# Renewing the National Oceanographic Research Fleet

Material to accompany a Marine Science Facilities Panel
presentation to the U.S. Commission on Ocean Policy

by

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## I. Introduction

The purpose of this short paper is to present the case for renewal of the U.S. academic research fleet - the UNOLS fleet - in an orderly, planned set of steps over the next two decades, as current ships reach the ends of their useful lives. This is a subject of prime long-term importance for U.S. ocean science, and as such it falls squarely under the charter of the Commission on Ocean Policy. The commission is charged to recommend national policy to promote eight goals. The future research fleet will be absolutely central to goal #5 - the expansion of human knowledge of the marine environment - and to goal #8 - preserving U.S. leadership in ocean and coastal activities. It will be important for goal #2 - stewardship of ocean and coastal resources and for #3 - protection of marine environment and prevention of marine pollution, and it is not unconnected to the remaining goals.

## II. The University-National Oceanographic Laboratory System (UNOLS)

To a good approximation the American academic research fleet is the UNOLS fleet. It is thus appropriate to summarize what UNOLS is and what it does in the service of ocean science.

UNOLS is a 31-year old non-federal consortium of about 60 oceanographic institutions, with a governing council and several major standing committees. These council and committee positions are filled by an all-volunteer, rotating and elected group of seagoing scientists, mariners and marine technical leaders. Activities of the council and committees are supported by a small paid secretariat, currently hosted at Moss Landing Marine Laboratories in Moss Landing, CA. The ships of the UNOLS fleet are all operated by individual member institutions, not by UNOLS. The financial arrangements that fund the operations of the vessels take the form of grants or contracts between the operating institution and the agency or agencies that sponsor the research projects requiring ship time. The ships are variously owned by institutions, by states, and by the federal agencies. UNOLS fosters safety and scientific capability standards for the whole fleet. UNOLS was created in large part to encourage and referee effective fleetwide ship scheduling on the basis of a level playing field of access to appropriate ship time for all funded U.S. researchers, whether affiliated with ship operating institutions or not. It has fulfilled this purpose well and stands as a model for the rest of the world.

In considering the issue of fleet renewal, it should be noted that UNOLS is the best single ongoing connecting channel between the ocean science community and the federal

agencies for identifying broadly based and scientifically sound requirements for new ships and related facilities. It is the best channel for bringing coordinated community advice and expertise to bear on the features and designs of those ships and facilities, making them as research-favorable to the whole community as possible.

As figure 1 indicates schematically, the UNOLS organization occupies a middle ground between the member institutions, the facilities themselves (primarily the ships of the fleet) and the federal agencies that sponsor most of the science requiring the ships. It is a somewhat complicated arrangement, but a successful one. A major review of the academic fleet (Fleet Review Committee, 1999), conducted in 1998-9 found:

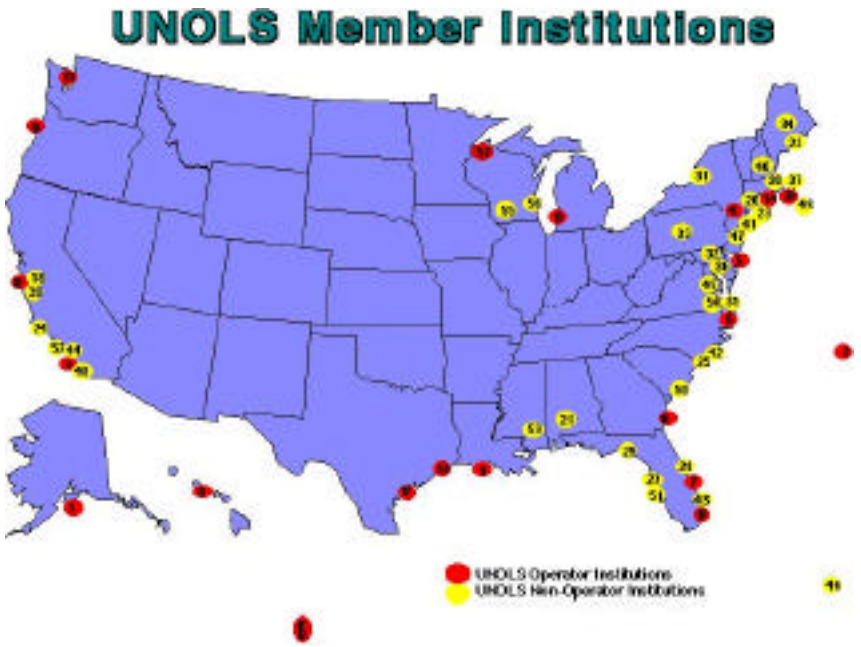
> *"The UNOLS system should be retained. The NSF-UNOLS current practices, using institutional operators funded by NSF and other federal agencies with centralized scheduling through UNOLS seems to provide excellent access to the sea for U.S. investigators. To the extent the committee can assess, costs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

The institutional membership of UNOLS is very similar to the membership of CORE - the Consortium for Ocean Research and Education. Both organizations have a fundamental concern for ocean science. The primary difference is that CORE, supported by non-federal funds, can and does lobby. Since the UNOLS secretariat and the activities of the UNOLS Council and major committees (travel, meetings, etc.) are supported by federal funds, UNOLS cannot lobby but advises agencies.

Figure 2 lists UNOLS operator and non-operator member institutions and their locations. Every coastal state has at least one UNOLS institution. More extensive information about UNOLS, including particulars of the current ships of the fleet, can be found on the web (www.unols.org) and in a general-interest brochure "The Research Fleet" (UNOLS, 2000) available from the UNOLS Office.


Figure 1. An illustration of the position of UNOLS as a connection for advice and coordination between member institutions, the UNOLS fleet, and the funding agencies.

| | | | |
|---|---|---|---|
| Ala. Mar. Env. Sci. | Harvard | U NH | SEA |
| Bermuda BSR | Hobart & Wm. Smith | SUNY - SB | U So. Carolina |
| Bigelow Lab. | Johns Hopkins U | U NC - Wilmington | U So. Florida |
| Brookhaven NL | Lehigh | Nova U | USC |
| UCSB | U Maine | Occidental | U So. Miss. |
| Cape Fear CC | Mar. Sci. Consortium | Old Dominion U | VIMS |
| UConn | U MD | U Puerto Rico | U Wisc. - Madison |
| FIT | MIT | Rutgers | U Wisc. - Milwaukee |
| FIO | MBARI | SDSU | U Wisc. - Superior |
| FSU | US NPGS | | |




**Pacific**

UW
OSU
MLML
SIO
U Alaska
U Hawaii
STRI

**Great Lakes**

U Minn
U Mich

**Atlantic/Gulf of Mexico**

WHOI
URI
LDEO
U Delaware
Duke/UNC
BBSR
U Georgia
HBOI
RSMAS
LUMCON
TAMU
UT

Figure 2. UNOLS operator (red dots) and non-operator (yellow dots) member institutions. Non-operator institutions are listed at top of page. Operator institutions are listed in three geographical groups at bottom of page.

## III. Fleet Renewal - What Is the Problem?

At one level the answer to this question is straightforward. Ships do not last forever. At the present time one can forecast probable useful lifetimes for the existing fleet. This has been done across the fleet, based on the experience, judgements and estimations of the ship operators. The results are given in Appendix A of the fleet renewal plan of the Federal Oceanographic Facilities Committee (FOFC, 2001) discussed in section IV below, and are further illustrated in figures 3-7. Unless new ships are planned and built the fleet will wither away, and rather dramatically, as current ships reach the ends of their useful lives.

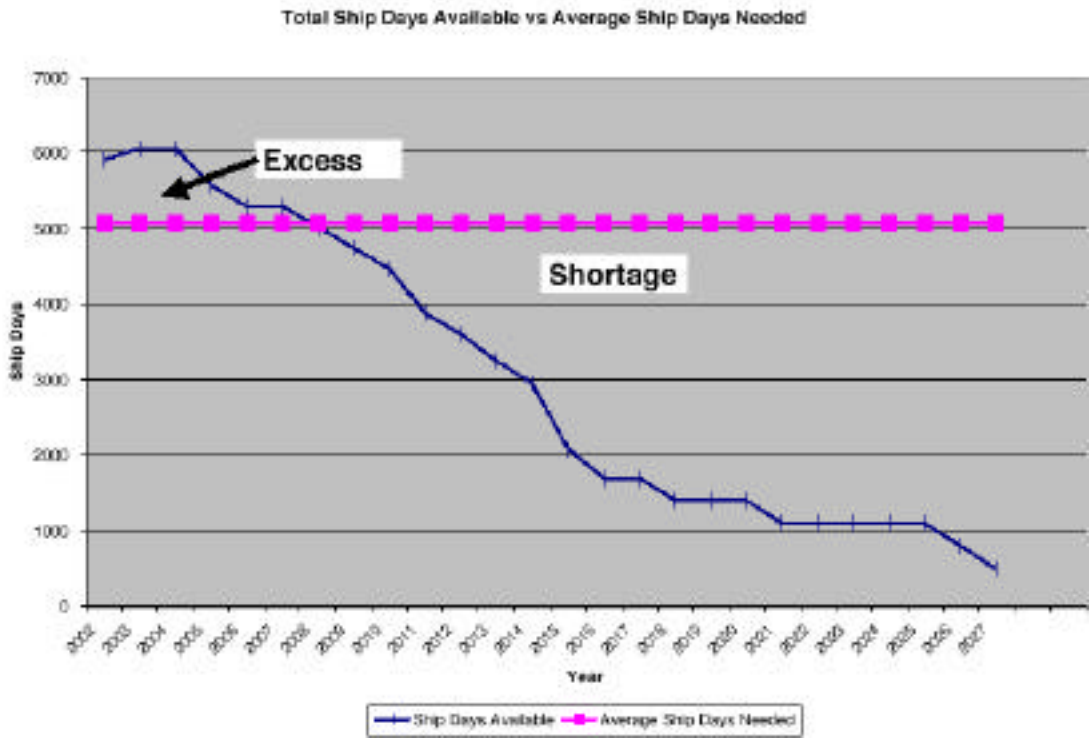



Figure 3. Available ship days, and 1997-2002 average ship days required, for entire UNOLS fleet assuming scheduled future retirements of vessels as in FOFC plan (FOFC, 2001) and no new ships.

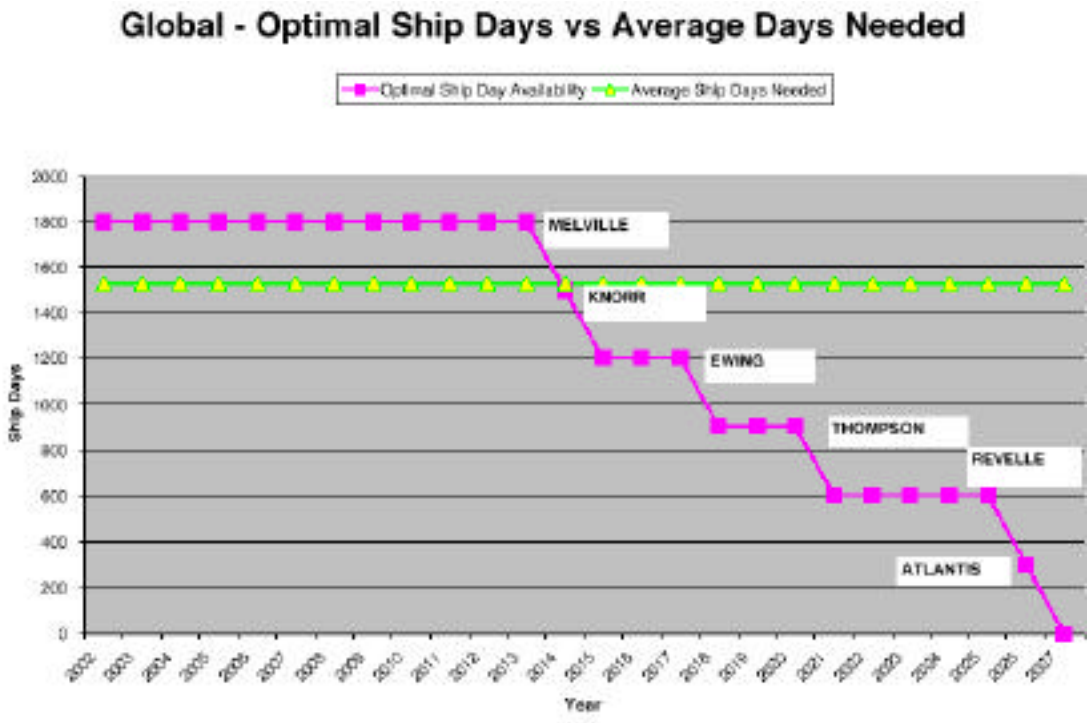



Figure 4. As in figure 3, but for Global Class ships as defined in FOFC plan. Individual scheduled ship retirements are indicated by names.

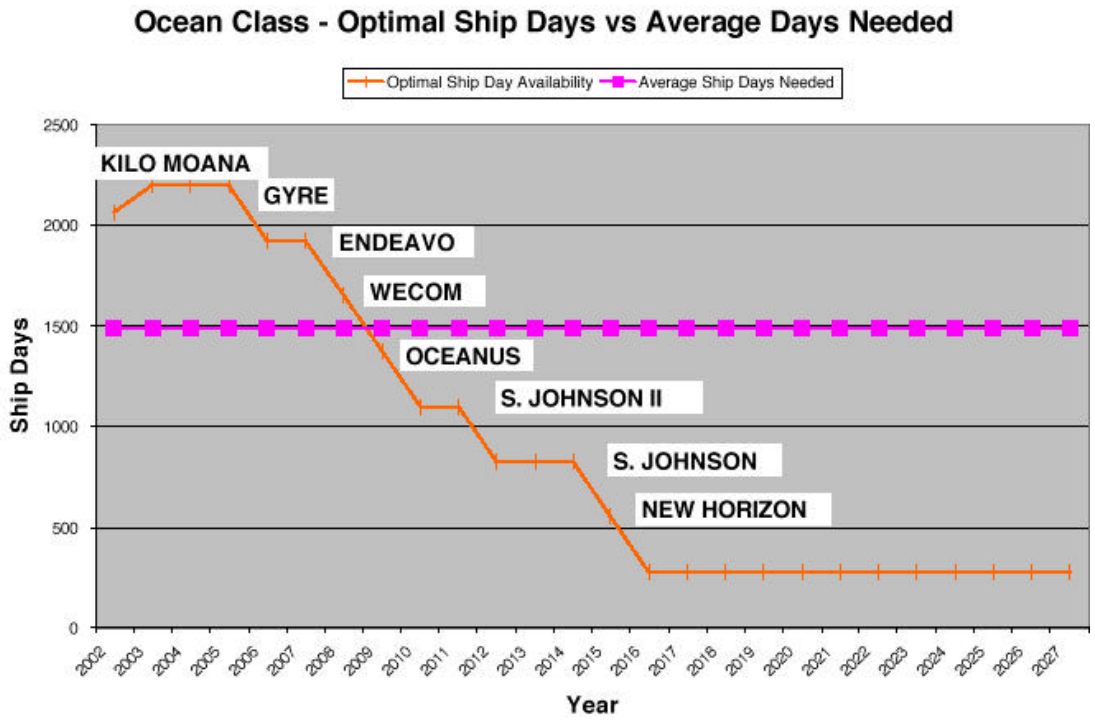



Figure 5. As in figure 4, for Ocean Class ships.

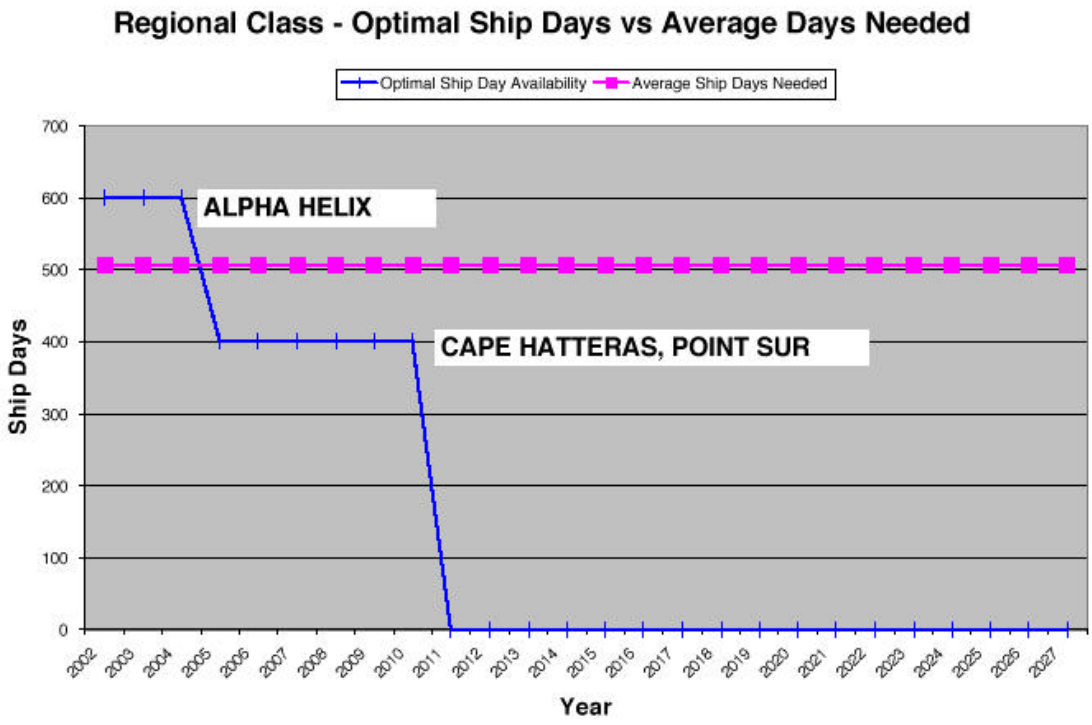



Figure 6. As in figure 4, for Regional Class ships.

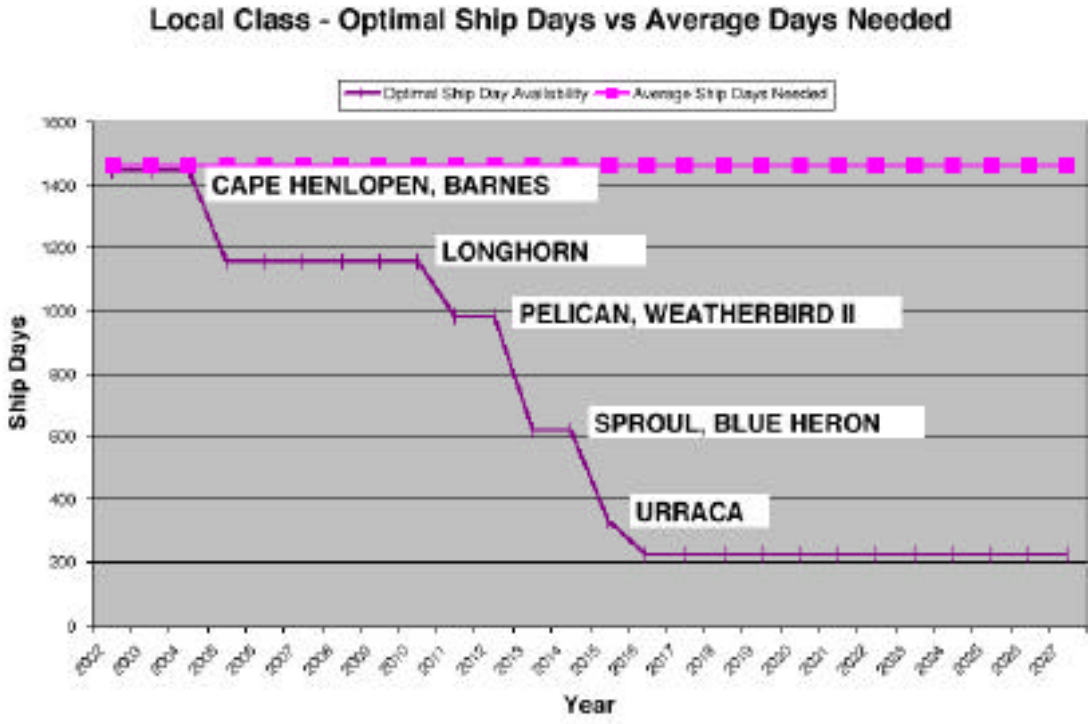



Figure 7. As in figure 4, for Local Class ships. The FOFC plan (FOFC, 2001) assumes that this fleet sector will be renewed by non-federal sources.

The figures indicate current modest surpluses of available days. But some amount of apparent surplus is appropriate and even necessary, for otherwise the ship schedules become too rigid to accommodate scientific constraints such as remote study sites, requirements to work in particular seasons of year, the conflicting obligations and schedules of researchers, key technicians, or unique pieces of scientific equipment, etc. The number of "usefully available" days on scientific grounds is therefore less than the plots indicate. There are recent instances of funded projects deferred for some years, notwithstanding the apparent margin of available time.

As figures 3-7 indicate the impending deficit of ship availability is particularly pressing in time for the midsize (Ocean Class) and smaller ships. This is not surprising. The most recent major round of UNOLS fleet renewal was begun in the mid-1980s, a Navy initiative led by then-Secretary Lehman and then-Chief of Naval Operations Watkins. At that time the ships nearest to obsolescence were the large ships in the fleet, so the initiative focussed on renewing that sector of the fleet. It yielded today's world-ranging AGOR vessels - the modernized and enlarged ships *Knorr* and *Melville* and the new ships *Thomas Thompson, Roger Revelle* and *Atlantis*. Today the midsize ships are the older ones, and they now drive the impending shortfall.

At a more fundamental level the problem of fleet renewal goes beyond replacing aging ships. We do not need or want new ships merely because current ones are getting old. We need new ships to be able to do the ocean science of the future. However, because ships take a long time to plan, fund and build, that future is coming at us very fast, perhaps faster than we are getting ready for it with real plans and real shipbuilding budgets. In this sense the problem is both real and urgent.

What does this scientific future hold in relation to ships? Perhaps the most basic answer comes from a recent comprehensive review of the field for the National Science Foundation. Over several years leading up to the 50th anniversary of the founding of NSF in 2000, the Ocean Sciences Division of NSF commissioned a set of looks ahead first by scientific discipline and then through a cross-disciplinary synthesis of the findings. Thousands of individual pieces of input from ocean scientists across the country were received in addition to the discussions at the four large national disciplinary workshops. The synthesis report (NSF, 2001) gives as its first recommendation:

> *"A substantial, well-coordinated, multi-agency fleet replacement plan is needed to maintain United States leadership in sea-going capabilities in the coming decades….. Maintaining a modern, well-equipped research fleet is* ***the*** *most basic*

*requirement for a healthy and vigorous research program in the ocean sciences." (emphasis added)*

An aspect of the "what is the problem?" question, sometimes implicit, sometimes not, is the idea that the modern advent of remarkably capable autonomous observational devices - satellites, floats, drifters, moorings, seafloor sensor networks and other such devices - will somehow supply the measurements required for research without the trouble or expense of going to sea. Then, the reasoning continues, this will lead to the gradual withering away of ships as an essential means for pursuing research in ocean sciences. If so, the research fleet could be allowed to decline without renewal, and ocean science would not suffer.

The NSF synthesis report clearly says "no" to that idea categorically. A more detailed assessment, also concluding "no," can be found in the report "Assessment of Future Science Needs in the Context of the Academic Oceanographic Fleet," a NSF-sponsored workshop held in August 2000 at Oregon State University. NSF has not published this report in paper form but it is on the web at http://www.unols.org/fic/biennial/futship.pdf. The workshop focussed on future scientific requirements in relation to the fleet.

Workshop participants all agreed that we are indeed currently witnessing a breathtaking increase in the capabilities of unmanned systems, in terms of space and time coverage and in terms of the suite of variables that can be sensed. Satellite-derived maps of sea surface temperature, ocean color and sea surface height are perhaps the most dramatic examples. But this fact does not consign research ships to the museums of the future; on the contrary. For the first time in the history of the science, we can anticipate using smart combinations of unattended devices and directed, adaptive observations from ships to sample ocean processes on space and time scales appropriate to the phenomena. For the first time we can see how to obtain contemporaneous information on the numerous variables that may be key to the processes - temperature, salinity, current, a welter of chemical and biological variables, details of the seafloor, and much more. For the first time we can envision a ship not as an isolated and lonely point in mid-ocean forever incapable of observing both "here" and "there" at once. The ship instead can become a sort of maritime AWACS or mobile concentration of brainpower governing the deployments, movements and schedules of its own sophisticated sampling work and also the actions of associated arrays of less sophisticated unmanned devices. Those aboard, and even those at the end of communication links ashore, will be able to make decisions based on the real-time flow of information from the ship, from many or all of those unmanned devices and from various ongoing global observing systems. This is indeed a new prospect in observing the ocean and understanding its processes.

It is important to note, as this workshop did, that many ocean variables of first-order significance cannot be measured by unattended devices now or in the foreseeable future, so that scientific and technical work by humans at sea will continue to be the only way to obtain such observations. New techniques for measuring heretofore unmeasured properties, often chemical and biological ones, also are constantly being developed by researchers, and these usually take the form of laboratory-style analyses at sea long before they ever become adapted to incorporation in any unattended device. When unattended devices are eventually developed to sense some new property there is often a lengthy period of cross-comparison with the older, established shipboard analyses for the same property. This is essential if the new approach is to be properly evaluated for accuracy and precision, and it is particularly crucial for the credibility of long time series when such changes of technique are made. Sometimes the cross-comparison must be sustained indefinitely at some level of effort because of calibration shifts or other intrinsic weaknesses in the unattended system. The workshop conclusion on these issues was:

> *"New observational tools will extend the reach of the fleet, but will not replace or reduce the fundamental use of vessels to conduct basic observational and experimental research at sea. This "dual use" of the fleet will lead to increased demand for shiptime. …… The need for expanded capabilities is driven by the requirements of the pending scientific questions, as well as by the continual technical advances in sensors and observational systems."*

## IV. Planning to Solve the Fleet Renewal Problem

The need for a renewed academic fleet thus is real and is rooted in the ocean science of the future. The next question is how to get there. Without specifying particulars, the NSF academic fleet review (Fleet Review Committee, 1999) was clear on the goal:

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

It is important to note that although the Fleet Review Committee was a NSF body this is a recommendation to agencies - plural - not just to NSF, recognizing that the UNOLS

fleet serves the research of several agencies (see figure 1) and historically has been capitalized by two of them - Navy and NSF - as well as by non-federal entities.

Note also the mention of the "high cost of obsolescent facilities." Old ships suffer more, and more sudden, repair problems, which cost money and also upset scientific plans, thereby costing even more money. They cost more in regular maintenance as hull and machinery parts wear. They can be and indeed are retrofitted with many new scientific systems, but certain systems - multibeam sonars or high-tech overboarding equipment for example - are so costly to implant in an old ship that it probably would not be done. Some fundamental properties of older ships such as acoustic self-noise, clean power, and reserve buoyancy can present showstopping obstacles to the retrofitting of some new scientific systems. Newer more cost-effective modes of ship operation - unattended engine rooms, etc. - also must await new ships. Another way to say this is that the decrease of the fleet depicted in figures 3-7 is predicated on reasonable estimates of useful lifetime of existing ships, and to try to extend those useful lifetimes would require significant investments in improvements and life extensions. Given the press of time we may be forced to do some of this life extension as an intermediate measure anyway, and that should be an integral part of the fleet renewal plan as needed. But the better course of action is to move briskly on new ships to renew the fleet, improve its capability, and retire existing ships on or even slightly before the ends of their useful lives. Putting our money into new ships with improved technology makes more sense.

Responding to this advice to prepare for a renewed fleet, the agencies under the auspices of FOFC generated a draft plan in late 2000, asking UNOLS to gather community reaction to the draft. UNOLS did this via the web in early 2001, received comments from over 150 seagoing scientists across the country, and drew up a critique of the draft to send to FOFC and to post on the web. The FOFC agencies then undertook a redrafting, and the final result is the report ""Charting the Future for the National Academic Research Fleet" (FOFC, 2001). This FOFC plan is fundamental reading on the matter of fleet renewal. It lays out the acquisition history of the present fleet, the future suite of ship retirement dates, and the scientific requirements for new ships. It is the first such overall planning document since the Navy large-ship initiative of the mid-1980s. The new FOFC plan is heartily welcomed by UNOLS, which has been advocating this kind of long-range planning since 1995.

The "bottom line" of the FOFC plan is its figure 17, shown here as figure 8 - a timeline for recommended new ships.

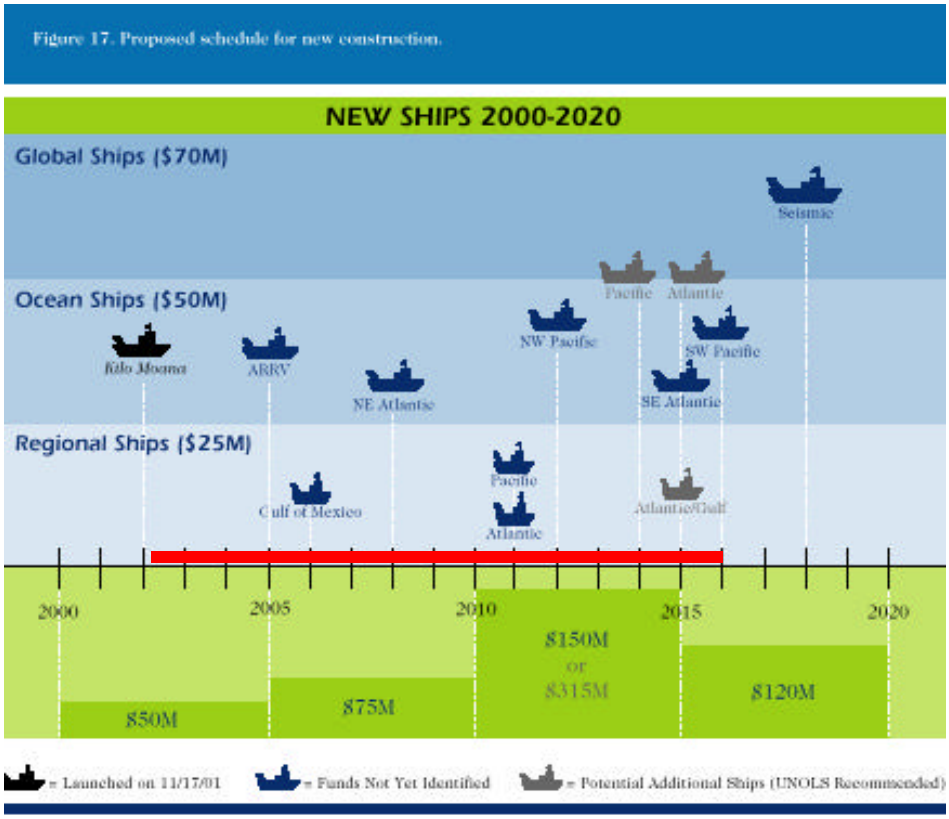



Figure 8. FOFC plan figure 17, showing a timeline for recommended new ships in size categories as defined by the plan. Red line of 14 years length added, as explained in text.

If new ships were to enter into service on the dates shown in the figure (and the plan is ambiguous as to whether the dates are planning, construction or in-service dates) then, plus or minus a ship or two, the fleet would barely maintain pace against the impending ship retirements noted above. It is, however, already questionable that the federal system can move ahead at this pace, given its inherent time lags. These lags are surprisingly long. The red line in the figure spans 14 years. This is the length of time that elapsed between the start of the 1980s CNO/SECNAV 5-ship initiative and the entry into service of the final ship under that initiative, R/V *Atlantis* at WHOI. The time span was comprised of agency budget formation, actual appropriations, then design, contracting

and construction periods, and assorted delays in all of these aspects. Against this gauge of time scale, the FOFC plan, involving twice as many ships, may already be late starting if we want the new ships to be ready on the dates indicated in the figure. No funds for any of these ships have yet been programmed by any federal agency. The point is that the country needs to move on the FOFC plan and execute it as briskly as possible, lest we fall farther behind the pace in the face of these realities of ship acquisition time scales. The situation is especially acute for the midsize ships as noted above. The FOFC document as it stands is only a prospectus. In itself it contains no concrete steps toward agency budget items and actual funded designs or ship acquisitions. These are the *implementation* steps that must go forward as soon as possible, and in coordination with the plan. Delay means piling up a huge ship acquisition bill that cannot possibly be met all at once. It must be spaced out in time, starting now.

Figure 8 shows three of the ships as UNOLS-recommended additional ships. The more conservative FOFC outlook would build only the other ships in the figure, thereby decreasing the census of the current fleet by four in this size range (the FOFC plan considers federal support for ship acquisitions only for the sector of the UNOLS fleet of ships over 40m in length, leaving the others to non-federal sources if they are to be renewed at all, as indeed they should be). The more optimistic UNOLS approach would build the additional three ships and end up with a fleet reduction of one. Neither of these outlooks is quite as optimistic as the workshop report discussed in section III above, where an *increased* demand for ship time was envisioned on scientific grounds. We see here the effect of differing levels of resignation toward the balance to be struck between estimates of scientific requirements or opportunities on the one hand and budgetary realities on the other. UNOLS took a somewhat more optimistic or aggressive stance than did the FOFC agencies, but still stopped short of what the science alone might suggest for the desirable scale of the future fleet.

This raises a broader issue of the overall health of the ocean sciences. The FOFC agencies, quite understandably, placed heavy weight on the fact that despite all the brave talk of the last two decades about the importance of the ocean to humankind, and despite the many research initiatives with their strong rationales for improved support, the stark net result has been flat funding for ocean research. This cautious tone is evident throughout the FOFC plan, and is exemplified in its figure 6, shown here as figure 9.

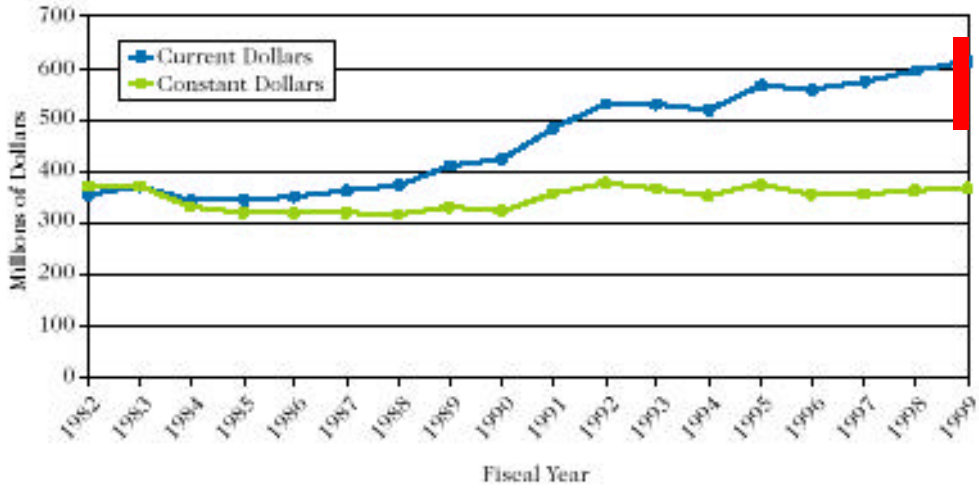



Figure 6. Total funding for ocean sciences in current and constant 1983 dollars for fiscal years 1982-1999. Compiled by the Ocean Studies Board, National Research Council.

Figure 9. History of total funding for ocean sciences in current and in constant dollars, from figure 6 of the FOFC plan. The bar at the right side indicates where the constant-dollar line would have ended in 1999 if it had kept pace with any of several other constant-dollar gauges as discussed in the text.

The line showing the inflation-adjusted value of total U.S. ocean science outlays from 1982 through 1999 obviously is essentially flat. It is therefore small wonder that FOFC, and to a lesser extent UNOLS, was not so bold as to insist on planning for an expanded fleet, though there are excellent scientific reasons in favor of this, as noted above. We see here the impact or discipline of fiscal realism imposed by almost two decades of hard budgetary experience.

Have other plausible standards of funding comparison been equally flat over the same time period? For reference the increases of U.S. GDP and U.S. per capita GDP, each inflation-corrected in two different ways, were calculated over the same time span. CPI-corrected calculations for total federal outlays and for the OMB category of outlays for "general science, space and technology" were also made. All six of these comparisons end up in the band plotted at the right side of the figure. That is, if the line for ocean science constant-dollar outlays had kept pace with any one of these other inflation-adjusted gauges, it would have ended up somewhere in that band, between 30 and 80 per cent higher than at the left side, not level with the left side where it actually lies. The question therefore is not whether ocean science deserves special treatment of some sort. The question is why the nation cannot accord it even equal treatment when compared to one or more plausible external fiscal gauges like the ones plotted.

This is an issue about which the chairman of the Commission on Ocean Policy has spoken for many years, as exemplified by one of his statements at the National Ocean Conference of 1998 (Proceedings, p. 83):

> *"We know what we need to do. From academia to federal agencies to state laboratories to industry we have the greatest scientific and technological capability on Earth to face any challenge. But we're mired in the status quo paradigm and a fear of stepping out that has relegated the oceans to the end of the soup line. It doesn't have to be this way. It shouldn't be this way."*

Perhaps the most important single thing the commission could do, for the ocean sciences as a whole and thereby for the academic fleet in particular, is to somehow prod the nation to unshackle ocean science from the end of the soup line. The field may not warrant, and would probably never receive, favoritism to be jumped ahead in the queue. If it could merely hold place in line as the line moves forward that would be a wonderful new departure from the experience of two decades. The scientific opportunities sketched above, and more fully detailed in numerous program planning documents and research prospectuses, would blossom and become real. New demands and uses for ships would then increase naturally as driven by the new science, which is the way it should be. We would be in the happy position of finding that the FOFC ship timetable in figure 8 is rather too pessimistic and should be augmented to meet the real demands of the research. The FOFC plan does call for its own review at intervals, and if it were found at the next review to have underestimated the funded demand for the fleet, that would be a superbly positive outcome from the standpoint of fleet planning and of ocean science overall.

## VI. Summary

- The nation needs a renewed academic fleet for sound scientific reasons. The fleet is "the most basic requirement" for a healthy future research program.

- There exists a fleet renewal plan - the FOFC plan. One can debate its level of cautiousness and other particulars, but it is a good plan overall, and we should back it. UNOLS does so.

- The plan needs a corresponding implementation strategy immediately. The lead-time problem in ship acquisition is very large and will soon overwhelm us if we do not act.

- Underlying the entire issue is the "soup line" syndrome for the ocean sciences as a whole. Breaking the tether that holds U.S. ocean science to the end of the line is fundamental.

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