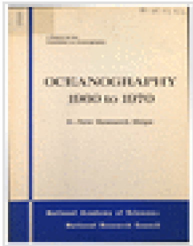

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OCEANOGRAPHY
1960 to 1970

6—New Research Ships

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PANEL ON NEW RESEARCH SHIPS

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OCEANOGRAPHY 1960 TO 1970

Chapter 6 - New Research Ships*

I. INTRODUCTION

Although oceanography has been carried on successfully from many different types of ships having displacements ranging all the way from 6 to 6,000 tons, the scientific efficiency of research ships of all sizes can be increased greatly through careful designing. One reason for this statement is that the instrumentation in marine science is rapidly reaching a considerable degree of sophistication. In most cases a ship originally designed for completely different duties does not make a good platform for the support or towing of a complex array of instruments. It is also clear that the future requirements in oceanography will place much greater demands on the capabilities of the ships than has prevailed in the past.

The operation of research ships consumes a large share of the funds available to marine science. For example, operation and maintenance of ships presently consumes nearly a third of the income of the larger private laboratories. While such expenses are less of a burden at the Navy laboratories, where the ships used for research and development are manned by Navy crews, the costs of running these ships are paid for out of Navy operational appropriations. It is important that they be suitable for the work and that they be operated as economically as possible. The goal should be the maximum scientific output for the least expense to the taxpayer. Few of the ships now in service approach having an optimum design in this respect.

In the discussion which follows, the term "ship" is used for seagoing craft capable of extended voyages and having the ability to carry at least 20 people. This means that as the term is used here a ship must have a displacement of at least 300 tons. In general the term "vessel" is used for smaller craft. These are also most useful in oceanographic research, but we have not studied the design problems of vessels for research, nor made any estimates as to the number that will be needed. The oceanographic laboratories have not found it much of a problem to acquire suitable vessels. Moreover, the amounts of money involved are small.

The ideal ship for science should have some roll and pitch stabilization, should be highly maneuverable at very slow speeds, should radiate a minimum amount of noise into the water, should be as free as possible from machinery

*A report of the Panel on New Research Ships vibration, and should be highly seaworthy. A submarine comes close to meeting these particular requirements. The ideal research ship should also have large laboratory spaces, ample working areas on deck, and the ability to remain at sea for long periods of time with a relatively large number of people on board, about half of whom should be living in an atmosphere favorable for research.

This special peculiarity of a research ship, namely that for a given size she should carry nearly twice as many people as are necessary on comparable nonmilitary ships, is the most difficult one to satisfy on a small ship. The pay load is laboratory space and comfortable quarters for the scientific party. There must also be good quarters for the crew, for many of the voyages are long and in any case little time should be spent in port to provide for rest and relaxation. It is this problem that largely dictates the size of the ship, especially if a civilian crew is used. In general the number of men in the crew (12 is about the practical lower limit for sustained operation of an all-weather, seagoing ship) should not be greater than the number of scientists, technicians, and students aboard. Few research ships now in use have this capability.

The operating costs of research ships have risen very rapidly during the last fifteen years. To cite a specific example, during the pre-World War II period the auxiliary ketch "Atlantis," which was built in 1930, cost on the average $200 per day at sea. Today her costs are up nearly fivefold and her accommodations are marginal for a scientific party of only eight.

At least as important as the type of ship and an effective design is the training, enthusiasm, and loyalty of the crew. Their duties and responsibilities are very different from those prevailing in the merchant service, on fishing vessels or on Navy ships. While this is especially true of the men on deck, a high degree of cooperation with the scientific party is desirable even in the engineroom. At present there is no pool of trained manpower from which scientific ships draw crews. In any considerable expansion of marine science the assembly and training of crews could become a bottleneck, unless a plan is properly formulated and followed.

II. GENERAL RECOMMENDATIONS

1. A national plan to replace, modernize, and enlarge the number of ocean-going ships now being used for marine research, development and surveying must be put into effect.

Nearly all the ships now being used for research and development in this country are at least fifteen years old and some of them have been in service for as much as thirty years. These ships are listed in Table 8. Merely to replace these ships during the next ten years will require building at least two ships each year. Even this minimum could be the means of a modest increase in oceanographic research since the new ships could be designed to carry more scientists and to be more efficient in terms of scientific output per day at sea.

For each ship used primarily for research there should be another available for routine biological, chemical, and physical survey work. While these ships too should be especially designed for the job the design requirements are somewhat better understood and less critical than for research ships. They do not become obsolete as rapidly as research ships, but it is important that they be operated as efficiently and economically as possible. Too often unnecessarily large and expensive ships have been used to collect quite routine information.

2. Scientific ships should be exempt from regulations that are practical and sensible only for large (>3,000 tons) merchant ships.

During the past six months, and well after this particular recommendation was agreed to, most of the difficulties which had existed for a number of years suddenly vanished due to a new ruling by the U.S. Coast Guard. It was formerly required that a privately owned research ship of more than 300 gross registered tons be operated as a documented craft. This meant that the same regulations for manning, for living accommodations, and for safety that had grown up over the years for generally much larger commercial ships had to be adhered to. These requirements were particularly difficult to meet in the size range between about 125 feet and 185 feet in length, just the range of greatest interest to most oceanographers. Since in general research ships should be able to carry about twice as many people as are needed to man a commercial ship of the same size, the rule that only two men could be berthed in a cabin and that these compartments should have a rather generous size made it almost impossible to save adequate interior space for laboratories. Also the regulations that the lifeboats on one side had to hold all the people was very difficult to meet without much restricting the scientific spaces on deck. Finally the officers and crew had to have the same sorts of licenses that are necessary on large cargo ships.

Early in January 1959, the U.S. Coast Guard ruled that the privately owned research ships of more than 300 G.R.T. could operate as numbered undocumented vessels, and thereby eliminated most of the design and manning difficulties. This is borne out by a number of preliminary design studies carried out by M. Rosenblatt & Sons and published in March 1959. (Progress Report July 1958-March 1959, History and Summary of Current Research Ship Design Work, PD-717-3.) However, the original recommendation has been retained here partly because there remains some uncertainty as to just how the new ruling might be interpreted in the case of a specific design and also because it does not make it any easier to use steam either as a quiet means of auxiliary propulsion or for the main power plant. Until it is known just how quiet a diesel power plant can be made, it might or might not be necessary to resort to steam in an optimum design.

3. Research ships at the private laboratories should be financed (at least in part) through a facilities-type contract.

The financing of the operating costs of research ships maintained at the private laboratories has been a major problem during the past ten years and will continue to be so, unless the present system is changed. Most of the ship time at sea is paid for project by project. Often there is no assurance at the beginning of the year that the ship can be kept busy on approved research projects for more than a few months. Since allowance for time at sea cannot be judged accurately in advance, too often the work of research ships and even of the smaller vessels has to be tailored to immediate development programs rather than to research.

Ideally the costs of operating research ships at the nongovernment laboratories should be contracted for separately from the other expenses of the research. However, it would be almost as helpful if about 50% of ship operating costs could be financed by a facilities-type contract with various projects contributing the other 50%. The director of the laboratory could then use the ships much more wisely from the scientific point of view. In addition, he could find private support for research more easily. The general attitude both inside and outside the government is "Let the Navy pay for the ships" and within the Navy the military desks having to do with development have much more money than the desks supporting basic research. Survey and Navy Research and Development ships do not at present operate on a project basis.

The method of financing the operations of research ships even enters into the design, for under present conditions most research projects cannot afford to use more than the minimum-sized ship that can handle the necessary instruments. Often an investigator with a modest budget will wait for good weather so that he can use an inexpensive, fair weather craft. Small and inexpensive ships remain in demand. The larger research ships often have to take on quite undesirable tasks, from the scientific point of view, just to keep running.

4. The Maritime Administration should be consulted in the designing of all ships paid for out of public funds and used for any phase of marine science.

One agency in the government should have continuing (although not exclusive) responsibility for the development of efficient research ships. The most suitable agency appears to be the Maritime Administration. This would insure that all such ships have some general capability for deep-sea oceanography in case of emergency and also that a systematic development program can be assured.

The design of research ships could become an important experiment in naval architecture. Their performance and behavior at sea can be studied in as much detail as may be profitable to improve seaworthiness and stability. The ships can be elaborately instrumented for stress and motion studies and there will be people on board to maintain the instruments. Measurements of the characteristics of the seaway in which the ships are operating could become a routine part of the observational program. Small deviations in hull form for a given-sized ship could be studied under natural conditions rather than in the towing tank.

Although the Navy is by no means uninterested in improving the seaworthiness of small ships, the military mission must dominate the design of Navy ships. Such factors as long life, costs of maintenance and reasonable habitability are secondary considerations. Furthermore, the Maritime Administration already has considerable experience in the design of survey and charting ships and is experienced in commercial practices in ship construction. To design to commercial standards usually results in a less expensive ship than to adhere to Navy specifications arising from combat requirements.

5. The development of all-weather ships in three size ranges is recommended: about 500 tons displacement, about 1,200 tons displacement, and about 2,200 tons displacement. (More exact sizes will emerge from a sustained design effort.)

The smallest of the three sizes is probably the most difficult to design.* The aim in this class is to design the smallest and least expensive vessel that can work effectively in the open ocean in all reasonable weather, but not in ice, and can cruise 6,000 miles or so with a scientific party of fifteen.

The 1,200-ton class would be a major improvement over any of the existing ships. Such a ship could handle heavy weights, contain ample laboratory spaces, and carry a scientific party of about eighteen (plus temporary quarters for about six students). Ample endurance of about 10,000 miles could be provided, the ships could remain productive in ordinary winter weather, and some ice-resistant characteristics could be included.

One ship of the 2,200-ton size is at present under construction for the U.S. Coast and Geodetic Survey. At least two such ships are needed for general oceanographic research, if this country is to play a considerable part in oceanography in the southern hemisphere and to work effectively in the approaches to the polar seas.

Smaller craft are also needed. Many of the smaller laboratories are interested mainly in coastal waters where a vessel displacing as little as 100 tons is quite adequate. The need for such vessels is not as acute as is that for larger ships, nor is it as difficult to finance their construction. Nevertheless, increasing attention should be given in future to the construction of small vessels that are specially designed for oceanographic purposes. Most of these now in operation are converted trawlers, yachts, or naval craft. Few of these have a satisfactory operational record. Fishing craft generally have inadequate space for laboratory and living quarters, and some have poor riding qualities when deprived of their usual payload. The hull design of yachts and naval craft is likely to be inferior for oceanographic purposes; the power plant often does not permit the low minimum speeds necessary for biological collecting; and expensive alterations may be required in order to install winches. In not considering these needs in detail, the Committee is postponing a problem of lesser priority than that of large oceangoing ships. However, there will be a continuing need for craft in this size range, even at the largest laboratories. The problem of financing the operations of small ships at private

*For additional discussion of this problem see WHOI Report No. 59-33, "Design of Oceanographic Research Vessels," by Francis Minot. Progress report and references to the National Science Foundation under Grant No. 6002. June 1959.

laboratories is by no means unconnected with the problem of financing the considerably larger oceangoing types. The Committee's recommendation (3, above) regarding the financial support of oceangoing ships also applies to smaller coastal craft. (A list of small coastal craft is contained in Table 9.)

6. All surface ships used for research, development, or surveying should have civilian crews.

This recommendation includes the ships used by the Hydrographic Office and by the Navy laboratories. It is important that the loyalty of the crew be to the organization using the ship and that attractive career opportunities be provided within the research, development, and survey system. It is also important that some commercial practices that have developed on much larger ships engaged in quite different types of operations not be carried over into scientific ships. The civilian crews on ships and smaller craft operated by the Coast and Geodetic Survey have been particularly successful and efficient. The Navy might well consider adopting a similar system for its survey and its research and development ships.

7. Conversions should be kept to a minimum.

The matter of conversions versus new construction has been studied. The committee concludes that conversions will be more expensive (in the long run) than well-designed new construction in terms of research accomplished per dollar. For some survey-type operations conversions can be quite satisfactory. Indeed practically all the ships being used in this country for marine research today are conversions, Nevertheless, it is believed that from the standpoint of over-all costs, conversions should be kept to a minimum.

III. SHIPS REQUIRED FOR MARINE SCIENCE DURING THE NEXT TEN YEARS

It is difficult to recommend exactly the number of research, military research and development, and survey ships that will be needed both by government agencies and by the private laboratories and other government contractors. As already indicated, about twenty new ships during the next ten years are needed just for replacement and modernization of the existing research and development fleet. Further expansion of seagoing facilities must be geared closely to the expansion of laboratory facilities. In general, four scientists and/or technicians are needed in a laboratory on shore to work up data, develop theories, and prepare new instrumentation for every scientist at sea.

The use of surface ships in this country for the various phases of science in the open ocean can be subdivided according to their primary missions as follows:

1. Basic Oceanographic Research Ships

These are the ships being used by the various private laboratories, but their operations are largely supported through government contracts. If some quite small and marginal vessels are excluded, there are 11 such ships in this country that are now in use or will be ready for work within a few months. With one 28-year-old exception, they are all conversions. Most of them were originally government-owned and became available to the laboratories as surplus or obsolete types. These are the ships that are doing most of the basic research, that represented our country during IGY, that are developing new techniques and methods, and that are producing the ideas and observations on which advanced-design weapon systems in undersea warfare are based to a considerable extent. Some of them are still quite efficient for limited purposes, but most of them are effective only during relatively fair weather. It is estimated that only six of them can survive the next ten years.

If oceanography is to grow at the rate of about 10% per year for the next 10 years, and such is the primary conclusion of this report, then it will be necessary not only to double the number of ships engaged in basic research, but also to give them improved capabilities. Especially it will be necessary for the new ships to have accommodations for the graduate students and trainees that will be needed to staff an expanding program.

The recommended construction program for this class of ship during the next 10 years is set forth in Tables 1, 2, and 3. This is the minimum required to keep us abreast of the other leading maritime nations in this particular type of scientific activity. Since this is the activity on which the effectiveness of all the rest of the program depends, first priority must be given to the construction of research ships. Without a stockpile of basic research information the more routine activities of the other classes of ships will not keep us in the forefront of marine science.

There is room for some give and take in the size distribution of the recommended new ships. This is especially the case under the heading of basic research. However, we will not have an optimum program if there is a significant change from the recommended total budget for new construction. In no case are we recommending scientific ships nearly as large as the newest ones operated by some of the other maritime nations. It is our conclusion that through better design smaller ships can become competitive in terms of new basic knowledge. For us this is necessary because of our considerably higher standard of living. As of 1958 an able seaman on a U.S. ship earns at least $300 per month. In general it will require the very best in naval architecture for us to compete in terms of science accomplished with foreign crews and foreign scientific salaries. We have the knowledge to excel, but under present circumstances it is not being fully brought to bear.

2. Military Research and Development

These are the ships serving the various Navy laboratories. They are used in part for important measurement programs, mainly in underwater acoustics, and in part for testing new types of equipment, and weapons. They have all been converted from the smaller Navy World War II hulls and nearly all of them are about to be declared obsolete. With few exceptions they are manned by Navy crews.

Nothing could do more to increase the output of useful results at Navy laboratories than to replace the present ships with ones designed as research and development ships, and to man them with civilian crews. It is also obvious that as detection systems reach out in range the ships should have greatly increased capabilities for remaining at sea. Furthermore, as more powerful sonar systems come into being they should have the capability of handling much heavier weights, and of setting out and retrieving large equipment at considerable depths. Of course, Navy laboratories will continue to need the services of some ships having combat capabilities. This is especially important in the development and testing of the final design of new weapons systems. However the same hull designs that will best serve research in oceanography will also be a major improvement for military research and development. The recommended needs under this heading are given in Tables 1, 2, and 3.

3. Survey Ships

These are the ships being used to map the oceans. Some are operated by the Hydrographic Office, some by special Navy projects and some by the Coast and Geodetic Survey. The Hydrographic Office ships use Navy crews, the more specialized Navy survey ships are using MSTS crews, and the Coast and Geodetic Survey has its own very effective organization under Civil Service. The Maritime Administration has handled the design of the larger ships operated by the Coast and Geodetic Survey. Until now, in their work at sea, both the Hydrographic Office and the Coast and Geodetic Survey have had rather limited objectives.

As originally conceived the survey ships had the job of mapping the shallower parts of the ocean so as to locate accurately the shore line and all obstacles to navigation. During more recent years in going to and from distant areas where coastal maps were being developed the survey ships have usually operated echo sounders so that some knowledge of the deep-water bottom topography has accumulated gradually. Since the original mission of survey ships was to obtain data for navigational charts, their design has stressed this particular need. What is required now is to give survey ships additional scientific capabilities so that the whole ocean can be mapped in all ways that are significant to science and to national defense.

As adequate coastal charts become available, survey ships should turn their attention increasingly to future rather than past needs. Geophysical anomalies, if they are well mapped, can serve many important research and applied uses. The nuclear submariner has an urgent need for better charts of the three-dimensional current system than are available today.

In short, the design of survey ships should evolve in much the same direction as the design of research ships. In case of emergency they would then have the capability of tackling any kind of technical job at sea.

All survey ships should cooperate within a national plan to gain the desired information in accordance with uniform standards and procedures. Although survey work is of a more routine nature than research work (so that in general engineers can replace scientists on these ships) the highest possible standards of accuracy should be practiced. In theory one can foresee an end to our survey needs. In practice, there has never been sufficient imagination exercised as to the future requirements. By fully instrumenting survey ships one can gain much additional information at a relatively low cost.

In Chapter 9, "Ocean-Wide Surveys," will be found recommendations as to kinds of survey programs that should be undertaken. The ships that will be needed are specified in Tables 1, 2, and 3.

4. Resources and Fisheries Ships

These ships have one additional requirement that need not be designed into other types of scientific ships. They should be able to catch fish as well as, if not better than, the best commercial fishing craft. However, they do not need to store or to process large quantities of the catch. This fishing requirement should not interfere seriously with their ability to do scientific work. The same hulls and power plants should serve both research ships and fisheries ships, but some rearrangement of the deck and hold spaces may be necessary to improve them for fishing. Also some of the crew must have had fishing experience.

A large share of the world's scientific ships are employed in resources and fisheries work. Our present small fleet of such craft includes assorted old commercial fishing ships which are severely limited in laboratory space, cruising range, and endurance; and most of them are not fitted with adequate deep-sea scientific winches.

The construction recommended for marine resources research can be found in Tables 1, 2, and 3.

IV. SCHEDULE OF CONSTRUCTION BY AGENCY AND YEAR

Table 4 gives the recommended schedule of construction during the next 10 years. If this is followed, by 1967 our fleet of scientific ships will be modernized and enlarged to meet the requirements set forth throughout this report. The dates given are the calendar year during which the ships should become ready for sea.

Table 3 in effect recommends that insofar as research and development ships, survey ships, and resources and fisheries ships are concerned, present practices should be continued: namely, that the Navy provide for all of its research and development ship needs and for about half of the national need for research ships and survey ships, that the Coast and Geodetic Survey provide for the other half of the survey fleet, and that the Bureau of Commercial Fisheries construct and operate ships needed for biological resources research and development work. The innovation in Table 3 is that the National Science Foundation and the Maritime Administration should in the future provide for half of the ships required for basic science. During the past 10 years or so the Navy has arranged for and financed nearly all of the ships engaged in basic research.

This arrangement recognizes the special skills and interests of the Maritime Administration in ship design and construction, and the responsibility of the National Science Foundation for the support of basic research.

The annual construction schedule given in Table 4 also recognizes the condition of the ships now in service and the degree to which each agency should share in a continuing national program.

Tables 5 and 6 summarize the costs of construction and operation of the various classes and sizes of ships. Costs, as throughout the report, are expressed in 1958 dollars. Construction costs are estimated at $1.65 million for 500-ton class ships, $3.8 million for 1200- to 1500-ton ships and $5 million for ships larger than 2000 tons. These are the same as used in making the original estimates for Chapter 1. Operating costs are estimated at $0.2 million, $0.35 million and $0.5 million respectively for the same three ships classes. We have not attempted to estimate the year-to-year increase in operating costs but have calculated the costs which would prevail at the end of 10 years (provided the recommended program is followed). The operating costs for resources and fisheries ships at the end of 10 years is the same in Table 6 as estimated for this same class in Chapter 1; that is, $3.1 million a year or $1.7 million above the present estimated costs of $1.4 million. The operating costs estimated in this chapter for research ships at the end of 10 years is $6.65 million, or 3.4 above the present level. This is not significantly different from the 4.15 figure in Chapter 1 and represents a slightly different estimate of operating costs of these ships.

The most significant difference between this chapter and Chapter 1 is in the estimated costs of operating survey ships. We believe that 29 properly designed survey ships can be operated for slightly less than our best estimate of the present operating costs of 18 survey ships! This is due in large part to the very high operating costs of the large converted Navy ships now being used for survey purposes. Essentially this constitutes a recommendation that new specially designed survey ships be built as soon as possible to replace the large conversions now in use. In the long run such new construction will be less expensive and the results achieved will be superior in quality and quantity.

V. TECHNICAL RECOMMENDATIONS

The useful mechanical life of a research ship is about 30 years. However, unless the ship is very carefully designed for both the present-day techniques and the probable requirements of the next generation of oceanographers and marine engineers, it can become technically obsolete before 30 years. Above all, one needs to design versatility into the scientific spaces on the ship. This is true not only for research, for development work and for resources work, but also for surveying.

In addition there are some specialized characteristics of the hull and power plant that are desirable but for which as yet there is little design experience.

1. In order to maintain zero forward speed and at the same time to be able to alter the heading of the ship, some form of bow propulsion seems required. A retractable electrically driven propeller, trainable through 360° and with about one-tenth the power of the main plant, would seem to be the answer. Activated rudders have also been suggested, but these could not do the whole job required. While it should be possible to vary speed continuously between 0 and 3 knots, such exact speed control is not required at higher speeds.

2. A space near the center of motion of the ship should be saved for gravity measurements and other instruments requiring a stabilized platform.

3. For the ship as a whole, roll and pitch should be reduced. Both active and passive antirolling tanks have been suggested. These may in practice prove to be too noisy. Active fins would help stabilization during transit, but do little good while on station, which is the most critical time. Sails are by no means ruled out, especially for the smallest seagoing size recommended above.

4. Some high-latitude capabilities should be designed into practically all new ships and they must also be comfortable in the tropics. The laboratory spaces especially must be carefully air-conditioned.

5. Provision should be made for a large battery capacity or a well-isolated, deck-mounted generator with sufficient capacity to allow the ship to be as silent as possible for as much as 12 hours at a time. Great care should also be devoted in the design to quieting the ship when under way. Since sound is rapidly becoming one of the principal tools used in oceanography, the advantages of a ship which radiates a minimum of noise into the water cannot be overemphasized. Devices operating over a very wide range of frequencies are commonly employed on research and on development ships. Since it is much easier for the designer if his main effort can go into eliminating particular bands of frequencies, rather than trying to suppress all frequencies, he should consult with the probable user of the ship early in the design. In general it can be said that in geophysics the greatest need is to eliminate the very low frequencies (down to a few cycles per second), while the biologists at present are mainly using high frequencies. Survey people want to eliminate noise near the operating frequencies of their echo sounders. Thus the requirements for different types of work vary somewhat and some users will be willing to pay more for noise reduction in terms of displacement or cruising range than others will.

6. Provision should be made on the larger ships for carrying on deck a portable laboratory roughly the size of a trailer truck. This will reduce the time in port now required to install and check out specialized type of instrumentation on the ship. It also seems the best way to reduce the danger of contaminating the main laboratories in the course of radioactive tracer experiments.

7. A shielded space for storing small quantities of radioactive materials should be provided.

8. If marine biology is to flourish, some space should be set aside for aquaria having temperature control and a supply of pure sea water. This is chiefly a question of plastic pipes and plastic pumps carrying water to a "wet" laboratory space and to the deck.

9. Winches capable of handling long cables in rough weather are a prime requirement on all scientific ships, yet there is little accumulated design experience for such equipment. New types of cables having electrical leads have recently become available, and these alone are capable of revolutionizing deep-sea research and surveying. Towed sensing elements are being increasingly introduced, but the engineering effort in the development of superior winches and cables remains at a relatively low level. The required effort is somewhat beyond the resources of any one group. Thus both for the ships and their basic equipment a centralized design effort is indicated.

10. Finally, it can be said that biological oceanography has suffered severely from lack of help from an adequate engineering facility. The counterpart of an agricultural experiment station has been almost completely missing in marine resources research and development. This sort of advanced design engineering development should be carried on in close association with naval architects, for the devices must be usable from a ship which may have to be somewhat specialized to accommodate them, just as a farm tractor should be designed to simplify the functions of a hay bailer.

TABLES

Table 1

Oceanographic Ships Needed During the Next Ten Years

	Research	Military R and D	Survey	Resources and fisheries	Total
Present Fleet	11	9	18	7	45
Still operational in 1970	6	-	9	-	15
To be replaced	5	9	9	7	30
Additional new construction	11	11	11	7	40
Total construction	16	20	20	14	70
Total Fleet in 1970	22	20	29	14	85

Table 2

Recommended Size Distribution of New Construction

Size	Research	Military R and D	Survey	Resources and fisheries	Total
500 tons	5	10	4	12	31
1200-1500 tons	9	6	11	2	28
Larger than 2000 tons	2	4	5	-	11
Total	16	20	20	14	70

Table 3

Recommended Construction by Agency, Function, and Size

	Size			
Agency	500 tons	1200-1500 tons	larger than 2000 tons	Total
NAVY				
Research	-	7	1	8
Military R&D	10	6	4	20
Survey	2	5	3	10
COAST & GEODETIC SURVEY				
Survey	2	6	2	10
BUREAU OF COMMERCIAL FISHERIES				
Fisheries	12	2	-	14
NATIONAL SCIENCE FOUNDATION				
Research	3	-	1	4
MARITIME ADMINISTRATION				
Research	2	2	-	4
TOTAL	31	28	11	70

Table 4

Recommended Scheduling of New Ship Construction by Size and Agency

(Year denotes time ship is put into service)

Agency:	Navy			C and G S			B of C F			N S F			M A			Total		
Size in tons:	500	1200-1500	>2000	500	1200-1500	>2000	500	1200-1500	>2000	500	1200-1500	>2000	500	1200-1500	>2000	500	1200-1500	>2000
Year																		
1960	-	2^{r}	-	-	-	-	-	-	-	1^{r}	-	-	1^{r}	-	-	2	2	-
1961	3^{d}	3^{r}	-	1^{s}	1^{s}	-	2^{f}	-	-	-	-	-	-	1^{r}	-	6	5	-
1962	3^{d}	3^{s}	1^{r}	-	-	1^{s}	2^{f}	1^{f}	-	1^{r}	-	-	-	1^{r}	-	6	5	2
1963	2^{s}	2^{d}	2^{d}	-	2^{s}	-	2^{f}	1^{f}	-	-	-	1^{r}	1^{r}	-	-	5	5	3
1964	2^{d}	2^{r}	2^{d}	1^{s}	1^{s}	-	2^{f}	-	-	1^{r}	-	-	-	-	-	6	3	2
1965	1^{d}	2^{s}	2^{s}	-	-	1^{s}	2^{f}	-	-	-	-	-	-	-	-	3	2	3
1966	1^{d}	2^{d}	1^{s}	-	1^{s}	-	2^{f}	-	-	-	-	-	-	-	-	3	3	1
1967	-	2^{d}	-	-	1^{s}	-	-	-	-	-	-	-	-	-	-	-	3	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	12	18	8	2	6	2	12	2	0	3	0	1	2	2	0	31	28	11
		38			10			14			4			4			70	

r research ship
s survey ship
f fisheries ship
d Military R&D ship

Table 5

Costs of Construction and Operation by Size and Function

(in millions of 1958 dollars)

	New Construction	Still Operational in 10 Years	Total after 10 Years	Construction Costs[2]	Estimated Total Annual Operating Costs[3]
Research Ships					
500 tons[1]	5	4	9	$ 8.25	$ 1.80
1200-1500 tons	9	2	11	34.20	3.85
Larger than 2000 tons	2	0	2	10.00	1.00
	16	6	22	52.45	6.65
Military R&D Ships					
500 tons	10	0	10	16.50	2.00
1200-1500 tons	6	0	6	22.80	2.10
Larger than 2000 tons	4	0	4	20.00	2.00
	20	0	20	59.30	6.10
Survey Ships					
500 tons	4	2	6	6.60	1.20
1200-1500 tons	11	4	15	41.80	5.25
Larger than 2000 tons	5	3	8	25.00	4.00
	20	9	29	73.40	10.45
Fisheries Ships					
500 tons	12	0	12	19.80	2.40
1200-1500 tons	2	0	2	7.60	.70
Larger than 2000 tons	0	0	0		0
	14	0	14	27.40	3.10
Totals					
500 tons	31	6	37	51.15	7.40
1200-1500 tons	28	6	34	106.40	11.90
Larger than 2000 tons	11	3	14	55.00	7.00
	70	15	85	212.55	26.30

[1] Tons are expressed as displacement in the fully loaded condition.

[2] Construction costs are estimated at $1.65 million for 500-ton ships, $3.8 million for 1200- to 1500-ton ships and $5 million for the 2000-ton class.

[3] Operating costs are estimated at $0.2 million for 500-ton ships, $0.35 million for 1200- to 1500-ton ships and $0.5 million for the 2000-ton class.

Table 6

Summary of Construction and Operating Costs

(in millions of 1958 dollars)

	New construction	No. ships	Present operating costs	No. ships	Average cost per ship	Annual operating costs in 10 years	No. ships	Average cost per ship
Research Ships	52.45	16	3.25	11	.30	6.65	22	.30
Military R&D Ships	59.30	20	3.96	9	.44	6.10	20	.31
Survey Ships	73.40	20	10.74	18	.60	10.45	29	.36
Resources & Fisheries	27.40	14	1.40	7	.20	3.10	14	.22
Total	212.55	70	19.35	45	.43	26.30	85	.31

Table 7

Estimated Capital Costs for New Oceanographic Ships by Agencies

(in millions of 1958 dollars)*

	Navy	C and G S	B of C F	N S F	M A	Total
1960	23.95	5.45	3.30	1.65	5.45	39.80
1961	21.35	5.00	7.10	1.65	3.80	38.90
1962	20.90	7.60	7.10	5.00	1.65	42.25
1963	20.90	5.45	3.30	1.65	--	31.30
1964	19.25	5.00	3.30	--	--	27.55
1965	14.25	3.80	3.30	--	--	21.35
1966	7.60	3.80	--	--	--	11.40
1967	--	--	--	--	--	--
1968	--	--	--	--	--	--
1969	--	--	--	--	--	--
Total	128.20	36.10	27.40	9.95	10.90	212.55

*Budget allocations have been assigned to the year immediately preceding that in which the ship is to be put into service.

Table 8

Oceanographic Ships

A. Seagoing Research Ships

Name	Tonnage	Length	Operated by
1. ATLANTIS[1]	300	142	Woods Hole Oceanographic Inst.
2. CRAWFORD	280	125	Woods Hole Oceanographic Inst.
3. BEAR[1]	260	100	Woods Hole Oceanographic Inst.
4. CHAIN	2100	214	Woods Hole Oceanographic Inst.
5. VEMA[1]	533	202	Lamont Geological Lab.
6. HIDALGO	240	136	Texas A & M College
7. SPENCER F. BAIRD	505	143	Scripps Inst. of Oceanography
8. HORIZON[1]	505	143	Scripps Inst. of Oceanography
9. ORCA	200	100	Scripps Inst. of Oceanography
10. STRANGER	300	134	Scripps Inst. of Oceanography
11. BROWN BEAR[1]	270	114	University of Washington

B. Military Research and Development Ships

Name	Tonnage	Length	Operated by
1. GIBBS[1]	2700	310	Hudson Laboratory
2. ALLEGHENY-ATA[1]	760	146	Hudson Laboratory
3. EPCE(RP)856[1]	818	184	Underwater Sound Lab.
4. GROUPER[1]	1500	308	50% Underwater Sound Lab. 50% Naval Research Lab.
5. ROCKVILLE[1]	800	180	Naval Research Lab.
6. SOMERSWORTH[1]	800	185	Naval Research Lab.
7. HUNTING[1]	800	200	Naval Research Lab.
8. YAMACRAW(ARC-5)	1000	109	Bell Telephone Labs.
9. EPCE(R)857[1]	818	184	Navy Electronics Lab.

Table 8—Continued

Oceanographic Ships—Continued

C. Oceanographic Survey Ships

Name	Tonnage	Length	Operated by
1. PIONEER[1]	2600	312	Coast & Geodetic Survey
2. PATHFINDER	2000	229	Coast & Geodetic Survey
3. EXPLORER	1900	220	Coast & Geodetic Survey
4. HYDROGRAPHER[1]	1106	164	Coast & Geodetic Survey
5. HODGSON[1]	267	136	Coast & Geodetic Survey
6. BOWIE[1]	267	136	Coast & Geodetic Survey
7. PATTON	150	88	Coast & Geodetic Survey
8. MARMER	150	101	Coast & Geodetic Survey
9. LESTER JONES	150	88	Coast & Geodetic Survey
10. COWIE	128	103	Coast & Geodetic Survey
11. GILBERT	95	78	Coast & Geodetic Survey
12. SURVEYOR	3070	293	Coast & Geodetic Survey
13. SAN PABLO[1]	2700	310	Hydrographic Office
14. REHOBOTH[1]	2700	310	Hydrographic Office
15. DUTTON T-AGS[1,2]	13000	455	Bureau of Ordnance
16. BOWDITCH T-AGS[1,2]	13000	455	Bureau of Ordnance
17. MICHELSON T-AGS[1,2]	13000	455	Bureau of Ordnance
18. EVERGREEN[3]	1025	180	U.S. Coast Guard

D. Resources and Fisheries Ships

Name	Tonnage	Length	Operated by
1. OREGON[1]	254	100	Bureau of Comm. Fish. Pascagoula Lab.
2. SILVER BAY[1]	239	96	BCF, Pascagoula Lab.
3. HUGH M. SMITH[1]	392	128	BCF, Pacific Oceanic Fishery Inves. Lab.
4. CHARLES H. GILBERT[1]	196	122	BCF, Pacific Oceanic Fishery Inves. Lab.
5. BLACK DOUGLAS[1]	370	150	BCF, Biological Lab., Pacific Fishery Investigation
6. ALASKA[1]	240	100	California State Dept. of Fish & Game
7. JOHN N. COBB[1]		100	Bureau of Comm. Fish., North Pacific Fisheries Exploration
8. ALBATROSS III[4]			

[1]To be replaced within 10 years.
[2]In service by end of 1959.
[3]Seasonal use of the ship during ice patrol and similar seasonal use of other Coast Guard and Navy ships bring the total number of U.S. survey ships to about 18.
[4]Laid up January 1959.

Table 9

Partial List of Small Oceanographic Vessels

Name	Tonnage	Length	Laboratory
PANULIRUS	40	65	Bermuda Biological Station
ASTERIAS	25	40	Woods Hole Oceanographic Institution
VENUS	-	40	Duke University
SHANG WHEELER	25	50	Long Island Oyster Investigations Milford, Connecticut
R/V MANNING	-	65	Hudson Laboratories
ACTION	28	65	Department of Meteorology and Oceanography, New York University
QUEEN OF FRANCE	26	46	Narragansett Marine Laboratory
LCVP	-	36	Narragansett Marine Laboratory
R. V. GOLDBERGER	140	71	Lamont Geological Observatory
Small boats at Bermuda Geological Station	14	38	Lamont Geological Observatory
Small boats at Bermuda Geological Station	95	65	Lamont Geological Observatory
SEXTANT	-	28	New Jersey Department of Fish & Game
MAURY	33	63	Chesapeake Bay Institute
LYDIA LOUISE II	12	39	Chesapeake Bay Institute
YF - 854	-	132	Hydrographic Office
R/V PATHFINDER	-	55	Virginia Fisheries Laboratory
cabin cruiser	-	38	Radiobiological Investigations, North Carolina
T-19	40	65	Bears Bluff Isles, South Carolina
J-11	10	40	Bears Bluff Isles, South Carolina
GLENMORE	128	90	University of Miami
GERDA	80	75	University of Miami
SEA GOOSE	20	43	University of Miami
RAMONA	12	42	University of Miami
HERMES	-	40	Bureau of Commercial Fisheries Ocean Springs, Mississippi
M/S ELENA	-	53	Texas A & M
KINGFISH	-	43	Gulf Fishery Investigations Galveston, Texas
12 Inboard cruiser 21'-40' type boats			Texas Game & Fish Commission
PAOLINA-T	111	80	Scripps Institution of Oceanography
TAGE	-	40	Hopkins Marine Station
BIOS PACIFIC (converted LCI)	-	36	Pacific Marine Station
N. B. SCOFIELD	186	100	California Department of Fish & Game
NAUTILUS	37	46	California Department of Fish & Game
MOLLUSK	-	26	California Department of Fish & Game
-(cabin cruiser)	-	26	Walla Walla College Biological Station
O. KETA	8	34	Alaska Department of Fish & Game
IVIK	10	36	Arctic Research Laboratory
2 LCMs	27	54	Arctic Research Laboratory
SALPA	-	46	Hawaii Marine Laboratory