ranges widely while one or two smaller ships (possibly class III or IV) conduct detailed measurements on smaller spatial scales. In this way the study will link small and meso-scale processes.

1.E. *Land/Sea Interface*

The objectives of this program will be to study the interface between the land and ocean with attention to biological productivity, geochemical processes, origin of sedimentary rocks and the evolution of life. A workshop was held in Woods Hole in May, 1987, to advise NSF about research needed in this area. The report of the workshop will be distributed by the end of 1987. Present developments of this initiative give no indication yet of its impact on the UNOLS fleet.

Initiative 2: OCEAN LITHOSPHERE STUDIES

2.A. *Tectonics and structure of submerged continental margins*

There are two distinct types of margins: subduction margins and rifted margins. Both types will be important components of the "ocean lithosphere studies" cited in the NSF Unified Plan for Ocean Sciences.

The major questions that will be addressed on rifted margins are:

* What is the geology, structure and evolution of the continental crust underlying the passive margins? What are the important hydrological, geothermal and geochemical processes occurring in this regime?

* How does the geology vary along a passive margin and with age? What is the relation between tectonic evolution of rifted margins and onshore basins?

Studies of passive margin formation are being actively pursued as part of the core marine geology and geophysics programs, and plans for a program are in the earliest stages of development. However, some estimates of the required shiptime and types of ships can be made. A key element in all passive margin studies will be large aperture multichannel seismic (MCS) surveys using powerful acoustic sources. Some of the studies will be multiship operations. An effective passive margin program will require at least 2 months per year of MCS work using advanced techniques. A small amount of station work by Class II and III ships (2 ship month per year) and up to 2 month per year of deep submersible work will also be required. A five or ten year program will probably not start before 1991.

Addressing problems at subduction or active margins will require quite different techniques. The major questions include:

* What is the structure and composition of the accretionary complexes, the overiding wedge and volcanic zone?
* What are the natures of the many processes active in large sedimentary wedges: deformation, diagenesis, and metamorphism?
* What is the role of fluids in the mechanical, chemical, petrological and thermal regime of accretionary complexes?
* What processes and parameters control the geological and tectonic diversity of subduction complexes?

Field programs addressing these questions will require:

* A combination of high resolution, 3-dimensional and deep penetrating MCS techniques. One or two months per year would be required during a ten year program. The more sophisticated studies may require leasing commercial technology.

* Submersibles will be extensively used for studies of the small-scale structure, sedimentary petrology, and fluid expulsion features.

* Deep tow studies using side-scan sonar and near bottom seismic experiments will be employed.

* Multibeam and side scan bathymetric surveys from surface ships will be a fundamental part of studies of subduction complexes, as will station work to measure heat flow, water flux and *in situ* pore-pressures.

* Deep sea drilling continues to be an important component of studies of subduction zones. Some of the marine geological and geophysical work may be done as surveys in support of drilling.

Many studies of subduction margins are currently in progress as part of the NSF Ocean Sciences core programs. A more structured program could require an additional 1 to 2 ship months per year, assuming that initiation of a subduction margin program would enlist some of the investigators now supported through the core program.

2.B. *Ridge Interdisciplinary Global Experiments (RIDGE)*
The scientific objectives of RIDGE are to obtain a long-term data set to test hypotheses and answer scientific questions regarding ridge crest processes. These include the driving forces of plate tectonics, thermomechanical properties of the oceanic lithosphere and hydrothermal, volcanic and mineralization processes.

Planning for RIDGE has just begun; the initial scientific organizational meeting was held in April, 1987, at Salashan, Oregon. The preliminary scientific plan is for three components that will involve UNOLS ships.

1) Global mapping of the crest of the Mid-Ocean Ridge (MOR)
The goal of this component is to map the axial zone of the MOR along much of its 40,000 km length. The axial survey will include multibeam bathymetry, SEAMARC II surveys, MCS lines along the MOR, as well as gravity and magnetic measurements. Little or no station work will be done by ships engaged in the axial mapping project.

Two to three ship years will be required to carry out the MOR survey in 1990 to 1995. Class II ships that carry SEABEAM, SEAMARC II and MCS will probably be dedicated to the RIDGE survey for significant periods of time. It will be most efficient to use ships that carry both multibeam and MCS capability.

2) Regional studies of segments of the MOR
Up to five segments on the MOR system will be mapped in greater detail. Each segment will be approximately 200 by 500 km. The surveys will include multibeam and side-scan mapping, and will emphasize station work such as dredging and heat flow. Deeply towed vehicles for high resolution bottom studies and submersibles will also be used for this part of the RIDGE program.

Plans are still preliminary, but it is estimated that the detailed study of MOR segments will require 3 to 5 ship years. A mix of class II and III ships could be used for the sampling and station work. The ATLANTIS II is required for the submersible operations, and class II MG&G ships are required for the deep tow and bathymetric work. The time frame for this component of the program will probably be 1990 to 1995.

3) Long-term monitoring stations on the sea floor
A critical part of the RIDGE program is to install instrumented observatories on the sea floor at up to three locations on the axis of the MOR. These observatories will consist of a suite of sea-floor instruments that will monitor areas that are about 30 km along strike and 10 km across. The goal is to record data at these observatories for at least 10 years. A wide variety of instruments will be incorporated into these long-term observatories: seismometers, thermometers, flow meters, photographic monitors of biological and geothermal activity, and others.

Deployment of the RIDGE observatories will require considerable deep submersible time and use of the larger Class II ships. A ship with a large centerwell would be preferred for many of the deployment activities. Visits to the observatories will be made periodically to retrieve data and replenish and refurbish the instrumentation. Much of this work can be done by Class III ships and ships of opportunity. Some ship time will also be required for detailed and high resolution geological surveys of the sea floor in areas where deployments are to be made. We estimate that about 0.5 years of Class II shiptime will be required per deployment of an observatory and about 4 ship months per year for maintenance of all installations during the period from 1992 to 2002.

Multichannel seismic (MCS) technology

MCS studies warrant further discussion because they require increasingly expensive systems and over the past decade the systems in the academic community have been hard to support financially. At present there are two vessels in the UNOLS fleet with MCS capability, R/V CONRAD and R/V MOORE. The MCS systems currently owned by the academic community are much below state of the art, but recent NSF funded improvements in the two systems have made them adequate for most projected fundamental research in marine geoscience.

The level of support for both MCS ships over the past few years has been around 300-350K per year, which translates into about 3 to 4 months of ship time. The current use is a mix of individual projects supported by NSF as well as geophysical site surveys in support of the Ocean Drilling Program.

The projected use MCS can be broken down as follows:

1. Core programs are the main source of funding for MCS. The traditional support is 1-2 months per year.
2. ODP site surveys currently use 1 to 2 months per year. Although the 1988 USSAC program plan requested a doubling of funds for regional geophysics and site surveys, NSF has chosen to keep the funding at current levels. Thus, an increase in the immediate future is not likely.
3. If the new Ocean Science initiatives in "Ocean Lithosphere Studies" come to fruition, the utilization of the academic MCS systems for these programs could amount to 3 to 5 months per year. The utilization will probably increase over a 4 to 5 year period.
4. ONR has supported a few MCS experiments in the past, the North Atlantic Transect and the soon to be implemented Western North Atlantic experiment. Currently ONR shows little interest in supporting extramural academic MCS research. Unless prospects change, only a few special programs will be supported by ONR during the next 5 years.

In summary, if plans are realized, over the next five years, MCS usage will grow to about 6 to 8 months per year. The support would derive almost entirely from NSF. Table 2 summarizes scientific demands on the U.S. UNOLS Fleet.

It appears that the demand for the U.S. UNOLS Fleet will increase from its present 20 ships to 24 ships in 1990-1995. The demand from the present global initiatives will then decrease to 21-22 ships in 1995-2000 (Table 3). It is reasonable to expect that the high demands for the new initiatives in 1990 to 1995 will result in some reduction in the core program demand; however, this is difficult to evaluate at present.

The new Global Initiatives will almost certainly result in growth of the field of ocean sciences. These initiatives will either continue in some form or be replaced by new ones so that it is reasonable to predict that a UNOLS fleet of 22 to 24 ships will be needed through the year 2000.

IV. Scientific Support

Another approach to estimating demand for the UNOLS fleet is to look at the past, present, and projected budgets by NSF, ONR and other funding sources. These amounts are summarized in Table 4. Most ship support is provided on a calendar year basis, so this table was prepared accordingly.

The non-ONR ship support figures for the years 1981 to 1988 (projected) were obtained from NSF staff and the UNOLS office. The NSF Long Range Plan (p.77, Table IV-G) shows predictions for ship operations from 1984 through 1996. The NSF plan separates the core program and the global program, which are listed separately in Table 4 together with the total. We have shown only the support projected for ship operations. ALVIN support is not included, but the ATLANTIS II is. Also included in the ship operations budget line is some support for the Ocean Drilling Program, even though Ocean Drilling is also shown separately in the NSF budget (Long Range Plan, p.69). This amount was estimated at about $1.1 million for 1988.

The actual expenditures by NSF and their planning overlap now by 5 years and provide a test of the estimates in the NSF Long Range Plan. The actual growth of NSF ship support is already falling behind the Long Range Plan by about 20% or $5.2 million in 1988!

Table 3. Present estimates of U.S. UNOLS ship needs by the Core Programs and new NSF Global intiatives.

```
                                YEAR
                  1990          1995          2000

                   I-------------------------I--------------------------I

WOCE               I--------------------------------I
                        1+/yr  (50% ≥ class II, 50% class III or IV)

TOGA               I-------------------------I
                        0.33/yr  (50% class III)

GOFS               I-------------------------I
                        0.33/yr  (50% class II, 50% class III)
                   I----------------------------------------------------I
                                0.75/yr  (50% class II, 50% class III)

RIDGE              I-------------------------I
                        0.33/yr  (MCS)
                   I-------------------------I
                        1.5/yr  (≥ class III)

Continental             I-------------------------I
                         0.33/yr  MCS

Margin                  I-------------------------I
                         0.66/yr  (≥ class III)

CORE               I----------------------------------------------------I
                                20/yr  (class II, III, IV)
--------------------------------------------------------------------------------------------------
Total              I----------I
                      24.2
                             I----------------I
                                  25.2
                                              I-------I
                                                22.7
                                                       I---------------I
                                                             20.8
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The ONR ship support amounts for 1981 to 1988 (projected) were obtained from ONR and UNOLS staff. ONR has recently announced a funding enhancement of $5M per year beginning in 1988. This will be added onto $3.6 M which is considered by ONR as their projected base line level prior to this enhancement.

The total number of ship days supported by the three funding sources are shown for 1981 to 1988. These were obtained from the UNOLS fleet statistics summary which is attached as Appendix A. Ship usage is grouped according to class of ship. Only class II, III and IV ships are included.

The relation between ship support and days supported is also given in Table 4. Because large ships are more expensive than small ships, this ratio reflects the mix of ships supported by the different funding sources. It is a good index of the cost of fleet operation. From 1981 to 1988 the cost has been essentially constant in spite of inflation, averaging about $8,500 per day with a standard deviation of about 4%.

One approach for determining the number of ships required is to use the projected budgets for ship support, the projected cost per day, and the average number of days per ship. Although it is not a reasonable long range projection, for the purposes of this exercise we have assumed that the cost per day will remain at $8.5 thousand. In projecting ship support, we assume that actual NSF support will continue to lag behind the long range plan by 20%. Thus, while Table 4 indicates that $61.0 million will be available for ship support in 1989, we use $51.3 million in this calculation. On this basis the budget predicts a demand for 6056 days or 24 ships in 1989, assuming 250 days/ship. It appears that a safe prediction (based on ship support projected to be available) is that requirements for the UNOLS fleet will increase from 20 (at present) to about 24 as the new Global Initiatives come on line. This is consistent with the earlier estimate of 22 to 24 based on the preliminary plans of the specific programs.

Table 4 shows the actual ocean sciences research support (OSRS) (physical, chemical, biological, MG&G) for 1981 to 1987 from the NSF Ocean Sciences Division (from NSF staff) and the predicted values from the Long Range Plan. The plan has separate estimates for core programs, critical needs and global programs (Long Range Plan, pp. 69-70). The actual NSF research support for 1987 ($66.5 million) agrees well with the plan estimate

Table 4: Summary of ship support and UNOLS ship days according to different funding sources. Based on calendar years. Page numbers refer to NSF <u>Long Range Plan.</u>

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Ship Support ($M)																
NSF (Actual)	20.2	20.5	23.6	25.2	25.1	25.2	27.7	30.4								
(2) NSF (LRP Core Programs p77)				25.3	27.1	26.4	26.0	26.0	28.6	31.5	34.6	38.1	41.9	46.1	50.7	55.7
(LRP Global Programs p77)							3.2	9.6	19.8	28.7	37.4	45.1	49.6	53.6	56.2	59.0
(Total)							29.2	35.6	48.4	60.2	72.0	83.2	91.5	99.7	106.9	114.7
ONR	3.4	3.4	3.9	4.0	4.1	3.4	5.7	5.4	←-----(3.6+5)--------------→							
Other	6.0	4.7	5.7	6.8	6.3	4.4	3.6	2.9	←-----(4.0)----------------→							
TOTAL	29.6	28.6	33.2	36.0	35.5	33.0	37.1	38.7	61.0	72.8	84.6	95.8	104.1	112.3	119.5	127.3
Ship Days																
NSF	2364	2570	2690	2956	3013	3056	3151	3083								
ONR	495	394	447	426	446	351	585	1091								
Other	727	679	560	868	744	359	514	395								
TOTAL	3586	3643	3697	4250	4203	3766	4250	4569	6056							
(ships)	(19)	(17)	(18)	(21)	(21)	(19)	(20)	(19)	(24)							
Ship Support/Days ($T)																
NSF	8.54	7.98	8.77	8.52	8.33	8.25	8.66	9.41								
ONR	6.87	8.63	8.72	9.39	9.19	9.69	9.74	7.79								
Other	8.25	6.92	10.2	7.83	8.46	12.3	7.00	7.34								
TOTAL (4)	8.25	7.85	8.98	8.47	8.45	8.76	8.61	8.38	8.47----------------------→							
NSF Ocean Science Division ($M)																
Research Support																
(3) Actual	47.4	47.0	49.9	54.6	58.3	56.9	66.5	74.3								
(1) LRP (OSRS Core Programs p69)				54.7	57.4	55.5	57.8	60.5	65.1	71.6	78.8	86.7	95.3	104.9	115.4	126.9
(OSRS Critical Needs p69)								1.5	21.0	32.8	45.5	49.0	47.7	45.5	45.2	48.6
(Global Program p70)							10.5	20.7	44.9	74.9	103.1	124.9	140.0	147.0	150.5	156.3
Total Research Support							68.3	82.7	131.0	179.3	227.4	260.6	283.0	297.0	311.1	331.8
NSF Science $ ($T) / NSF Ship Days	20.0	18.3	18.5	18.5	19.3	18.6	21.1	24.1								

(1) Science Research Support only, no ship construction or OCFS support included
(2) Ship operations and facilities only, no ship equipment or construction/conversion
(3) Does not include ocean drilling program
(4) The average of this ratio for 1981-1988 is 8.47±0.34 (4%)

($68.3 million). The projected actual budget for 1988 is 10% less, indicating that the LRP may be a little optimistic.

The last row of Table 4 shows the ratio of NSF-OSRS support to NSF ship days. This ratio has been remarkably constant at about $18.5 thousand/day until 1986. The increases in 1987 and 1988 probably reflect planning and equipment items for the new initiatives. Assuming this ratio stays at 18.5 and that the actual NSF-OSRS support continues to lag behind the <u>Long Range Plan</u> by 10% (i.e. $118 million in 1989), the projected need is for 6378 days of ship time in 1989. This is significantly larger than the projection based on ship support; it seems unrealistic to envision the oceanographic community using that much more ship time.

In summary, the projected increases in the ship support and ocean science research support lead to the predictions that the demand for ship time will increase substantially. Although the predictions become less reliable with time, it appears that on the basis of financial support a UNOLS fleet of 24 vessels will be required by 1989.

Appendix A. UNOLS Fleet Statistics

Table 1. Five-Year Summary, 1982-1986

DAYS/Percent

	NSF	ONR	OTHER	TOTAL	AVERAGE DAYS PER SHIP
1982					
Class II (5 ships)	956/78	168/14	102/08	1226/100	245
Class III (6 ships)	875/64	180/13	324/23	1379/100	230
Class IV (6 ships)	739/71	46/05	253/24	1038/100	173
< Class IV (7 ships)	496/66	23/03	237/31	756/100	108
FLEET TOTAL (24 ships)	3066/70	417/09	916/21	4399/100	183
1983					
Class II (5 ships)	836/75	212/19	69/06	1117/100	223
Class III (7 ships)	1166/68	205/12	332/20	1703/100	243
Class IV (6 ships)	688/79	30/03	159/18	877/100	146
< Class IV (7 ships)	484/61	39/05	274/34	797/100	114
FLEET TOTAL (25 ships)	3174/71	486/11	834/18	4494/100	180
1984					
Class II (6 ships)	1225/77	237/15	137/08	1599/100	266
Class III (8 ships)	955/58	189/11	508/31	1652/100	206
Class IV (7 ships)	776/78	0/0	223/22	999/100	143
< Class IV (6 ships)	430/76	30/05	107/19	567/100	94
FLEET TOTAL (27 ships)	3386/70	456/10	975/20	4817/100	178
1985					
Class II (7 ships)	1310/68	352/18	254/13	1916/100	274
Class III (7 ships)	788/67	74/06	315/26	1177/100	168
Class IV (7 ships)	915/82	20/02	175/16	1110/100	158
< Class IV (5 ships)	394/70	33/06	139/26	566/100	113
FLEET TOTAL (26 ships)	3407/72	479/10	883/18	4769/100	183
1986					
Class II (7 ships)	1330/83	172/11	110/07	1612/100	230
Class III (6 ships)	913/77	127/11	151/12	1191/100	198
Class IV (6 ships)	813/85	52/05	98/10	963/100	160
< Class IV (4 ships)	347/70	13/03	133/27	493/100	123
FLEET TOTAL (23 ships)	3403/80	364/09	492/11	4259/100	185
1982-1986 FIVE YEAR TOTALS					
Class II	5657/76	1141/15	672/09	7470/100	249
Class III	4697/66	775/11	1630/23	7102/100	209
Class IV	3931/79	148/03	908/18	4987/100	156
< Class IV	2151/68	138/04	890/28	3179/100	109
FIVE YEAR FLEET TOTAL	16,436/72	2,202/10	4,100/18	22,738/100	182
AVERAGE/YEAR	3,287	440	820	4,548	-

Appendix A. UNOLS Fleet Statistics

Table 2. Short-Term Projection

DAYS/Percent

	NSF	ONR	OTHER	TOTAL	AVERAGE DAYS PER SHIP
1987					
Class II (7 ships)	1401/77	293/16	117/07	1811/100	258
Class III (7 ships)	1076/71	252/17	185/12	1513/100	216
Class IV (6 ships)	674/73	40/04	212/23	926/100	154
< Class IV (4 ships)	479/81	10/02	104/17	593/100	148
FLEET TOTAL (24 ships)	3630/75	595/12	618/13	4843/100	202
1988					
Class II (7 ships)	1543/77	418/21	37/02	1998/100	285
Class III (6 ships)	690/46	624/42	185/12	1499/100	250
Class IV (6 ships)	850/79	49/05	173/16	1072/100	179
< Class IV (4 ships)	328/75	16/04	94/21	438/100	110
FLEET TOTAL (23 ships)	3411/68	1107/22	489/10	5007/100	218

Table 3: Five-Year Fleet History, 1982-1986

1981	1982	1983	1984	1985	1986	1987
Class II (5)	**Class II (5)**	**Class II (5)**	**Class II (6)**	**Class II (7)**	**Class II (7)**	**Class II (7)**
MELVILLE	MELVILLE	MELVILLE	MELVILLE	MELVILLE	MELVILLE	MELVILLE
KNORR	KNORR	KNORR	KNORR	KNORR	KNORR	KNORR *28*
ATLANTIS II	*4*	*10*	ATLANTIS II *13*	ATLANTIS II	ATLANTIS II	ATLANTIS II
1 *	CONRAD	CONRAD	CONRAD	CONRAD	CONRAD	CONRAD
THOMPSON	THOMPSON	THOMPSON	THOMPSON	THOMPSON	THOMPSON	THOMPSON
WASHINGTON	WASHINGTON	WASHINGTON	WASHINGTON	WASHINGTON	WASHINGTON	WASHINGTON
				MOANA WAVE *17*	MOANA WAVE	MOANA WAVE
Class III (8)	**Class III (6)**	**Class III (7)**	**Class III (8)**	**Class III (7)**	**Class III (6)**	**Class III (7)**
VEMA	*5*	ENDEAVOR	ENDEAVOR	ENDEAVOR	ENDEAVOR	ENDEAVOR
ENDEAVOR	ENDEAVOR	OCEANUS	OCEANUS	OCEANUS	OCEANUS	OCEANUS
OCEANUS	OCEANUS	WECOMA	WECOMA	WECOMA	*23*	WECOMA
WECOMA	WECOMA	GYRE	GYRE	GYRE	GYRE	GYRE *29*
GYRE	GYRE	ISELIN *11*	ISELIN	ISELIN	ISELIN	ISELIN
ISELIN	*6*	NEW HORIZON	NEW HORIZON	NEW HORIZON	NEW HORIZON	NEW HORIZON
NEW HORIZON	NEW HORIZON	KANA KEOKI	FRED MOORE *14*	FRED MOORE	FRED MOORE *26*	FRED MOORE
KANA KEOKI	KANA KEOKI		KANA KEOKI	*18*		
Class IV (6)	**Class IV (6)**	**Class IV (6)**	**Class IV (7)**	**Class IV (7)**	**Class IV (6)**	**Class IV (6)**
CAPE FLORIDA *2*	CAPE FLORIDA	CAPE FLORIDA	CAPE FLORIDA	CAPE FLORIDA	PT SUR *24*	PT SUR
ALPHA HELIX	CAPE HATTERAS *7*	CAPE HATTERAS	CAPE HATTERAS	CAPE HATTERAS	CAPE HATTERAS	CAPE HATTERAS
CAPE HENLOPEN	ALPHA HELIX	ALPHA HELIX	ALPHA HELIX	ALPHA HELIX	ALPHA HELIX	ALPHA HELIX
EASTWARD *3*	CAPE HENLOPEN	CAPE HENLOPEN	R. SPROUL *15*	R. SPROUL	R. SPROUL	R. SPROUL
VELERO IV	*8*	VELERO IV	CAPE HENLOPEN	CAPE HENLOPEN	CAPE HENLOPEN	CAPE HENLOPEN
R. WARFIELD	VELERO IV	R. WARFIELD	VELERO IV	VELERO IV	*25*	R. WARFIELD
	R. WARFIELD		R. WARFIELD	R. WARFIELD	R. WARFIELD	
< Class IV (7)	**< Class IV (7)**	**< Class IV (7)**	**< Class IV (6)**	**< Class IV (5)**	**< Class IV (5)**	**Class IV (4)**
SCRIPPS	SCRIPPS	SCRIPPS	SCRIPPS	*19*	*27*	BLUE FIN
CAYUSE	CAYUSE	CAYUSE	CAYUSE	CAYUSE	BLUE FIN	LAURENTIAN
LONGHORN	LONGHORN	LONGHORN	*16*	BLUE FIN	LAURENTIAN	BARNES
BLUE FIN	BLUE FIN	BLUE FIN	BLUE FIN	*20*	BARNES	CALANUS
HOH	HOH *9*	ONAR	ONAR	LAURENTIAN *21*	CALANUS	
ONAR	ONAR	BARNES *12*	BARNES	BARNES		
CALANUS	CALANUS	CALANUS	CALANUS	CALANUS		

* Numbers in italics refer to notes on next page.

Table 3: Notes

1. CONRAD out of service (midlife) 1981.
2. CAPE FLORIDA entered fleet midway 1981.
3. EASTWARD operated only 2 days 1981.
4. ATLANTIS II out of service 1982 (modification); CONRAD back.
5. VEMA retired 1982 (no sponsored use).
6. ISELIN did not operate 1982 (no schedule).
7. CAPE HATTERAS operated all of 1982.
8. EASTWARD retired from fleet.
9. HOH retired during year.
10. ATLANTIS II out of service 1983 (modifications for ALVIN).
11. ISELIN back in operation 1983.
12. BARNES entered fleet late in 1983.
13. ATLANTIS II returned to service 1984.
14. FRED MOORE entered fleet 1984.
15. ROBERT SPROUL entered fleet late in 1984.
16. LONGHORN out of fleet 1984.
17. MOANA WAVE stretched to CLASS II 1985.
18. KANA KEOKI retired 1985.
19. SCRIPPS retired 1985.
20. ONAR retired 1985.
21. LAURENTIAN added 1985.
22. ISELIN operated only 4 days in 1985.
23. WECOMA did not operate in 1986.
24. CAPE FLORIDA transferred, renamed POINT SUR in 1986 (all vessel use listed herein).
25. VELERO IV retired 1986.
26. FRED MOORE had no federally funded use in 1986.
27. CAYUSE out of service 1986.
28. KNORR out of service - 6 months.
29. GYRE out of service - 6 months.