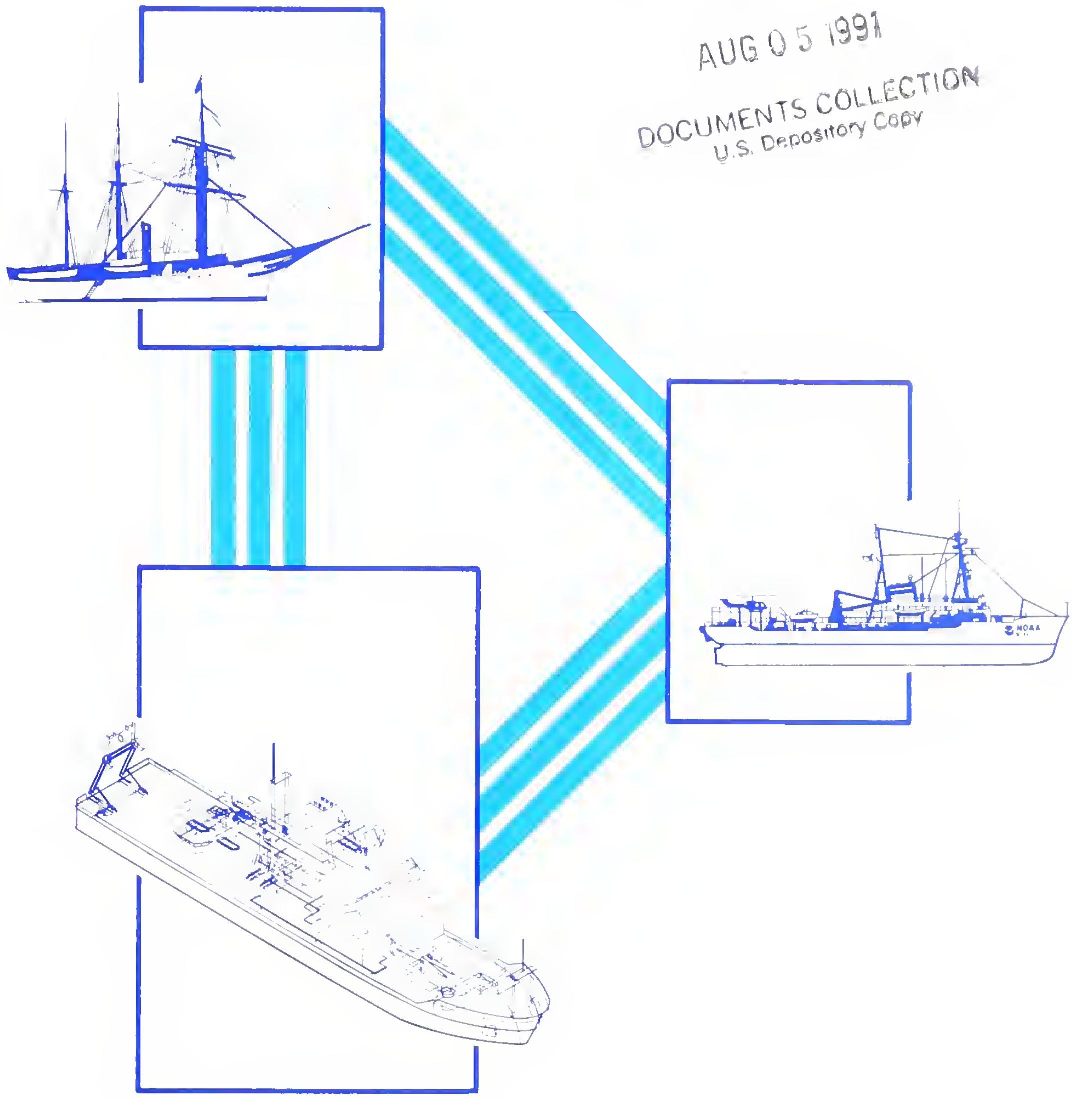
NOAA'S OCEAN FLEET MODERNIZATION STUDY

Highlights of Phases I-III



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of the Chief Scientist

NOAA OCEAN FLEET: YESTERDAY, TODAY, TOMORROW

NOAA was created in 1970 through a Presidential reorganization, but the survey activities of the fleet of one of its predecessor agencies, the U.S. Coast and Geodetic Survey, became well established in the nineteenth century. Sketched from a photo is perhaps the best-known survey vessel of its time, the PATTERSON, built by James D. Leary at Brooklyn, NY, in 1883. It was a wood auxiliary barkentine, 435 tons, 163 feet long, with a 27 foot beam, and a draft of 14 feet. Much of its survey work was done in Alaskan waters.

Commissioned in April 1960, the SURVEYOR, here depicted in a drawing, is a part of NOAA's current ocean fleet. The ship has a welded steel/ice-strengthened hull and is 2,653 gross tons, 292 feet long, with a 46-foot breadth and a draft of 19.5 feet. It was built by the National Steel and Shipbuilding Company of San Diego, CA. The SURVEYOR conducts worldwide oceanographic research but is nearing the end of its useful service life (see p.2).

A modernized NOAA fleet might employ ship designs such as the one shown for the JAMES CLARK ROSS which will soon join the fleet of the British Antarctica Survey. This ship is ice-strengthened. It is being built at the Swan Hunter Shipyard at Newcastle, England, and was scheduled to be commissioned this year.

(Photo of the PATTERSON and drawing of the SURVEYOR courtesy of NOAA/Office of NOAA Corps Operations. Sketch of the JAMES CLARK ROSS courtesy of British Antarctica Survey and Swan Hunter Shipyard.)

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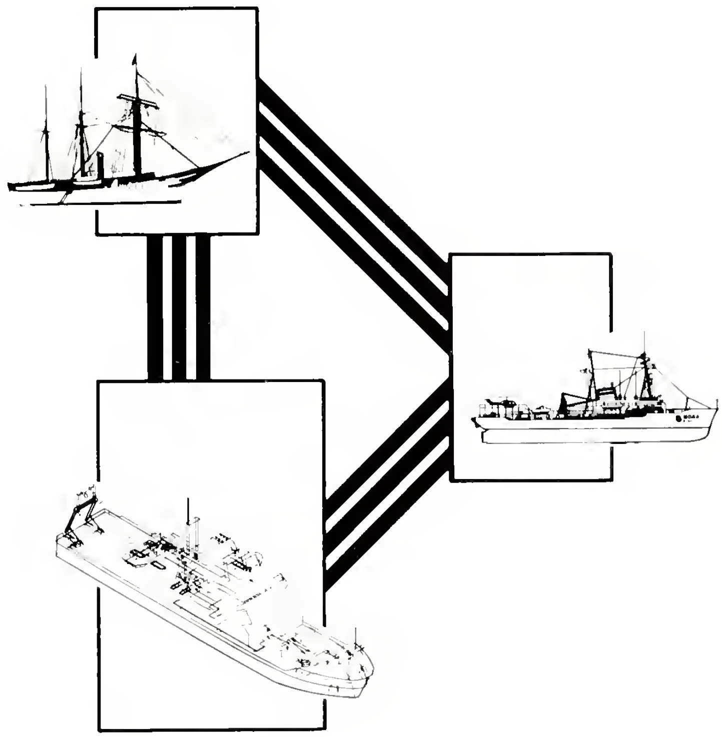


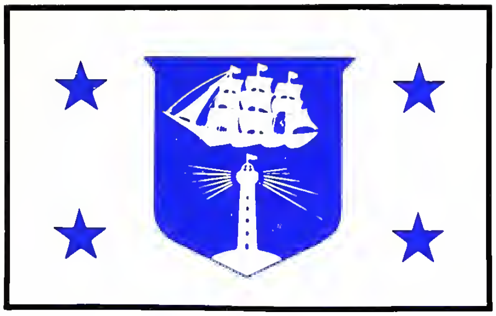
April 1991

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

National Oceanic and Atmospheric Administration
John A. Knauss, Under Secretary

Office of the Chief Scientist
Sylvia A. Earle, Chief Scientist

THIS ASSESSMENT STUDY PROVIDES A SERIES OF OPTIONS FOR MODERNIZING NOAA'S FLEET. THE STUDY DOES NOT INCLUDE A COMPREHENSIVE ANALYSIS OF THESE VARIOUS OPTIONS AND ALTERNATIVES, AND THE RELATED MAINTENANCE, OPERATING AND LIFE-CYCLE COSTS ASSOCIATED WITH FLEET MODERNIZATION. STATEMENTS INCLUDED IN THIS DOCUMENT ARE NOT TO BE CONSTRUED IN ANY MANNER AS POLICY-RELATED DECISIONS.



Under Secretary of Commerce

A Message From The Under Secretary For Oceans and Atmosphere and Administrator

The advanced age of the NOAA fleet and its growing functional obsolescence are widely recognized both within and outside NOAA. A 1988 study of the Marine Board of the National Academy of Sciences drew attention to the need for a modernized fleet capable of supporting a diverse array of complex scientific missions.

To determine the shape and size of the next-generation fleet, we in NOAA initiated an assessment of mission requirements for the fleet into the next century and the existing fleet's capability to meet these requirements. This assessment, which started in early 1990, was conducted in three phases. The findings have already been published (Phase I, September 1990; Phase II, October 1990; and Phase III, October 1990).

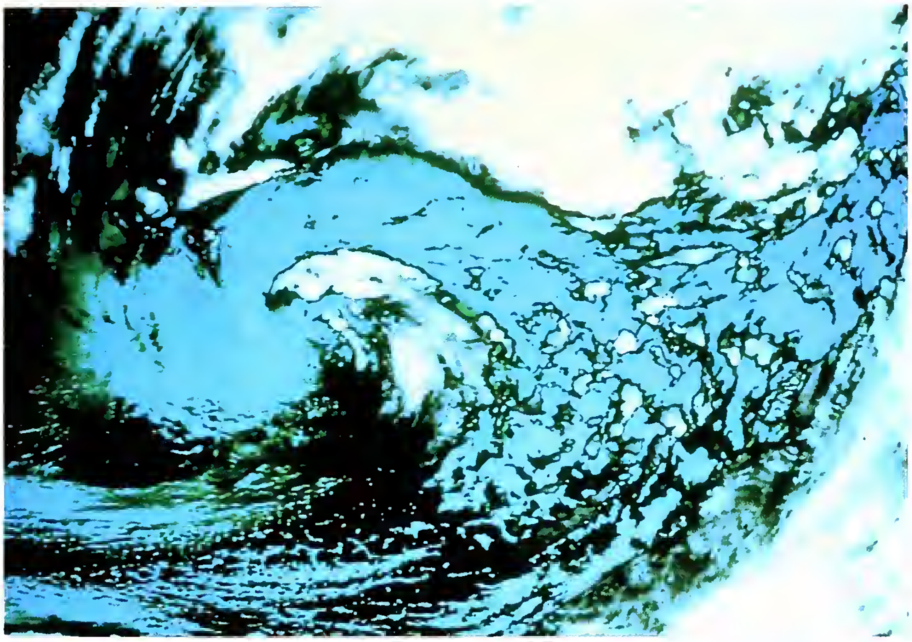
This "Highlights" document provides a synopsis of the three volumes. It covers the background of the study, methodology, implementation, significant findings, and conclusions and recommendations of the study groups.

I hope this document will provide a brief and useful overview of fleet modernization to all those interested in NOAA's ocean missions and its future fleet to support these missions.

John A. Knauss

"RESEARCH AND SURVEY VESSELS ARE ESSENTIAL FOR NOAA'S MARINE AND ATMOSPHERIC MISSIONS."

--see page 17



Highlights of Phases I – III

Priorities...and Problems

The National Oceanic and Atmospheric Administration (NOAA), as the Nation's "earth systems agency," has expanding responsibilities for a variety of oceanographic and atmospheric research, assessment of living marine resources, nautical charting, and mapping. Since its formation in 1970 through a Presidential Reorganization Order, NOAA's legislatively mandated responsibilities have increased the scope and complexity of its missions. At a time when the Nation's focus is increasingly drawn to such issues as climate change and marine environmental quality these responsibilities carry with them a high sense of priority.

Yet one of NOAA's major tools by which it discharges these responsibilities is in decline, thereby imperiling the conduct of its missions. The age of the NOAA fleet and, in some cases, its functional obsolescence have been major factors in the declining mission capability of the vessels. Since 1970 NOAA has commissioned only one new ship. The average age of the ships of the NOAA fleet is 25 years (Figure 1) with 30 years being the life expectancy of a vessel which has benefitted from a major midlife rehabilitation. Of the twenty-three NOAA ships, only six have had even a partial midlife rehabilitation. For the other ships, the midlife rehabilitation has been deferred due to budget constraints or proposed replacement. For those ships which have undergone some rehabilitation, the work has not been comparable to the service-life extension practiced by the University National Oceanographic Laboratory System (UNOLS) fleet and certain foreign countries, where the ship is totally gutted and refitted with new machinery and facilities.

Since 1971 the total capital investment made by NOAA in vessel construction and refit has been under $3 million. Indeed, funding for capital improvements in the NOAA fleet has undergone a serious decline relative to other

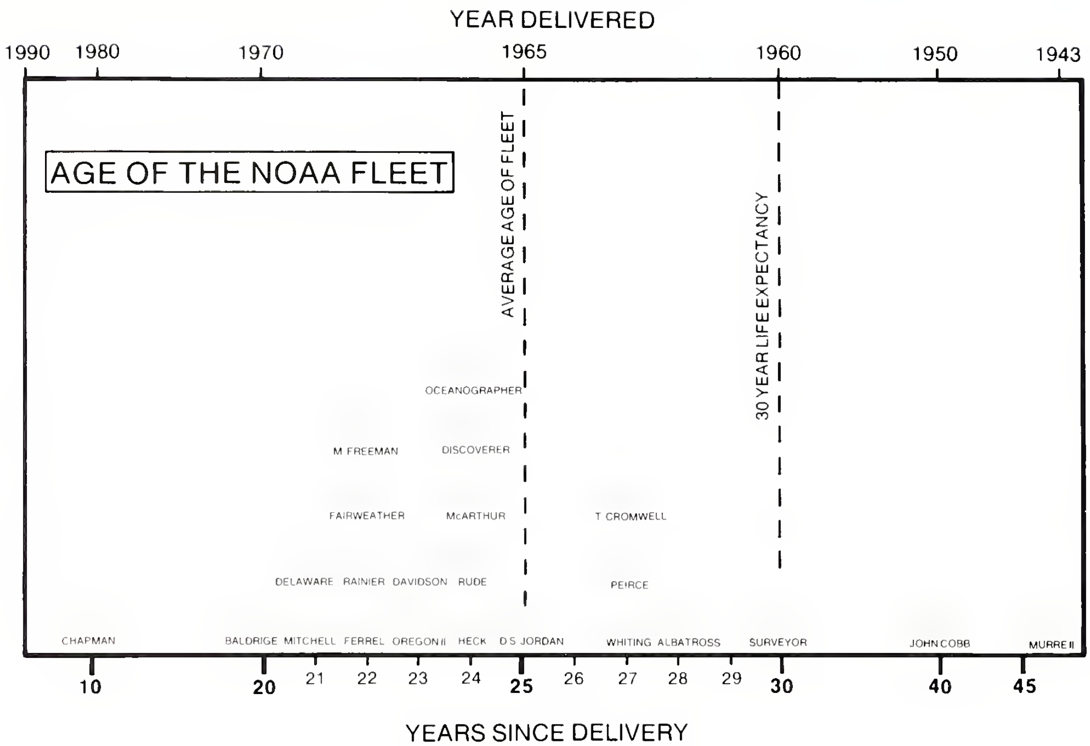


Figure 1. *Age of the NOAA fleet. Silhouettes of named vessels are plotted at year of construction. The average age of the fleet is shown to be approximately 25 years. Note that the time scales have been distorted to clarify the data.*

organizations conducting oceanographic research. (Figure 2).

Increasing Age and Declining Mission Capability. The age of the vessels affects the research mission of NOAA in a number of ways. The most obvious of these is the number of days at sea (DAS) the fleet can achieve. Currently less than 3600 days at sea (DAS) per year are provided by the NOAA fleet to support NOAA's missions. *This present level of DAS support is only 84% of the average annual number of DAS provided over the past 15 years.* This level of support is in large part a function of funding. If, however, funding were available, the material condition of the current fleet would limit the available DAS to a less–than–desirable level. Another problem caused by the age of vessels is the annoyance of unscheduled breakdowns or delays inherent in old machinery regardless of how well it is maintained. As the ships age, replacement parts are more difficult to obtain thus making repairs more costly and repair periods longer. Also of concern is the expense involved in operating these older vessels due to increased maintenance and the added manpower costs relative to modern vessels which employ labor–saving technology.

The mission capability of the NOAA vessels in many regards is of more serious concern than the age of the ships. The ships were built with the technology of the 1960's and to satisfy very specific oceanographic objectives. The principal NOAA missions at the time were geological and physical oceanographic research, launch hydrography, and trawling to determine stock assessment. During the past

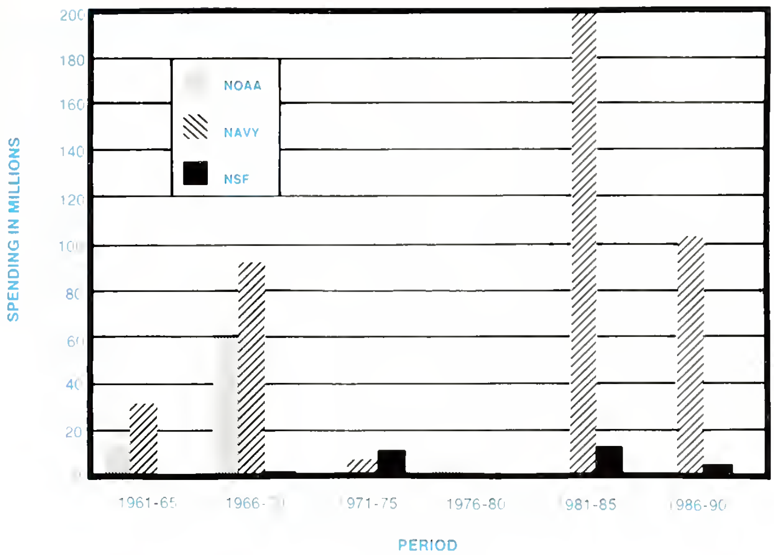


Figure 2. *Comparison of capital investments in ships among NOAA, the Navy, and the National Science Foundation (NSF) since 1960. Figures for 1961 through 1970 are for NOAA's predecessor organizations.*

two to three decades major advances have been made in areas of technology and mission protocol. One major difference is scale. Thirty years ago descriptive investigations were still being conducted to obtain a localized understanding of phenomena. Today, the research is directed toward understanding those processes driving regional or global phenomena, such as climate change and long-term changes in fish stocks. Understanding these processes involves deciphering local events, frequently achieved though experimental studies and long-term monitoring activities, and relating these to large-scale phenomena. Furthermore, this research involves multidisciplinary investigations using sophisticated analytical techniques unknown 20 to 30 years ago. In the same manner NOAA's charting and mapping efforts have shifted toward more efficient tools and methods. Only the traditional methods of fishery stock assessment, e.g., trawling, have remained relatively constant over the years. However, with advances in various optical and acoustic remote-sensing technologies, changes in these methodologies are also expected in future years. Research specifically addressing environmental issues was not undertaken in NOAA's early years; today it has become a strong component of the overall research effort. These new thrusts place a strain on NOAA's aging fleet.

Development of a Study Plan

The need for a NOAA fleet with more sophisticated research platforms is now widely recognized both within and outside the organization. For example, in a recent study, the Marine Board of the National Academy of Sciences (1988) recommended that: "NOAA should commission ... a study to define the characteristics of an idealized fleet to meet present and projected ship services needs. The results of this study should serve as the basis for the modernization of the NOAA Fleet..." In partial response to this stated requirement and a similar perception on the part of NOAA, such a study was initiated. The study reflects our efforts to determine NOAA's mission needs into the next century in the areas of oceanographic, charting/mapping, and fishery research, and to specify how these mission needs translate to the next generation of NOAA ships.

The goals of the fleet modernization study plan were to:

- articulate the ocean mission of NOAA in charting/mapping, living marine resource stock assessment, and oceanographic research into the next century

- determine the character and size of charting/mapping, stock assessment, and oceanographic research vessels to form a fleet to respond to NOAA's ocean mission requirements

- anticipate future technology and its application to NOAA's mission
- develop a technical framework to decide an orderly replacement and/or upgrade of the existing fleet considering both material condition and functional capability
- determine cost estimates for fleet modernization associated with various mission requirement levels
- provide a technical data base for preparing a fleet modernization plan that will be defensible in the federal funding process

To determine the character of NOAA's next generation of oceanographic vessels two considerations were most important. First, the users, rather than managers, must determine the mission requirements for the ships; and second, the assessment must focus on NOAA's future. To assure that such a study was not biased by existing resources, the approach was to delay any comparison to the present NOAA fleet until quite late in the process. To do so a method was chosen to identify, first, the mission requirements; second, to define what type of ship specifications are needed to satisfy these requirements and to develop a series of fleet management recommendations; and, finally, to compare projected vessel needs to the existing fleet. Figure 3 outlines this process. This three-phase process was chosen to be developed in a serial rather than a parallel sequence. Each part, or phase, was designed to be independent of the others but using data obtained in previous phases. An accelerated timeframe was developed in order to meet both a NOAA budget submission deadline and to ensure that the findings of the first part of the process were still valid at the conclusion of the study.

PHASE I

Implementation of Phase I

NOAA's ocean missions require a diverse array of research activities which can be viewed as a continuum with charting and living-marine-resource stock assessments as two end members, each with unique requirements. Bridging the continuum, without clear boundaries, is oceanographic research. The broad spectrum of oceanic research encompasses all aspects of marine science as they relate to understanding the oceans as part of the earth system. For the two end members, the organizational structure

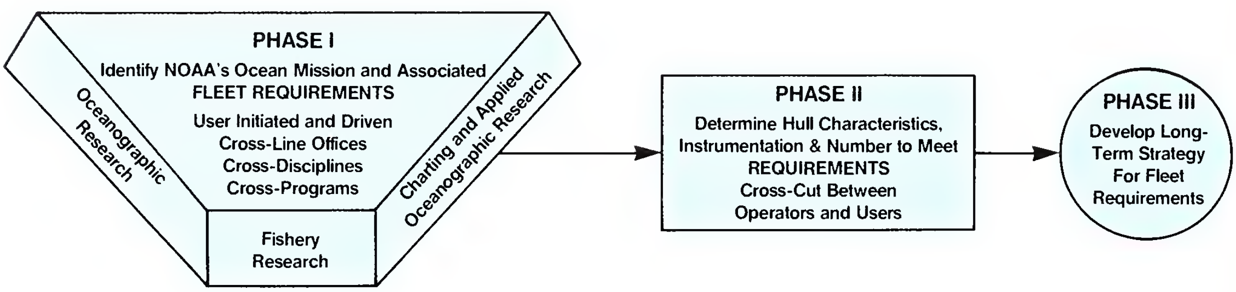


Figure 3. *A threefold process was used for the assessment. A serial, rather than a parallel sequence was adopted.*

is clear: charting is under the purview of the National Ocean Service (NOS) and stock assessment is under the National Marine Fisheries Service (NMFS). Oceanographic research, however, has no similar organizational niche. Portions of this research reside in each of the five NOAA line offices. The greatest involvement in ocean research, however, is found in the three line offices which are the principal users of NOAA ships. These are the Office of Oceanic and Atmospheric Research (OAR), NOS, and NMFS. There is some overlap in mission requirements among these three groups for particular ships. At the Phase I level this overlap was natural and was encouraged; as part of the Phase II study these overlaps, where appropriate, were integrated.

Crucial to the study plan was to develop as thoroughly as possible the direction of NOAA's research missions into the twenty-first century. The Working Group in Phase I included some of the leading scientists and technical experts in their subject fields from within and outside of NOAA. Included were persons expert in such subject areas as physical, chemical, biological, and geological oceanography; hydrography; and living marine resources. Many of these scientists were also expert with newer methodologies such as satellite remote-sensing and acoustic technologies. These persons were asked to consult with other colleagues, who were not part of the Working Group, in considering: anticipated rate of growth in areas of activity, funding, and technology; and trends in data collection, analyses, and communications. The responses to this charge were presented as position papers prepared prior to the convening of the Working Group and appear as an appendix to Phase I of the study. When the ideas presented in the position papers were viewed together, a reasonably accurate prediction of NOAA's future research program emerged. From this future view, specific mission requirements for the ships to support this research were developed.

A major point to be noted was the overwhelming consensus of the writers of these technical papers that the need for ships in future oceanographic research to take *in-situ* measurements and other observations would increase rather than diminish as a result of new technologies such as remote sensing. As one scientist wrote:

Because of advances in remote sensing [i.e., satellites], doubts have been raised on the necessity of ships. The promise of remote sensing, though, is not to replace ships but to greatly increase our ability to monitor conditions and processes ... Ships ... will never be replaced because there are myriad chemical and biological variables whose quantification requires manipulation of samples; whenever samples are needed ships are essential. Also, the more valuable remote sensing becomes the more ships will be needed to provide ground truth and to deploy and service moored arrays. (Phase I, p. A20)

For the purpose of this study two points must be emphasized. Phase I did not consider mission requirements for vessels less than 65 feet. This is consistent with NOAA's policy as discussed in "Ships of the NOAA Fleet" (1989). Also, the criteria determined by UNOLS for various sizes of oceanographic research vessels were used as a guide. The completeness of the ongoing UNOLS effort served as an excellent starting point.

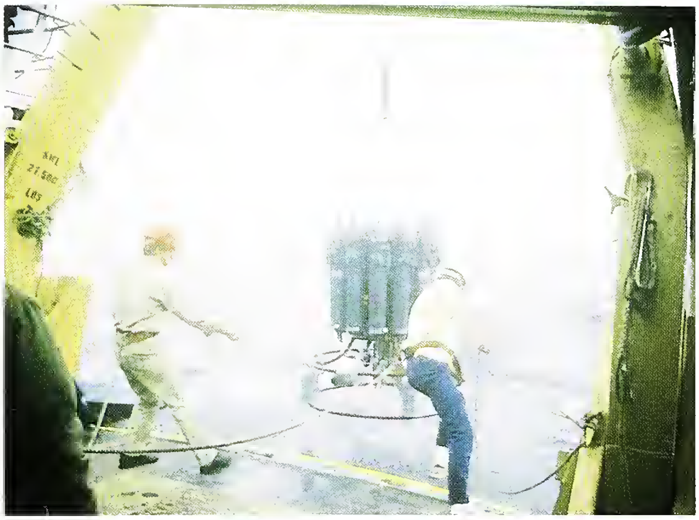
Mission Requirements Identified in Phase I

As identified by the Phase I Working Group, there are several trends in NOAA's mission which impact vessel characteristics. The impact is not constant between programs or between types of vessels. For example, what is required on certain large vessels primarily

SAMPLING

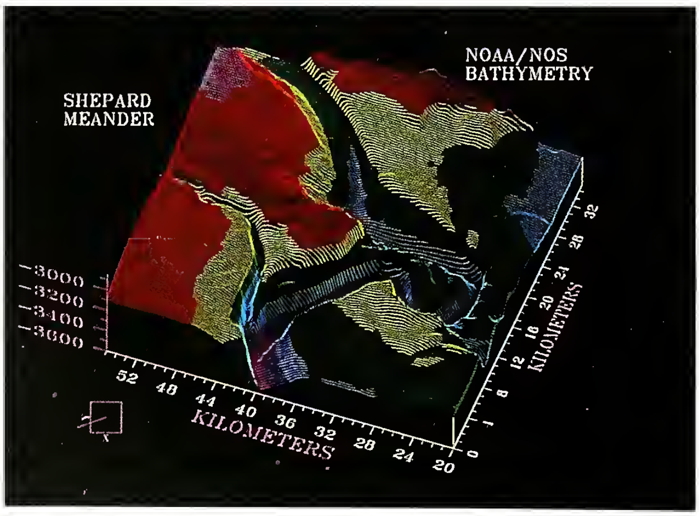
OBSERVATIONS

DIVERS



IN-SITU MEASUREMENTS

LONG-TERM MONITORING



CHARTING

MAPPING

supporting multidisciplinary research is not necessarily required on smaller ships engaged in nearshore charting or estuarine research activities. Requirements which apply to one or more of the mission programs are:

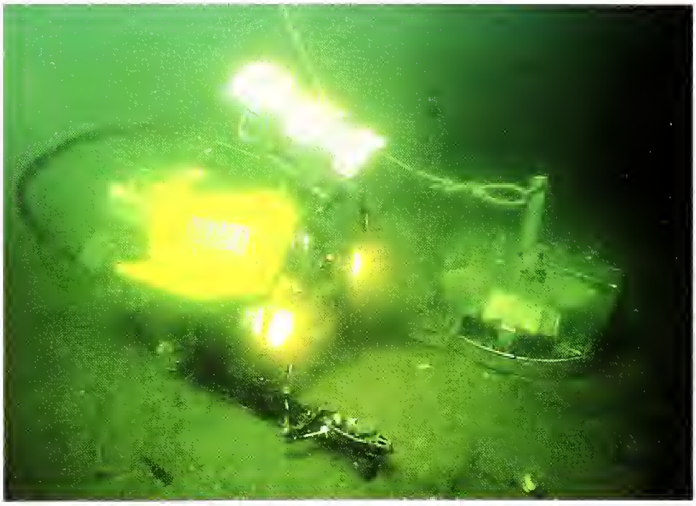
1. *Remote Operation*. Global climate research will expand into the western Pacific basin, the Southern and Indian Oceans, and the Norwegian and Greenland Seas. Charting and mapping will expand to include the U. S. Trust Territories in the central and western Pacific Ocean. Assessment of certain overexploited migratory fish may require voyages into all parts of the Atlantic, Pacific, and Indian Oceans. Global climate research, fishery oceanography, and living marine resource assessments will require more frequent and longer cruises to be made to the polar and sub–polar regions, the Arctic (global climate studies), and Antarctica (stock assessments). In high latitudes, there will be increased pressure to work for a greater portion of the year and on some occasions to work further into the ice.

For the larger vessels, these remote operations will require ships capable of long endurance (up to 60 days), a range of 15,000 nautical miles, and ability to carry large science payloads [i.e., 15 ocean moorings, one or more remotely operated vehicles (ROV's), 30–meter spar buoys]. All size vessels, however, will require greater endurance and longer range than generally available on NOAA ships. To ensure maximum utilization of station time these vessels must be able to operate in higher sea states than now possible with less risk of injury to personnel and loss or damage to equipment. At least one vessel needs to be able to operate within the marginal ice zone (must be ice–capable, but not an icebreaker).

2. *Multidisciplinary Research*. In the areas of global climate, fishery oceanography, and coastal ocean programs, the research efforts are becoming progressively process oriented. The processes which drive phenomena as diverse as climate, nearshore circulation, and fisheries recruitment are quite complex, encompassing components of several science disciplines. The roles of biology, chemistry, physics, and geology in influencing global and regional oceanic circulation patterns, which in turn influence climate, have yet to be fully understood. Likewise, the understanding of climatic variability and circulation patterns on fishery recruitment processes is in its infancy. This complexity requires multidisciplinary research efforts. Within various disciplines, such as biological and chemical oceanography, several specialties are often involved. In order to support the wide–ranging research requirements the vessels must be able to berth large numbers of scientists. Dedicated analytical laboratories to support multidisciplinary research must be much more sophisticated and varied for specific analytical functions than now exist on NOAA ships. Also the laboratories and deck equipment must be sufficiently flexible and versatile to accommodate a variety of science requirements. Flexibility for the laboratories should be achieved through interchangeable modules rather than vans or containers.

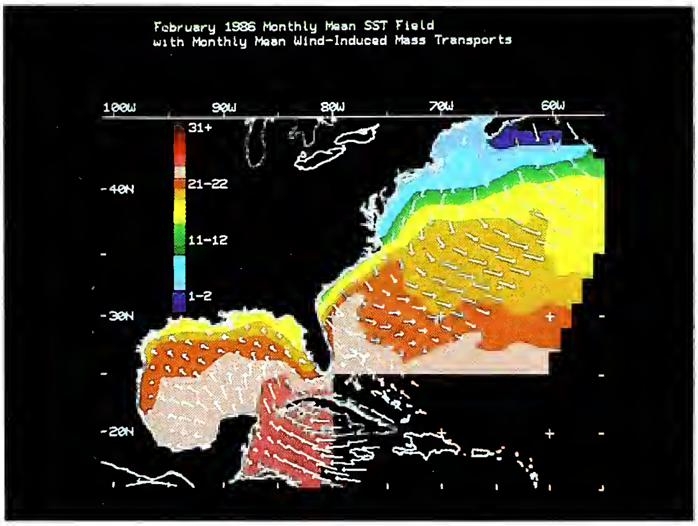
3. *Enhanced Data and Sample Collection and Storage*. This includes designing ships that will accommodate:

Remote–sensing technology. With the advances in remote–sensing technology, such tools are being used in more varied and more demanding sampling protocols. Future research envisions even greater use of this technology, especially ROV's, *in–situ* bottom instrumentation, and sophisticated buoy systems. Ship capabilities need to be upgraded to more efficiently deploy and recover instruments and to better monitor the position of and control ROV's.



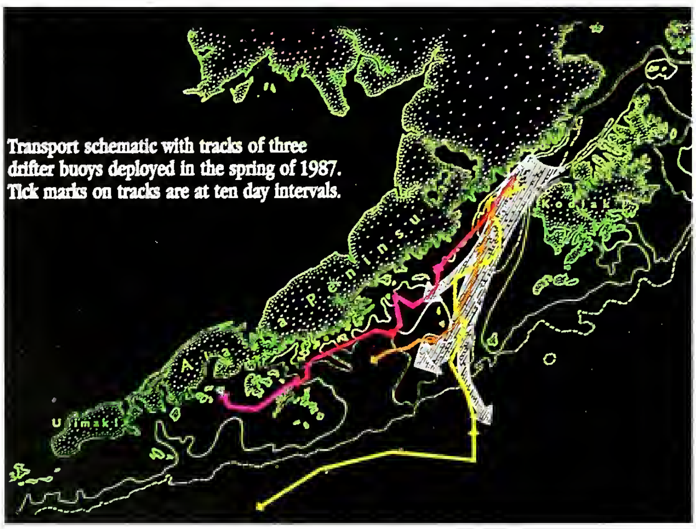
DEPLOYING/
SERVICING DATA
BUOYS & SENSORS

LAUNCHING/
CONTROLLING ROV's



GROUND-TRUTHING

CALIBRATING
SATELLITE SENSORS



Transport schematic with tracks of three drifter buoys deployed in the spring of 1987. Tick marks on tracks are at ten day intervals.

FISHERIES RESEARCH

MULTIDISCIPLINARY
PROJECTS

Precision stationkeeping and speed control. The importance of precisely maintaining the ship's position is assuming even greater importance. With the development of the Global Positioning System (GPS), real-time navigation is now sufficiently exact to permit the required positioning. What is needed now is computer control of thrusters and main propulsion systems to fully utilize the GPS data input. Precise speed control at slow speeds for prolonged periods of time is required for tracking ROV's or tagged marine animals, and for fine-tuning the shape of bottom and midwater trawls.

Real-time sampling and analysis at sea. The sophistication of analytical tools now permits elucidation of chemical and biological parameters which a few a years ago was thought impossible. Unfortunately, with rare exceptions, this sophistication has not been incorporated into real-time sampling and processing while at sea. Furthermore, for certain chemical and biological samples, without real-time processing, valuable data are lost. Depending on size, the vessels should be equipped with some or all of the following facilities to perform these analyses: environmentally isolated laboratories; input from a wide spectra of environmental data; ability to process a large volume of samples; precise temperature control in the range of -25 to -2°C, -2 to +5°C, +5 to +25°C; ultra-clean facilities; "clean" power; and onboard production of liquid nitrogen and oxygen.

Acoustically quiet construction and instrumentation. With the developments in hydroacoustics, acoustically quiet vessels are required for fish finding, bottom profiling, side scanning, or bathymetric surveys. Present systems can be grouped into several frequency ranges: echosounding--12 kHz for deep ocean systems but often higher frequencies (up to 200 kHz) in shallow water; and water-column characterization--typically in the 100 to 300 kHz range for current measurements, biological scattering layer, biomass estimation, and suspended sediments.

Vessels must be designed to accommodate these systems. Machinery should be installed to minimize interference due to radiated or structure-borne noise. Hull shapes and propulsion must be designed to avoid disruption to acoustic sensors due to noise, bubble sweepdown, or other phenomena. Access to transducers or transducer spaces without the ship going into drydock is needed.

4. *Productivity*. All programs seek to maximize productivity. For those ships engaged in charting and mapping activities this can be accomplished through broader swath sonars, and perhaps eventually through the use of remote vehicles. Vessels capable of faster speeds, both during transit and surveying, are needed. Furthermore, the ships must be designed so that personnel and equipment can continue to operate over a broad range of weather conditions. Automation and remote monitoring systems need to be incorporated in ship designs to reduce crew manpower requirements. In terms of design, the ships should be able to operate for greater portions of the year, both in terms of increased number of sea days and an extended field season.

5. *Continuous Collection of Data*. The Phase I Working Group recognized the importance of continuous collection of environmental and physical data on a routine basis. The environmental data collected and transmitted in near-real-time serve two major functions: input into global and regional oceanic and atmospheric circulation models and verification of earth-observing satellites. Physical data, while not required in near-real-time, are used for a multitude of solid-earth studies and provide important collaborative input to satellite data.

Ship observations provide the only surface data over large portions of the earth. For these data to be effectively incorporated, the environmental and physical parameters must be collected digitally on a continuous basis. Required data streams include:

Positioning: X, Y, and Z

Meteorological: Relative Humidity, Short- and Long-Wave Insolation, Visibility, Water Vapor

Water Column: Directional Wave Spectra, Ocean Skin Temperature, Surface Temperature/Salinity, Chlorophyll, Oxygen, Subsurface Current Shear, Mixed Layer Depth, Particulates, Biological Scattering Layers

Ocean Bottom: Swath Bathymetry, Shallow Sub-Bottom, Magnetic Field, Gravity Field

At the present time, none of the NOAA ships provide these required data on a continuous basis.

6. Enhanced Communications. This would include: *internal communication* into and between science spaces including van, key working areas, and selected science staterooms; in addition to high quality voice, the communication should include real-time transmission, monitoring, and recording systems of all data, closed-circuit television monitoring and recording of working areas, and monitoring of ship control, environmental parameters, and over-the-side equipment performance; *external communication* to include high-speed data transmission to shore laboratories and other ships on a continuous basis, high-speed graphics and hard-copy text, and reliable voice channels; and *satellite monitoring* to receive readouts of environmental remote sensing.

PHASE II

Implementation of Phase II

Objectives of the Phase II Working Group were twofold: 1) to transform requirements identified by Phase I into specific hull characteristics and instrumentation requirements (major requirements developed in Phase I are listed below), and 2) to provide recommendations concerning funding and staffing issues relative to fleet operating needs and responsibilities today and for the future.

QUANTIFIABLE MISSION REQUIREMENTS

Mission Complement
Maximum Speed (SS1)
Cruising Speed (SS4)
Range at Cruising Speed (nm)
Endurance (Days)
Seakindliness (at various SS)
Stationkeeping
Precision Trackline
Dynamic Positioning
Laboratory Area (Sq. Ft.)
Itinerant Load (Long Term)
Climate Control Lab (Sq. Ft.)
Working Deck Area (Sq. Ft.)
Science Storage (Cu. Ft.)
Vans/Modules
Helicopter/ROV's
Stern Ramp
Cranes
Frames
Winches
Boats
Ice Strengthening

SS - Sea State *nm - Nautical Miles*

To meet objectives of Phase II, a Working Group different from that of Phase I was assembled representing the broad spectrum of backgrounds associated with conducting research at sea. These were active scientists, research program directors, managers of fleets, experienced vessel captains, marine engineers, and naval architects. Participating were representatives from four federal agencies (including nine different units of NOAA) and the Dominion of Canada; others came from academia and industry. The short time allotted for the study did not permit addressing tasks in sequence. Therefore, the Phase II Working Group was divided: one sub-group addressing the policy issues of funding and staffing and the other addressing vessel hull and instrumentation issues. The sub-groups met concurrently as well as in joint sessions.

Funding and Staffing Recommendations

Recognizing the potential for future change in mission requirements and supportive technology, the governing principle adopted in deliberations over funding and staffing issues was to find approaches to perceived requirements which would offer opportunity for future change.

For funding-related issues, a major concern was to determine the opportunities assuring continued support of the fixed costs of vessels. Another major concern was to ensure the efficiency of mission function of the designated vessel(s) through an appropriate mix of the complement of operational (ship) to technical (scientific) staff. The appropriate mix will vary but the mix now on NOAA ships must be changed to provide an increase in the number of technical people. Ideally, on an oceanographic research vessel, a ratio of 1:2 (ship:scientific) should be the target. Improvements in technology as well as social changes now allow for reduction in ship personnel, which can improve the ratio.

The complete list of recommendations of the Funding and Staffing Sub-Working Group are highlighted on p. 12.

Hull and Instrumentation Recommendations

The mission requirements of Phase I were broken into four classes of needs based upon cruise length and the effect that they had on sample storage requirements, cargo, and fuel capacity. These needs were then translated into four major vessel classes: high endurance (60 DAS, 15,000 nautical miles); medium endurance (20-45 DAS, 10,000-12,000 nautical miles); low endurance/coastal (15-20 DAS, 5,000 nautical miles); and nearshore/estuarine (4-10 DAS).

In order to evaluate the design of a ship to meet mission requirements, without the time and expense of developing conceptual designs, the adopted approach was to find existing, excellent-functioning ships or completed designs which met all or most of the specified requirements. These models also offered the opportunity to measure the "reasonableness" of NOAA requirements. A list of the models adopted by consensus of the Hull and Instrumentation Sub-Working Group is shown on p. 13. By determining on a gross scale modifications needed to minimize differences between the model and the desired vessel, an approach was found to "design" new ships.

Once able to "design" a ship it became possible to estimate the cost. There were a sufficient number of U.S. and Canadian-built ships with known costs to permit defining a curve when a measure of ship size was plotted against cost. The curve, actually a pair, defined an envelope of minimum and maximum estimated dollar costs. Two sets of cost envelopes were developed--one for fully outfitted ships, and one covering only hull costs. These cost envelopes, together with the requirements matrices, made it possible to

Recommendations Of Funding And Staffing Sub-Working Group

FUNDING

ISSUE	**RECOMMENDATION**
Base Funding	Base-funded NOAA-owned or NOAA-leased ship support should be provided for continuing long-term ship requirements. Centralized management and operation of ships supporting these core requirements should continue.
Funding Fleet Replacement	Funding for NOAA ship replacement is a stand-alone initiative and must be part of an integrated plan delineating long-term vessel needs.
Funding Ship Requirements for Major New Programs	Requirements for ship support of any new program initiative must be accounted for in the initiative.
Alternative Financing	Alternative financing methods should complement conventional funding for construction of the proposed NOAA fleet.
Other Chartered Vessels	NOAA Program Office budgets should continue to identify funding for charter vessel support required to meet special needs.
Vessels under 65 Feet	Vessels in the 40-65' class should be maintained and operated as units of the centrally managed NOAA fleet.

STAFFING

ISSUE	**RECOMMENDATION**
Scientific Staff	Maximum efficiency is attained from the lowest crew-to-scientist ratio which will adequately meet mission requirements while providing for proper operation and maintenance; a 1:2 ratio should be the target.
Increased DAS	Days at sea to meet mission needs and improve effectiveness must be increased.
National and International Roles	NOAA's fleet should continue its role as the U.S. national fleet and must do so with modern well-equipped ships.
Interagency Cooperation in Ship Use	Cooperative use of ships must be maximized.

Models of Consensus

CLASS	MISSION	MODEL
High Endurance (Including Ice Variant)	Oceanographic Research	METEOR/FRG AGOR-23/UNOLS SWATH PT 3500 (PT = POINT)
Medium Endurance	Oceanographic Research	CHARLES DARWIN/UK CLASS II/Canada SWATH PT 2500
	Charting (4 Launches)	CHARLES DARWIN/UK CLASS II/Canada SWATH PT 2500
	Living Marine Resources (LMR)	FARV-A/Canada
Coastal/ Low Endurance	Oceanographic Research	POSEIDON/FRG WECOMA/UNOLS SWATH PT 1350
	Charting (2 Launches)	BORDA/FR POSEIDON/FRG SWATH PT 1350
	LMR	NMFS CONCEPT 206' NMFS CONCEPT 138'
Nearshore/ Estuarine	Charting	VICTOR HENSEN/FRG SWATH PT 450
	LMR	95' COASTAL RES. (U. OF TX DESIGN)

create a conceptual design and provide a reasonable cost estimate to build ships needed to meet NOAA requirements. As an example of the methodology employed, a requirements matrix for the medium-endurance oceanographic research vessel, CHARLES DARWIN (United Kingdom), a consensus model, is shown in Table 1. The cost envelope for fully equipped vessels of this class appears in Figure 4.

Given the history of oceanographic research and survey operations, emphasis in this study was toward monohull ships. However, a small-waterplane-area twin-hull (SWATH) ship may offer considerable benefit in meeting some of NOAA's needs. This is especially true in meeting requirements for improved seakeeping in high sea states. Therefore, the Phase II Working Group evaluated SWATH alternatives where appropriate. Costs were also estimated for the SWATH vessels. With fewer SWATH ships having been built, these estimates should be used with caution in making comparisons.

The issue of speed was also addressed by the Working Group. A requirement of 20 knots resulted from Phase I deliberations. To achieve this speed, other requirements being equal, larger vessels are required. Therefore, for the purposes of the assessment study, the speed requirement was reduced to 15 knots.

The Phase II Working Group also recommended that each of the larger NOAA vessels (i.e., high endurance and medium endurance) be equipped with multibeam swath bathymetric systems.

PHASE III

Implementation of Phase III

The Phase III Working Group reviewed the results of the previous phases and collected new information in order to get a "total view" of the issues associated with fleet modernization. For example, the estimated cost structure which was used in Phase III was based on the functionality requirements and construction and instrumentation costs developed in Phases I and II.

The new material developed by the Phase III Working Group to arrive at this "total view" included, among other things, determining: the status of the existing fleet in terms of material condition, functional capability, and deployment; annual number of days at sea on various types of ships to support programmatic requirements; mission consequences of having either the wrong type of vessels or an insufficient number of vessels; use of technology in promoting efficiency of at-sea operations; and, where appropriate, exploring opportunities for using leased ships from either the university community or the private sector to satisfy NOAA's needs.

After the "total view" was developed, a series of alternatives for fleet modernization were identified. These alternatives were analyzed, in turn, in terms of impact on the varying missions, level of urgency for implementation, short- and long-term costs, and budget constraints. A series of general conclusions from the study and a set of recommendations for NOAA action were then developed.

Upgrade Strategy and Funding

Unquestionably, NOAA will continue to need a seagoing capability to fulfill its statutory-based mission. This assessment study addresses several approaches for modernizing NOAA's fleet, but should not be viewed as a policy or decision document. NOAA should consider options on addressing NOAA's seagoing capability needs. This conclusion by the Phase III Working Group resulted from the following specific findings:

Table 1. Sample Requirements Matrix

MEDIUM ENDURANCE VESSEL					
		Model: CHARLES DARWIN			
Requirements	Proposed Oceanographic Research Vessel	Existing	Difference	Modifications Necessary to Meet Requirements	Mission Consequences if Requirements Not Met
Mission Complement	20-25 to 30 with vans	18 (all in single cabins)	-2 to -12	Convert to double cabins	Reduction in types of research programs and multidisciplinary research conducted
Operating Complement	-----	21 (all in single cabins)	-----	----------	----------
Trial Speed (kts) at 100% mcr	(17-22)	(15)	-2 to -7	Increase ship length and power	Reduction in resolution of synoptic events tracking dynamic events station days
Cruising speed (kts) in Sea State 4	15-20	11 "nominal"	-4 to -9	Increase ship length and power	Same as trial speed
Seakeeping	Normal SS5 Limited SS6	Unknown	-----	----------	----------
Range (nautical miles)	8 000	9 200 @ 11 kts	+1 200 @ 11 kts	Reduce fuel capacity	----------
Endurance (days)	45	35	-10	Add stores volume	Moderate to severe reduction in operating regions
Laboratory Area (sq ft)	2 400	2 300	-----	----------	----------
Climate-Controlled Lab (sq ft)	150	170	+20	Reallocate deck area	----------
Working Deck Area (sq ft)	4 000	2 600	-1 400	Add deck area	Unable to handle some large gear, e g spar buoys, long cores fishing nets
Science Storage (cu ft)	10.000	11 000	Similar	----------	----------
Itinerant Load (long tons)	100	(100)	0	----------	----------
Vans/Modules	2 @ 8 x 20 ft 4 @ 150 sq ft	2 @ 8 x 20 ft 2-4 others	Similar	----------	----------
Helicopter/ROV	Hover/ROV hangar	No/No	-Hover area -ROV hangar	Reconfigure or add deck area aft Add deck area and ROV hangar	Unable to provide full ROV support
Stern Ramp	Yes	No	-Ramp	Add deck area and ramp	Reduced ROV handling capability and no stern trawl capability
Cranes	1—5 ton @ 24 ft 2—2 5 ton SWL	1—2 7 ton @ 38 ft 1—2 7 ton @ 22 ft	-1	Add one crane	----------
Frames	Stern A/Hydro J Boom fwd	Stern 20 ton SWL Side 12 5 ton SWL	-----	----------	----------
Winches	2 hydro 1 trawl/core/EM	1—10 ton 2—hydro	Similar	----------	----------
Boats	2—25 to 30 ft RHIB	1—20 ft RHIB	-1 RHIB	Add one RHIB	----------
Stationkeeping	35 kt wind/SS5/ 2 kt current/BH	Unknown	Unknown	----------	----------
Precision Trackline	95% operability	Unknown	Unknown	----------	----------
Dynamic Positioning	Yes	Unknown	Unknown	----------	----------
Towing Force (lbs @ kts)	25 000/2 5	>25 000 @ 2 5 kts	0	----------	----------
Ice Strengthening	ABS 1A	None	-Structure	Add structure	Precludes operations near ice
( ) - inferred requirements					

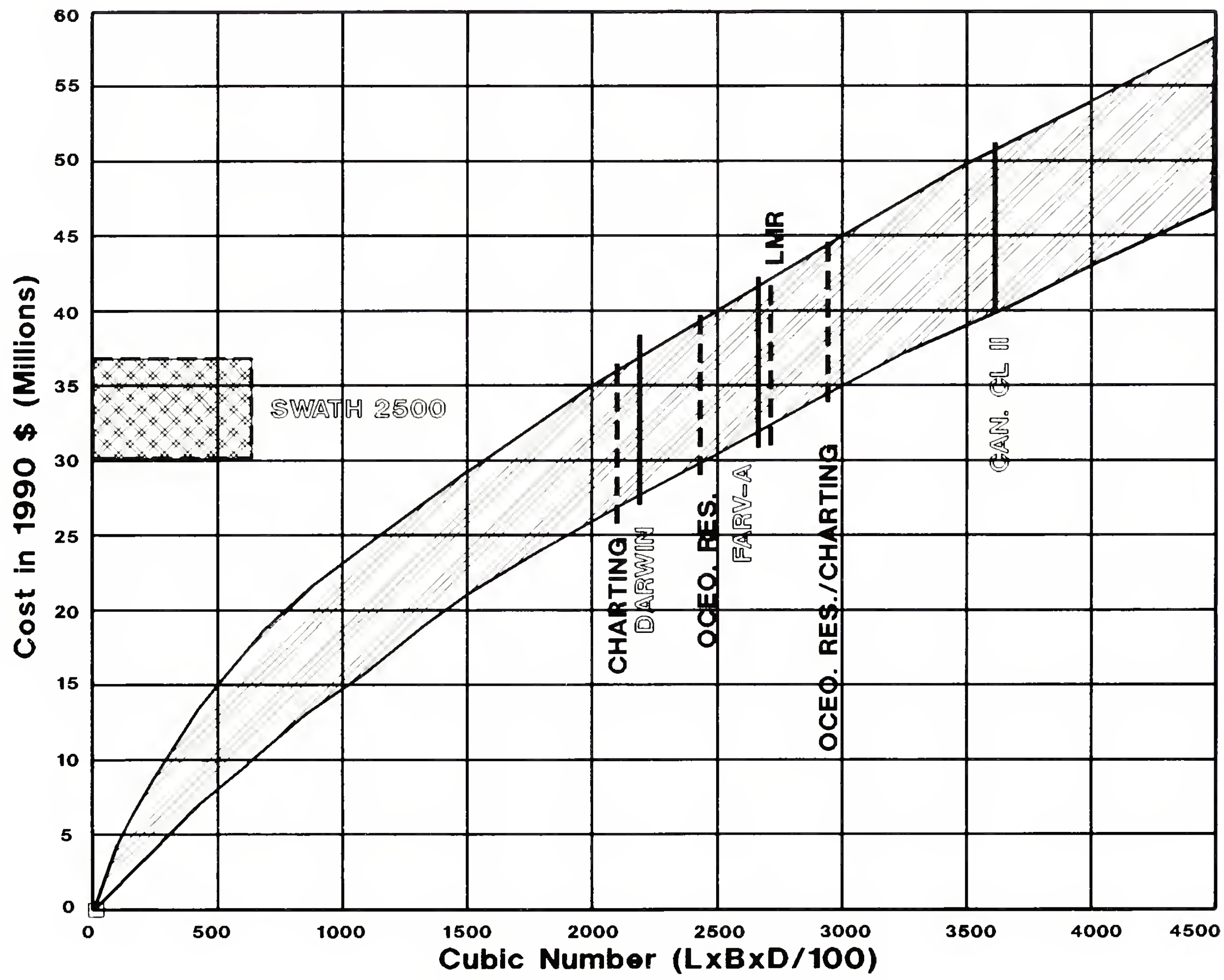


Figure 4. Sample Cost Envelope For Fully Outfitted Medium-Endurance-Type Vessels

1. RESEARCH AND SURVEY VESSELS ARE ESSENTIAL FOR NOAA'S MARINE AND ATMOSPHERIC MISSIONS. Great advances have been made during the last twenty years in aircraft and satellite remote-sensing as well as unmanned instruments and buoys, and these advances will continue to contribute significantly to oceanography in the future. However, research and survey oceanographic vessels remain the only platforms for certain kinds of observations at sea and virtually all *in-situ* sampling must be performed from vessels.

2. THE CONDITION OF THE FLEET IS A MAJOR PROBLEM IN THE CONDUCT OF NOAA'S MISSIONS. NOAA's base program for marine services ($60 million in FY 1990) includes approximately $6 million for routine maintenance and repairs. At present NOAA has a $40 million backlog of critical maintenance items in ships' systems. Added to this is a $50 million backlog for replacement of obsolete instrumentation. Given the age of vessels in NOAA's fleet, the fact that no vessel has had a major service-life extension, and the current material condition of the fleet, it is projected that all NOAA vessels will become non-functional by the year 2000 if no capital investments are made above the level of the marine-services basic program. Figure 5 depicts the projections for the vessel life of current ships of the NOAA fleet and achievable DAS.

3. CURRENT NOAA MISSIONS REQUIRE --AND PROJECTED MISSIONS WILL INCREASE THE NEED FOR--MODERN, FUNCTIONALLY CAPABLE VESSELS. NOAA's missions were documented in Phase I of the study. The ship requirements--current and projected--to meet these missions are determined to be:

Current Level: Support of 18 ships (missions inadequately supported). The current level of support (3600 DAS) provides only 84% of the average DAS over the past 15 years. NOAA's at-sea monitoring and assessment requirements continue to increase in the face of decreasing resources. Table 2 shows the current and projected ship needs for NOAA missions. Of interest is that for each line organization approximately 65% of their identified needs cannot be met with the present allocation.

Expanded Levels: Increased number of ships to support programs:

Planning Level A: Would support programs in NOAA's present budget (6100 DAS)

Planning Level B: Would support programs in NOAA's FY 92 budget request (7910 DAS)

Planning Level C: Would support programs envisioned by the Year 2000 (10,215 DAS)

4. NEW TECHNOLOGIES ALLOW SIGNIFICANT INCREASES IN MISSION PERFORMANCE, PRODUCTIVITY, AND EFFICIENCY. Advances such as automation of vessel operation, improved seakeeping and stationkeeping, precise positioning, upgraded data analyses, and modular laboratory technology could be incorporated in new ships at a high programmatic return for investment.

5. NEW WAYS OF DOING BUSINESS ALLOW SIGNIFICANT FLEXIBILITY AND EFFICIENCY IN FLEET OPERATIONS. The following categories of cost control show promise for acquisition or operations strategies that NOAA employs for its fleet: crewing efficiency, crew augmentations, chartering, and build/lease options.

A major thrust of Phase III methods was to assess current fleet capability, evaluate current and projected NOAA missions, and develop information on the kind of result to be

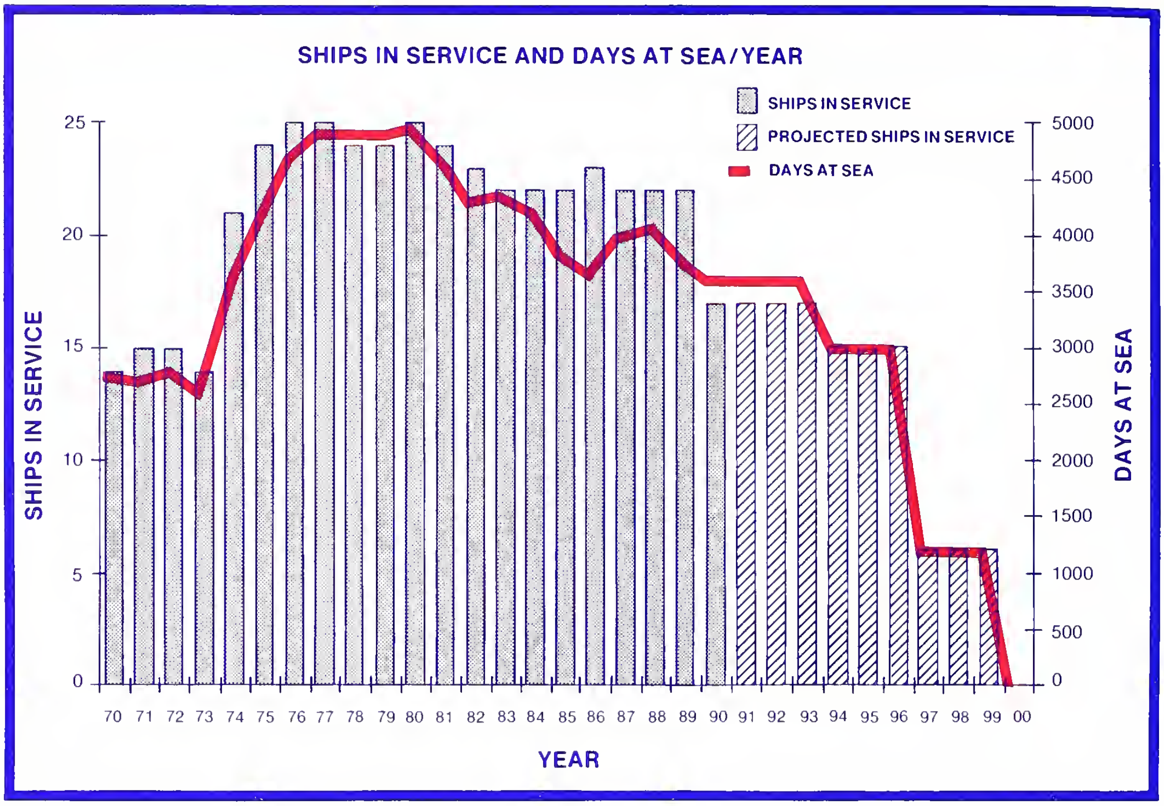


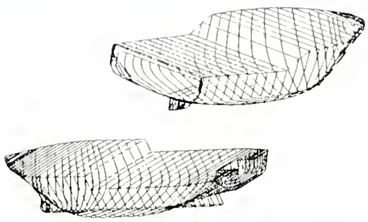
Figure 5. *Bar graph showing the number of operating ships during the 20 years since the organization of NOAA and the projection of the number of vessels for the next decade. The projection is based on the material condition of the various ships. Superimposed on the number of vessels is the number of sea days available or projected to be available per year.*

expected at various levels of support. Fourteen distinct scenarios were developed based on the four mission levels described above in Finding 3. These scenarios were then condensed into the five strategies as shown in Table 3. The strategies have several variants which allow for flexibility.

Of major significance is the fact that the "Current Level" was characterized by rapid degradation of ocean missions. One of the five strategies which the Phase III Working Group developed was in a range between Planning Levels A and B. It is presented below in detail as an example.

Planning Level A/B: During a 15-year period all of the NOAA ships would be replaced. Also the size of the NOAA fleet would be increased in order to satisfy mission requirements. The number of ships would range from 22 to 33 depending on the variant employed. With the variants of operating the larger ships at 240 or 300 DAS per year (small ships operate at 240 DAS) and employing no charter, 10–20% charter, or 100% charter, the costs for the entire 15-year period vary between $1.1 to $1.5 billion over present funding.

A feature of this level is that it would provide a functional fleet capable of satisfying those programmatic missions which are either funded (Planning Level A) or viewed as high priority by NOAA (Planning Level B). Furthermore, if implemented, future block obsolescence of the fleet would be avoided. Table 4 is a summary of the budget impact of various 15-year investment strategies.



Conclusions

Based upon the results of Phases I and II, and the additional material obtained or developed in Phase III, the Working Group arrived at the following conclusions with respect to the future of the NOAA fleet:

- An analysis of all significant alternatives to obtain a modern NOAA fleet to carry out NOAA's missions is provided, but should not be viewed as determinative for decision purposes.

Table 2. 1990 and Projected Ship Needs of Days At Sea

	1990	Projected	Percent Unmet
NMFS			
Resource Assessment	1,233	2,307	
Environmental Assessment	170	2,091	
Protected Species	292	415	
Subtotal	**1,695**	**4,813**	**65%**
OAR			
Climate & Global Change	380	830	
Coastal Ocean	128	715	
Subtotal	**508**	**1,545**	**67%**
NOS			
Charting	570	2,150	
EEZ	530	1,540	
Coastal Ocean/NSTP	207	769	
Other OMA	67	70	
Subtotal	**1,374**	**4,529**	**70%**
Total	**3,577**	**10,887**	**67%**

Note: Days at sea (DAS) summarized from information provided to Phase II. Unmet requirements are calculated as: (Projected DAS – 1990 DAS/Projected DAS) x 100.

Table 3. Fleet Modernization Strategies

MISSION REQUIREMENTS	STRATEGY FOR NOAA FLEET
Current (3600 DAS)	Degradation of Ocean Missions Rapid Slow Arrested
Planning Level A (6100 DAS)	Planning Level A/B
Planning Level B (7910 DAS)	Planning Level A/B
Planning Level C (10,215 DAS)	Planning Level C

- Future mission requirements and program funding levels are subject to change, and there may well be unanticipated technology breakthroughs. Some flexibility to adapt to these changes is desirable.

- Annual funding profiles for fleet modernization can be tailored within a relatively broad range of funding levels. For

Table 4. 15-Year Cost Summary Over Current Funding Required For Fleet Modernization At Various Operating Levels

DAYS AT SEA (DAS)*	NUMBER OF SHIPS	15-YEAR COST ($M) Capital	Operating	Total	ANNUAL COST ($M)
CURRENT - RAPID DEGRADATION (3600 DAS)					
Slow Degradation (4320 DAS)	18	277	55	332	22
Arrested Degradation (4320 DAS)	18	672	64	736	49
All Charter (4320 DAS)	18	0	896	896	60
PLANNING LEVEL A (6100 DAS)					
240	25	920	222	1142	76
240 /10% Charter	23	838	266	1104	74
240 /All Charter	25	0	1465	1465	98
300	23	852	252	1104	74
300 /10% Charter	22	810	267	1077	72
PLANNING LEVEL B (7910 DAS)					
240	33	1139	361	1500	100
240 /10% Charter	26	915	540	1455	97
300	31	980	426	1406	94
300 /10% Charter	24	858	568	1426	95
PLANNING LEVEL C (10215 DAS)					
240	43	1472	446	1918	128
240 /10% Charter	36	1241	596	1837	123

* At 240 All Ships Operate At 240 DAS/Year; at 300 Larger Vessels Operate At 300 DAS/Year
M = Million

example, if innovative private capital financing were selected, a fleet scenario could be funded with an annual budget level that would be significantly different from funding totally appropriated by Congress.

- In order to take maximum advantage of the flexibility in obtaining vessel capability, NOAA must obtain legislative authorization for multiyear chartering. At present, long-term chartering (multiyear) cannot be undertaken by NOAA without legislative authorization.

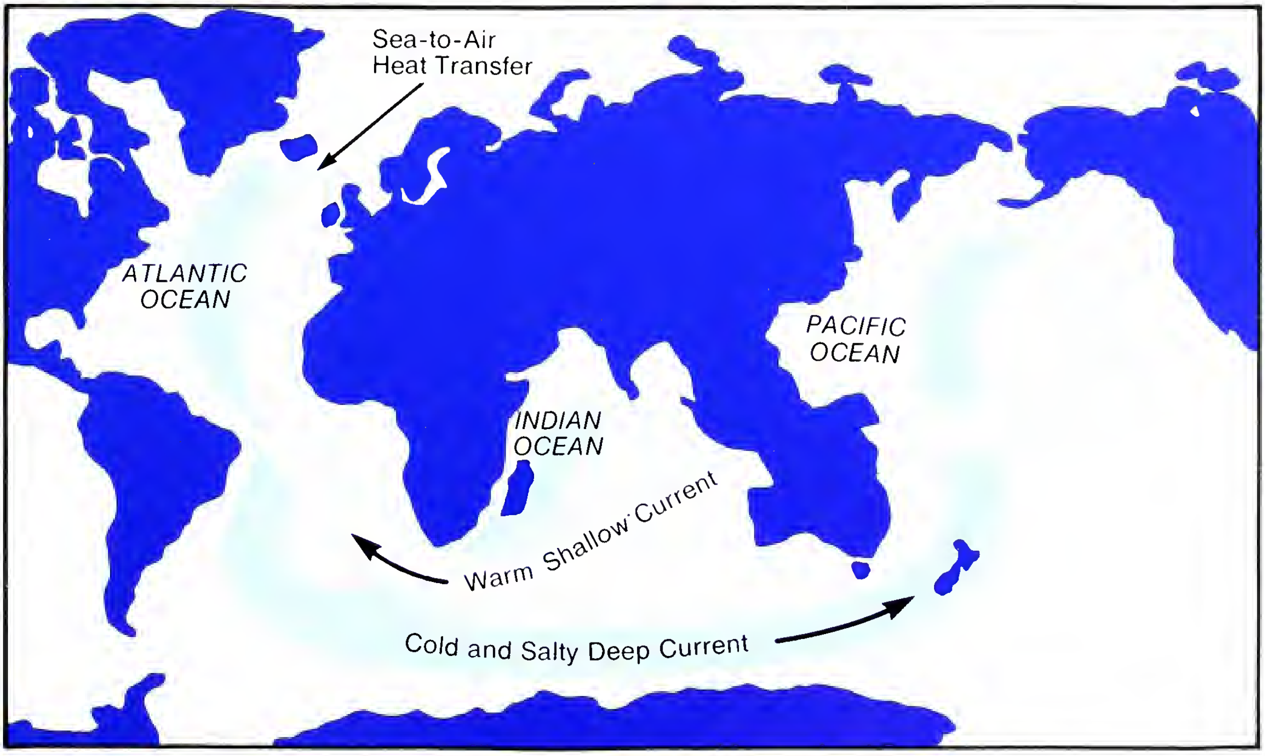
- The step-by-step approach to modernize the NOAA fleet discussed in the study will not lock NOAA into a fleet of a particular size or character. An initial investment during the first 5 years of a 15-year program can be done in such a way so as to preserve the choice of maintaining the NOAA-owned fleet at a number ranging from 18 to 43 vessels by the fifteenth year.

Recommendations for NOAA Action

In addition to developing the foregoing general set of conclusions from its deliberations, the Phase III Working Group adopted the following recommendations to provide a flexible framework for action to implement a fleet modernization program:

NOAA should

- make the modernization of the ocean fleet an urgent priority throughout the organization
- propose a long-term, cost-effective fleet capability strategy beginning in FY 1993
- establish a clear and objective methodology to facilitate the analysis of trade-offs between new-vessel performance and cost taking into account life-cycle estimating techniques
- establish a fleet modernization program office to perform strategic planning and technical analysis in support of policy decision-making
- seek and maintain maximum cooperation with other vessel operators in the U.S. and abroad to respond in a cost-effective manner to the important oceanographic and atmospheric problems on the national agenda
- continue its efforts to effectively manage and operate an oceanographic fleet



Global Climate Change is and will continue to be a major thrust of NOAA ocean research. Depicted here is the Great Ocean Conveyer Belt (Broeker, 1987), a simplified view of the thermohaline circulation system of the global oceans.

Symbol of the Nation's maritime past, the Cape Hatteras Light was a beacon for ships caught in coastal storms off North Carolina. Today, this historical landmark is itself imperiled by the winds and waves that have caused severe coastal erosion. NOAA ships play a significant role in supporting research into such problems in coastal ocean areas.

Glossary

C	Celsius
Cu. Ft.	Cubic Feet
DAS	Days At Sea
DOC	Department of Commerce
FARV-A	Fisheries Assessment Research Vessel-A
FR	France
FRG	Federal Republic of Germany
GPS	Global Positioning System
In-situ	"In the natural or original position" (Webster's Third New International Dictionary)
kHz	Kilohertz: A unit of frequency equal to one thousand hertz
nm	Nautical Miles
NMFS	National Marine Fisheries Service (NOAA)
NOAA	National Oceanic and Atmospheric Administration (DOC)
NOS	National Ocean Service (NOAA)
NSF	National Science Foundation
OAR	Office of Oceanic and Atmospheric Research (NOAA)
ROV	Remotely Operated Vehicle
Sq. Ft.	Square Feet
SS	Sea State
SWATH	Small-Waterplane-Area Twin-Hull
U. of TX	University of Texas
UK	United Kingdom of Great Britain
UNOLS	University National Oceanographic Laboratory System
U.S.	United States of America