EXECUTIVE SUMMARY

Federal funding agencies are facing declining or, at best, constant budgets. The two primary support agencies for the UNOLS Fleet of academic research vessels (NSF and ONR) are no exception. During the period of fiscal austerity, the arrival of the long-awaited Navy AGOR Class I research vessels ROGER REVELLE and ATLANTIS in 1996 and 1997, respectively, will further increase operational costs for the federally-supported UNOLS Fleet. Budget projections indicate that by 1997 the academic fleet, which at that point will be the most scientifically capable in UNOLS history, will face a $13 million shortfall. This is equivalent to the annual operating costs for two Class I vessels and one intermediate class research vessel.

Over the short-term (1-3 years), it is possible to reduce operations for the entire UNOLS Fleet, but for the long-term (>3 years) it is not prudent to operate the 27 ship fleet on marginal schedules. The only viable solution to sustained budget limitations is to: 1) reduce the size of the UNOLS Fleet or; 2) expand the user base. The forces that have lead to the configuration of the current fleet include a host of important science initiatives ranging in scale from global to coastal. Given that the delays inherent in building oceanographic field assets (10-15 years) is much longer than the associated science initiatives (3-7 years) . The issue of fleet reduction is one that needs to be approached most carefully. In essence, until concerted efforts are made to build new partnerships with potential users of the UNOLS Fleet, we consider it unwise to reduce it. For example, possible multi-agency coordination for coastal zone research and fisheries should be carefully considered. However, if it ultimately becomes necessary to reduce its size then the current mix of capabilities in the UNOLS Fleet should be maintained.

Even in the face of limited resources, the UNOLS/science community should continue planning for new assets that are vital to oceanographic science - the Arctic Research Vessel and platforms to support coastal science. Finally, there is little question that new observational technologies will emerge and, further, that they will greatly enhance both land-based and sea-going science. Specifically, AUVs, ROVs and buoys equipped with multiple sensor systems (optical, acoustical, and chemical) will improve our understanding of oceanographic processes just as they will provide the academic research fleet with the capability of carrying out synoptic, three-dimensional studies in the open ocean.

PROJECTIONS FOR UNOLS' FUTURE - SUBSTANTIAL FINANCIAL CHALLENGES

I. INTRODUCTION

Over the past six years there has been unprecedented construction/renovation activity that has substantially expanded UNOLS' major sea-going assets. During this period the United States Navy has funded construction of three Class I (>250') vessels - THOMPSON (1991), REVELLE (1996), and ATLANTIS (scheduled for 1997). In addition, ONR has supported extensive modifications for KNORR (1991) and MELVILLE (1991). In total, the Navy's investment over this period is in excess of $150 million. The National Science Foundation also contributed significantly to improving our sea-going assets by acquiring the research vessel EWING (1990) with its special geophysical capabilities and by supporting extensive mid-life refits, starting in 1991, for its three intermediate class vessels - ENDEAVOR, OCEANUS, and WECOMA. In short, since 1990, fully one third of the UNOLS Fleet (i.e. nine vessels) - including all of the large vessels - underwent a major transformation. The global science initiatives that are currently underway (WOCE, JGOFS and RIDGE) have relied heavily on the new and improved Class I vessels, and it is clear that without these ships we would not be in a position to support the extensive sea-going science operations these diverse programs require. Indeed the configuration and justification for these vessels were driven by the scientific requirements to support major expeditionary science projects like WOCE, JGOFS, RIDGE and GLOBEC. Importantly, the modernization program was predicated upon funding agency projections of significant growth in out-year science funding.

While UNOLS now has a more capable oceanographic fleet and more large vessels than at any time in its history, there is continuing concern that federal science budgets have not kept pace with this growth and are now insufficient to fully support the existing 27 ship fleet. Indeed, funding shortfalls in the 5 to 10% range have been characteristic of the UNOLS Fleet support for a number of years. However, the completion of REVELLE in 1996 and ATLANTIS in 1997 and the addition of an Arctic research platform possibly in the very late 1990's will further strain federal support resources unless additional operating funds are provided. Yet, for the first time federal resources may be static or declining. It is noteworthy that between the time the latest UNOLS fleet modernization program was conceived (early 1980's) and its realization (late 1990's), the Cold War ended. The Cold War was a major impetus to both Naval and national ocean research programs.

Some insights into the current situation can be gained by examining federal funding for the UNOLS Fleet over the past 27 years (Figure 1). In 1968 a substantial portion (34%) of federal support for UNOLS ship operations came from the Office of Naval Research with the National Science Foundation accounting for 57% of the total expenditures. Examination of the trends in federal funding for UNOLS (Table 1) shows that there has been a marked increase in the proportion of operating funds supplied by NSF to 75% in 1995. Over this period, NSF's funding for the UNOLS Fleet has increased more than five-fold, from $6.8 million in 1968 to $37.2 million in 1995. During the same period ONR's funding for UNOLS operations increased only 1.5 times ($4.1 million in 1968 to $6.4 million in 1995). Given the rate of inflation over this period, ONR's 1995 ship operations expenditure has less purchasing power now than its 1968 allocation. ONR's contribution in 1995 is only about one in every eight dollars and essentially matches that of all other federal/state contributors. The situation in 1968 was markedly different - at that time ONR's contributions were four times those of all other state and federal agencies. In short, UNOLS has evolved to the point where it is largely an NSF-supported operation.

TABLE 1. Trends in Federal Support ($M) for UNOLS over the past 27 years

Year	NSF	ONR	OTHER	TOTAL
1968*	6.8	4.1	1.0	11.9
1975	12.6	3.6	2.9	19.1
1985	25.9	4.1	5.8	35.8
1995	37.2	6.4	6.0	49.6

*1968 is the first year for which numbers are available

These long-term trends in agency support for the UNOLS Fleet, the growing presence of the larger, more expensive research vessels that are integral to global science initiatives, coupled with the fiscal realities that are being imposed by the federal government, make it prudent for us to question (a) whether or not there will be sufficient science and operational funding in the future for ocean science to continue support of the entire UNOLS Fleet as currently configured and (b) if not, what actions might be taken to maximize the effectiveness of the U. S. ocean science enterprise within available resources.

Toward this end, an ad hoc UNOLS Committee consisting of Peter Betzer, Chair, Dennis Hayes, Bob Knox, Chris Mooers, Dick Pittenger and Bob Wall was asked to consider the following:

1. The budget projections of Don Heinrichs, NSF, for UNOLS ship operations, giving special regard to the possible expanded participation of supporters/users other than NSF (e.g., ONR, NRL, NOAA, USGS, MMS, DOE, EPA and NASA);

2. Within reasonable budgetary assumptions, assess a general model for the UNOLS Fleet requirements for supporting science. This assessment should be based on the model the UNOLS Fleet Improvement Committee projected (in 1995) for the year 2000 but modified to reflect more accurately current status and updated projections;

3. If any imbalance exists between requirements and resources, offer suggestions as to how we might best reconcile the mismatch. (i.e., increase the user base, reduce the fleet, and/or adopt different modes of operation);

4. What UNOLS operational/fiscal changes would work best for the U.S. oceanographic community?;

5. Could fleet realignment lead to a more effective use of our ships? If so, what are the particular criteria that should be used to evaluate the merits of shifting sea-going assets.

The following is the committee's synthesis of the available data from federal agencies related to the above issues. In addition, the committee presents some implications from these data and recommends some courses of action for UNOLS and other elements of the community to pursue in the near future. It is important to note that the report does not provide a complete set of answers to the topics cited above.

II. FEDERAL FUNDING PROSPECTS

As all who project future budget prospects know, there are large areas of uncertainty that must be borne in mind. First, the political process itself is far from predictable. Major parts of the federal budget can undergo fluctuations that dwarf the sums considered here. Further, they can do so on short time scales. There is a severe mismatch between the political fluctuation time scale and the ship planning/funding/construction time scale, making it important not to overreact and eliminate ships that might have real prospects of revitalized support in a year or two or even five. Note again that it took over 15 years to acquire the new ATLANTIS - AGOR 25. This attitude is not to take a Pollyannish view of current budget difficulties, but rather recognizes that replacing a scrapped ship is something that cannot be done quickly. Thus, such a decision should be weighted by the probability that any serious underlying

budget problem is indeed of long duration. Second, within any given agency, it does not always follow that cuts are distributed pro-rata down the several levels to the sub-budgets of interest to UNOLS. Specific policy and budget decisions can modulate this effect. The ocean science community need not and should not be inert in this arena, nor is it. Third, the overall federal budget-cutting activity can lead to counter-intuitive effects in the specific micro-context of the UNOLS Fleet and its sources of support. There is current evidence that the ability of NOAA to support its own in-house seagoing research and survey work on its own ships may suffer fairly rapid near-term erosion, as has been the case for the Navy labs in recent years. Navy and NOAA sea-going science and survey demand might therefore be channeled in part onto UNOLS ships, increasing the user base and funding for the fleet or at least blunting the effective decrease of conventional NSF and ONR funding to a degree. The outcome for this possible alternative use is far from certain, but it is not one that can be dismissed out of hand.

With these caveats in mind, the committee members have met with agency staff and followed closely the current Congressional activity with regard to authorizing and appropriating legislation pertinent to ocean science. The picture that emerges from these discussions and assessments is as follows (Note - all references to funding levels are in current dollars and ignore inflation):

National Science Foundation -

NSF's funding appears likely to decrease slightly over the next several years. There is no evidence suggesting any significant change in allocations internal to NSF. Currently (FY '95), the NSF Ocean Sciences budget spends about 22 cents of every dollar on ship support. The total Ocean Sciences budget (less the Ocean Drilling Program) is $153M and $33.9M (average of FY '93-95) is used for operational support of oceanographic facilities. The present balance between science and facilities will probably be maintained. Any NSF support for major new facilities will require commensurate science support.

Office of Naval Research and other Navy -

The Navy is projecting that their use of UNOLS ships will increase beginning in 1996 (see Figure 2). Navy funding for academic oceanographic facilities has fluctuated widely over the past five years, ranging from $3.1M to $6.4M per year. In 1995, ONR budgeted $103M for basic (6.1) ocean science projects, and they have averaged (FY '93-95) $4.9M for operational support of academic oceanographic platforms. The allocation of five cents on the ocean science dollar for operations of the UNOLS Fleet, in which the Navy is a major owner, is low when compared to NSF. ONR is adjusting the algorithm used to calculate the ship "cost" seen by individual science programs. Eighty percent of the ship expenses will come from a budget for ship support, while the remaining 20% will come from the science program budget. This will ease the direct impact of field programs on the science budget, and it should stimulate use of sea-going platforms. Additionally, the Navy is seriously considering ways of expanding its use of the UNOLS Fleet by in-house scientific staff at NRL and by the Naval Oceanographic Office for surveys.

National Oceanic and Atmospheric Administration -

The NOAA budget for extramural ocean science programs (NURP, Sea Grant, Cooperative Research Institutes, Coastal Ocean Program, Climate and Global Change Programs) in 1995 was $79M. Over the past three years, NOAA support for UNOLS operations has averaged $2.1M. The bulk of NOAA's oceanic research has been conducted on NOAA vessels and, as a result, their past support for academic sea-going facilities has been weak (3% of the UNOLS budget). Many of the NOAA ocean science programs such as Sea Grant use essentially no ship time. Both internal and external marine program funding within NOAA appear likely to be reduced substantially for FY '96. This new level will likely reflect the future operational base for NOAA. There remains much uncertainty about how Congress will deal with NOAA's programs and operations, and how NOAA will respond to what it is dealt by Congress.

Nevertheless, it would appear that past NOAA support for UNOLS assets (including NURP support for ALVIN and HBOI ships) amounting to $2-3 M/yr could disappear. Countering this are possibilities that some or much of NOAA's in-house marine research (and even fisheries, but probably not so-called hydrographic survey work) might be switched over time from NOAA fleet ships to UNOLS vessels.

Environmental Protection Agency -

The EPA has the fourth largest budget dedicated to ocean science research ($41M) among Federal agencies. The agency's ocean science mission is primarily monitoring and research in the coastal zone. The EPA has operated a small fleet of coastal vessels (primarily the ANDERSON) to support this research. All their vessels are aging and they may not be replaced. The EPA is unlikely to become a major user of large vessels unless they begin interdisciplinary studies of coastal pollution that require large science parties. However, EPA could use a significant amount of Class IV vessel time in the future, and it has begun using a very modest amount of UNOLS ship time in FY '95 ($65K) or 0.15% of the agency research budget.

NASA -

NASA conducts a significant amount of ocean science research in support of its remote sensing mission ($39M). This work focuses on both open ocean and coastal waters and NASA requires access to all areas of the ocean to validate remotely sensed data and to study the processes that control the signals detected from space. However, for the past three years they have not supported any use of the UNOLS Fleet.

US Geological Survey -

Marine aspects of USGS appear likely to be more or less level funded at a fairly significant level ($36M). In the past, the USGS operated two large research vessels, LEE and POWELL. These have both been retired. Their newly acquired Navy TAGOS vessel has been placed on long-term lease with the Army in the Pacific. USGS planning now calls for small (30 days) but relatively stable use of Class IV UNOLS vessels each year with occasional use of EWING, perhaps every other year. This level of effort has amounted to less than 0.2 cents on each dollar of their ocean science research budget in FY '93-95. Certainly there is the potential for this agency to develop ties with UNOLS as they expand their coastal ocean research programs.

Minerals Management Service -

The MMS conducts some $13M in ocean science research, primarily in support of offshore oil and gas exploration and production activities. They have used modest amounts of UNOLS vessel time, primarily in the Gulf of Mexico ($0.2M, or 1.5 cents per research dollar). MMS has also used non-UNOLS vessels for much of this work.

Department of Energy -

The DOE conducts ocean science research through both its Carbon Dioxide and Ocean Margins Programs. These programs were budgeted at a level of $11M in FY '95. The Carbon Dioxide Program focuses on open ocean CO2 distributions and the processes that control it. Although this program has participated in large field efforts, it has not supported UNOLS Fleet operations. The Ocean Margins Program has used some $0.4M (3.6 cents per research dollar) in ship time averaged over the past four years, and plans a large field effort in FY '96.

ARPA -

ARPA intermittently conducts ocean science research ($7M in FY '95). The Acoustic Thermometry of Ocean Climate program now funded by ARPA has used an average of $0.24M for UNOLS ship time. As this program moves on-line it may use more ship time, but it is unlikely to become a major player because of its broad areas of interest.

Federal Agency Summary -

The combined ocean science research budgets of all agencies other than NSF ($329M) are more than double that of NSF ($153M) - see Table 2. The data in Table 2 underscore the substantial differences in UNOLS ship support between NSF and the other federal agencies that support oceanographic research. First, NSF's support for UNOLS is over four times the total for all other federal agencies - $33.9M/year versus an aggregate $7.9M/year. When normalized to total available research dollars, NSF is applying nine times more support for UNOLS than the average for all other federal agencies involved in ocean research. With NOAA operating its own research fleet, the contrast with NSF is not as great as depicted in Table 2, but the great majority of the other federal agencies allocate precious little to ship support. The large discrepancy in the percentage funding for support of the UNOLS Fleet among federal agencies conducting ocean science research suggests that it may be possible to build stronger partnerships with many of these agencies. It would be irresponsible to suggest shifting funds just to support fleet operations without considering the mix of science needs, agency mission, etc. However, it appears possible that stronger support could be created for the UNOLS Fleet outside of NSF. In addition, there is a potentially great intellectual synergism that could accrue over time to both the academic and agency programs as they work together. This is especially true in the area of fisheries research, an area of considerable societal import that requires both effective and extensive multidisciplinary cooperation.

Table 2. Agency expenditures for ocean science research in FY '95 and the average amount that each agency has spent in the past three years for UNOLS ship time.

Agency	Ocean Sci. Res. $M#	UNOLS Sup. $M@	UNOLS/Research
NSF *	$153	$33.9	0.22
ONR**	$103	$ 4.9	0.048
NOAA***	$ 79	$ 2.1	0.026
EPA	$ 41	$ 0.065	0.002
NASA	$ 39	$ 0.0	0.000
USGS	$ 36	$ 0.07	0.002
MMS	$ 13	$ 0.20	0.015
DOE	$ 11	$ 0.40	0.036
ARPA	$ 7	$0.24	0.037

* Does not include ODP
** ONR 6.1 Research
*** NOAA Sea Grant, NURP, COP, Global Change, Coop Inst
# FY '95
@Average FY '93-95

Recent Levels of Likely Ship Support and Future Trends -

Recent UNOLS Fleet operations support (current $) for 1993-95 compiled by NSF is summarized in Table 3 and depicted in Figure 3. To this we have added rough projections in current dollars of the annual level of ship-operational funding likely to be available from present sources assuming unchanged support modes during the period 1996 to 2000.

TABLE 3. UNOLS OPERATIONS SUPPORT (1993-2000) (funding in 'current' $K)

UNOLS	ACTUAL	ESTIMATED	ESTIMATED	ROUGH PROJECTIONS**
TOTALS	1993*	1994*	1995*	1996-2000
NSF	30,558	34,012	37,166	36,000
ONR/NRL	7,581	4,253	6,395	6,300
NOAA	1,981	1,975	2,280	1,000
OTHER	3,266	4,484	1,975	2,000
INST	2,790	2,342	1,787	2,000
	$46,176	$47,066	$49,603	$47,300

DATA SOURCES

- *1993 - 1995 NSF Ship Operations Proposals (Revised 1995)
- **1996 - 2000 Rough Estimates based on:

    - a. FY '96 Congressional activity to date.
    - b. The intent to balance the Federal budget within the next seven to ten years.
    - c. An assumption that there are no changes in current modes of support and no increased appropriations tied to additions to the fleet.

Clearly there is considerable uncertainty and some interannual variability that will place the out-year figures in question - at least in detail. The projections for 1996 to 2000 can be modified as well by actions that would negate assumption c. in the Table footnotes. Nevertheless these projections do not even cover inflationary increases and suggest that some action is warranted.

III. PROJECTED UNOLS FLEET OPERATING COSTS AND SUPPORTING RESOURCES

Estimates of future operating costs were recently assembled, presented, and discussed by the Fleet Improvement Committee in its 1995 Plan. Their 1992 optimal utilization costs estimate was adopted here. The basis for the projected fleet costs beyond 1992 was simple extrapolation, assuming a 4%/year cost inflator AND making allowances for known additions to and subtractions from the fleet as footnoted. The known and projected composition of the UNOLS Fleet, from 1992 to 2000, is presented in Appendix I. The additional columns of Table 4 reflect (1) the total actual funding for 1992 to 1995 and the funding projected for 1996, assuming flat funding thereafter; (2) the corresponding projected shortfalls are shown in both millions of dollars ($M) and percentage of projected costs (%).

TABLE 4. Estimated Costs, Funding and Shortfall for the UNOLS fleet in ($M)

Year	Costs (4% Inc) for Optimal Utilization	Funding	($M)	Shortfall (%)
1992	49.7	46.8	2.9	6 %
1993	51.7	46.2	5.5	11 %
1994	53.8	47.1	6.7	12 %
1995	53.8	49.6	4.2	8 %
1996	57.1*	47.3	9.8	17 %
1997	60.5**	47.3	13.2	22 %
1998	60.5	47.3	13.2	22 %
1999	63.0	47.3	15.7	25 %
2000	65.5	47.3	18.2	28 %

Notes: Assumptions as in Table 3 of this report and in the FIC 1995 Plan (i.e *no resources for an Arctic Research Vessel*).

Table 4 includes the costs associated with the anticipated arrival of REVELLE* in late 1996 and

ATLANTIS** in mid 1997 as well as retirements of ISELIN at the end of 1994, of ATLANTIS II at the end of 1996, and of R/V's ALPHA HELIX and MOANA WAVE at the end of 1997 (See Appendix I).

It is clear from Table 4 and also Figure 4 that there is a serious funding shortfall projected for the UNOLS Fleet in the late 1990's. Specifically, the deficit is projected to be $13.2 million in 1997 and grows to $15.7 million in 1999. The latter figure is roughly equivalent to the current operational costs for three *Class I research vessels*. Thus, even without any resources being applied to support floating Arctic platforms (see Table 4), the 1999 deficit ($15.7 million) represents almost 25% of UNOLS projected funding. To maintain the academic fleet at its current level (27 ships) some adjustments will be needed such as: (1) increased federal funding; (2) decreased costs; (3) participation by federal agencies with oceanographic programs such as NRL, NAVOCEANO, USGS, NASA and NOAA and, possibly; (4) additional support from states/institutions/foundations.

Funding shortfalls can be accommodated over short periods by operating the fleet on a reduced schedule. This is best accomplished by periodically taking a ship out of service for periods ranging from several months to a year. In fact, to accommodate small budget shortfalls, UNOLS has regularly taken ships out of service for short (less than 1 year) periods. However, temporary lay-ups are not a viable solution for large deficits. The cost of operating a research vessel is roughly divided into three equal fractions: one third for fuel, one third for crew costs and one third for equipment and maintenance. Thus, substantial savings can be achieved when a ship is taken out of service only by laying off the crew and deferring maintenance. We believe that a **crew experienced in oceanographic operations and a well maintained ship are the key to safe and efficient research at sea**. The ship's crew is highly integrated into science operations. The science operations that are conducted on a modern research vessel represent a broad spectrum of work carried out in some of our nations premier scientific laboratories. This work may include deploying large instruments such as Remotely Operated Vehicles and deep-sea moorings, probing the atmosphere with laser based instruments and studying trace elements under clean room conditions. The crew must be ready to adapt to constant changes in the type of science that will be performed and the services they must provide to the science complement. They play a critical role in properly handling and deploying instruments, station keeping and providing ship services that range from highly regulated power to safe areas for radiotracer research. This type of experience is not developed elsewhere in the commercial shipping industry and the crew of a research vessel cannot be readily or easily replaced. Rather, an experienced, accomplished crew is grown from within by long practice. Infrequent, short-term lay-ups can be accommodated by sharing crew between various UNOLS vessels. However, long-term lay-ups of a vessel invariably result in the permanent loss of this accumulated crew experience. Successful and efficient operations of the oceanographic fleet require that a ship be used over its full operating year. Long-term underutilization saves relatively little money if the crew is retained and the ship maintained or, it results in a low efficiency operation that will ultimately be rejected by users in the scientific marketplace.

If it becomes necessary to reduce the fleet size, we believe that a mix of vessel should be retained across all UNOLS size classes that reflects the distribution of vessels found in the 1995 UNOLS Fleet Improvement Plan. This distribution of vessels described in the 1995 FIP includes a mix of size classes and specialized facilities such as a Deep Submergence Support Ship to accommodate the broad range of needs identified in the oceanographic community. The 1995 FIP is the result of a decade's long effort to quantify the facility needs of the oceanographic community. It best represents the requirements of the community, which range from shallow-water estuarine work to global expeditionary work and deep submergence science.

In light of our fiscal constraints and a clear need to support adequately the UNOLS Fleet we should underscore the fact that the bulk of the academic fleet is in excellent condition and capable of supporting a diverse array of ocean-going science - not only for academic institutions but also for our colleagues in

federal and state agencies. The challenge for UNOLS is to demonstrate effectively to potential users that we can and will consistently meet their requirements. There is little question that this can happen, but it will take several years for non-traditional users to become familiar with, and regular participants on, UNOLS vessels. The corollary is that, if agencies develop a partnership with and a dependency on the UNOLS Fleet, then UNOLS will acquire a permanent (long-term) obligation to accommodate them.

IV. DISCUSSION

Three (of many) Eternal Truths

- We must live within the ambiguity of partial freedom, partial power, and partial knowledge.
- All important decisions must be made on the basis of insufficient data.
- Yet we are responsible for everything we do.

The information contained in Sections II and III above deserves our serious attention. We readily admit that the projections we have used are rough and that uncertainty abounds. Nevertheless, it seems plausible that we are witnessing a fundamental shift in federal funding that could significantly impact U.S. marine science and the UNOLS Fleet in the years to come. We should prepare ourselves to minimize negative aspects of this potential impact and to take effective advantage of some of the opportunities the shift in federal funding might present.

If there truly is the strong likelihood of a long-term oversupply of UNOLS ships in comparison to research demand and funding projections, the logical long-term response is to strike ships from the fleet that depend on the limited funds. In most cases the "limited funds" means the total pool of federal funding, and normally cutting off a ship from this source is tantamount to scrapping it. There can, however, be exceptions - for example, even though it receives little federal funding, GYRE continues to function and to operate in a limited fashion.

It is worth noting that, within the last few years, two fleet reductions of significant size have taken place by force of circumstances and economics, without a formal guiding agency policy or UNOLS policy in place. VICKERS was taken out of service by the University of Southern California, and the University of Miami currently plans to take COLUMBUS ISELIN out of service. The ad hoc committee considered the question of whether economic forces, without any policy overlay, would preserve the best fleet for the future. The real question is whether the available operating funds (agencies cannot spend what they do not have) would be inefficiently used for a long period of time (years) by spreading them around a fleet too large to sustain operational and programmatic efficiencies. One might reasonably expect institutions with ships chronically undersubsribed to make the decision to dispose of those ships, without external coercion.

It is ironic that the newest ships now coming on line (ROGER REVELLE and ATLANTIS), as late-arriving claimants at the declining operations funding table, are actually the final ships of the decade-old NSF/Navy large ship replacement plan. These plans, were clearly aimed at carrying out the general recommendations of the 1986 UNOLS Fleet Replacement Committee study. They called for two or three Navy sponsored large ships and two or one NSF sponsored ships that would replace five ships - the four older AGORs (old THOMAS THOMPSON, THOMAS WASHINGTON, CONRAD, MOANA WAVE), and ATLANTIS II. In fact, when AGOR 25 (ATLANTIS) is delivered and MOANA WAVE retired (See Appendix I) their plans will be fulfilled. In the optimistic atmosphere of 1987, NSF predicted in their Unified Plan for Ocean Science that by the **early 1990's a significant shortage of ship time on Class I vessels would exist** even if all the newly proposed Navy/NSF construction came to fruition. We now ponder the question of whether or not we may soon be woefully undersubscribed (budget-driven) in the large ship category.

As a first principle, it is imperative for UNOLS and the funding agencies to bear in mind that the ocean science community's overarching goal is to maximize our scientific understanding of the ocean in the broadest possible fashion, and by whatever means are necessary and technologically feasible. Recognizing that principle, how is it that we find ourselves ship facilities-driven at the present time, rather than being focused on optimizing our facilities to best serve scientific research? It is tempting to blame the current dilemma (of UNOLS Fleet oversizing relative to customary NSF and ONR science support) on contemporary federal budget machinations. However, we are dealing with a pre-existing problem which has been made considerably more acute by constrictions in federal funding for research and development. Perhaps the fundamental problem stems from the mismatch in time scales of an R/V's lifecycle (roughly ten years from conception through construction plus 30 years of useful life) versus the duration of major field programs (five or six years). A major exception is the Ocean Drilling Program which operates on a generational time scale and has been successful in acquiring the expensive, specialized facilities essential to its goals. Ironically, the major contemporary oceanographic field research programs (e.g., WOCE, JGOFS, RIDGE, GLOBEC) also have generational goals but their funding is of much shorter duration, and their field periods are not automatically well-phased with the availability of the most desirable platforms (nor is the essential supporting technology development well-synchronized). The future, with more alternative types of platforms and sensors and the explosion of information technology and knowledge, will make it even more challenging for seagoing scientists, UNOLS, and federal agencies to plan and to function effectively. It is likely that the new and future technology environment will necessitate that UNOLS and the funding agencies learn quickly how to coordinate plans and management in a multi (observational technology) -resource, and possibly limited financial-resource environment. Strengthening regional research consortia for the purposes of sharing ship and related resources is one option which should be explored, especially since cost reductions might be achievable. As a corollary, there is a bright new future for UNOLS in facilitating the integration of research vessels with other platforms into comprehensive ocean observing systems designed to simultaneously solve outstanding basic research questions and address societal needs.

One of the signal accomplishments of the combined Navy and academic ocean science community in the past year has been the invigoration of the Navy's fundamental policy toward ocean research by the mechanism of a CNO Executive Board (CEB) convened earlier this year. This is a rare event, the result of a great deal of effort at the highest levels in the Navy and in the ocean science community. The last time a CEB convened to deal with oceanography was over a decade ago. It was from that CEB that the initiative to build the new AGORs arose in response to demonstrated UNOLS needs, and to make other first-order enhancements to Navy support of ocean sciences. It is also pertinent to recognize this 1995 CEB for encouraging Navy use of the academic fleet.

This brings us to the possibilities of increasing the funding for the UNOLS Fleet by 'growing' the user base. In general there are two primary ways of doing this. One is by shifting the balance of marine science activities from land-based to sea-going. The second is to bring into the UNOLS user community additional marine scientific activities which heretofore had made use of other research ships.

With regard to the first of these it is important to recognize that the agencies most concerned with funding the UNOLS Fleet - primarily NSF, ONR, NOAA - have the power within their own ocean science budgets, externally constrained at whatever level they may be, to influence significantly the relative shares of those budgets devoted to sea-going and shore-based research projects (Table 2). All of these agencies would say that to one degree or another their division of resources between these two uses is driven primarily by scientific "demand" for sea-going and shore-based projects. This stance is certainly proper as far as it goes. But it is also true that the "demand" in turn is conditioned by the ease or difficulty that research scientists perceive in getting sea-going programs and projects funded. Choices subsequently made by scientists about whether to devote time and energy to proposing sea-going or land-based projects are pragmatically driven. Many individual scientists are capable of adjusting accordingly. The generation

of "demand" and the division of budgets between sea-going and non-sea-going research therefore are not independent activities; they influence each other. The resultant budget ratios between sea-going science, non-sea-going science project support, and ship operations, thus, can be modified by conscious agency actions; they are not simply calculable results of an external process and may not lead to an improvement in ship operations support.

At the present time it is likely that the rather larger ratio of ship support to research support at NSF when compared to ONR, and the trend of recent years toward NSF supporting an increasing fraction of total UNOLS Fleet costs, are partly reflections of perceptions by scientists that getting a large sea-going project funded is easier at NSF than at ONR. The degree of enthusiasm or pessimism with which agencies react to early suggestions or prospectuses for sea-going programs, the degree to which they foster or stand aside from efforts to develop program plans, the selection of reviewers for such plans and proposals, all these factors and others influence: 1) the success of initial ideas for sea-going science, and 2) the choices that scientists make when deciding what to propose next. ONR's consideration of a change to its own internal mode of funding reflects a recognition of these influences on what is proposed.

The second approach to 'growing' the user base, by bringing in new partners to the UNOLS community, is one that is fraught with a combination of uncertainty, change, and opportunity. Possibilities within in-house Navy elements have been noted above. Another potentially significant user agency is NOAA. Its future status, programmatic responsibilities, and mode of field research operations are unsettled at this time. Nevertheless, to the extent that NOAA's marine scientific and survey responsibilities continue to be supported, there is a real opportunity for UNOLS to serve NOAA's needs for marine research platforms. Similar circumstances apply, albeit to a lesser extent, to other agency marine programs including those in DOE, EPA, USGS, MMS, and NASA.

In pursuing this approach, it would be easiest to view it as simply a marketing of excess UNOLS shiptime. A more satisfying, productive, and sustainable guiding philosophy would take the form of developing new partnerships. This perspective is presented well in the 1992 NRC report, entitled "Oceanography in the Next Decade - Building New Partnerships" in its section titled "Toward New Partnerships", by stating: "As the context in which oceanography is conducted changes, how can federal agencies and oceanographers in academic institutions strengthen and improve their cooperative efforts? In general, partnerships must be extended beyond financial relationships to include the sharing of intellect, experience, data, instrument development, facilities, and labor."

Success with this approach will take time and will probably not resolve any near-term problems with regard to the UNOLS Fleet. On the other hand, over the long-term, well-founded partnerships could be of significant mutual benefit to the marine academic community (including UNOLS) and the federal agency partners in both political and scientific terms.

An example of a multi-institutional consortium is the MARCO group which has formulated a proposal for a coastal vessel which would serve about nine mid-Atlantic oceanographic institutions. In the southeastern Atlantic/Gulf of Mexico, the University of Miami, Texas A&M University and the University of Texas (Austin) are working to revitalize their consortium (SECOR) and to develop joint ship operations. Presumably some of the institutional support that was applied to GYRE will be provided to this joint operation. The University of Miami is also working with Harbor Branch Oceanographic Institution to develop cooperative marine operations.

UNOLS might also be able to improve operations at the JGOFS time series adjacent to Bermuda by coordinating the schedules of three vessels - HATTERAS, ENDEAVOR and OCEANUS - capable of servicing the Bermuda Time Series Station. All of these vessels are superior to WEATHERBIRD II and their presence would offer substantial scientific advantage not only to The Bermuda Biological Station for

Research, Inc. but to all of the scientists involved in the JGOFS time series experiment. Certainly, UNC/Duke, Rhode Island and Woods Hole would benefit from the additional business (i.e., east coast intermediates have light schedules). The real question is logistical - can these vessels adequately serve the Bermuda station without causing problems for the other users. While the above scenario might have shortcomings, our community needs to take a careful look at the ways we might improve cost/scientific effectiveness of future UNOLS operations.

In addition to the above, it is most important that the UNOLS community develop support for ship operations from outside of the federal agencies which at the present time have almost complete fiscal responsibility for the research fleet. An excellent example is the University of Washington that annually contributes 45 days of ship time from state funds on their new AGOR, THOMAS THOMPSON. This is a line item in the state budget and the state has made a long-term commitment to supporting ship operations at the University of Washington. Similarly, Scripps Institution of Oceanography currently adds $725K per year of university funds toward support of ships, that, among other things, buys: 1) days of time for university projects at the regular day rates; 2) equipment; 3) matching funds on equipment proposals; 4) occasional improvements to the shore base; and 5) portions of the salaries for senior managers for ship operations and shipboard technical support. In addition, when REVELLE comes on line, Scripps will augment its support by $750K per year, all of which will be directed toward support of REVELLE. This will bring their total annual support of ship operations to $1.5 million. As in the previous case, these institutional funds might go to: 1) days of use; 2) to equipment, and 3) to other expenses that enhance the use and effectiveness of this particular vessel. Significantly the mix of these institutional support funds changes from time-to-time. The fiscal constraints may bring federal agencies to propose groundrules for ship support that include specific requirements for non-federal support of UNOLS ships. The bottom line is that states/institutions may end up bearing additional financial responsibility for the operating cost of research vessels.

It is clear from many reports and workshops that the Arctic Ocean is an important scientific research frontier in need of specialized support facilities. The ocean science community has recently updated its long-term plan for Arctic research and the facilities that are integral to it. Ice-capable, sea going research platforms (such as an Arctic Research Vessel) are vital to conducting oceanographic science in the Arctic's icy interior.

As UNOLS looks to the future, exciting prospects lie ahead afforded by new observational technologies that will cause the role of R/Vs to evolve further, and very rapidly. For example, two decades ago, satellite infrared imagery began to be transmitted to R/Vs in near-real-time. For the first time, shipboard oceanographers were provided with a synoptic, spatial and temporal context, which led to major advances in the study of mesoscale eddies, fronts, and meandering jets. These advances, in turn, led to adaptive, physical/biological studies of the influence of mesoscale variability on marine ecosystems - this research, which is still underway today, has fundamentally changed the way shipboard oceanography is performed. Similarly, in the near future, we can anticipate that application of multiple, multi-sensored Autonomous Underwater Vehicles (AUVs) will allow adding a third dimension to quasi-synoptic studies, and to breakthroughs in subsurface marine ecology, etc. As additional satellite sensors become operational, moored and drifting telemetric buoy systems become commonplace, shore-based and airborne radars are made more available, and ocean bottom observatories become established, sea-going oceanographers will be operating in a new, information-rich world, and they will be able to perform better focused studies of ocean processes. Hence, the future use of R/Vs will become increasingly focused on experiments (versus surveys), necessitating both a high level of shipboard instrumentation and much more information processing at sea, with the shipboard regime well-integrated into networks of fixed, drifting, airborne, and spaceborne sensors. Clearly, the existing and future UNOLS Fleet must be managed appropriately for such a multi-platform, multi-sensor future, a future in which the shorebased theoreticians, modelers, and analysts will be integrated (through telecommunications) into interactive field programs.

In light of the tightening federal funding for R&D, its likely evolution over the next few years, and the potential changes, impacts, and opportunities thus confronting the UNOLS infrastructue, the Committee recommends the following actions:

V. RECOMMENDATIONS

1. FUNDING AND THE FUTURE OF THE UNOLS FLEET

The results of our analysis confirm NSF's warning that the funding for, and the operating costs for, efficient utilization of the UNOLS Fleet, as currently projected, may soon diverge to the extent that significant decisions for change will be required. Federal agencies responsible for and/or dependent upon the UNOLS Fleet should be advised. If such decisions are to be made they should take due account of the trends and issues discussions (pp 51-62) and recommendations (pp 64-67) in the UNOLS Fleet Improvement Plan of 1995. And, because of the effective irreversibility of retiring ships, all alternative approaches should first be thoroughly assessed and tried, if promising. We recognize that there may be alternate approaches to addressing the funding shortfalls for the UNOLS Fleet. Specifically, it might make sense to consider a two- to three-year period with limited numbers of lay-ups and to then assess the projected balance between our sea-going science/ship needs and the likelihood of commensurate support forthcoming.

2. EXPANDED FEDERAL PARTICIPATION IN UNOLS

Immediately hold in-depth discussions with NOAA, EPA, USGS, MMS, DOE, and NASA (and possibly others) with the objective of determining how best to bring them into the UNOLS system as participating partners. These partnerships should be developed in philosophical accord with the pertinent discussions on "Inter-Agency Cooperation" contained in the UNOLS FIC 1995 Plan and on "Building New Partnerships" contained in the 1992 NRC Report: "Oceanography in the Next Decade". For example, the Fleet Improvement Committee should consider coordinating their effort to examine coastal zone research capabilities with EPA, USGS, MMS and ONR. Additionally, coastal zone/shelf dynamics are an important aspect of fisheries research and, as such, should be coordinated with NOAA.

3. NEW MODES OF SHIP SUPPORT AND OPERATIONS

Task an ad hoc UNOLS 'futures group' to (1) assess the feasibility and impact of new approaches to the support and operation of ships such as: (a) enhanced institutional/state support, (b) strengthening the role of regional consortia, and (2) translate these assessments into recommendations to UNOLS and the federal ship funding agencies for implementation as appropriate.

4. ALTERNATIVE USES OF CLASS I VESSELS

Because the large global ocean science programs will reach the end of their field phases in the next few years, it becomes increasingly important to explore the potential utilization of Class I R/Vs in multidisciplinary coastal ocean studies. The strong national (inter-agency) programs for coastal ocean science anticipated in the early 1990's have yet to materialize substantially. However, the scientific and societal needs remain and, if these programs arise, they could increase the demand for Class I as well as intermediate R/Vs. Another option may be to commit significant amounts of Class I R/V time to ocean survey work conducted by NAVOCEANO and NOAA (NOS and NMFS), and to engineering tests conducted by the Navy's naval warfare systems laboratories. These two options should be explored by the UNOLS Council with the appropriate agency program managers.

5. NEW FACILITIES

Strongly encourage the ocean sciences community and the involved federal agencies to continue planning for new generations of oceanographic facilities. These plans should include consideration of the Arctic Research Vessel and new coastal research assets. The fundamental mismatch in time scales of an R/V's lifecycle (roughly ten years from conception through construction plus 30 years of useful life) versus the duration of major field programs (five to six years) dictates that the fleet capabilities will not always match the community's needs. We can, however, ill afford a period where ocean science focuses on data reduction/data synthesis to the extent that planning stagnates. In short, the oceanographic community must maintain a long-term outlook when assessing the fleet.

APPENDIX I : **UNOLS FLEET OPERATIONS FROM 1992 THROUGH 2000**