UNIVERSITY - NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

ON THE ORDERLY REPLACEMENT OF THE ACADEMIC RESEARCH FLEET

A REPORT OF THE UNOLS ADVISORY COUNCIL

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JULY 1978

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NOTE

This report entitled "On the Orderly Replacement of the Academic Fleet" was endorsed as a planning document at the Eighth UNOLS Annual Meeting 19 May 1978 with the following stipulations and assumptions:

1. This report pertains only to replacement costs and assumes adequate availability of both operating funds and funding of necessary mid-life refits.

2. Because of the no-growth assumption and in order to monitor potential growth and evolution within the field of Oceanography UNOLS Advisory Council must periodically review and update this report.

3. This report pertains to only one category of the total U.S. research fleet -- that of the so-called "UNOLS Fleet" of vessels operated by academic institutions.

4. This report assumes that continuation of an academic research fleet is justified. This assumption is supported by recommendations of the National Advisory Committee on Oceans and Atmosphere (NACOA) in their Sixth Annual Report dated June 30, 1977, and Ocean Research in the 1980's--Recommendations from a Series of Workshops on Promising Opportunities in Large Scale Oceanographic Research, prepared by the Center for Ocean Management Studies, University of Rhode Island, August, 1977 (Post-IDOE Planning (PIP) reports). Further justification can be found in the 1975 report of the National Academy of Sciences Panel on Biological Oceanography, 1976 report of the National Academy of Sciences assessing the Directions for Naval Oceanography, 1978 draft report of the National Academy of Sciences Panel on Continental Margins, and the 1977 report of the Lamont-Doherty workshop on Ocean Crustal Dynamics.

5. Although not specifically referenced, UNOLS retains and emphasizes its interests in growth and in development of specialized facilities, such as submersibles.

6. The report highlights the need for $46M for replacement of intermediate size vessels and $48M for major vessel replacement between 1978 and 1994 (constant value dollars).

7. The naming of specific vessels within the report is necessary so that overall estimates can be made, however, details of specific vessel replacement remain to be worked out.

ON THE ORDERLY REPLACEMENT OF THE ACADEMIC RESEARCH FLEET

A Report of the UNOLS Advisory Council

Summary

The Advisory Council of the University-National Oceanographic Laboratory System (UNOLS) after reviewing the present status of the Academic Fleet, has reached the following conclusions:

1. Projections for the development of ocean science in the United States during the 1980's and beyond suggest that the basic size of the fleet requires little change. More emphasis will be placed on research in coastal and continental margin waters, and this will require more and better equipped vessels (approximately 500 tons displacement) than are presently available. Larger ships will be needed, both for coastal work in the winter, for multi-disciplinary studies in margin waters, and for distant water and open ocean operations.

2. A program of orderly renovation and modification of UNOLS vessels is necessary to permit continuing cost effective and safe operation. Such refits are estimated to cost between $400,000 and $1,000,000 (constant value dollars) per year during the period from now through the next decade and beyond.

3. The steady annual expenditure of $3 M (constant value dollars) over the next fifteen years should be adequate to replace intermediate and smaller vessels. Additional funding of about $48 M (constant value dollars) will be required to replace four major vessels which should be retired between 1983 and 1993.

4. These expenditures will maintain a fleet of about the present size and with somewhat enhanced capabilities, especially in coastal waters. Additional funds will be required for specialized vessels and to accommodate growth in the academic ocean research program.

5. Specialized ships will be required for research in high latitudes as well as research submarines and their support vessels.

6. Some research vessel needs can be met by chartering commercially operated ships and by using Federal agency ships. Chartering has not been generally cost-effective for long term research activities. Incompatibilities between Federal and university operating missions and practices have limited the success of academic use of Federal vessels.

7. It will sometimes be desirable to dedicate vessels to specific scientific uses, returning them subsequently to general purpose use. Such assignments of UNOLS vessels must be evaluated in the context of overall institutional needs and the needs of the national ocean science program.

8. Usage of UNOLS vessels during recent years on both fundamental and mission-oriented work suggests that a research fleet of at least the present size will continue to be needed. The occasional appearance of surplus capacity has resulted from transitory mismatch between fleet composition and science requirements and from the vagaries of research funding. Some surplus capacity will continue to be needed to accommodate mid-life overhauls and to provide general flexibility of operation including the investigation of unforeseen natural events.

ON THE ORDERLY REPLACEMENT OF THE ACADEMIC RESEARCH FLEET

A Report of the UNOLS Advisory Council

Introduction

In its Sixth Annual Report, the National Advisory Committee on Oceans and Atmosphere (NACOA) noted that much of the oceanographic research in the United States depends on seagoing research vessels operated and coordinated by universities and other academic institutions with financial support from Federal agencies. Maintaining the effectiveness and efficiency of this fleet requires continued maintenance and upgrading of ships and shipboard equipment. A long-range plan for replacement, modification, or addition of vessels is needed to ensure that the mix of vessel size and capability and the fleet distribution are suited to the national ocean science program.

Accordingly, NACOA recommended that:

"The Federal Coordinating Council for Science, Engineering, and Technology, with advice from the University-National Oceanographic Laboratory System, should develop a national plan for maintaining an effective academic research fleet, and should recommend funding and timing to implement that plan. The National Science Foundation should be designated lead agency for implementing the plan."

The condition of the academic fleet has been a matter of continuing concern to the University-National Oceanographic Laboratory System (UNOLS). As stated in its charter, one of the primary

responsibilities of the Advisory Council is to "evaluate the need for replacement and additional facilities" and to "make recommendations to funding agencies of the needs for specialized facilities or new concepts in facilities."

The UNOLS Advisory Council has considered aspects of the problem on previous occasions. For example, in its 1973 Annual Report, the Advisory Council noted that a third of the fleet was approaching obsolescence and recommended construction of two coastal research vessels in FY 1975 and one large (over 175 ft.) vessel in FY 1976. In a more comprehensive analysis in 1974, the Advisory Council recommended development of a long range plan under the following guidelines:

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

Initial work on such a plan was undertaken by a UNOLS workshop which met at the Santa Catalina Marine Laboratory in October 1974. Although the report of the workshop has never been completed or adopted, several useful conclusions were reached:

"There was general, almost surprising, agreement amongst the members of the meeting that the numbers of university ships needed for the foreseeable future is not significantly greater than presently exist. One exception to this might be the "Continental Shelf" (or larger coastal type vessel). A unanimous point of agreement was that, while the numbers - and even sizes - of future ships need not to be significantly greater - their capabilities for doing science at sea must be vastly improved. Furthermore, existing ships having a reasonable life remaining should be included in a general capability upgrading - especially in the quality of laboratories and overside gear handling. Areas of priority needs - some to the point of being critical - included suitable vessels for coastal research; vessels so adapted and equipped for geological and geophysical research that they become - or very nearly so - dedicated vessels; and a specially constructed vessel for operating in ice... In general regard to ships there was a majority conservative viewpoint against experimenting with untested hull designs."

The NACOA recommendation initiated further review by the UNOLS Advisory Council at its November 1977 and February 1978 meetings. This report summarizes the conclusions reached at these meetings.

The National Ocean Research Fleet

The national ocean research enterprise is conducted by a variety of entities, including state and federal government agencies, academic institutions (largely funded by federal government agencies), and industry. Most research at sea is conducted on dedicated research vessels. Some vessels are highly specialized; many others have general purpose capabilities. Most research

vessels are owned by the operating institution; however, most of the larger academic vessels are owned by the Navy or the National Science Foundation. Some work is done from chartered vessels, and "ships of opportunity" are occasionally used for research and for monitoring.

The overall oceanographic fleet can be classified as follows:

A. Government operated vessels
    1. Federal (Navy, NOAA, USGS, other)
    2. State
B. Academic operated vessels
    1. UNOLS Fleet (government or institution owned)
    2. Other
C. Industry operated vessels

The present report is concerned with the maintenance, upgrading, and replacement of the UNOLS fleet (class B.1). A similar problem undoubtedly exists with regard to government and industry operated vessels but is more properly treated by those organizations. Replacement of other, usually smaller, academic vessels is generally considered to be the responsibility of the operating institutions.

The UNOLS fleet is distinguished from other academic vessels in the following ways:

1. Operations are coordinated by UNOLS.
2. Vessels are available for use by scientists of institutions other than the operating institution.
3. Operating expenses of the vessels are met in large part by the Foundation and by other Federal agencies.

Present Composition and Status of UNOLS Fleet

In 1978 the UNOLS fleet consists of approximately 30 vessels (including one under construction) displacing about 23,000 tons (see Table 1 for detail of fleet composition). The fleet can be divided into four arbitrary classes (see Table 2 for details):

Size	Nom. Displ.	No.	≤10 yrs.	11-20 yrs.	>20 yrs.
>200 ft.	1500 T	7	2	5	0
150-199 ft.	1000	9	7	1	1
100-149 ft.	500	5	1	3	1
<100 ft.	200	10	5	2	3

Several important characteristics of the fleet are indicated in this summary:

a. *Five of the seven major vessels are about the same age (built in 1962-1965) and will require mid-life refit and eventual replacement at about the same times.*

b. *Similarly, six of the nine intermediate vessels were built within a brief period (1973-1978) and will have similar refit and replacement schedules.*

c. *There are few large coastal vessels (500 tons) and only one new ship has been added since 1967.*

Proposed Scientific Needs During the 1980's

Projections for the development of ocean science during the 1980's indicate no fundamental shifts in research directions. The evolutionary nature of the proposed research suggests that the basic size of the university-based fleet of research vessels requires little change.

But the scale and type of problems to be investigated in the 1980's will shift somewhat. More emphasis will be placed on phenomena in the coastal belt, on the shelf and within a few hundred miles of the U.S. coast. Far more research will be done on important oceanographic and ecological events of relatively short duration, many of them having major significance for society. Examples of these important, but presently unpredictable, events include:

- o El Niño
- o Major Floods, such as the Agnes floods in 1972
- o Anoxia in near-bottom waters of New York Bight in 1976
- o Large scale anomalies in ocean surface water temperatures

Given the continuation of Federal funding of ocean science, at approximately the level of the late 1970's, present projections indicate that no radical changes are needed in the number of research vessels available to the U.S. university-based oceanographic community; this appears to be generally well matched to the research needs. Adjustment of fleet capabilities will be needed during the 1980's to support large integrated research projects in coastal and margin waters. In particular, more and better equipped vessels of 125 feet or somewhat larger (500 tons displacement) will be needed to carry out the complex research program proposed for these regions. These are necessary, for instance, to provide more complete analysis and seasonal coverage of coastal ocean phenomena. Ships larger than 150 feet will be required to provide the year-round observations now

lacking in most coastal ocean areas, to support multi-disciplinary studies, and to handle the deployment, servicing and recovery of large instrument arrays. Furthermore, there is no evidence that the need for a distant water or open ocean operating capability will diminish in the coming years.

Specialized Ocean Research Facilities

Several specialized research facilities will be needed to support high priority research opportunities during the 1980's. Some of the facilities needed during the next decade include:

1. Research Ships for High Latitude Ocean Science.

   Safe and effective oceanographic operations at ice-dominated latitudes require specially designed (ice strengthened) large vessels. No such vessel is now operated by the United States. Consequently, high latitude oceanography is conducted from Coast Guard ice breakers, from a 125' wooden vessel in the Antarctic (appropriately named "Hero") and through cooperative arrangements with Argentina. This situation seems paradoxical in light of the growing significance of high latitude economic resources and the fact that Alaska has a larger continental shelf area than the other 49 states put together. A research vessel adequate for reliable operations in pack ice would cost ca. $15 M. Proposals have been made to construct two such vessels, for use in Arctic and Anarctic waters.

2. Research Submarines and Support Vessels.

Deep-sea scientific observation and exploration have benefited greatly from use of the only manned Deep Submersible Research Vessel (DSRV) now available in the U.S. academic fleet on a regular basis, i.e. the DSRV ALVIN operated by the Woods Hole Oceanographic Institution. Exciting biological and geological information of a fundamental sort unlikely to have been discovered by any other means has been brought to light by DSRV use in the last 5 years. There is strong scientific justification for at least one additional submersible research vessel of an even greater depth capability to be built in the next decade. The single DSRV facility currently available must be maintained; this requires early replacement of the submersible's tender vessel LULU. The replacement tender should be large enough and have sufficient capability to eliminate need for a separate vessel to accompany the submersible and its tender during open sea operations. Such capability could be built into the existing large research vessels. Doing so would limit the ability of the U.S. academic ocean science community to operate in distant water areas, but it would possibly allow the use of ALVIN in more distant waters.

3. Specialized Facility Charter.

There is a compelling need to capture deep sea mid-water organisms for study using large nets. No U.S. research vessel is equipped to handle the nets necessry to catch large fast swimming organisms. An attractive cost-effective approach is to charter such vessels (e.g. R/V WALTER HERWIG

Federal Republic of Germany; Norwegian ice strengthened trawlers) rather than to build new vessels with these extensive and expensive gear-handling capabilities. Such charter opportunities must continue to be explored as new scientific prospects are identified.

Alternative Sources of Research Vessel Time

Short term needs for time on research vessels are sometimes met by chartering commercially operated ships. This practice is likely to continue where appropriate during the 1980's. However, the experience of the university ocean science community during the past decade has been that chartering is not cost-effective for long-term research programs (with the notable exception of GLOMAR CHALLENGER).

The use of Federal agency ships in academic research has had limited success. Costs, operating procedures, and scheduling of the Federal ships have often been incompatible with the needs of university-based research programs. Some of the problems experienced by academic scientists in the 1970's might be met by changes in the priorities given by the Federal agencies to the support of university-based research. More effective academic use of these facilities might result from more flexible operating practices, and better coordination in ship scheduling.

It seems unlikely that the Federal agency ships can provide more than a small fraction of the research vessel time required by the ocean science community. Each agency fleet is designed,

built, and funded for operations in support of that agency's mission. None of the Federal agencies now has a high priority mission that includes supporting the nation's academic ocean science community. However, use of large federal ships for distant water work by academic scientists is an attractive possiblity and should be further explored.

Dedicated Vessels

For reasons of efficiency and cost, it is often desirable to dedicate a vessel to a specific scientific use. One example is geophysical work requiring the installation of computers and specialized geophysical equipment. Because of the complexity of the installation, such instruments are best left aboard and used by several investigators and projects.

Unlike specialized research vessels, which are designed and built for a particular use, dedicated vessels can be outfitted temporarily and later returned to general purpose use at relatively low cost. Some of the larger general purpose UNOLS vessels are sufficiently versatile to be used as dedicated vessels when the need arises, without major cost or loss of time for refitting. However, if any of these vessels is to be so dedicated, it is essential that sufficient sea-going capacity remains for other requirements of the operating institutions.

Fleet Utilization

Between 1972 and 1977 the U.S. academic fleet averaged 30 ships. This fleet has been effectively utilized by ocean science programs,

the bulk of which have been university-based. Projections of the levels of support for ocean science research suggest that ships' usage will not diminish during the next decade.

In the mid 1970s the equivalent of several ship years was used by ocean science programs supported by mission-oriented Federal agencies and by state and local governments. While the precise magnitude of such usage cannot be predicted, it is reasonable to expect that such demands for ship time will continue. If one extrapolates a continuation of research funding and the other mission-oriented usage at levels similar to the past few years, a research fleet of at least the present size will be required.

Some surplus ship capacity has occasionally been observed in UNOLS ship schedules. Part of this apparent surplus results from a transitory mismatch between fleet composition and science requirements. In some regions and at some times the coastal vessels of the UNOLS fleet have occasionally been heavily scheduled while larger deep ocean ships have been laid up. Furthermore vagaries of research funding have exacerbated the apparent surplus. Efficient ship scheduling (especially for the larger vessels) is done about two years in advance. Yet project funding decisions are often made only a few months before a scheduled cruise. Problems with funding a research project may result in last-minute rescheduling and loss of operational efficiency. On occasions, abrupt and last-minute termination of scheduled cruises by mission-oriented agencies has left significant gaps

in ship schedules.

The question of surplus capacity is also affected by mid-life overhauls which are necessary to maintain a ship's productivity, reduce operating costs, and prolong its useful life. To maintain the present fleet capability, such overhauls should be scheduled on an average of two ships per year during the next decade or more. Each overhaul can take up to six months, so an average of one-half to one ship-year annually will be unavailable for research activities.

Inadequate reserve ship capacity in the past has prevented investigation of important events which cannot be precisely predicted, such as major ocean-weather anomalies, major floods, biological catastrophes, etc. The inability to respond to these events has greatly limited the potential contributions of the ocean-science community to the solution of significant societal problems. Planning for total fleet size should provide the capacity to take advantage of these unplannable events.

Improved coordinated planning for ship construction, maintenance and refitting should contribute to even more efficient ship use in the next decade.

Refitting of Existing Vessels

Nearly all the large and some of the smaller research vessels in the UNOLS fleet are approaching the limit or are well into their

expected life. Thus a program of orderly renovation and modification of these vessels is necessary in the 1980's in order to permit continuing efficient and safe operation of the ships. Unlike the practice in industry where capital equipment is routinely replaced to take advantage of technological developments and potential economics, such action within the UNOLS fleet normally requires extensive review and case-by-case justification. The Federal agencies should develop a continuing program for timely upgrading of hulls, for replacing propulsion systems, and for extensively refitting the vessels. In many cases, more than one cycle of refitting will be prudent and necessary.

Of particular importance is the fact that most of the over 200 foot vessels in the UNOLS fleet have now reached mid-life (assuming a 28-30 year life-span for ships in this class). To maintain effective operation of these ships throughout their full 30-year life, major upgrading is necessary by the second decade. Without such upgrading, earlier replacements would be required. Refitting the existing UNOLS fleet is estimated to cost between $400,000 and one million per year, commencing now.

Vessel Replacement Schedule and Costs

The proposed schedule for replacing the UNOLS fleet is based on the age and condition of its vessels (Table 1). In developing the schedule, the remaining life of each vessel was estimated from its age and material condition (Table 2). A size-dependent weighting factor was applied in each case. If no funds

for new construction were made available, the fleet would be reduced to an alarming degree. During the period 1980-1989, eleven vessels would be retired, and fleet tonnage would be reduced by 6200 tons (27%).

For estimating replacement costs for the UNOLS fleet, we used the following constant value dollar figures:

LOA	Class displ.	Cost
>200'	1500 T	$12 M
150-200'	1000 T	6
100-149'	500 T	3
<100'	200 T	1

If replacement construction were funded at $3 M per year throughout the decade, most of the needed vessels could be built (Table 3). Having spent $32 M (constant value dollars) in 1980-1989, there would be a slight reduction (800 T) in overall tonnage, and the number of major vessels (>200 ft, 1500 tons) would be decreased from 7 to 5. At the same time, the number of large coastal vessels (125 ft., 500 tons) would be nearly doubled, from 5 to 9.

While the reduction in the number of major vessels under the $3 M per year schedule would be unfortunate, it might be acceptable if three more major vessels (>200 ft.) were not due for retirement in 1990 to 1995. Continuation of new construction funding at $3 M per year would not permit replacement of any of these major vessels, therefore by 1994 the distant water fleet would be reduced to two major vessels (KNORR and MELVILLE), and fleet tonnage would be down an additional 3800 tons. Additional funding of $48 M for replacement of four (4) major vessels would result in an overall increase (718T) in fleet tonnage and the number of major vessels would only decrease from 7 to 6 (Table 4).

Replacement of the UNOLS fleet thus appears to fall into two categories:

a. Intermediate and smaller vessels: steady expenditure of about $3 M per year (constant value dollars) over the next fifteen years should be adequate for all necessary replacements.

b. Major vessels: Four of these will require replacement during the next fifteen years: CONRAD (1983), THOMPSON (1992), WASHINGTON (1993), and ATLANTIS II (1993). The total cost of these replacements is estimated at $48 M (constant value dollars). Separate funding, in addition to the $3 M per year required for smaller vessels, will be needed to replace these larger vessels.

It should be noted that even with such funds - $48 M for major vessels, $46 M for intermediate and smaller vessels - the fleet would be no larger in 1994 than it was in 1978 although its capabilities, especially in coastal waters, would be significantly greater. Any growth in academic marine research will necessitate additional funds for the increased general purpose or specialized fleet capacity.

TABLE 1

CURRENT STATUS AND DISTRIBUTION OF ACADEMIC FLEET

REGION NAME	LOA (FT)	CONDITION IN 1978 DERIVED FROM SOCC REVIEWS	YEAR BUILT	AGE WEIGHTING FACTOR* (years)	PROJECTED TO LEAVE FLEET	DISPL. LT
GREAT LAKES						
LAURENTIAN	80	Excellent	'74	+26	2000	175
NORTHEAST						
KNORR	245	Good	'69	29	1998	1915
ATLANTIS II	210	Fair/Good	'63	30	1993	2300
CONRAD	208	Fair/Poor	'62	21	1983	1370
VEMA	197	Fair	'23	-	1985	743
OCEANUS	177	Excellent	'75	27	2002	960
ENDEAVOR	177	Excellent	'76	27	2003	972
CAPE HENLOPEN	120	Good/Excellent	'76	25	2001	179
WARFIELD	106	Good	'67	25	1992	162
MAURY	65	Poor	'50	23	Now	100
SOUTHEAST & GULF						
GILLISS	208	Fair	'62	25	1987	1370
GYRE	172	Good/Excellent	'73	27	2000	950
C. ISELIN	170	Excellent	'71	27	1998	830
EASTWARD	118	Fair/Poor	'64	24	1988	610
LONGHORN	80	Good	'70	23	1993	200
BLUE FIN	72	Fair/Good	'72	23	1995	70
CALANUS	64	Excellent	'70	23	1993	111
N W & ALASKA						
T.G. THOMPSON	209	Fair/Good	'65	27	1992	1362
WECOMA	177	Excellent	'76	27	2003	962
ACONA	85	Fair	'61	21	1982	179
CAYUSE	80	Good	'68	23	1991	173
HOH	65	Poor	'43	27	Now	81
ONAR	65	Poor	'54	23	Now	95
S W & HAWAII						
MELVILLE	245	Good	'70	29	1999	1915
T. WASHINGTON	209	Fair/Good	'65	27	1992	1362
MOANA WAVE	172	Excellent	'73	27	2000	950
NEW HORIZON	170	New	'78	27	2005	800
KANA KEOKI	156	Fair	'67	18	1985	500
ALPHA HELIX	133	Fair/Good	'65	25	1990	512
VELERO IV	110	Fair	'48	40	1988	540
E.B. SCRIPPS	95	Good	'65	23	1988	234
					TOTAL:	22,682

*Age Weighting Factor: Useful life of vessel by class: ›200' 29 years
150-199 = 27
100-149 = 25
‹100 = 23

In some cases, material condition of vessel indicated use of a modified factor.

TABLE 2

PROFILE OF ACADEMIC FLEET BY AGE AND SIZE (1978)

	10 YEARS & UNDER	11-20	21-30	30+ YEARS	TOTAL
OVER 200 FT.	KNORR MELVILLE	ATLANTIS II CONRAD GILLISS THOMPSON WASHINGTON	0	0	7
150-199 FT.	ENDEAVOR GYRE ISELIN MOANA WAVE NEW HORIZON* OCEANUS WECOMA	KANA KEOKI	0	VEMA	9
100-149 FT.	CAPE HENLOPEN	ALPHA HELIX EASTWARD WARFIELD	0	VELERO IV	5
65-99 FT.	BLUE FIN CALANUS CAYUSE LAURENTIAN LONGHORN	ACONA E.B. SCRIPPS	MAURY ONAR	HOH	10
TOTALS	15	11	2	3	31

*Scheduled for delivery July 1978

Table 3

REPLACEMENT SCHEDULE FOR THE ACADEMIC FLEET
AT $3M PER YEAR (CONSTANT VALUE DOLLARS)

			VESSEL CLASS NOW	VESSEL CLASS NEW		
	LOA*	DISPL+			Δ** DISPL	COST
			1980 - 1989			
VEMA	202'	743T	1000T	1000T	+257T	$ 6 M
MAURY	65	100	200	200	+100	1
HOH	65	81	200	500	+419	3
ONAR	66	95	200	200	+105	1
ACONA	85	179	200	500	+321	3
CONRAD	208	1370	1500	0	-1370	0
KANA KEOKI	156	900	1000	500	-400	3
GILLISS	208	1370	1500	1000	-370	6
SCRIPPS	95	234	200	500	+266	3
EASTWARD	118	610	500	500	-110	3
VELERO IV	110	540	500	500	- 40	3
NET TONNAGE CHANGE & TOTAL COST					-822T	$32 M
			1990 - 1994			
ALPHA HELIX	133'	512T	500T	1000T	+488T	$ 6
CAYUSE	80	173	200	500	+327	3
THOMPSON	209	1362	1500	0	-1362	0
WASHINGTON	209	1362	1500	0	-1362	0
WARFIELD	106	162	500	500	+338	3
ATLANTIS II	210	2300	1500	0	-2300	0
LONGHORN	85	200	200	200	0	1
CALANUS	63	111	200	200	+ 89	1
NET TONNAGE CHANGE & TOTAL COST					-3782T	$14 M

RESULTING FLEET COMPOSITION:

	NUMBER OF VESSELS IN EACH CLASS			
	1500T	1000T	500T	200T
1978	7	9	5	10
1989	5	9	9	7
1994	2	10	9	6

* LOA, Length over all
\+ DISPL, Displacement, in tons
** Δ DISPL, change in displacement tonnage resulting from new construction

TABLE 4

REPLACEMENT SCHEDULE FOR THE ACADEMIC FLEET
INCLUDING REPLACEMENT OF FOUR MAJOR VESSELS
(Constant Value Dollars)

			VESSEL CLASS			
			NOW	NEW	△**	
	LOA*	DISPL+			DISPL	COST
			1980 - 1989			
VEMA	202'	743T	1000T	1000T	+257T	$ 6 M
MAURY	65	100	200	200	+100	1
HOH	65	81	200	500	+419	3
ONAR	66	95	200	200	+105	1
ACONA	85	179	200	500	+321	3
CONRAD	208	1370	1500	1500	*+130*	*12*
KANA KEOKI	156	900	1000	500	-400	3
GILLISS	208	1370	1500	1000	-370	6
SCRIPPS	95	234	200	500	+266	3
EASTWARD	118	610	500	500	-110	3
VELERO IV	110	540	500	500	- 40	3
NET TONNAGE CHANGE & TOTAL COST					+678	$44 M
			1990 - 1994			
ALPHA HELIX	133'	512T	500T	1000T	+488T	$ 6 M
CAYUSE	80	173	200	500	+327	3
THOMPSON	209	1362	1500	1500	*+138*	*12*
WASHINGTON	209	1362	1500	1500	*+138*	*12*
WARFIELD	106	162	500	500	+338	3
ATLANTIS II	210	2300	1500	1500	*-800*	*12*
LONGHORN	85	200	200	200	0	1
CALANUS	63	111	200	200	+ 89	1
NET TONNAGE CHANGE & TOTAL COST					+718	$50 M

RESULTING FLEET COMPOSITION:

	NUMBER OF VESSELS IN EACH CLASS			
	1500 T	1000T	500T	200T
1978	7	9	5	10
1989	6	9	9	7
1994	6	10	9	6

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* LOA, Length over all
\+ DISPL, Displacement, in tons
** △ DISPL, Change in displacement tonnage resulting from new construction