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FISCAL YEAR 1973

FEDERAL COORDINATOR FOR
MARINE ENVIRONMENTAL
PREDICTION

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

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FEDERAL COORDINATOR FOR
MARINE ENVIRONMENTAL
PREDICTION

INTERAGENCY COMMITTEE FOR
MARINE ENVIRONMENTAL
PREDICTION

Federal Plan for Marine Environmental Prediction

FISCAL YEAR 1973

WASHINGTON, D.C.
March 1972

PREFACE

This Federal Plan is published to provide the Executive Branch with a coordinated, overall summary of Marine Environmental Prediction (MAREP) Services and of relevant research and development programs to improve those Services. Such Services include monitoring, assessment, and timely predictions of the ocean, its living resources, its pollutants, and the adjacent overlying atmosphere which affect man's activities, interests, and well-being; included are forecasts, warnings of hazardous conditions, and data summaries and studies issued for the benefit of commerce, navigation, fisheries, offshore drilling and mining, recreation, defense, and other marine activities.

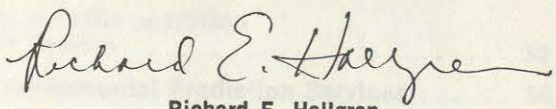
On November 7, 1969, the Vice President, as Chairman of the Marine Science Council, assigned a lead agency role to the Secretary of Commerce for the coordination and planning of Federal civil programs in marine observations and predictions. Because of the interactions between programs dedicated to support civil interests and the marine environmental activities of the Department of Defense, close liaison is maintained with that Department to ensure that elements of Defense activities are included, jointly coordinated, and planned with the civil MAREP program.

The principal tasks of coordinating Government MAREP activities and of preparing and maintaining the Federal Plan are performed by the Interagency Committee for Marine Environmental Prediction. This Committee and its subgroups conduct systematic reviews of basic and specialized marine monitoring and prediction techniques and services and of relevant research in support of MAREP. Long-range specialized plans in specified areas of MAREP that need improvement and coordination are also developed under the auspices of the Committee.

This Plan covers programs for FY 1972 and FY 1973 of all participating Federal agencies. Data for FY 1973 are those included in the President's FY 1973 budget.

The first section of the Plan identifies applications for MAREP services, reviews the activities of the Interagency Committee for Marine Environmental Prediction, and reflects on related international MAREP activities. A summary of fiscal

data is also presented. Two sections present the Basic MAREP Services and the several Specialized Services, identifying contemplated improvements to these Services in FY 1973. The final section discusses relevant research programs that will contribute immediately and in the long term to the improvement of individual MAREP Services. The acronyms used in the Plan are summarized in a glossary which appears as an appendix.



Richard E. Hallgren
Federal Coordinator for
Marine Environmental Prediction

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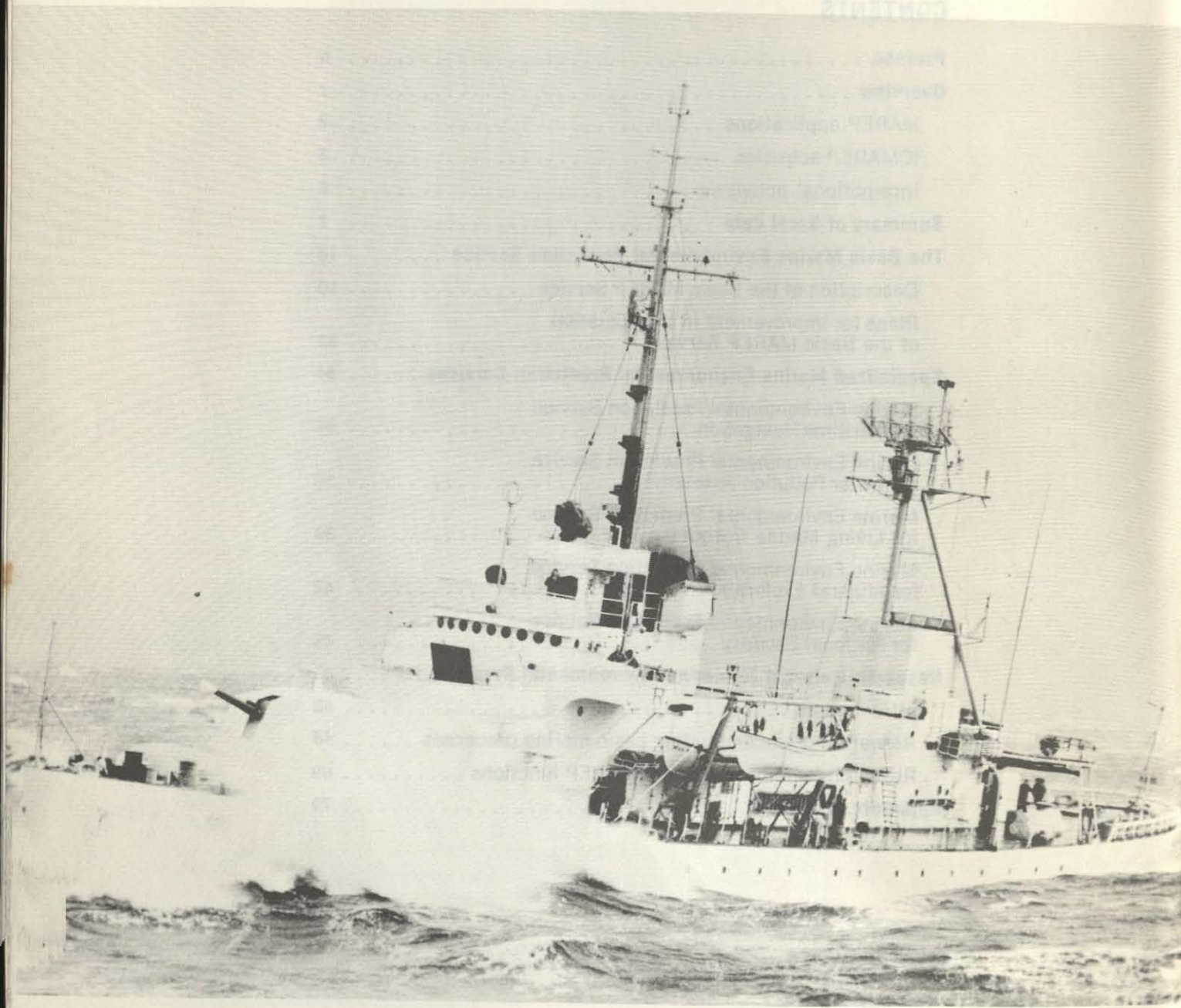


U.S. Coast Guard Cutter *Mendota* under rough-sea conditions on Ocean Station *Delta*.

Overview

"The oceans represent the last great frontier for natural resources on our planet. They are, and will continue to be, essential to communications, security, and the well-being of a very substantial portion of the world's population."[1]

". . . realization of the full potential of the oceans will require a long-term program of exploration, observations, and study on a worldwide basis . . ."[2]

Accordingly, one of our Nation's most urgent and economically significant scientific needs today is that of marine environmental prediction (MAREP).

"Improved understanding of ocean processes would enhance the protection of life and property against severe storms and other hazards, would further the safety of maritime commerce, would directly contribute to the development of coastal areas of the Nation, would benefit the Nation's fisheries and mineral extractive industries, and would contribute to the advancement of a broad range of scientific disciplines."[3]

Immediately recognized are the interrelations between the ocean and the atmosphere. Scientifically, the oceans and the atmosphere together constitute a single geophysical system. The long-term behavior of either the atmosphere or the ocean cannot be understood or predicted without reference to the other. Recent technological advancements have enhanced the potential for data acquisition, data collection and relay, data processing and product formulation with electronic computers, and product dissemination. It is obvious that both meteorology and oceanography must move forward together —scientifically, technologically, and operationally.

Oceanographers and meteorologists have learned much about the physical, chemical, and biological properties and processes of the ocean and the adjacent overlying atmosphere, their interactions, and their dynamic behavior. There have been technological advances in acquiring, transmitting, processing, and disseminating marine environmental information and in formulating better mathematical models and prediction methods. Nevertheless, MAREP has had difficulty keeping pace with the increasing need for services by the national security, maritime industry, commerce, and other marine-related economic activities. Basically, ocean monitoring and prediction are identified as important areas in which action should be taken. This Federal Plan is intended to provide a continuing mechanism to identify public needs and user requirements for prediction products and services, to formulate through joint activities the agencies' programs required to provide these services, and to coordinate their implementation at the Federal Government level.

For this Plan, Marine Environmental Prediction or MAREP is defined as the monitoring, assessing, and forecasting of the physical, chemical, biological, and hydrodynamic states of the ocean and its interaction with the overlying atmosphere and the adjacent terrestrial boundaries. The marine environment is broadly interpreted not only to include the open oceans and sea, but also the Great Lakes and all air, sea, and land interactions in coastal regions involving marine-related variables.

The growing number of persons concerned with the oceans both for pleasure and livelihood, the increasing amount of our economy engaged in marine activities as the Nation looks to the effective use of the oceans as a source of resources, and the full spectrum of national defense operations have an expressed need for accurate and timely MAREP Services. The areal extent of the need for such Services includes the coastlines from Maine to Texas and from California to Alaska where 80 percent or more of our marine activities take place,

[1] U.S. Congress, House, Committee on Foreign Affairs, Subcommittee on International Organizations and Movements, *The Oceans: A Challenging New Frontier,* 90th Cong., 2d sess., October 9, 1968, H. Rept. 1957, p. 2R.

[2] U.S. Congress, Senate, Committee on Commerce, *Ocean Exploration,* 90th Cong., 2d sess., July 26, 1968, S. Rept. 1476, p. 3.

[3] *Ibid.,* p. 2.

the Great Lakes where over 50 percent of our inland waterborne commerce occurs, and the open seas where a very considerable amount of U.S. interests are vested in marine transportation, commerce, oceanic research and exploration, and national defense operations.

The steady increase in these areas of marine activity vividly demonstrates the increasing need for effective and improved MAREP Services. To give a few examples:

- the waterborne commerce increased by approximately 11 percent in 1970 from 426 to 473 million tons.
- the estimated 8.5 million recreation boats are projected to increase by nearly 50 percent (to 12 million) during the next 10 years.
- the total number of people who make use of waterways and lakes will grow from 43 million to more than 60 million by 1980.
- the offshore oil and mining industries increased by 10 percent in 1970, from 525 to 575 million barrels.
- the commercial fishing industry, with a current annual harvest of 6.5 million tons, is projected to increase during the next decade.
- saltwater sport fishermen have increased by over one million to 9.5 million persons between 1965 and 1970 and spent $1.4 billion on their sport in 1970.

The nature of the benefits extends from the technological and the scientific through the economic to the political. Improved data gathering and processing will increase man's knowledge of the oceans and atmosphere and of the complex processes that occur in and at the boundaries of the geophysical system. Improved and expanded prediction services can reduce losses of life and property and can increase effectiveness of planning in industry, commerce, mariculture, transportation, public utilities, recreational activities, national defense, and management of natural resources.

Tangible benefits from environmental prediction programs are not readily translated into quantitative terms. The number of lives saved from drowning would be most difficult to estimate. Total costs for ship-operating time range from a few hundred to one thousand dollars per hour. Predictions of waves, currents, or winds can enable ship operators to select a least-time-track, effecting savings of several hours along a coastal route or up to one or more days on transoceanic routes. Similar prediction services for fisheries operations can assist in preventing the loss of many thousands of dollars worth of fishing gear, in increasing the effectiveness of ship-operating time, and in helping the saving of lives. Prediction services for operators of recreational facilities and equipment in the marine environment can allow for an avoidance of hazardous conditions to personnel and equipment and, in fact, can prevent the loss of lives by controlling the use of such facilities whenever hazardous conditions are forecast. Prediction services for offshore mining and similar operations can provide the operators with a means to anticipate and to prepare for damaging and hazardous weather and sea conditions in sufficient time to curtail operations and to avoid placing lives in jeopardy. Monitoring and prediction of the pollution and state of degradation of marine waters is essential in view of present, impending, and long-range threats to marine ecosystems, to living marine resources, to esthetic and recreational values of the marine environment, and to man's ultimate survival.

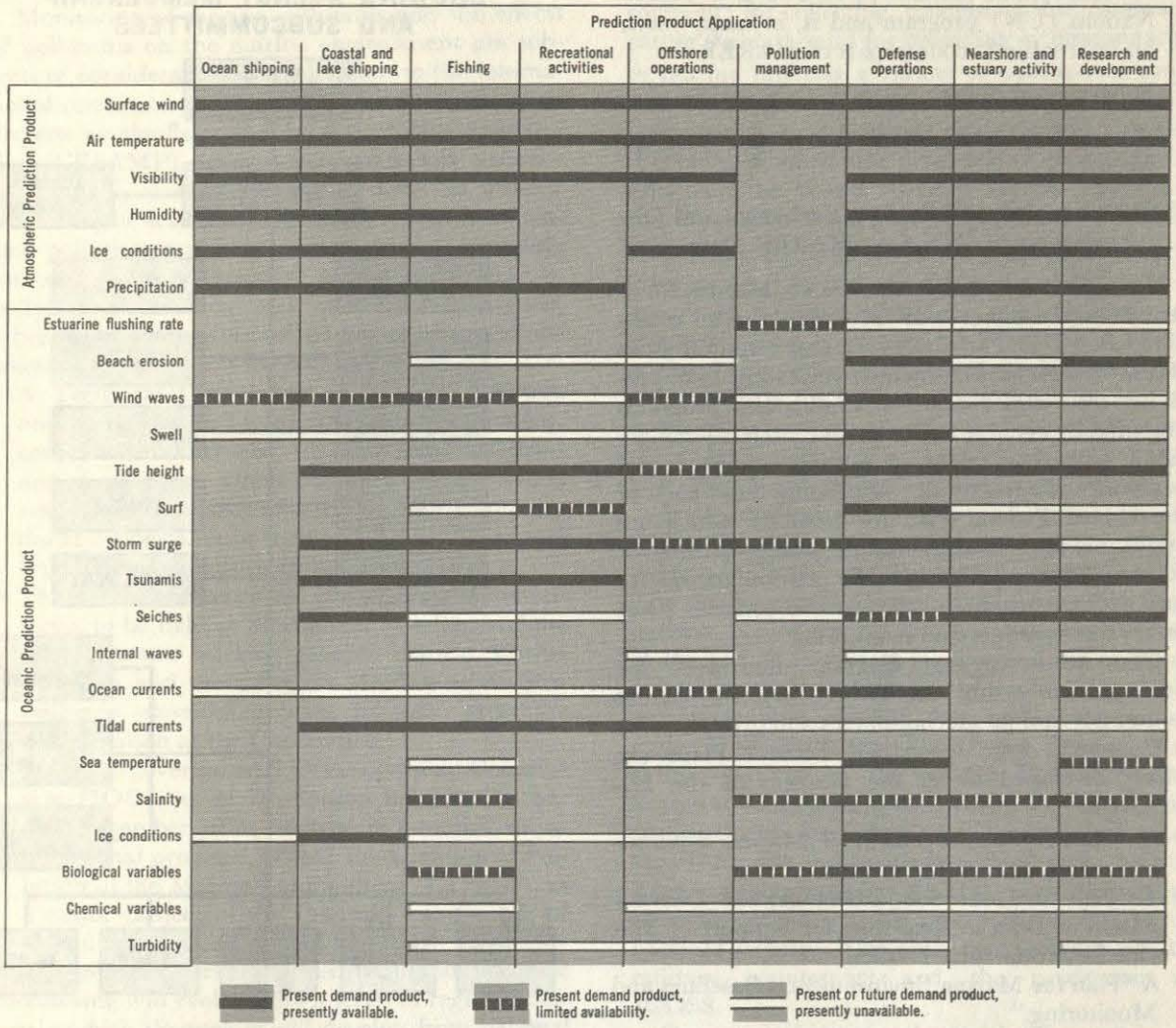
Principal goals of the Federal effort in MAREP are:

- ☐ Provide an integrated program for marine prediction and information services, including timely warnings of hazardous environmental conditions—both natural and manmade—on the high seas, in coastal waters, and on the Great Lakes for the protection of life and property.
- ☐ Develop an integrated environmental monitoring system that will satisfy effectively the needs for physical, chemical, biological, and certain geological data from oceanic and contiguous regions to support service-oriented programs and to facilitate effective control of environmental pollution.
- ☐ Provide assessments and predictions of the distribution and abundance of the living marine resources that are of principal importance to the United States.

MAREP APPLICATIONS

The accompanying table summarizes, in matrix display, the wide range of prediction products and services as they relate to the needs of various user groups. These are products and services that are or might be provided by the Federal Government. The table identifies the user groups that will apply the prediction variables; subsequent columns identify the variables for which predictions are required. These variables fall into two groupings—oceanic variables and those atmospheric variables above the sea surface which are integral to the marine environment and are interactive with the oceanic variables at or below the sea surface.

MAREP PRODUCTS AND SERVICES—AS RELATED TO THE NEEDS OF VARIOUS USER GROUPS



ICMAREP ACTIVITIES

The magnitude of Federal responsibilities for prediction products and services and for relevant research and technology development reflects action needed in response to a wide range of current and potential user applications in Marine Environmental Prediction (MAREP). The Departments of Commerce, Defense, the Interior, State, and Transportation, the Environmental Protection Agency (EPA), the Atomic Energy Commission (AEC), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Smithsonian Institution either conduct or fund efforts in or related to MAREP, and efforts are generally integral elements of programs being conducted in fulfillment of the respective agency missions.

The Interagency Committee for Marine Environmental Prediction (ICMAREP) was formed in 1970 to aid in planning effective MAREP Services, to prevent unnecessary overlapping of products and services, and to promote advanced MAREP Services and relevant research. The Federal agencies mentioned above comprise the membership of ICMAREP.

To define MAREP Services further, it was deemed necessary by ICMAREP members to assign definitive MAREP problems to subcommittees with appropriately appointed representation from each Federal agency. In recognition of the need for various planning efforts, the following ICMAREP subcommittees were formed:

- ☐ Subcommittee on Marine Environmental Baselines and Monitoring.

☐ Subcommittee on the Integrated Global Ocean Station System (IGOSS); IGOSS is a United Nations (UN) program and is, in many ways, an international counterpart of MAREP.

☐ Subgroup on Buoys.

☐ Task Group for MAREP Techniques Development.

☐ Task Group for Collection, Exchange, and Dissemination of Real-time MAREP Data.

The permanent Subcommittee on Marine Environmental Baselines and Monitoring was established in 1971. The objectives and responsibilities of this Subcommittee include reviewing and providing recommendations on studies and proposals prepared by agency, national, and international organizations that relate to marine environmental baselines and monitoring; developing those parts of the annual Federal Plan for MAREP which are applicable to the Subcommittee; and preparing for ICMAREP the proposed U.S. position papers for international meetings scheduled to consider items on marine baselines and monitoring.

The accompanying diagram illustrates the agency membership on the ICMAREP parent committee and its subcommittees and groups.

Currently, four specialized Federal Plans are being developed under the auspices of the ICMAREP:

- A "Plan for Improvement of Marine Environmental Prediction Techniques."
- A "Plan for Collection, Exchange, and Dissemination of Data in Real-time for Support of Marine Environmental Prediction."
- A "Plan for Marine Environmental Baselines and Monitoring."
- A "Plan for Environmental Data Buoys."

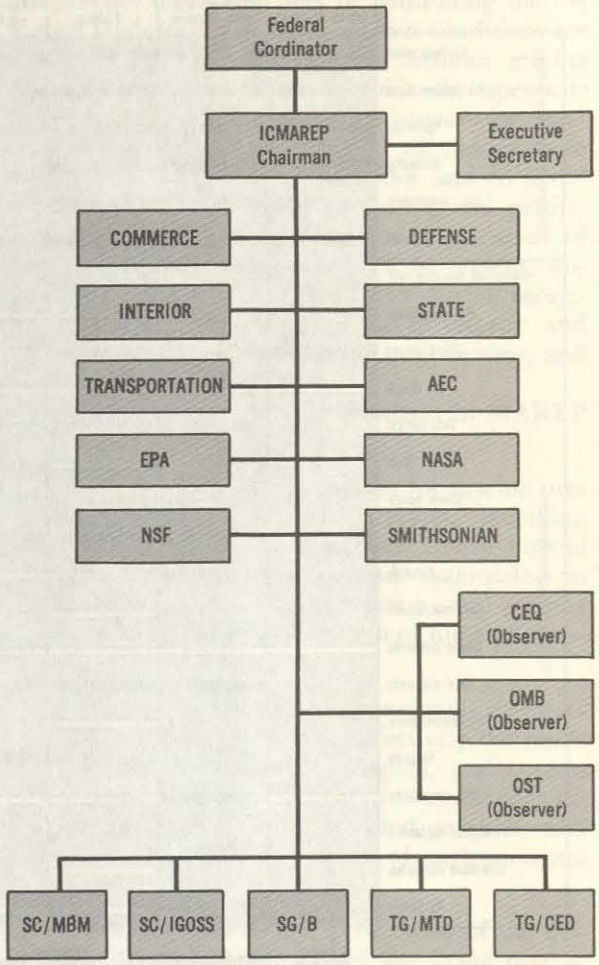
The various subcommittees and groups have been charged with the responsibility for preparing these Plans.

Aside from coordinating the activities of the ICMAREP subcommittees and groups, the parent committee has also been involved in other tasks. An Ad Hoc Committee on Biological Requirements developed a report which highlighted potential MAREP resolution for biological research, fishery oceanography, and marine resources programs.

ICMAREP is the interagency organization for monitoring the International Field Year for the Great Lakes (IFYGL). This is a joint United States-Canadian program to study water quality and water quantity in Lake Ontario during 1972.

ICMAREP has agreed on an annual basis to assist the U.S. Coast Guard in the assembly of requirements for logistic support to data buoy projects.

ORGANIZATION OF THE ICMAREP, SHOWING AGENCY MEMBERSHIP AND SUBCOMMITTEES



An international project, the IGOSS Pilot Project for Collection, Exchange, and Evaluation of Bathythermograph Data, began in early 1972. The ICMAREP Subcommittee on IGOSS has been actively involved in giving aid to the preparation of an international operations plan and in coordinating the U.S. participation in the Pilot Project.

To reflect the association of Federal activities with comparable international activities, a brief description of the latter is also included.

INTERNATIONAL ACTIVITIES

Because man's physical environment respects no national boundaries, the problem of environmental prediction cannot be solved effectively along nar-

row national or regional lines. Many ocean problems require international cooperation.

Monitoring of marine pollutants and the effects of pollutants on the marine environment are subjects of considerable current interest to the international community. An international joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), sponsored by specialized agencies of the UN, was established in 1969 to provide advice on the scientific and technical aspects of marine pollution problems and to develop proposals for cooperative programs of action with respect to pollution monitoring and control. In addition, other groups have focused on monitoring and assessment requirements for pollution:

- A Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing, convened in December 1970 by the UN Food and Agriculture Organization, adopted several resolutions directed toward improved international cooperation in monitoring techniques and urged increased efforts in pollution reesarch.
- The UN Conference on the Human Environment, to be held at Stockholm, Sweden, in June 1972, has two working groups—one on Marine Pollution and the other on Monitoring or Surveillance—developing plans in these areas for consideration at the Conference.
- The Intergovernmental Oceanographic Commission (IOC), at its 7th Session held in October and November 1971, resolved to establish an international program, Global Investigation of Pollution in the Marine Environment (GIPME), as a major project of the International Decade of Ocean Exploration (IDOE).

It is generally acknowledged that global oceanic monitoring will evolve from a series of regional networks which themselves will develop from national systems. Because pollution problems are generally multidisciplinary—physical, chemical, and in part biological—the need for close cooperation between specialized agencies of the UN has been emphasized. The major UN-sponsored international marine monitoring and prediction program is the Integrated Global Ocean Station System (IGOSS) which was initiated by IOC.[4] The IGOSS program is viewed as the international counterpart of the Marine Environmental Prediction (MAREP) Services of the United States. Appropriate elements of the MAREP program constitute the principal contributions by the United States to the IGOSS program.

The purpose of IGOSS is to bring together various national environmental monitoring and prediction systems in a responsive dynamic worldwide system for measuring or observing the marine environment; for collecting, processing, and communicating the data; and for providing or disseminating to marine interests a variety of operational products for their use. This service-oriented program concentrates on the marine environment, although it is being planned and developed in close conjunction with the World Weather Watch program of the World Meteorological Organization (WMO).

The IGOSS program was established to meet the growing need for oceanic data on a global scale by groups in forecasting services, research, engineering, navigation, commerce, and fisheries. An international committee, made up of the Member States most active in the field, was established to plan and to coordinate the development of the IGOSS program, both within IOC and jointly with WMO and other interested international organizations.

A pilot project for the collection, exchange, and evaluation of selected oceanographic data on an international basis was initiated in January 1972. The project marks a significant milestone in international oceanographic cooperation under the aegis of the UN. The project inaugurated the exchange of bathythermal observations by the high-speed telecommunications systems that have been set up under UN agreements. The Global Telecommunications System of the WMO World Weather Watch is being used as the principal means for operational data exchange. For a number of years, the U.S. has cooperated with North Atlantic Treaty Organization (NATO) countries in exchanging oceanographic information vital to the national security. This exchange program was the military counterpart and the predecessor to IGOSS.

Oceanographic research resulting from and contributing to the ongoing development of IGOSS is identified within the Long-Term and Expanded Program of Ocean Exploration and Research (LEPOR), which is being implemented in accordance with UN General Assembly Resolution 2414 (XXIII) of December 17, 1968, and Resolution 2560 (XXIV) of December 13, 1969. Serving as a stimulus and acceleration phase for LEPOR, the IDOE also includes oceanographic research of benefit to the development of IGOSS.

There is also the possibility of conducting oceanographic experiments of potential benefit to the development of IGOSS in conjunction with the Global Atmospheric Research Program (GARP) Atlantic Tropical Experiment (GATE), sponsored jointly by the International Council of Scientific Unions (ICSU) and WMO. Problems of ocean-at-

[4] IOC Resolution V-20, adopted in September 1967.

mosphere interaction have been identified as part of LEPOR and work on these problem areas is also interrelated with GARP.

Several regional investigations are expected to contribute toward the further development of IGOSS and MAREP. Among such investigations are:

- The Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR) for air-sea interaction studies, current and water mass variation studies, geological studies, and biological studies. The organization and implementation of CICAR was coordinated by IOC.
- The Cooperative Investigation of the Northern part of the Eastern Central Atlantic (CINECA) for studies of upwelling phenomena and nutrient distributions. The organization and implementation of CINECA is being coordinated by the International Council for Exploration of the Sea (ICES) in cooperation with the Food and Agriculture Organization, the WMO, and the IOC.

On the basis of a bilateral agreement, there was established in 1964 a United States-Japanese Cooperative Program in Natural Resources Development (UJNR). Within the UJNR program on marine science, there is a U.S. and Japanese Panel on Marine Environmental Observations and Forecasting. Following the initial meeting of the U.S. Panel with its counterpart in Japan in 1970, the following recommendations were made: (1) to continue close coordination of the two Panels; (2) to encourage the exchange of scientists; (3) to promote the exchange of data, technical reports, and other related information; and (4) to coordinate plans for the monitoring of large-scale features of the dynamics of the Pacific Ocean. A second meeting of the counterpart Panels is being planned for late 1972 in the United States.

Summary of Fiscal Data

The following tables summarize fiscal information for programs of the Federal Government associated with Marine Environmental Prediction (MAREP). The funds shown are those used to provide services and to support relevant research that has both long- and short-term objectives for improving services. Information on observations made from land and marine stations for the unique purpose of collecting data for the Basic Meteorological Service is not included in this Plan, but is reported in the annual *Federal Plan for Meteorological Services and Supporting Research*. The Marine Meteorological Service, discussed as a Specialized Meteorological Service in the preceding Plan, is included as an integral part of this Plan for MAREP; appropriate sections contain funding information for and descriptions of the Marine Meteorological Service.

The fiscal information for operations in MAREP and for relevant research is presented by agency and by service in the first two tables, "Federal Plan for Marine Environmental Prediction, by Agency" and "Federal Plan for Marine Environmental Prediction, by Service"; data for FY 1972 programs and for planned activities in FY 1973 are included as proposed in the President's budget. The total Federal expenditure in MAREP planned for FY 1973 is $211,399,000, with an increase of $22,375,000 over FY 1972. Most Federal agencies plan activities at level funding or with modest increases. The largest increases are those of the Department of Commerce.

In the operations area, total MAREP costs for FY 1973 are expected to be $79,410,000, a net increase of $4,451,000 over FY 1972. The largest planned increases are those of the Department of Commerce and are accounted for by expansions and improvements in marine weather and ocean forecasting services, in services of the National Oceanographic Data Center (NODC), in the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program, and in satellite operations for the acquisition and processing of oceanic data.

The planned expenditures for FY 1973 research and development programs relevant to MAREP

FEDERAL PLAN FOR MARINE ENVIRONMENTAL PREDICTION, BY AGENCY

(in thousands of dollars)

	Operations			Relevant research			Total		
	FY72	FY73	Net difference	FY72	FY73	Net difference	FY72	FY73	Net difference
Commerce	24,182	25,888	+1,706	48,339	61,514	+13,175	72,521	87,402	+14,881
Defense	30,326	32,207	+1,881	23,631	25,027	+ 1,396	53,957	57,234	+ 3,277
Interior	1,205	1,206	+ 1	1,923	1,966	+ 43	3,128	3,172	+ 44
Transportation	12,397	12,911	+ 514	6,898	9,758	+ 2,860	19,295	22,669	+ 3,374
AEC				6,679	6,048	— 631	6,679	6,048	— 631
EPA	5,922	6,323	+ 401	3,734	4,384	+ 650	9,656	10,707	+ 1,051
NASA				2,212	4,027	+ 1,815	2,212	4,027	+ 1,815
NSF	352	250	— 102	20,399	18,840	— 1,559	20,751	19,090	— 1,661
Smithsonian	575	625	+ 50	250	425	+ 175	825	1,050	+ 225
Total	74,959	79,410	+4,451	114,065	131,989	+17,924	189,024	211,399	+22,375

FEDERAL PLAN FOR MARINE ENVIRONMENTAL PREDICTION, BY SERVICE

(in thousands of dollars)

	Operations			Relevant research			Total		
	FY72	FY73	Net difference	FY72	FY73	Net difference	FY72	FY73	Net difference
Basic	27,134	29,644	+2,510	56,795	62,828	+6,033	83,929	92,472	+8,543
Maritime navigation	2,818	3,082	+ 264	1,111	1,372	+ 261	3,929	4,454	+ 525
Water pollution assessment	7,956	8,081	+ 125	26,257	32,350	+6,093	34,213	40,431	+6,218
Living marine resources	8,196	7,839	— 357	16,200	21,165	+4,965	24,396	29,004	+4,608
Mineral exploration	125	175	+ 50	272	462	+ 190	397	637	+ 240
National security	28,730	30,589	+1,859	13,430	13,812	+ 382	42,160	44,401	+2,241
Total	74,959	79,410	+4,451	114,065	131,989	+17,924	189,024	211,399	+22,375

INTERAGENCY FUND TRANSFERS FOR MARINE ENVIRONMENTAL PREDICTION, BY AGENCY, FY 1972

(in thousands of dollars)

	Funds transferred to									
	Commerce		Defense	Interior		Transportation	Smithsonian	Total		
Funds transferred from	Operations	Research	Research	Operations	Research	Operations	Research	Operations	Research	Both
Defense	43	12		37	45	40 [2]		120	57	177
AEC		245	10		43				298	298
EPA				10				10		10
NASA		300	800 [1]						1,100	1,100
NSF	352	425					250 [2]	352	675	1,027
Total	395	982	900	47	88	40	250	482	2,130	2,612

[1] NASA supports a Remote Sensing Oceanography (RSOC) Project under Defense management. The research aim of this Project is the development of civil applications of remote sensing of the marine environment.

[2] Smithsonian is a quasi-governmental agency, and funds reported as transfers are acquired through contracts with the private sector of the Institution.

Services total $131,989,000, showing an increase of $17,924,000 over FY 1972. The $13,175,000 increase for the Department of Commerce results from new or expanded efforts in connection with the International Field Year for the Great Lakes (IFYGL), the Global Atmospheric Research Program (GARP) Atlantic Tropical Experiment (GATE), the National Data Buoy Project (NDBP), MARMAP research, and a variety of projects in physical oceanography. In addition, a FY 1973 major initiative which involves broad participation by a number of National Oceanic and Atmospheric Administration (NOAA) components is the Marine Ecosystem Analysis (MESA) Program costing $2,090,000.

The major programs of the Federal agencies which contribute to the several MAREP Services listed in the table, "Federal Plan for Marine Environmental Prediction, by Service," are discussed, together with planned improvements, in succeeding sections of the Plan.

The "Interagency Fund Transfers for Marine Environmental Prediction, by Agency, FY 1972," shows the extent to which some Federal agencies

AGENCY OPERATIONAL COSTS, BY FUNCTION

(in thousands of dollars)

	Data acquisition		Communications		Data processing		Information dissemination		General agency support		Total	
	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73
Commerce	11,307	11,993	1,021	1,037	5,750	6,104	2,770	3,217	3,334	3,537	24,182	25,888
Defense	11,106	12,498	2,651	2,460	4,959	6,426	3,389	3,289	8,121	7,534	30,326	32,207
Interior	1,085[1]	1,086[1]							120	120	1,205	1,206
Transportation	10,857	11,193	711	711	127	133	180	337	522	537	12,397	12,911
EPA	2,961	3,158	987	1,055	987	1,055	987	1,055			5,922	6,323
NSF					352	250					352	250
Smithsonian	205	225			310	330	40	45	20	25	575	625
Total	37,621	40,153	5,370	5,263	12,485	14,298	7,366	7,943	12,117	11,753	74,959	79,410

[1] The funds listed are about 50 percent of total marine data acquisition costs of the U.S. Geological Survey, the remainder being provided by States and local agencies through cooperative agreements. These costs include data processing, not identified by the Survey as a separate function.

AGENCY MANPOWER ENGAGED IN MARINE ENVIRONMENTAL PREDICTION OPERATIONS, BY FUNCTION

(in man-years)

	Data acquisition		Communications		Data processing		Information dissemination		General agency support		Total	
	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73
Commerce	232	218			324	341	89	103	106	106	751	768
Defense	318	301	222	197	361	330	246	220	622	559	1,769	1,607
Interior	200	200							20	20	220	220
Transportation	1,074	1,086	10	10	51	51	9	9	53	53	1,197	1,209
EPA					25	30	25	30			50	60
Smithsonian	3	4			8	10	2	3	3	3	16	20
Total	1,827	1,809	232	207	769	762	371	365	804	741	4,003	3,884

are making use of each other's capabilities in arranging for MAREP Services or relevant research by interagency transfers in FY 1972.

The MAREP products and services are generated through the operation of a system made up of four interlocking functions plus a support function. As treated in this Plan, these five functions are: data acquisition, communications, data processing, information dissemination, and general agency support. These functions are further explained in the next section under the description of the Basic MAREP Services; however, a summary of fiscal information arranged according to functions is also given in the tables: "Agency Operational Costs, by Function" and "Agency Manpower Engaged in Marine Environmental Prediction Operations, by Function."

Tables showing agency support of the Basic and Specialized Services are included in succeeding sections. In the final section on relevant research, there is a summary table presenting "Agency Relevant Research Costs, by Function."

The Basic Marine Environmental Prediction Service

The general public, specialized segments of the economy, and national defense require marine environmental monitoring and prediction information to perform their daily activities effectively and safely. Many of these needs are fulfilled through the Basic Marine Environmental Prediction (MAREP) Service of the United States, which is intended to meet the needs of the public, to fulfill those requirements common to two or more user groups, or to provide the foundation for the Specialized MAREP Services.

Specialized MAREP Services provide the facilities, products, and distribution mechanism necessary to serve specific user groups. Such Services include those for maritime navigation, water pollution assessment, living marine resources, mineral exploration, and national security; they will be discussed in succeeding sections of the Plan, while this section will describe the Basic Service and the contemplated plans for its improvement.

The Basic Service must be viewed in conjunction with the Specialized Services to recognize the full spectrum of the environmental monitoring and prediction program.

BASIC MARINE ENVIRONMENTAL PREDICTION SERVICE, BY AGENCY

(in thousands of dollars)

	Operations		Relevant research		Total	
	FY72	FY73	FY72	FY73	FY72	FY73
Commerce	15,105	17,145	27,465	33,042	42,570	50,187
Defense ..	406	450	2,363	2,657	2,769	3,107
Interior ..	1,200	1,200	1,610	1,636	2,810	2,835
Transportation ...	9,496	9,974	2,777	2,801	12,272	12,775
AEC			530		530	
NASA			1,551	3,677	1,551	3,677
NSF	352	250	20,249	18,590	20,601	18,840
Smithsonian .	575	625	250	425	825	1,050
Total	27,134	29,644	56,795	62,828	83,929	92,472

DESCRIPTION OF THE BASIC MAREP SERVICE

The Basic MAREP Service provides fundamental observations and forecasts used by interested members of the general public, governmental agencies, specialized user groups, and many segments of the economy. This Basic Service also provides many of the observations, analyses and forecasts, and communications common to the Specialized Services in MAREP. It is recognized that certain meteorological observations, analysis and forecast centers, and their communication links, which are provided primarily for the Basic Meteorological Service, furnish invaluable support to the Basic and Specialized MAREP Services.[5]

The principal observation networks, communications networks, analysis and forecast centers, and other facilities of the several Federal agencies which contribute wholly or in part to the specific support of the Basic MAREP Service are listed below:

- ☐ Oceanographic and related meteorological observations by the Department of Defense, using naval vessels, research ships, ships of opportunity, and reconnaissance and patrol aircraft.
- ☐ Oceanographic and meteorological observations by the U.S. Coast Guard, using aircraft, fixed platforms, and vessels engaged in the Ocean

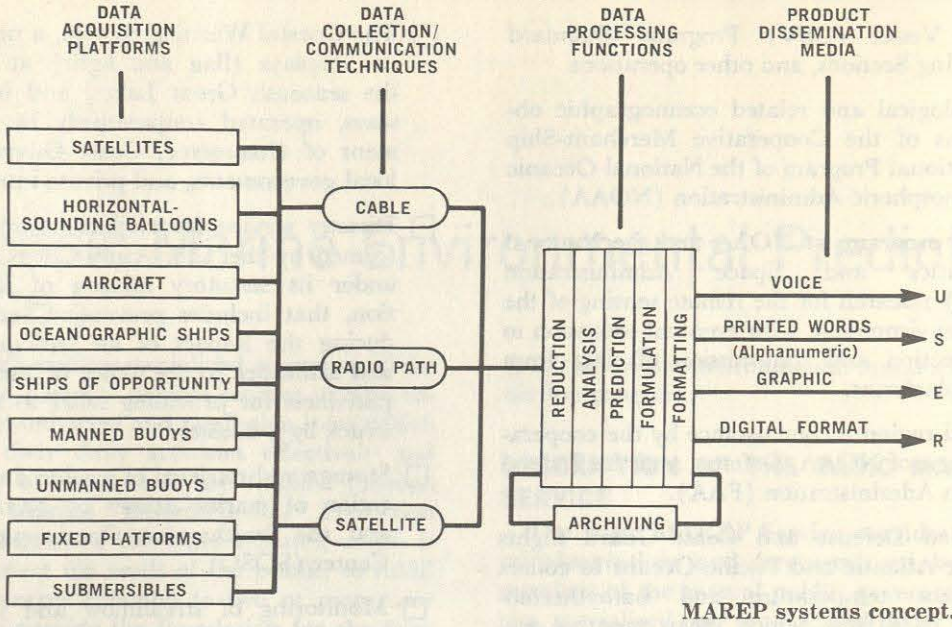
[5] A full description of the Basic and other Specialized Meteorological Services is contained in *The Federal Plan for Meteorological Services and Supporting Research*, published annually by the Federal Coordinator for Meteorological Services and Supporting Research. Description of these Basic and Specialized Meteorological Services and the associated facilities will appear only incidentally in this Plan as they interface with MAREP Services, except in the case of the Marine Meteorological Service and tropical cyclone warnings which are integral parts of MAREP Services.

Station Vessel (OSV) Program, Standard Monitoring Sections, and other operations.

- ☐ Meteorological and related oceanographic observations of the Cooperative Merchant-Ship Observational Program of the National Oceanic and Atmospheric Administration (NOAA).
- ☐ Satellite programs of NOAA and the National Aeronautics and Space Administration (NASA) research for the remote sensing of the marine environment, with eventual extension to the collection and transmission of data from *in-situ* platforms.
- ☐ Tropical region reconnaissance by the cooperative efforts of NOAA, Defense, and the Federal Aviation Administration (FAA).
- ☐ Scheduled Defense and Coast Guard flights over the Atlantic and Pacific Oceans to collect sea-surface temperature and bathythermographic data from which mean monthly sea-surface temperature charts and Gulf Stream charts are produced for distribution.
- ☐ Special procedures activated by the *National East Coast Winter Storms Operations Plan* which depend upon the cooperative reconnaissance and the surface observation, analysis, and warning capabilities of NOAA, Defense, FAA, and the Coast Guard.
- ☐ Tide and tidal current prediction and Great Lakes water-level monitoring services of NOAA.
- ☐ The Pacific Tsunami Warning System of NOAA.
- ☐ Marine data collection and relay by high-speed circuits and teletypewriter systems operated by the Departments of Commerce, Defense, and Transportation.
- ☐ Processing, analysis, and forecast centers for marine services of NOAA and Defense.
- ☐ Tropical analyses and storm and hurricane warnings by NOAA and Defense.
- ☐ Dissemination of marine forecasts and warnings by means of continuous very high frequency/frequency modulation (VHF/FM) radio broadcasts of NOAA and those of commercial facilities.
- ☐ Dissemination of marine forecasts and warnings by means of Defense and Coast Guard radio facilities.
- ☐ The Coastal Warning System, a network of visual displays (flag and light) at locations on the seacoast, Great Lakes, and inland waterways, operated cooperatively by the Department of Commerce, Coast Guard, State and local governments, and private interests.
- ☐ Disaster service for civilian communities, performed by the U.S. Army Corps of Engineers under its statutory mission of flood prevention, that includes prevention services for reducing the impact of an anticipated disaster and assistance to the Office of Emergency Preparedness for providing relief to a community struck by a disaster.
- ☐ Storage and retrieval of marine data and publication of marine atlases by NOAA, Defense, and the Smithsonian Oceanographic Sorting Center (SOSC).
- ☐ Monitoring of streamflow and water quality in estuaries, in the coastal zone, and in the Great Lakes by the United States Geological Survey (USGS), Defense, and NOAA.
- ☐ Hydraulic, hydrologic, and sedimentation study of the Army Corps of Engineers and USGS and the flood management services of the Army.
- ☐ Establishment of techniques and secondary reference standards for the assessment of oceanographic instrument performance and for information on performance and on instrument development programs by the National Oceanographic Instrumentation Center (NOIC) of NOAA.

MAREP has been defined as the monitoring, assessing, and forecasting of the physical, selected biological, chemical, and hydrodynamic states of the ocean and its interaction with the overlying atmosphere and adjacent terrestrial boundaries. It is therefore treated as a total system, made up of four interlocking functions (see diagram) and a support function. In general, the functions involved in the production of MAREP Services are the following:

- ☐ Data acquisition—periodically sensing, measuring, or otherwise determining or describing the state of the ocean and its overlying atmosphere. Methods of data collection, recording, and preprocessing; interfaces with communications systems; and deployment and maintenance of observational platforms are included.
- ☐ Communications—transmitting, with minimum delay, raw data acquired by various sensors to



MAREP systems concept.

the processing centers; processed data from center to center; and predictions, warnings, and other information to the user. This function includes message composition, handling, relaying, and receipt of data as well as those maintenance tasks directly related to communications systems.

- ☐ Data processing—correlating the data collected from the various participating elements and preparing analyses, assessments, and forecasts for the marine environmental phenomena. Also included are related operations such as data plotting, forecast verification, archiving, and statistical analyses and summarization.
- ☐ Information dissemination—the delivery of products and environmental services, involving output from data processing to the ultimate users so that users can make operational decisions or conclusions partly on the basis of the information provided.
- ☐ General agency support—activities which agencies must perform, such as training of personnel, maintenance of equipment and facilities, internal support, and management above the operating level so that the total system can be operated to provide MAREP Services effectively and efficiently.

Some MAREP Services do not include real-time forecasts; consequently, all of the functional steps are not always applicable. A general summary of Federal programs in the Basic MAREP Service, presented in terms of each of the functions, follows.

DATA ACQUISITION

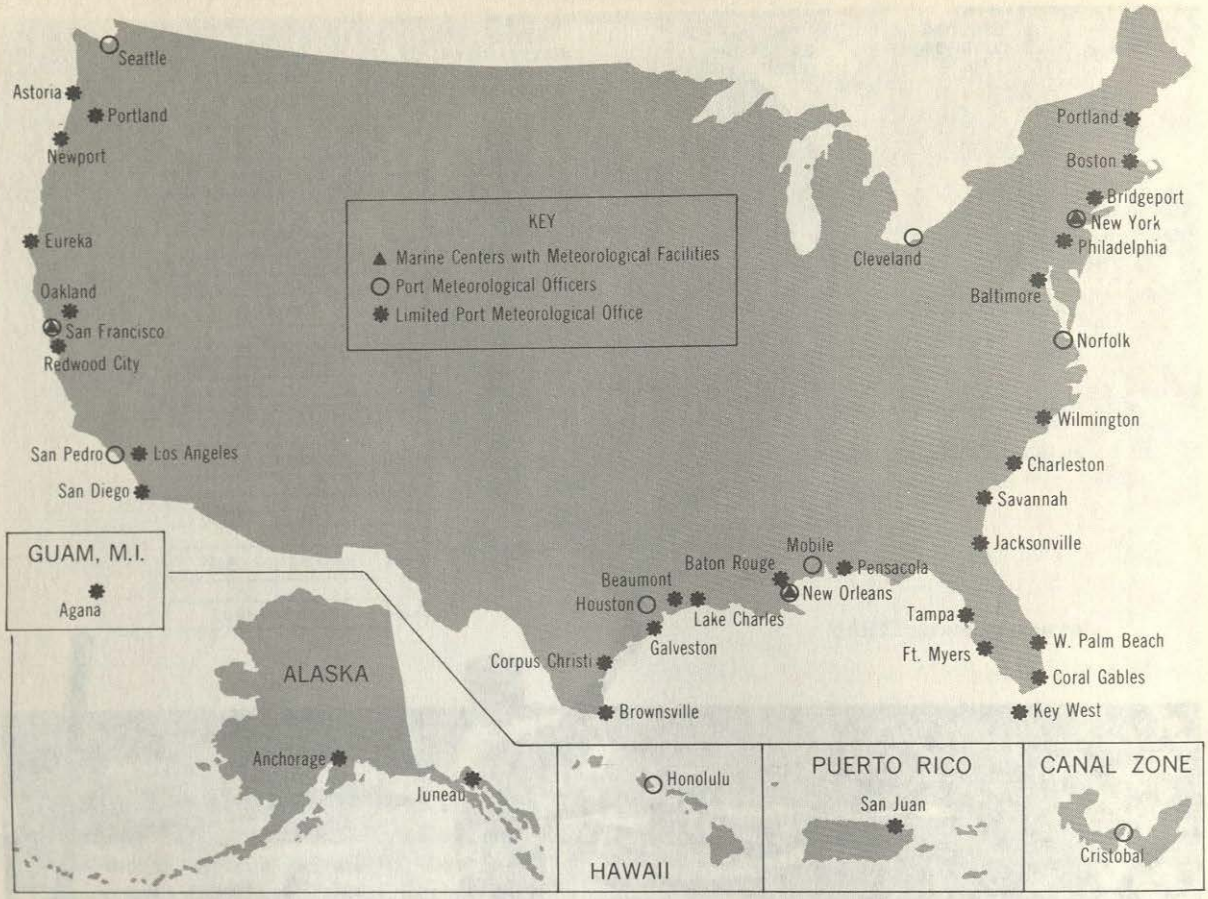
Observations for the Basic MAREP Service are obtained through a number of agency programs, using a variety of observing platforms and sensors. The diversity of requirements for the Basic Service and the variety of sampling or monitoring methods result in mixed and multi-purpose data-collection platforms and sensors. These factors, coupled with the need for standardization and the increase in definition of optimum-space and time-sampling intervals, are necessary considerations which are recognized in planning a complex yet responsive observational network for the Service.

Existing environmental data acquisition techniques partially satisfy requirements for both oceanic and meteorological information which are pertinent to MAREP. Measurements of meteorological parameters are made by ships, aircraft, satellites, coastal radar, and horizontal balloons and by radiosonde methods from ships and island stations as part of the Basic Meteorological Service. The Basic Meteorological Service provides observations of the atmosphere and the sea surface that are essential for MAREP, but which are reported in detail in the annual *Federal Plan for Meteorological Services and Supporting Research* and in the *Federal Plan for Marine Meteorological Services.*

Release of radiosonde at sea to obtain upper air measurements. (National Weather Service)

These observations are:

- Surface observations from land and oceanic areas to support broad-scale analyses and forecasts.
- Surface observations from the Cooperative Merchant-Ship Observational Program to supplement data coverage over the oceans.
- Surface observations from the Cooperative Coastal Observing Network to support detailed analyses for coastal and offshore areas.
- Upper air observations from land and ocean stations as fundamental inputs to atmospheric analysis and prediction.
- Weather radar observations of thunderstorms and precipitation over the coastal regions of the United States and observations of tropical cyclones and dangerous storms over the offshore areas.
- Weather satellite observations of the earth's cloud patterns on a daily basis as an aid to locate and to estimate the intensity of storms and tropical cyclones, especially in the less frequently traveled portions of the oceans, and of the sea-surface temperature.



Shore facilities associated with the Cooperative Merchant-Ship Observational Program of the National Weather Service.

- Aircraft reconnaissance measurements of the detailed characteristics and locations of tropical cyclones and of major storms over the oceans to support accurate, timely warnings to mariners and coastal occupants.

Also reported in detail in *The Federal Plan for Meteorological Services and Supporting Research* is the information on marine stations tabulated below, from which surface meteorological data are obtained.

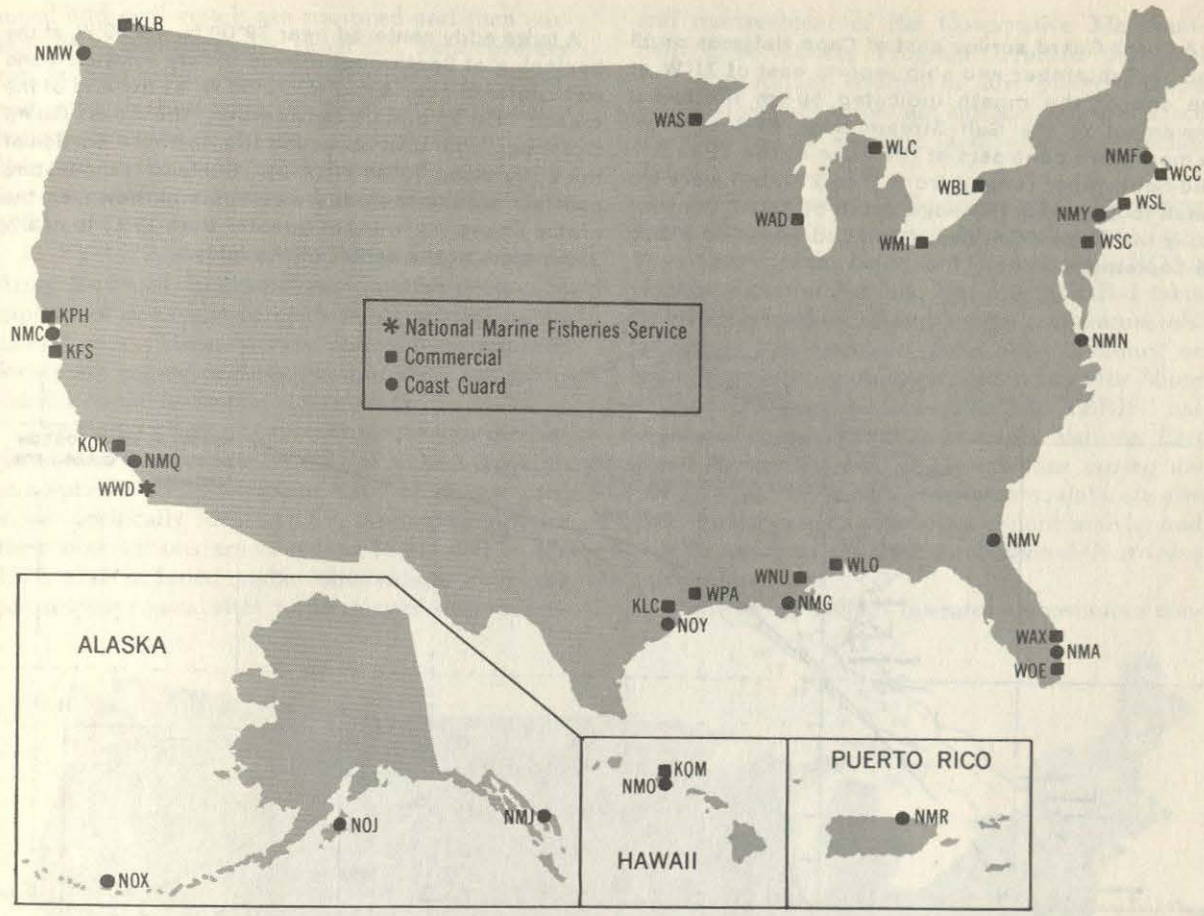
Satellite observations of large-scale synoptic weather patterns over oceanic areas add substantially to the forecaster's information on atmospheric conditions and thus enhance the predictions of oceanic storms. Pictures of sea-ice coverage are also useful in preparing information on the character and distribution of sea-ice fields.

Military users also depend upon the Basic Meteorological Service for observational support, but

MARINE SURFACE METEOROLOGICAL OBSERVATIONS

Agency	Number of locations FY 1972	FY 1973
Department of Commerce (Moving Vessels With Meteorological Personnel)	15	0
Department of Commerce (Cooperative Merchant-Ship Observational Program)	1,650	1,650
Department of Transportation (Coast Guard)	109 [1]	101 [1]
Department of Defense (Ships With Meteorological Personnel)	38	38
Department of Defense (Reporting Ships Without Meteorological Personnel)	550	550
Departments of Commerce and Transportation (Ocean Stations)	7	6

[1] In addition, 163 shore stations support marine meteorological activities.



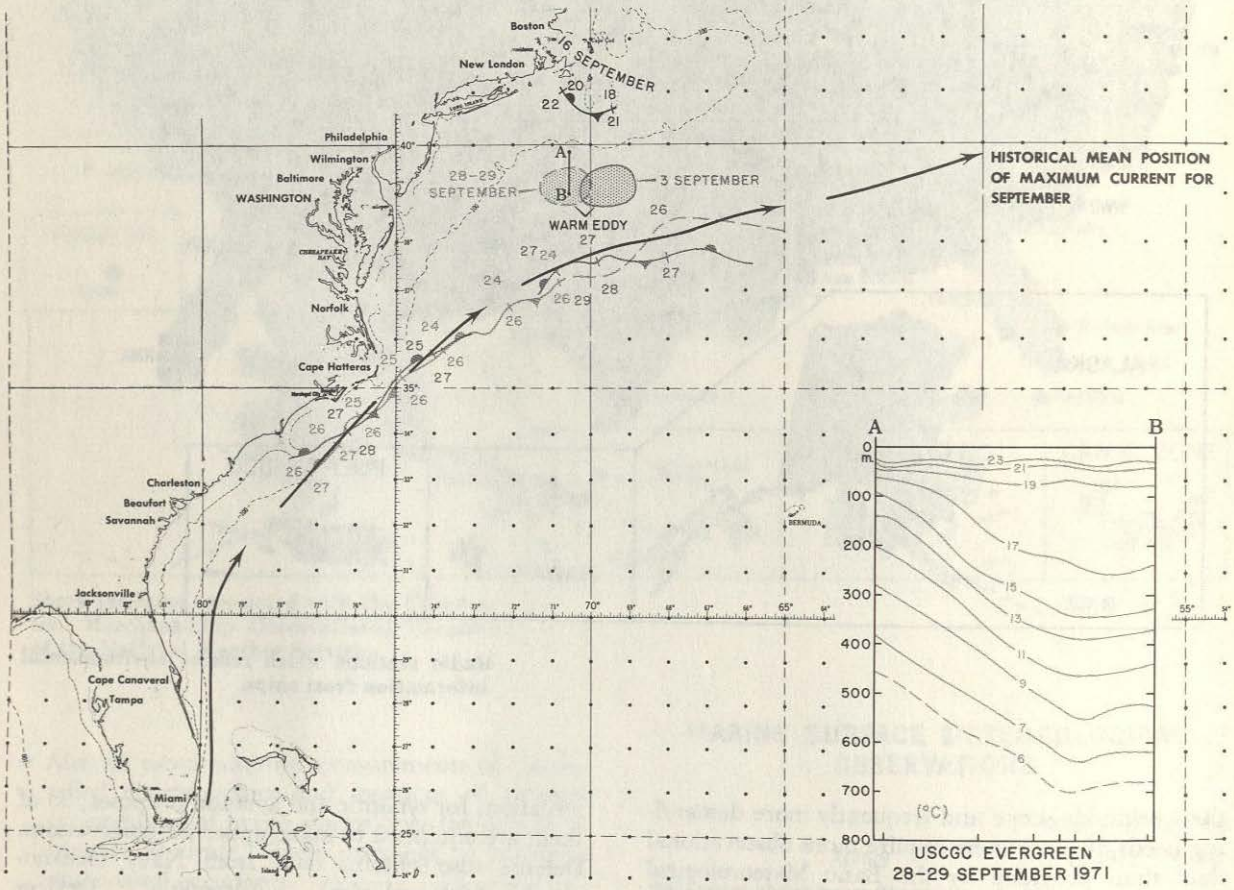
Radio stations which receive environmental information from ships.

the worldwide scope and frequently more demanding needs of these users require more observational data than provided by the Basic Meteorological Service programs. To meet this need for supplemental data, the U.S. Navy operates a marine observational program in which commissioned naval vessels record and report surface meteorological data when underway and, under certain conditions, while in port. Surface observations are made at 6-hour intervals as an additional duty by nonmeteorological personnel aboard these ships. Antisubmarine Warfare (ASW) ships and other selected ships also report bathythermograph observations at 6-hour intervals. To fulfill requirements for more accurate and detailed observations and to perform other essential functions, meteorological personnel have been assigned and more sophisticated meteorological equipment have been provided to 38 ships. All of these ships make scheduled surface observations for synoptic and aviation purposes; 35 of them are equipped to make upper air observations. Defense also obtains data from Navy Oceanographic/Meteorological Automatic Devices (NOMAD). These NOMADs are unmanned buoys, currently undergoing research and exploratory development, and are instrumented to observe and to transmit environmental data from oceanic areas. Although the Defense marine observational program is conducted primarily to fulfill military requirements, observational data are made available to other Federal agencies.

The Department of Defense conducts an airborne measurement program to collect synoptic sea-surface temperature data by flying monthly tracks over the north wall of the Gulf Stream with an airborne radiation thermometer. In another program with a cost of $2,756,000 in FY 1972, oceanographic information—consisting of sea-sur-

A Coast Guard survey east of Cape Hatteras on 15 and 16 September and ship reports east of 71°W. at the end of the month indicated 50-km northward movement of the Gulf Stream edge east of 69°W. Temperature contrasts at the edge of the stream in mid-September ranged from 1° to 2°C, but were too small to delineate the edge south of 33°N. Contrast along the Slope Front near Cape Cod was 2° to 3°C on 16 September.

A large eddy centered near 39°00'N. 69°30'W. at the beginning of September moved slowly westward and was centered near 39°00'N. 70°30'W. at the end of the month. On 28 and 29 September, the Coast Guard Oceanographic Unit observed the northern portion of the eddy along 70°30'W. (A-B). Surface temperature contrast around the eddy was minimal; however, the profile shows warm water (greater than 15°C) to nearly 350 meters at the center of the eddy.



Gulf Stream position—September 1971. (National Oceanographic Office)

face temperatures, bathythermal profilings, dropsonde samplings, and oceanic reconnaissances—was acquired from weather reconnaissance and patrol aircraft.

Defense operates the largest subsurface synoptic oceanographic net, mostly in the Northern Hemisphere; yet, quantities of high-quality synoptic oceanographic observations are insufficient from most areas of the oceans. Larger quantities of daily temperature-depth profile observations are required to describe and to predict properly the subsurface thermal features. Selected ships, both commercial and military, are equipped to make the necessary observations; some naval aircraft provide the needed types of observations. During FY 1972, the Naval Oceanographic Office (NAVOCEANO) operated research ships specifically to acquire subsurface oceanographic MAREP data at a cost of $4,694,000.

Improvements are being made in instrumentation to collect high-quality oceanographic data. In recent years, the Navy has introduced new and more precise devices—such as Near-Surface Reference Temperature (NSRT) devices and airborne and surface expendable bathythermograph equipment—to provide higher quality data. As more

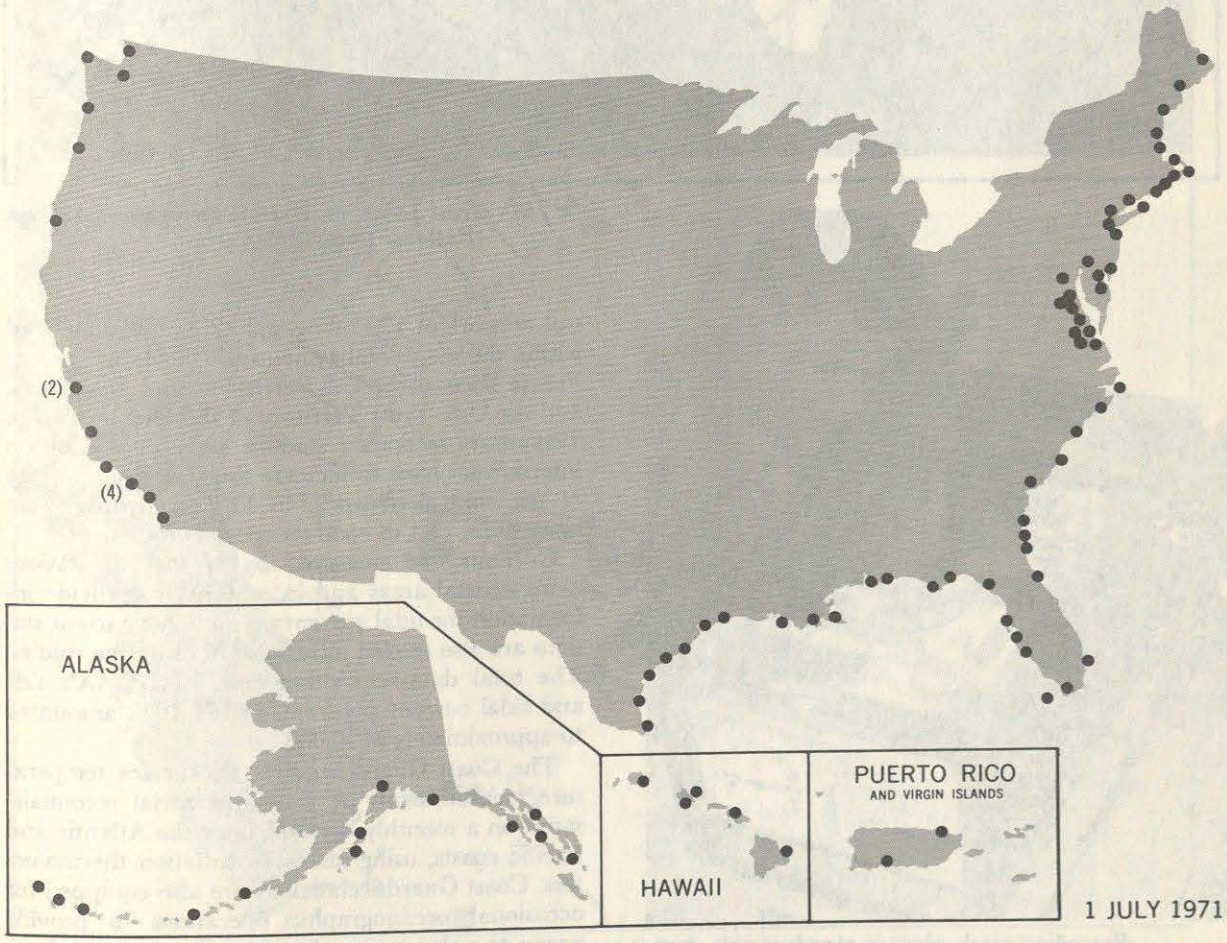
naval and civil vessels are equipped and then participate in oceanographic programs, data coverage can be improved. Approximately 70 civil, fishery, and research ships were equipped with expendable bathythermographs in the Ships of Opportunity Program of the Navy as of January 1, 1972, with 10 more being outfitted during Calendar Year 1972.

In FY 1972, a total of $49,000 was spent by the Army Corps of Engineers for data acquisition in support of a variety of engineering studies in the coastal zone. These include observations required for stream gaging, sedimentation studies, and information on the hydroclimatic network.

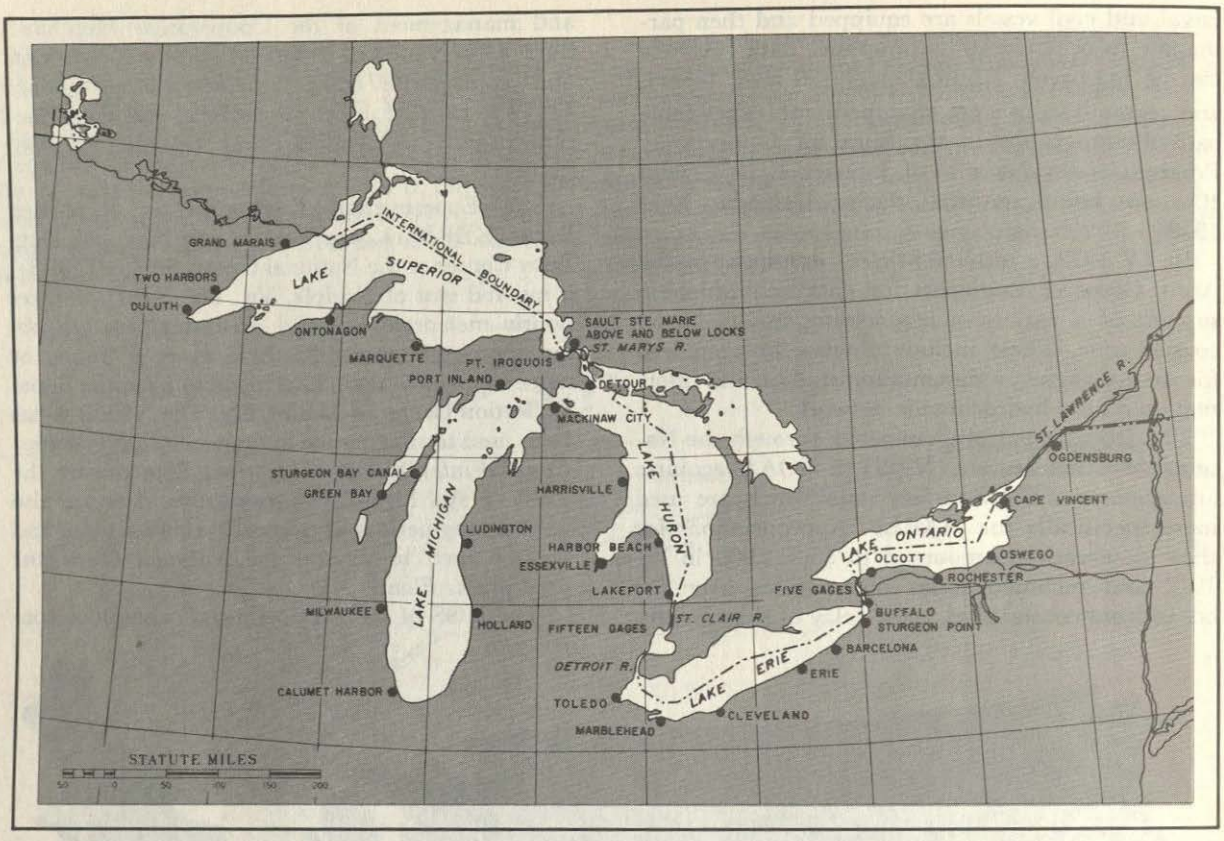
The Department of Commerce, through the National Weather Service (NWS) of NOAA, acquires atmospheric and sea-surface data which are used more specifically for MAREP. Appropriations for these observations amounted to $3,911,000 in FY 1972 and included radar observations over the ocean from coastal sites, radio relay of ship reports, and management of the Cooperative Merchant-Ship Observational Program. Trained personnel and appropriate equipment are placed aboard OSVs to provide upper air, surface, and subsurface observations as synoptic and climatic "anchor points."

The Experimental Environmental Reporting Buoy (XERB–1), operated by the National Data Buoy Center of the National Ocean Survey (NOS), is moored east of Norfolk, Va. The XERB–1 takes hourly meteorological and ocean-temperature observations and transmits these every 3 hours, or more frequently, upon interrogation from the Shore Collection Center at Miami, Fla. The XERB–1 has been used to support the interagency *National East Coast Winter Storms Operations Plan* during the 1970–71 and 1971–72 winter seasons; data are also used during periods of tropical cyclone activity and will be used to support the *National Hurricane Operations Plan.*

The NOS of NOAA operates a continuous con-



Control tide stations. (National Ocean Survey)



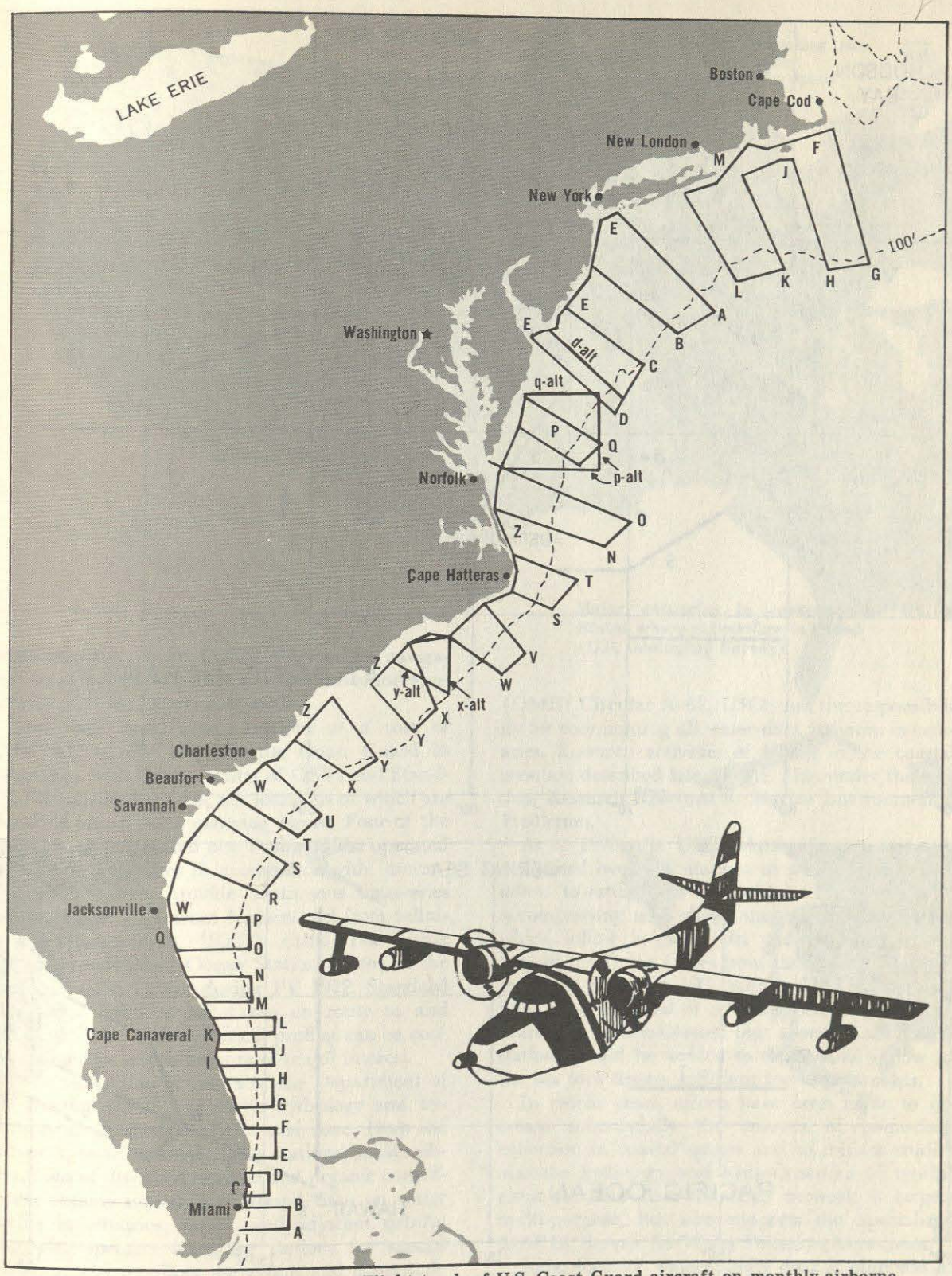
Great Lakes water-level monitoring stations. (National Ocean Survey)

Recording mechanism of standard tide gage. (National Ocean Survey)

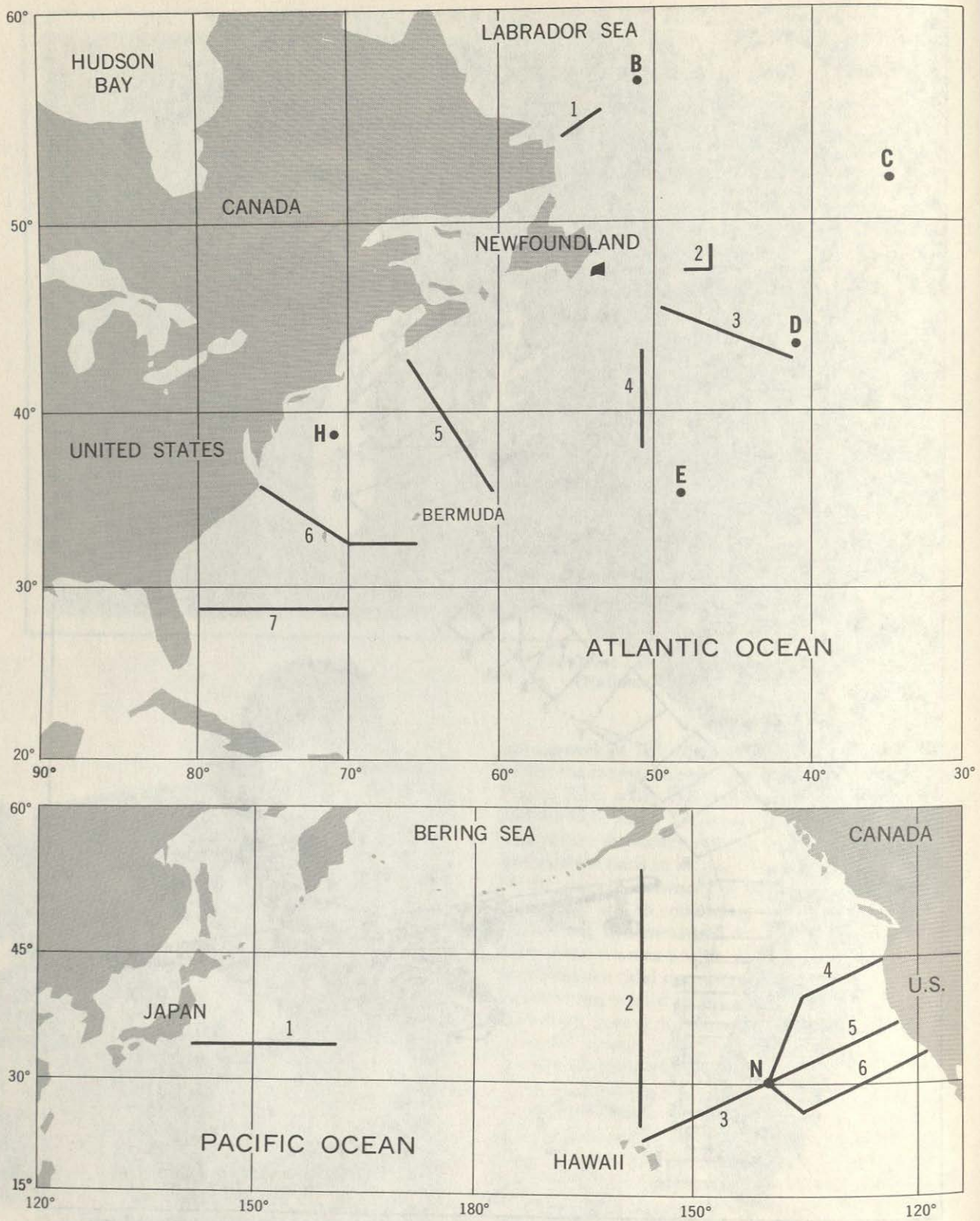
trol network of 120 tide gages along the coasts and within the major embayments of the United States, Puerto Rico, other U.S. territories and possessions, and the U.S. Trust Territory of the Pacific Islands. Temporary secondary stations are occupied on an intermittent basis to increase the effective coverage of the control network, to support hydrographic operations, and to conduct special studies.

Currents are measured by NOAA at stations along coastal areas and in estuaries to provide information for tidal current predictions; current stations are also tended in support of estuarine studies. The total data-acquisition costs of NOAA's tide and tidal current programs in FY 1972 amounted to approximately $650,000.

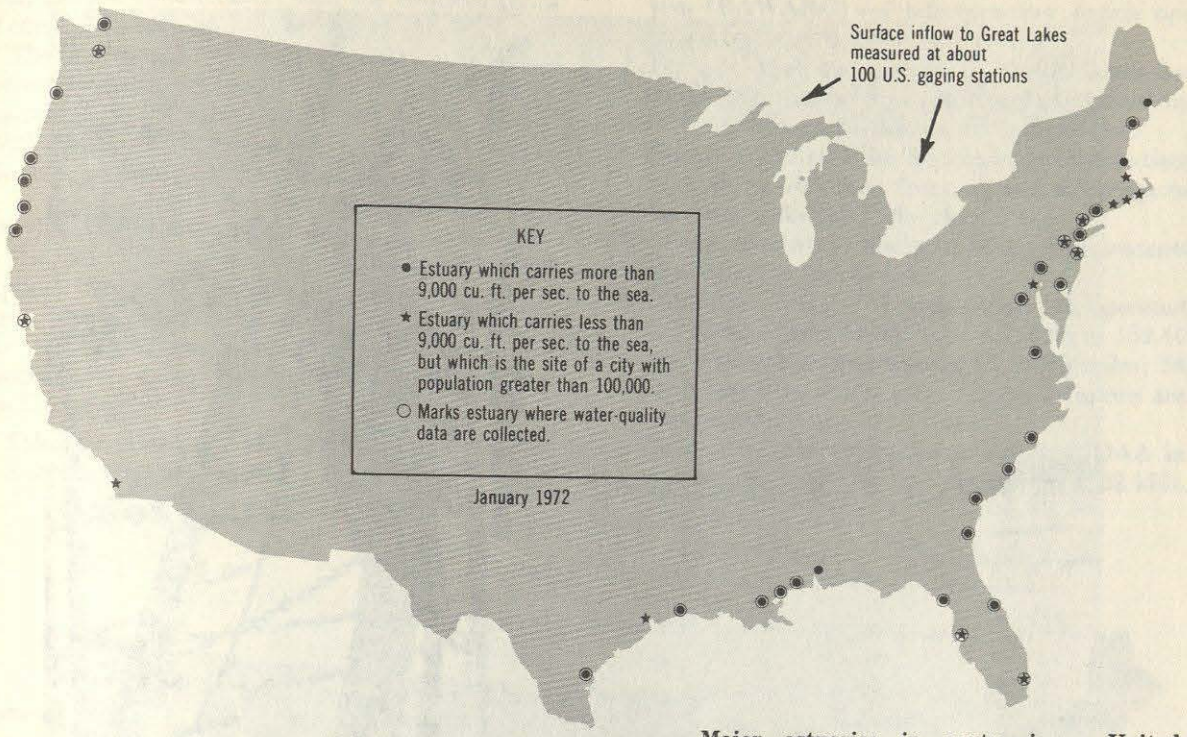
The Coast Guard acquires sea-surface temperature measurements by means of aerial reconnaissance on a monthly basis off both the Atlantic and Pacific coasts, using airborne radiation thermometers. Coast Guard icebreakers are also equipped for occasional oceanographic operations to provide access to polar regions for scientific observers from many disciplines. In FY 1972, the Coast Guard



Flight track of U.S. Coast Guard aircraft on monthly airborne radiation thermometer flights to determine sea-surface temperature.



Ocean Station Vessel (OSV) locations and tracks for Standard Monitoring Stations.



Major estuaries in conterminous United States where streamflow is gaged (U.S. Geological Survey)

procured, at a cost of $1,870,000, satellite navigation equipment for its vessels which collect oceanographic data for water-mass analysis.

Subsurface data were acquired at a cost of $3,063,000 in FY 1972 by the Coast Guard in connection with the operation of OSVs and Standard Monitoring Sections, the locations of which are identified on an accompanying figure. Four of the five Atlantic OSVs and one Pacific OSV, operated by the United States in accordance with international agreements, provide continuous time-series oceanographic data from Nansen and from salinity-temperature-depth (STD) casts. The Coast Guard disestablished Ocean Station *Victor* in the western Pacific Ocean during FY 1972. Standard Monitoring Sections are taken en route to and from the OSVs so that vertical profiles can be constructed across several regions of major interest.

Data acquisition activities of the Department of the Interior USGS in marine hydrology and hydraulics are limited to the coastal zone. Here the Survey operates coastal-gaging stations; makes observations of dissolved mineral and organic constituents; obtains similar background data on water quality in estuaries, canals, and adjacent natural channels; operates tide-gage stations for special purposes; and monitors the extent and magnitude of saltwater encroachment at certain localities. Under the Office of Management and Budget (OMB) Circular A–67, USGS has the responsibility for coordinating all water-data activities in estuaries. Research activities of USGS in the coastal zone are described later in this Plan under the section, Research Relevant to Marine Environmental Prediction.

As of 1970, the USGS data-collection network comprised over 600 stations at which fresh water inflow to estuaries is or could be computed. The accompanying map shows the major estuaries for which inflow is gaged. In addition, surface inflow to the Great Lakes from the United States is measured at about 100 stations. Most of the stations have a record of adequate length (20 to 25 years), but it is estimated that about 50 additional stations would be needed to define total inflow to the sea to a degree sufficient for today's needs.

In recent years, efforts have been made to increase substantially the amount of point-data collection in coastal waters and to initiate studies into the hydrology and hydrodynamics of typical estuaries. This data-collection network is largely multi-purpose, but also supports the Specialized MAREP Service for Water Pollution Assessment.

Some form of water-quality data is observed at about 300 stations. Some provide only temperature and/or sediment concentrations, but at about 250

Salinity-temperature-depth (STD) system being lowered through the ice from U.S. Coast Guard Cutter *Westwind*.

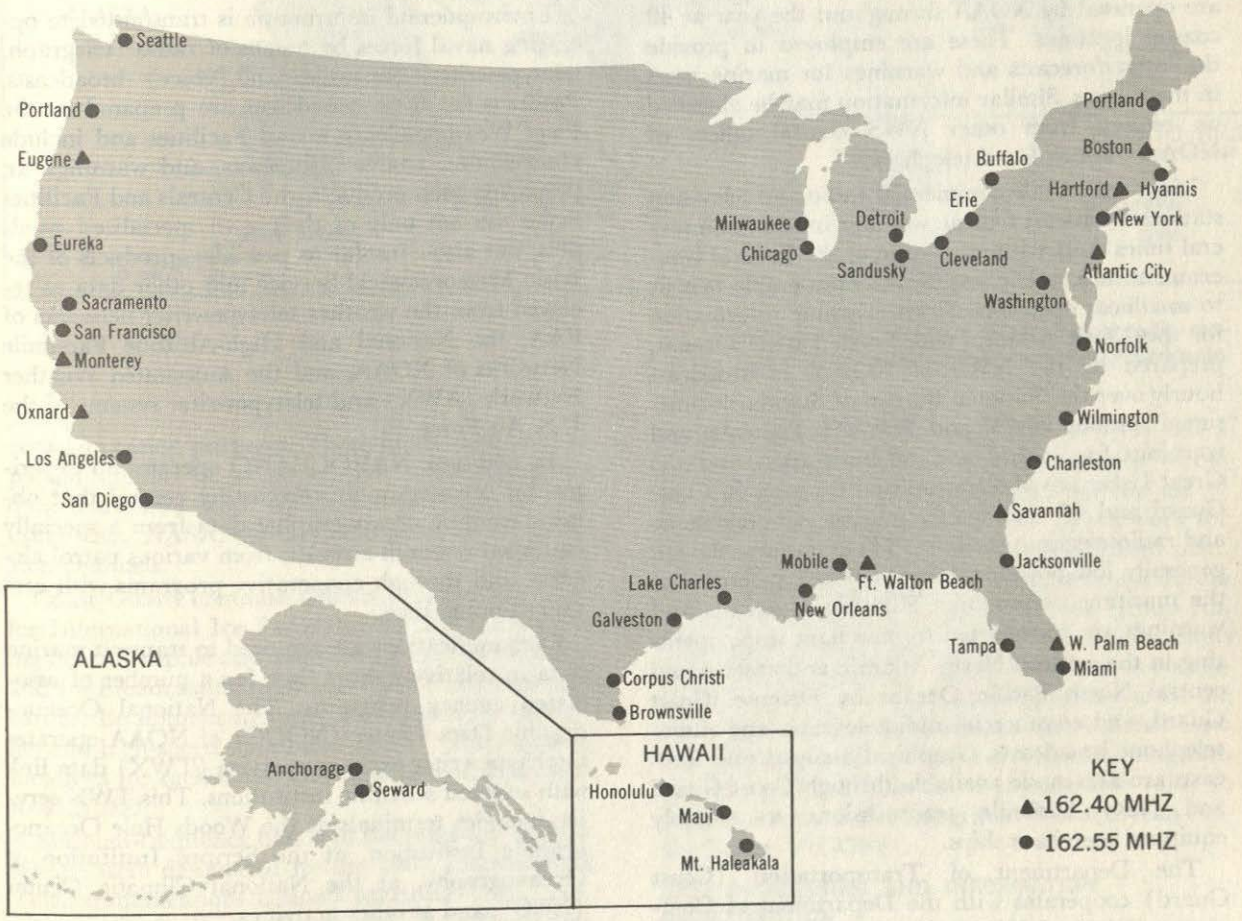
stations, there are regular observations of temperature, specific conductance, and the concentrations of common anions and cations.

The Smithsonian Institution employs marine scientists who are engaged in making collections of marine organisms throughout the world. In FY 1972, $180,000 was spent for the collection of samples used in making biological predictions.

COMMUNICATIONS

The Basic MAREP Service depends heavily for support upon the communication systems of the Basic Meteorological Service just as it does upon that Service for observational data. The communication media shared jointly by these Basic Services are listed below:

- Teletypewriter networks (Services C and O) operated by FAA.
- Radar Report and Warning Coordination System (RAWARC)—a teletypewriter system operated by NOAA.
- Teletypewriter and high-speed circuits, both domestic and with overseas terminals, operated by the Departments of Commerce and Defense.
- NOAA Weather Wire Service—a teletypewriter network to distribute forecasts and warnings to the press, radio, and television.
- Facsimile networks operated by the Departments of Commerce and Defense.
- Continuous VHF/FM radio broadcasts operated by NOAA. These broadcasts on 162.55 or 162.40 MHz have a range of about 20 to 40 miles; 58 facilities at coastal or inland water locations are now in operation.
- Eight NWS marine radio stations of NOAA in Alaska. Broadcasts are announced on 2182 kHz,



Weather Service Offices providing marine forecasts by VHF/FM radio. (National Weather Service)

but broadcast on 2382 kHz or 2512 kHz amplitude modulation/single sideband (AM/SSB).

- Marine continuous-wave (CW) radio broadcasts operated by the Navy.

Although these communications media supply a large measure of the communications support, they must also be supplemented by specialized civil and military facilities. There is an increasing reliance upon available high-speed civil and military computer-to-computer data relay-and-exchange facilities. These facilities include the Defense global automated environmental data networks. Commerce operates five international circuits to exchange meteorological data between the United States and Canada, the U.S.S.R., Great Britain, Japan, and Brazil. These include a Washington-Toronto high-speed circuit; a Washington-Moscow circuit for exchange of satellite information; and three other circuits—Washington-Bracknell, England, Washington-Tokyo, and Washington-Brasilia—as part of the World Weather Watch program.

Automatic marine telephone-answering services are operated by NOAA throughout the year at 40 coastal locations. These are employed to provide the latest forecasts and warnings for marine users in their areas. Similar information may be obtained on request from other NWS coastal offices of NOAA through listed telephones.

More than 2,000 commercial radio and television stations broadcast marine weather information several times daily without charge to the Federal Government as a public service of considerable benefit to smallboat operators. Storm warning information for the North Atlantic and North Pacific Oceans, prepared by the NWS of NOAA, is broadcast hourly over the National Bureau of Standards time-signal stations WWV and WWVH. Forecasts and warnings for coastal and offshore areas and the Great Lakes are also transmitted through 46 Coast Guard and 47 commercial marine radiotelephone and radiotelegraph facilities. These stations, though generally low-powered, serve a broad spectrum of the maritime community. High-seas forecasts and warnings are transmitted to merchant ships operating in the western North Atlantic and eastern and central North Pacific Oceans by Defense, Coast Guard, and commercial radiotelegraph and radiotelephone broadcasts. Graphical analyses and forecasts are also made available through Coast Guard and Navy facsimile transmissions to suitably equipped merchant ships.

The Department of Transportation (Coast Guard) cooperates with the Department of Commerce (NWS of NOAA) by broadcasting coastal marine weather information to shipping and other maritime users. Broadcasts emanate from 46 locations along the coasts and, although conducted on a not-to-interfere basis, constitute a major effort by the facilities concerned. Broadcasts—usually plain-language voice transmissions—are scheduled at 6- or 12-hour intervals, with warnings of hazardous conditions transmitted upon receipt and repeated periodically. Texts for these broadcasts are prepared by NWS and delivered to the nearest Coast Guard communications office.

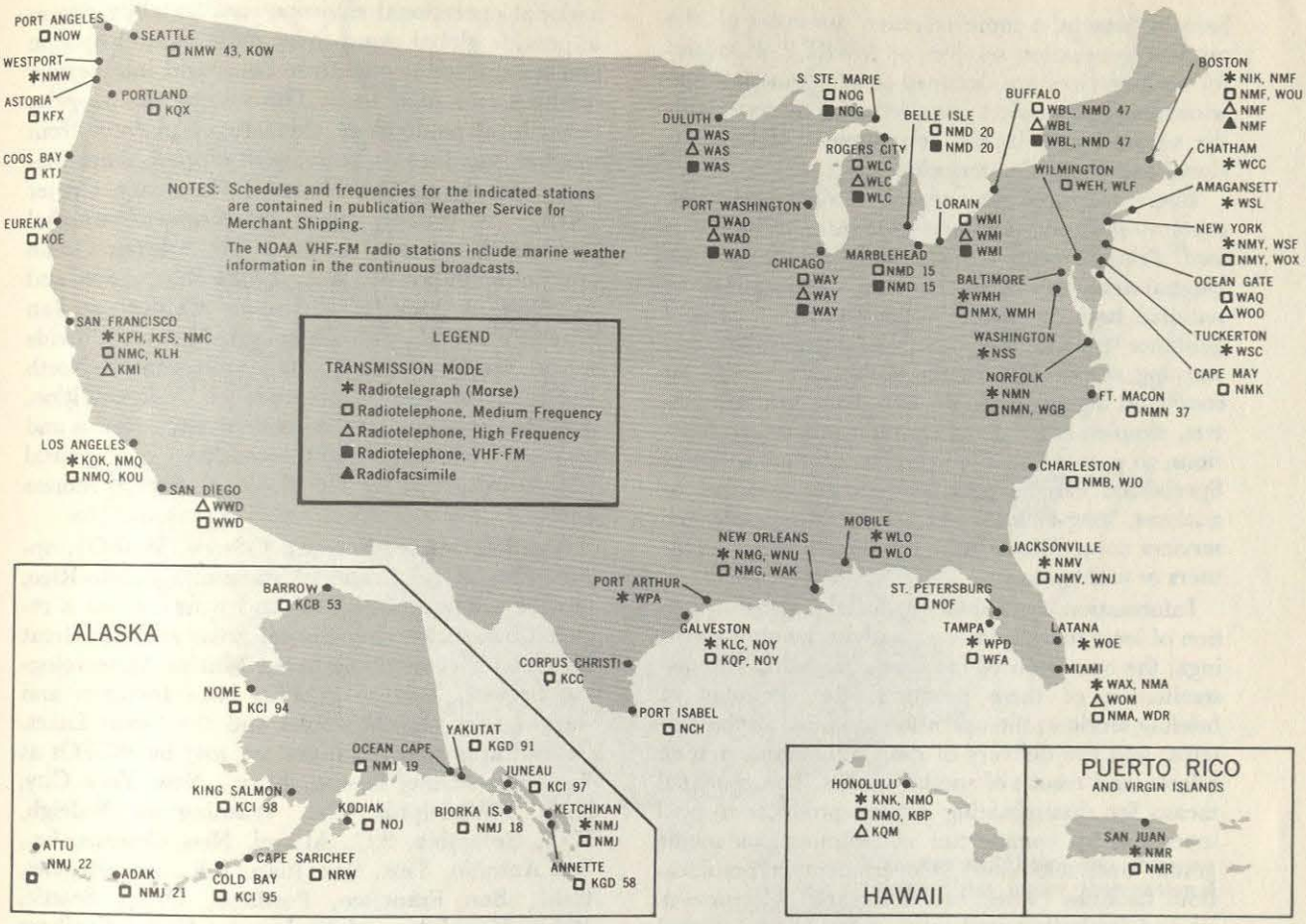
The Naval Communications System provides oceanographic support. Meteorological traffic is handled in the same manner as general traffic; there are no centers or units dedicated exclusively to serve as meteorological communications facilities. Additionally, the Naval Environmental Data Network (NEDN) provides for the dissemination of meteorological and oceanographic computer-generated products from the Fleet Numerical Weather Central (FNWC) at Monterey, Calif., to specially equipped locations in the United States and overseas.

Environmental information is transmitted to operating naval forces by means of radio (telegraph, teletypewriter, facsimile, and voice) broadcasts. Products for these broadcasts are prepared by the Fleet Weather Centrals and Facilities and include observations, analyses, forecasts, and warnings. In preparing such products, the Centrals and Facilities make use not only of their own specialized products, but also—insofar as possible—products of the Basic Meteorological Service and other data as received from the weather teletypewriter networks of FAA, the National and High-Altitude Facsimile Networks of NOAA, and the Automated Weather Network (AWN) and teletypewriter systems of the U.S. Air Force.

In addition, NAVOCEANO operates an experimental oceanographic forecasting central that obtains synoptic oceanographic data from a specially equipped research aircraft, from various patrol aircraft, and through cooperative programs with certain shipping lines.

Communications are required to transmit marine data in relatively short time for a number of associated agency programs. The National Oceanographic Data Center (NODC) of NOAA operates a teletypewriter exchange service (TWX) data link with selected scientific institutions. This TWX service includes terminals at the Woods Hole Oceanographic Institution, at the Scripps Institution of Oceanography, at the National Climatic Center (NCC), and at other activities.

In connection with its Pacific Tsunami Warning System, NOAA required $88,000 in FY 1972 for



Commercial and U.S. Coast Guard radio stations that make marine weather broadcasts.

communication purposes. These funds were used in partial support of a cooperative arrangement for data collection and watch-and-warning services using FAA, NASA, military, and other communication channels.

Coast Guard communications facilities are used for International Ice Patrol broadcasts, for reporting oceanographic and meteorological observations, and for broadcasting high-seas bulletins as reported earlier. Equipment includes teletypewriter, facsimile, and high-speed data links. In FY 1972, communications for such Coast Guard activities amounted to $127,000.

Six high-frequency bands in the maritime mobile service were designated by the 1967 International Telecommunications Union's Maritime World Administrative Radio Conference for use in the collection of data relating to oceanography. The Intergovernmental Oceanographic Commission/World Meteorological Organization (IOC/WMO) has a Group of Experts on Telecommunications whose work in preparing an interim plan for the use of these frequencies has also laid the groundwork for the development of a long-term coordinated plan. In the United States, an Interdepartmental Radio Advisory Committee (IRAC) Ad Hoc Group No. 100, under the Office of Telecommunications Policy, Executive Office of the President, is coordinating inputs to this plan which promises to be the major communication system for the National Data Buoy System and for various research programs and which should also be of considerable value to programs such as the Integrated Global Ocean Station System (IGOSS).

DATA PROCESSING AND INFORMATION DISSEMINATION

Agency activities involving data processing and information dissemination functions are described

here to present a more cohesive summary of the product generation services of MAREP. Facilities for such services are designed to accommodate the wide range of services required and to cope with the varied stages in the development of observational and prediction techniques.

There are three major types of data processing centers—*primary, area and guidance,* and *specialized.* Primary centers are facilities which prepare general analyses and forecasts on a hemispheric or national basis for use by other centers. Area and guidance centers have analysis, forecasting, and warning responsibilities on an area, regional, or command basis and use the outputs of primary centers, supplemented by their own processing functions, to provide detailed product services to users. Specialized centers provide data management or analyses, long-term predictions, or single-purpose services not available from other centers to specific users or user groups.

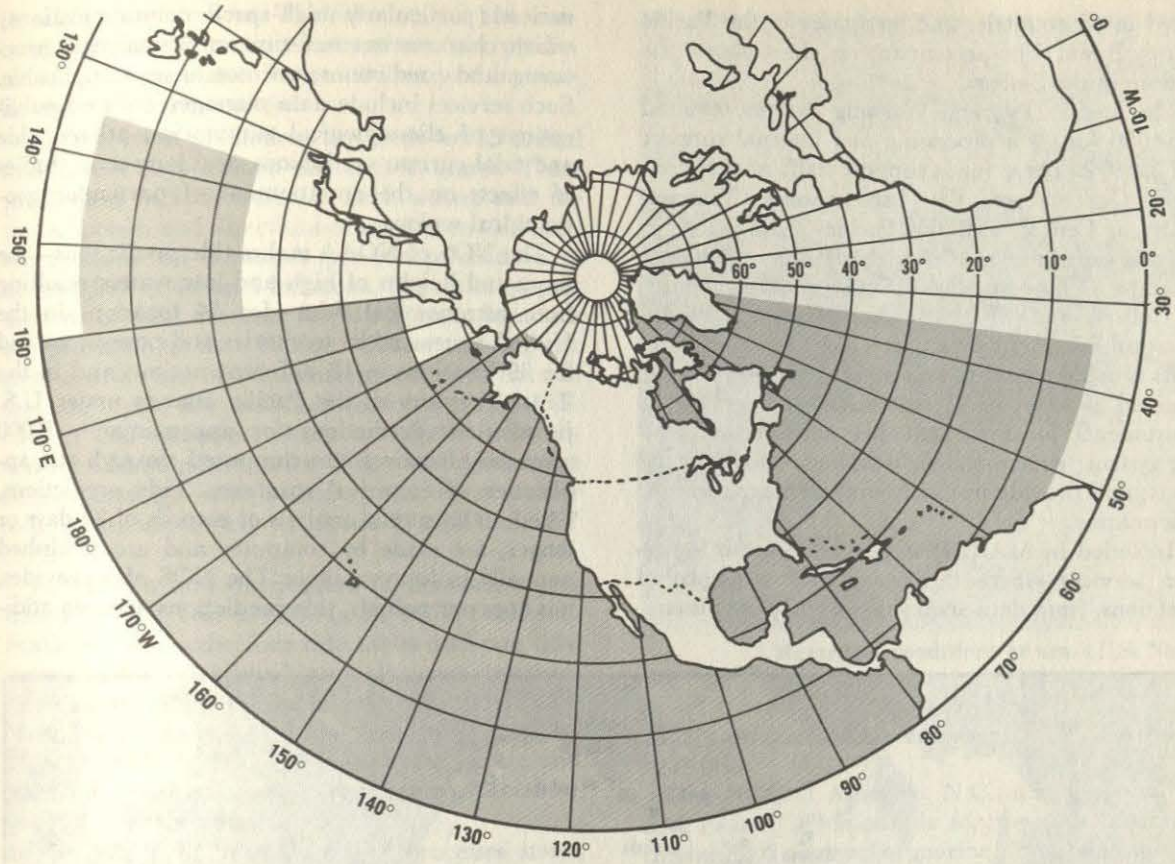
Information dissemination includes the distribution of local marine forecasts, advisories, and warnings; the operation of facilities engaged in the dissemination of these products; the provision of briefing services; the operation of visual display systems; and the delivery of data summaries, marine atlases, and results of special studies. The principal means for disseminating marine products to civil users are by commercial communications media (radio and television), Government communications facilities (voice, radiotelegraph, teletypewriter, and facsimile broadcasts), automatic telephone-answering systems, and through various Government publication services.

NOAA contributes significantly to marine meteorological predictions and warnings through its analysis and forecast centers and by means of a variety of information dissemination capabilities. Communication facilities of the Coast Guard and Navy as well as those of commercial facilities are used for the dissemination of marine meteorology products from NOAA. Currently available are forecasts of marine weather, sea state, breakers and surf, sea ice, storm surges, and seiches. The hurricane forecasting service also constitutes an essential element of the Basic MAREP Service.

NOAA operates four primary centers which provide products and support to marine meteorology in addition to their larger role in the Basic Meteorological Service. The National Meteorological Center (NMC) at Suitland, Md., provides broad-scale analyses and forecasts on a hemispheric basis and graphic products for facsimile transmission to high-seas users. The National Environmental Satellite Service (NESS), also at Suitland, operates the national operational environmental satellite system to provide global cloud-cover mosaics, atmospheric and sea-surface temperature data, and interpretive products on a daily basis. This system also provides direct local readouts of cloud-cover pictures from weather satellites to suitably equipped shore stations and ships. The National Hurricane Center (NHC) at Miami issues warnings of tropical cyclones (hurricanes) in the North Atlantic Ocean (west of longitude 35°W.), the Caribbean Sea, and the Gulf of Mexico. Hurricane Centers at San Francisco, Calif., and Honolulu, Hawaii, provide similar services in the eastern and central North Pacific Ocean east of longitude 180°. In addition, warnings of severe local storms (thunderstorms and associated winds, hail, and tornadoes) over coastal waters are issued by the National Severe Storms Forecast Center (NSSFC) at Kansas City, Mo.

Weather Service Forecast Offices (WSFO), operated by NOAA in the 50 States and Puerto Rico, provide analyses, forecasts, and warnings on a regional basis, including coastal areas and the Great Lakes, which contribute to the Marine Meteorological Service. Twenty WSFOs issue forecasts and warnings for coastal waters and the Great Lakes. Coastal area responsibilities are met by WSFOs at Portland, Maine, Boston, Mass., New York City, N.Y., Philadelphia, Pa., Washington, Raleigh, N.C., Columbia, S.C., Miami, New Orleans, La., San Antonio, Tex., San Juan, P.R., Los Angeles, Calif., San Francisco, Portland, Oreg., Seattle, Wash., Honolulu, and Anchorage, Alaska. Offshore and fishing activities in the Pacific and Atlantic are supported partly by the coastal and high-seas products provided for that area. Forecasts and warnings for the Great Lakes are issued by WSFOs at Chicago, Ill., Cleveland, Ohio, and Detroit, Mich.

High-seas marine condition forecasts, broadcast through Coast Guard radio facilities including facsimile, were initiated by NOAA in 1971 from the east coast; similar services will commence in 1972 from the west coast. These forecasts are in addition to those on radiotelegraph and voice broadcasts presently being disseminated through commercial facilities. Major WSFOs at Washington, San Francisco, and Honolulu provide support to meet the minimum analysis and forecasting requirements in the areas of U.S. responsibility for shipping forecasts and warnings (which include large designated portions of the North Atlantic and North Pacific) as part of the Convention on Safety of Life at Sea (SOLAS) and in response to agreements reached within the World Meteorological Organization (WMO). In the western North Pacific, the Department of Defense provides these services



Areas of U.S. responsibilities for shipping forecasts and warnings under international agreements.

through the Fleet Weather Central at Guam in the Mariana Islands. The areas of U.S. responsibility are shown on the accompanying chart.

The MAREP Services of the Coast Guard, in addition to participation in the Coastal Warning System discussed below, include voice and radioteletypewriter broadcasts of marine weather to the boating public, fishing vessels, and merchant fleets. The Coast Guard Oceanographic Unit processes data and provides technical and scientific support for Coast Guard marine programs. The Coast Guard also provides preliminary reduction and processing of environmental data from all of its sources at east and west coast centers to meet the requirement for operational continuity of its oceanographic programs.

The Coastal Warning System is a cooperative network of visual (flag and light) displays maintained at prominent locations along the seacoasts, the Great Lakes, and inland waterways to advise boating and other marine interests whenever small craft, gale, storm, and hurricane warnings, issued by the NWS of NOAA, are in effect. Yacht clubs, marinas, other private marine activities, State and local governments, the Coast Guard, and NWS participate in this System of 475 display stations. The Department of Transportation (Coast Guard) has 144 lighthouses, lifeboat stations, lightships, and other facilities participating in the Coastal Warning System. The Department of Commerce (NOAA) operates 75 displays; the remainder are operated on a cooperative basis by non-Federal interests. In addition, small-craft pennants are displayed by State police patrol craft on Chesapeake Bay, in the New York City area, and on Lake Michigan.

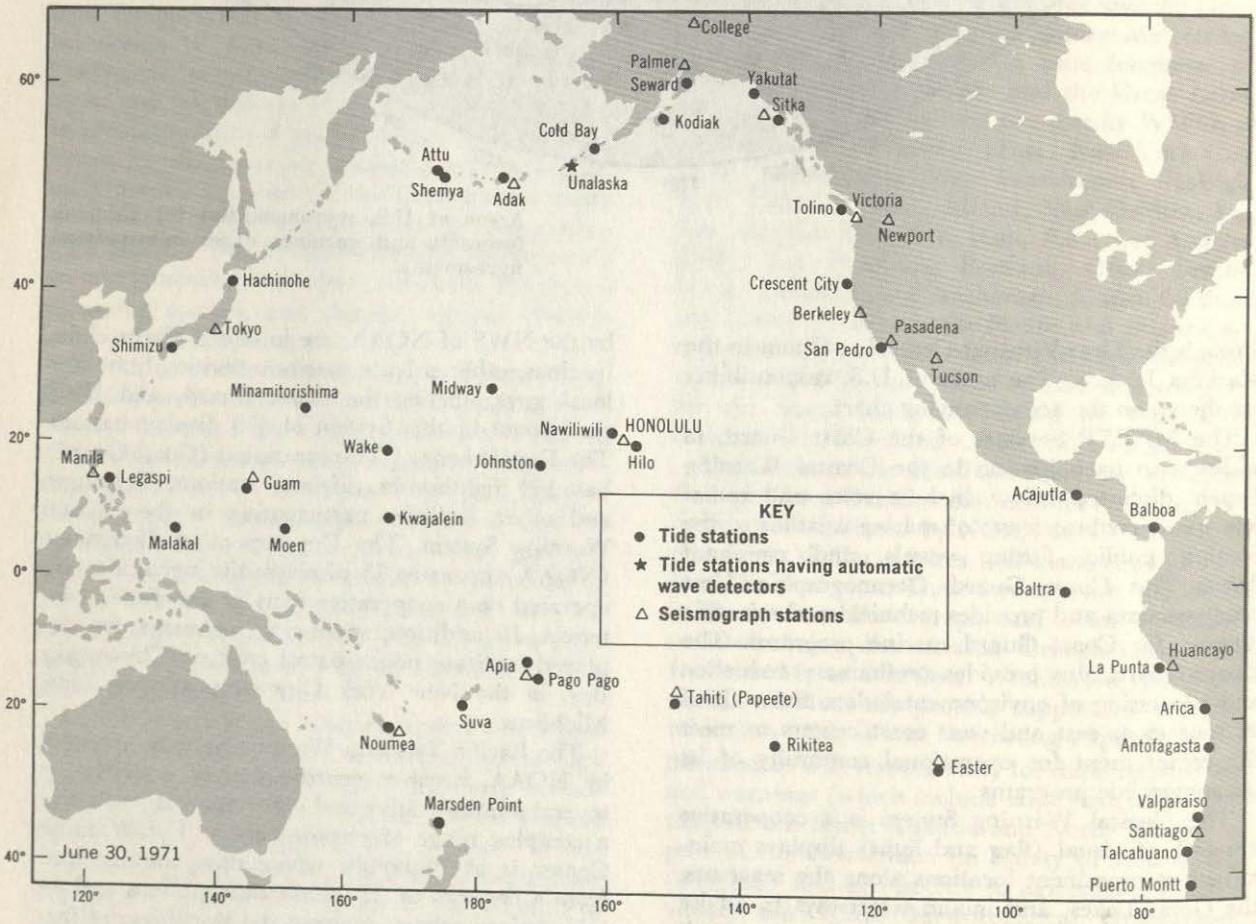
The Pacific Tsunami Warning System, operated by NOAA, involves coordination of activities at several administrative and governmental levels and a complex range of responsibilities. The Warning Center is at Honolulu where data are received from a network of 22 seismograph stations and 44 tide stations, where analyses and warnings are formulated, and from where warnings are dissemi-

nated to 15 countries and territories in the Pacific Ocean Basin. The accompanying chart shows the stations in the System.

The Pacific Tsunami Warning System required $362,000 for data processing and internal support in FY 1972. These funds support staffs at the Honolulu Observatory, the International Tsunami Warning Center, and the Pacific Tides Party in Hawaii, and the staffs at the Palmer Regional Warning Center in Alaska. Staffs at Observatories at College and Sitka, Alaska, Newport, Wash., Tucson, Ariz., and Guam are also funded. These staffs provide continuous monitoring of seismic and tsunami activity; install, maintain, and service the instruments; locate earthquakes; activate the warning system; issue watches, warnings, and cancellations; and provide historical and advisory scientific information.

Included in MAREP are nonreal-time information services where the usual total sequence of functions, from data acquisition to product dissemination (particularly high-speed communications) which characterizes real-time environmental processing and predictions, are not always applicable. Such services include data management and publications of climatological summaries, atlases, tide and tidal current predictions, and long-term studies of effects on the environment of particular geographical regions.

The NOS of NOAA makes tide predictions—the times and heights of high and low waters resulting from astronomical tides—for 54 locations in the United States and its territories and possessions and for 39 locations in 18 different nations and in the Trust Territory of the Pacific Islands under U.S. jurisdiction. Predictions for approximately 6,000 secondary locations are computed through the application of empirical constants. Tide predictions, based on harmonic analysis of records of 29 days or longer, are made by computer and are published annually in four volumes. The NOS also provides, but does not publish, tide predictions at seven addi-



Reporting stations of the Pacific Tsunami Warning System.

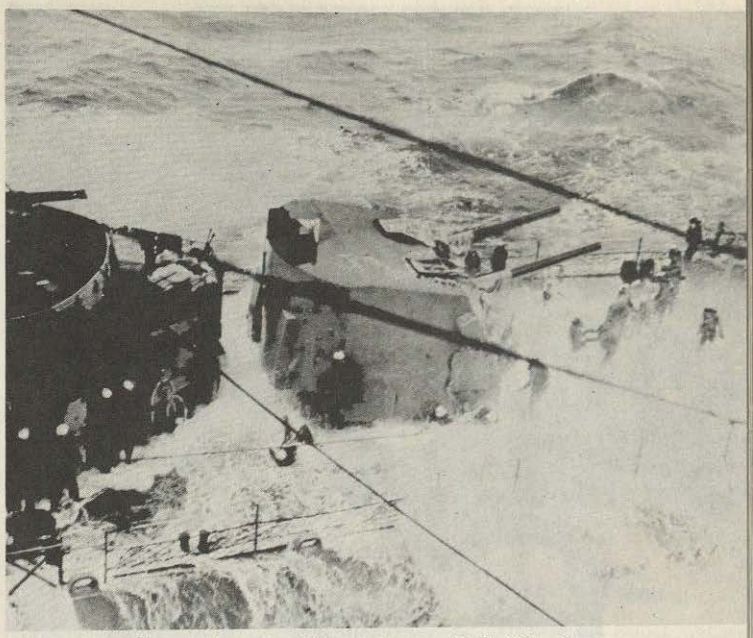
tional foreign locations. The tide data are also analyzed for the harmonic constants used in predictions, in datum plane determinations, and in secular changes of the sea level.

Tidal current predictions are made for 35 coastal and harbor locations in the United States. These predictions include times of slack waters and the times, speeds, and directions of maximum tidal currents. Empirical constants provide predictions at about 2,000 additional locations. Unpublished predictions of tidal currents for two Korean locations are provided to that Nation. Charts showing the areal distribution of tidal currents for each hour in the tidal cycle are available for nine major U.S. harbors and estuaries; charts are under construction for additional estuaries. Tide and tidal current data-processing costs, including use of computer techniques, amounted to about $740,000 in FY 1972.

Publication and distribution of documents produced by NOS cost $38,000 in FY 1972. Such publications include the four tide tables and two tidal current tables published annually, two temperature-density tables produced every 5 years, tidal-benchmark sheets, 11 tidal current charts, a *Monthly Bulletin* of Great Lakes water levels, and other information issued in response to special requests during the year.

The NODC of NOAA acquires, processes, stores, and disseminates nonreal-time data involving biological, chemical, geological, and other selected oceanographic parameters on a global basis. These data are used by the scientific community for the development of models and for the upgrading of such models to produce or to complete a description of the oceans. All data and information received by the Center are given an accession number and are then processed into files and storage media for quick retrieval. Using its Generalized Information Processing System (GIPSY), NODC can provide 48-hour turnaround time for routine requests. New data management techniques for improved processing are being developed for data compression, file structure, analog-to-digital conversion, and computer graphics. In FY 1972, personnel and facilities for acquisition, processing, quality control, storage, and retrieval of marine environmental data were augmented at an increased cost of $102,000.

The NODC provides data and data products from storage files to the total spectra of users in the national marine community and in response to international exchange agreements. Services include, but are not limited to, the provisions of listings, tapes, microfilm, statistical and analytical summaries, computer graphics, charts, and atlases. In FY 1972, product dissemination of NODC cost $248,000.



Hazardous conditions at sea. (U.S. Navy)

The NCC at Asheville, N.C., also a specialized data center, is responsible for the processing, archiving, and retrieval of marine climatological data —including reports from naval and merchant vessels—on a reimbursable basis for other Federal agencies and private concerns. The NCC is responsible for recording and describing the climate over the oceans in support of national requirements. Ship weather logs are received at NCC from about 2,100 merchant vessels each year. Observations entered in these logs are checked, recorded, summarized, and archived. Summaries are included in various Commerce, Coast Guard, Defense, and WMO publications. In addition, as part of a WMO program, marine observations are exchanged with other major maritime nations and summaries of observations by OSVs are provided.

The NCC also provides summarized marine meteorological data to private, public, academic, and governmental users. It is responsible for publication of the *Mariners Weather Log* and for information included in Pilot Chart revisions for Defense, in articles and climatological summaries in the Defense *Sailing Directions* and planning guides, and in the NOAA *Coast Pilot*. Defense provides a large share of the budgetary support to NCC, although NAVOCEANO prepares oceanographic charts, publications, atlases, and related materials as required for the operational readiness of the fleet and for

Plankton sample is prepared for sorting at the Smithsonian Oceanographic Sorting Center (SOSC)

the use of the merchant marine. The Marine Branch of the Center also has the responsibility for publishing the climatology of tropical cyclones on a worldwide basis and is involved in the publication of tropical cyclone summaries and in the answering of requests for data and other information on such storms. In FY 1972, marine product preparation and dissemination at NCC cost $120,000 in addition to significant reimbursable efforts.

The Great Lakes Data Center of NOAA has a program directed toward the processing, storage, retrieval, dissemination, and analysis of hydraulic, hydrologic, limnological, hydrometeorological, and ice and snow data. Such data are used extensively in research on fisheries, pollution, shore processes, currents, and ice formation and movement in the Great Lakes.

Operating as part of the Smithsonian Institution Office of Oceanography and Limnology, SOSC provides a service function for coordinating and processing collections of marine specimens to expedite their rapid analysis. This function, which includes the sorting, cataloging, and distribution of marine biological and geological collections, cost $460,000 in FY 1972 and is partially funded by the National Science Foundation (NSF) through its Office of Polar Programs.

The U.S. Army Corps of Engineers of the Department of Defense conducts a number of projects, categorized as specialized processing of marine environmental data, in connection with its assigned marine engineering studies. In support of basic and applied hydraulic and hydrologic studies are the development of stage-discharge relations in outflow rivers and the determination of the effects on the levels and outflows of the Great Lakes of such factors as: natural and manmade changes in the outflow rivers, diversions into and out of the Great Lakes Basin, and fluctuations between the Lakes. General hydrologic studies involve the analyses of rainfall-runoff relations, snowmelt studies, flood forecasting, analyses of past floods, infiltration indexes, and unit hydrographs as well as the development of flood hydrographs and other studies related to hydrology. The NWS of NOAA prepares meteorological studies required by the Corps for the planning, design, and operation of water-control structures.

The Army Corps of Engineers is providing technical services on request to State and local governments that cost $570,000 in FY 1972. These services constitute furnishing information on the use of flood plains of the coastal zone.

The Department of the Interior analyzes and processes data collected at estuarine and coastal stations by USGS in support of its projects in hydrology and hydraulics. The USGS also provides data on stream discharge and water quality which are processed in its own Computer Center Division. The Survey supplies water-quality information to the Storage and Retrieval (STORET) System operated in cooperation with the Office of Water Programs in the Environmental Protection Agency (EPA). These data are available to all users.

GENERAL AGENCY SUPPORT

General agency support is the function that covers activities which Federal agencies must perform to operate efficient MAREP Service programs and to provide effective, reliable support to their users. This function includes training, maintenance, internal support, and management above the operating level.

Training in marine observations, communications, maintenance, and similar technician-level

skills is accomplished in schools operated by Federal agencies; professional-level training is obtained at accredited colleges and universities.

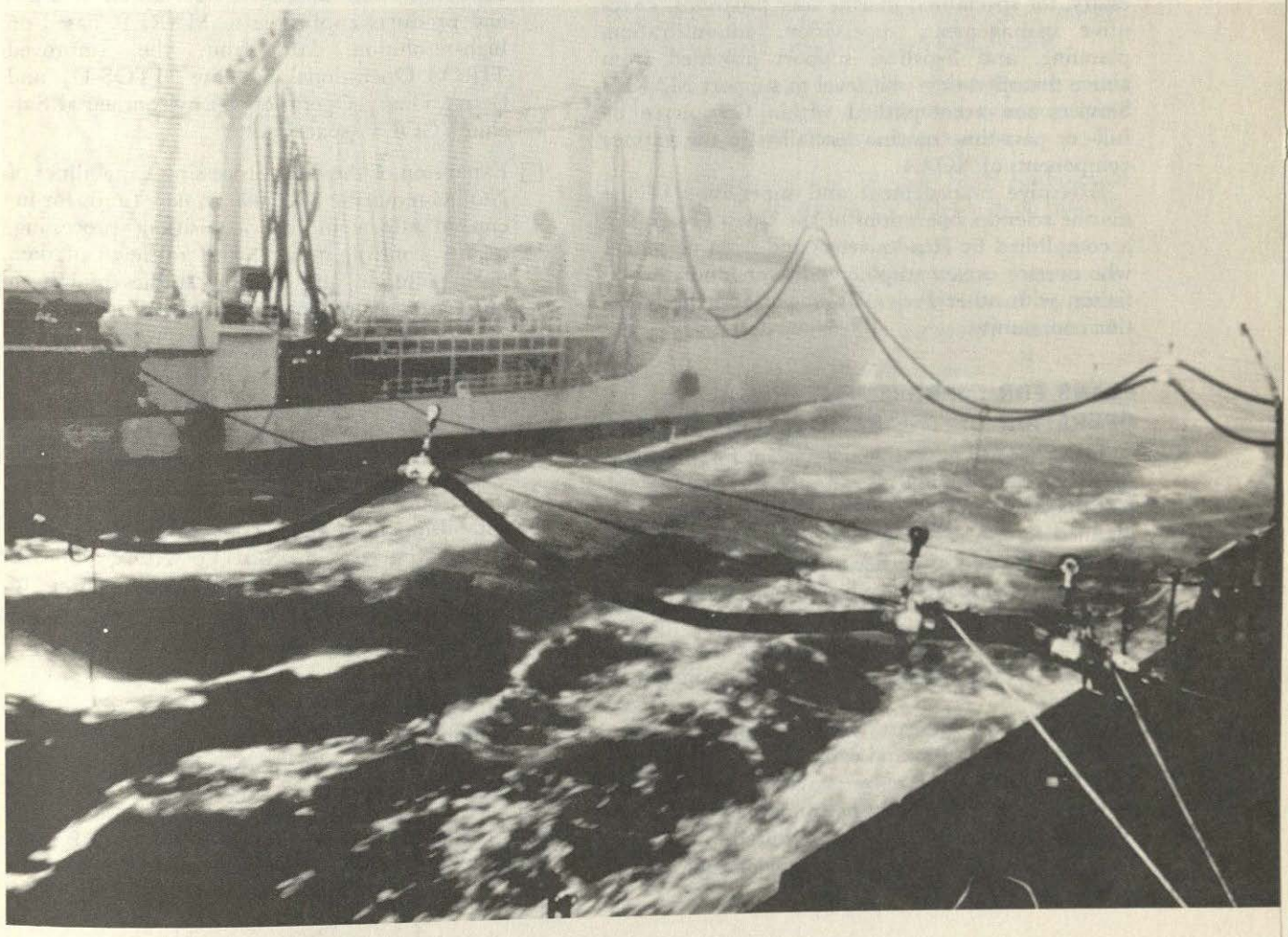
Maintenance costs cover those measures taken to keep equipment in proper operating condition and to repair such equipment when it fails. Included in costs are salaries and travel expenses of maintenance personnel, funds to furnish test equipment, and monies to purchase spare or replacement parts for meteorological and ocean-sensing equipment. Maintenance costs for communications systems are included in the cost figures for programs reported earlier. Maintenance is performed in central overhaul facilities and in regional shops. The largest portion of maintenance is allocated to swift emergency actions for restoring vital facilities to operation.

General mission-related activities in support of MAREP operations within a Federal agency include the following types of programs:

- Engineering support for planning, preparing specifications, surveying equipment sites for suitability, and inspecting and calibrating new equipment.
- Scientific studies and consultant services to determine the feasibility of new programs and to increase the effectiveness of current programs.
- Quality control of products to assure the maintenance of standards for accuracy and productivity.
- Employee housing and housekeeping or utility-type equipment at remote-area locations.

Coast Guard personnel receive advanced training at Navy schools to support Coast Guard participation in the Basic Meteorological Service observational program and to meet Coast Guard requirements. Basic meteorological training is conducted specifically as a part of the Marine Science Techni-

Refueling operation under adverse conditions at sea. (U.S. Navy)



cian Service School curriculum. The Coast Guard also supports postgraduate training in oceanography at several universities and provides an ocean sciences major within the curriculum of the U.S. Coast Guard Academy.

Selected forecasters from the NWS of NOAA are receiving oceanography training in university programs. Such training, in addition to that already received in meteorology, is valuable for producing sea, swell, surf, storm surge, and other marine services.

Commerce maintenance programs in meteorology are operated and funded as a part of the Basic Meteorological Service. Maintenance of other equipment by the several activities of NOAA is funded under other functional categories discussed earlier.

Internal support activities within Commerce are consolidated largely under the Basic Meteorological Service and are provided by NOAA staff elements of NWS and its Regional Headquarters, when necessary, for specialized marine user programs. Executive management, supervision, administration, planning, and logistical support provided from above the operating unit level to support MAREP Services are accomplished within Commerce by full- or part-time marine specialists in the various components of NOAA.

Executive management and supervision of the marine sciences operations of the Coast Guard are accomplished by Headquarters and Area personnel who oversee oceanographic endeavors and provide liaison with other Federal agencies and the scientific community.

PLANS FOR IMPROVEMENT IN THE OPERATION OF THE BASIC MAREP SERVICE

The FY 1973 operational program for the Basic MAREP Service reflects an overall increase of $2,510,000 from FY 1972. A number of programs planned for FY 1972 have been carried over into FY 1973 because of earlier budget restraints. Conversely, some budgets have been reduced because of the completion of facility construction or the expansion and other nonrecurring expenses funded through FY 1972 or because of the curtailment of services.

The FY 1973 increases are programmed to support the continuation and expansion of the existing Basic MAREP Service by providing replacement equipment, taking certain personnel actions, modifying or improving facilities required to support such Service, and providing for new and added improvements in the Service.

Research programs in support of the Basic MAREP Service are funded principally by the Departments of Commerce and Defense[6] and by NSF. Smaller programs in terms of funding are conducted by the Departments of the Interior and Transportation and by the Atomic Energy Commission (AEC), EPA, NASA, and the Smithsonian Institution. These programs will be discussed in the section of the Plan entitled, Research Relevant to Marine Environmental Prediction.

Areas in which significant improvements or new MAREP Services are planned for FY 1973 are as follows:

- ☐ Improvement of the marine weather and sea forecast and warning services of NWS by adding marine forecasters and staff support at an estimated increase of $305,000.
- ☐ Expansion of the capabilities of NESS at an increased cost of $137,000 to develop and produce new and improved specialized analyses and products applicable to MAREP, based on high-resolution data from the Improved TIROS Operational Satellite (ITOS-D) and Geostationary Operational Environmental Satellite (GOES) spacecraft.
- ☐ Expansion of the data-processing capabilities of NODC requiring $200,000 in new funds for increased efforts in the acquisition, processing, quality control, storage, and retrieval of data from pollution and baseline studies and from international oceanographic programs.
- ☐ Augmentation of product-dissemination activities of NODC at an increased cost of $150,000 through increased production of atlases and summaries, dissemination of a greater variety of data and information resulting from a broadened data base and referral services.
- ☐ Establishment of a Regional Calibration Center on the west coast by NOIC of NOAA. This is the first of these Regional Centers which are to be operated by NOIC and placed at existing installations appropriate to key geographical regions.
- ☐ Improvement of the tide and water-level prediction services of NOS through automation of 50 tide stations and expansion of data reduction

[6] All Defense research is directed toward national security; however, a large portion of this research is directly applicable to the improvement of basic environmental services which contribute to both the civil and the national security sectors.

and analyses capabilities requiring $606,000 in new funds.

- ☐ Performance by the U.S. Navy of a series of oceanic surveys between Halifax, Canada, and Bermuda, using surface expendable bathythermographs taken from a cruise ship on periodic runs to describe the thermal features of this area in terms of characteristics, variability, and movements.
- ☐ Purchase of a variety of oceanographic instruments costing $433,000 that are required to equip follow-on Navy reconnaissance aircraft.
- ☐ Development of stage-discharge relations in outflow rivers and determination of effects on the levels and outflows of the Great Lakes by the U.S. Army Corps of Engineers requiring $49,000 in new funds.
- ☐ Expansion of the Permit Management Program of the Corps of Engineers to evaluate the impact of all discharges into the Nation's navigable waterways so as to protect the ecosystems in the coastal zone.
- ☐ Improvement of knowledge on the tidal hydraulics and on the general coastal environment in the Arctic region of Alaska by the Corps of Engineers at a cost of $200,000.
- ☐ Improvement in technical services to State and local governments by the Corps of Engineers costing an additional $105,000.
- ☐ Expansion of the environmental data collection program of the Corps of Engineers to improve baseline data for engineering analysis in the planning, design, construction, operation, and maintenance of projects through the use of remote-sensing techniques.
- ☐ Expansion of the USGS network of stream-gaging stations and water-quality observation points in coastal areas are permitted in Federal-State cooperative programs at an additional cost of $460,000. (This amount will be matched in approximately equal funding from State or local cooperating agencies.)
- ☐ Expansion of the Smithsonian Institution program in collection of marine biological data and in increased services of SOSC at a total cost of $225,000.

Principal decreases in FY 1973 funding for the Basic MAREP Services have resulted from the following curtailments:

- ☐ Disestablishment of Ocean Station *Victor* in the western Pacific Ocean and subsequent decommissioning of vessels by the Coast Guard.
- ☐ Decommissioning of U.S. Coast Guard cutter *Rockaway,* a vessel dedicated to oceanographic operations and fisheries enforcement.
- ☐ Termination of the Moving Ship Radiosonde Program in the Pacific by NOAA as of June 30, 1972.
- ☐ Disestablishment of a Navy weather reconnaissance squadron in the Pacific resulting from Department of Defense budgetary constraints.

Specialized Marine Environmental Prediction Services

The description of the Basic Marine Environmental Prediction (MAREP) Service and of the planned improvements to the Service are contained in the preceding section of the Plan. As noted in that section, the Basic Service provides support for the Specialized MAREP Services which include those for Maritime Navigation, Water Pollution Assessment, Living Marine Resources, Mineral Exploration, and National Security. These Specialized MAREP Services will be described in this section along with planned improvements to their operational programs. Relevant research designed to improve the Specialized MAREP Services will be identified in the final section of the Plan.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR MARITIME NAVIGATION

Many Federal operations in MAREP, because of their applicability to a number of users and because of their support to other Specialized MAREP Services, are included as integral parts of the Basic MAREP Service; yet, their particular significance to maritime navigation is apparent. Nearly all marine forecasts, advisories, and warnings produced under the Marine Meteorological Service are of importance and of direct application to navigation. The shipping industry, fishing fleets, and recreational boatmen use these products mainly for the protection of life and for the altering of ship tracks so as to minimize damage to vessels and cargo and to effect optimum transit between ports. Elements of the Basic MAREP Service of importance to maritime navigation include sea-and-swell forecasts, storm surge and seiche forecasts, tropical and extratropical storm forecasts, and studies of sedimentation in channels and harbors. Also of primary importance are marine atlases, sailing directions, tide and tidal-current prediction tables, and other special publications. Conversely, nautical charts, navigational tables, periodic navigational publications, and electronic navigation materials are not considered to be part of these MAREP Services; consequently, they are not included in this Plan.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR MARITIME NAVIGATION, BY AGENCY

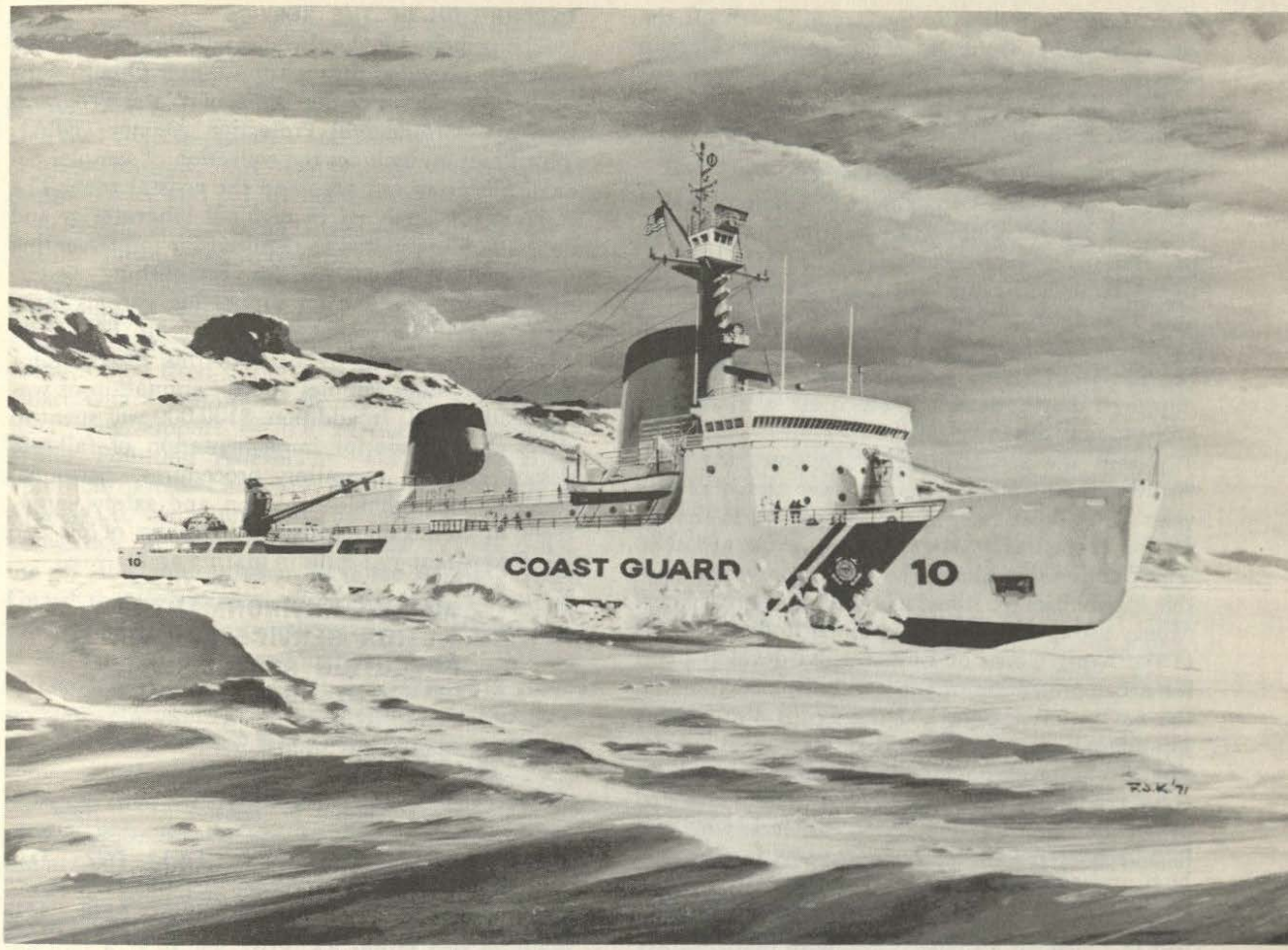
(in thousands of dollars)

	Operations		Relevant research		Total	
	FY72	FY73	FY72	FY73	FY72	FY73
Commerce	1,710	1,841	45	52	1,755	1,893
Defense	300	350	725	737	1,025	1,087
Transportation	808	891	181	583	989	1,474
NASA			160		160	
Total	2,818	3,082	1,111	1,372	3,929	4,454

DESCRIPTION OF THE SERVICE

Programs of the Departments of Commerce, Defense, and Transportation which uniquely serve the specialized requirements of a MAREP Service for Maritime Navigation include those concerned with ice forecasts and warnings and with ship-routing and channel-maintenance services.

The Department of Defense maintains a capability for sea-ice observations and forecasts by flying BIRDSEYE and fleet ice-reconnaissance aircraft flights over the Arctic icepack and by providing observers for aerial ice-reconnaissance of the Arctic and Antarctic regions. In FY 1972, Defense spent $899,000 on ice observations. The Naval Oceanographic Office (NAVOCEANO) prepares experimental long-range ice forecasts of 15 and 30 days in support of ship operations conducted by Defense, the U.S. Coast Guard, and other Federal agencies. These forecasts include data on initial formation, growth, movement, and decay of sea ice in the Arctic and Antarctic Oceans. A seasonal ice outlook, describing the ice conditions expected throughout the shipping season, is also prepared for selected areas. Another program provides experimental predicted wind-drift current charts and has as its objective the development of techniques for prediction of detailed features of the surface-cur-



World's most powerful icebreaker, first addition to the U.S. Coast Guard Icebreaking Fleet since 1954, will be in operation by 1974.

rent field. The Fleet Weather Facility at Suitland provides specialized ice-forecasting services for the Arctic and Antarctic.

The Fleet Numerical Weather Central (FNWC) at Monterey and Fleet Weather Centrals at Norfolk and Guam operate the U.S. Navy Optimum Track Ship Routing (OTSR) Program. The OTSR Program offers a high probability of one or a combination of the following: (1) least steaming time en route; (2) best weather route; and (3) bypassing of areas where storm damage may be expected. This Program service is available to naval ships, to Military Sea Transportation Service ships, and to vessels under contract to the Government. The Navy OTSR Program provided routing services to approximately 2,400 ships for Defense during 1971. Major processing activities of the Department provide over 3,000 separate oceanographic prediction products daily to meet existing requirements. As technology progresses and data acquisition becomes more adequate, the number and type of products increase and the modes of product application also expand.

The Coast Guard manages and operates the International Ice Patrol, established by the maritime nations of the Inter-Governmental Maritime Consultative Organization (IMCO) to advise shipping of the ice menace in the northwestern North Atlantic Ocean.. Aircraft reconnaissance and shipboard oceanographic observations support a program of reporting icebergs that enter the shipping lanes near the Grand Banks of Newfoundland and of predicting the drift of these icebergs. In FY 1972, the International Ice Patrol activities of the Coast Guard cost $630,000.

The Department of Commerce, through its National Weather Service (NWS), cooperates with Defense and Transportation in the monitoring and prediction of ice coverage and movement in the

Great Lakes as well as in the Arctic Ocean off the North Slope, in Cook Inlet, and in other Alaskan waters. The NWS provides data and analyses that support the provision of ship-routing services to civilian merchant ships.

PLANS FOR SERVICE IMPROVEMENT

In FY 1973, the Department of Commerce will augment its capabilities for marine forecasts by providing marine forecast specialists at Washington, Miami, San Francisco, New Orleans, Detroit, and Honolulu Weather Service Forecast Offices (WSFO). Although part of the Basic MAREP Service, these added personnel will contribute to improved marine forecasts which are of particular value to maritime navigation.

Within the Department of Defense, the U.S. Army plans increased funding over the next few years for improvement of services related to the extension of the navigation season in the Great Lakes. This funding should also result in improved predictive capabilities for snow, ice, and ice fog. An interagency group has been established under the lead of the Army Corps of Engineers to develop plans for a demonstration of the feasibility of extending the navigation season, and the Corps also intends to undertake deep-water port studies which are designed to improve navigation. These studies will involve consideration of requirements for expanded prediction services. Prediction services will also benefit from continuing Navy support in FY 1973 of the development and improvement of satellite-positioning systems. In addition, NAVOCEANO will establish an automated ice-data archive, permitting rapid access to ice information for the Arctic and the Antarctic as obtained from ship and shore station and by aircraft.

It should be understood that Coast Guard expenditures in support of the International Ice Patrol depend on actual costs incurred ($630,000 in FY 1972), which could conceivably increase or decrease in FY 1973.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR WATER POLLUTION ASSESSMENT

The problems of water pollution are great, particularly in the coastal zone and in the Great Lakes where man's activities have significant, immediate impact on environmental quality. These waters, already seriously affected, face prospects of further environmental degradation unless some form of management, based on adequate monitoring and prediction services, is maintained.

DESCRIPTION OF THE SERVICE

The principal Federal water pollution assessment service is provided through the Water Quality Surveillance Program of the Office of Water Programs in the Environmental Protection Agency (EPA). This Program includes the collection of samples periodically from estuaries and the coastal zone. The samples are analyzed in regional laboratories and data are disseminated as required for implementing water-quality standards, for establishing water-quality baselines, and for supporting various planning and management programs. In FY 1972, $750,000 was spent by EPA in this Program for analysis of water samples and dissemination of water-quality data. In addition, $100,000 was spent to develop programs for implementation of fail-safe design criteria, operating procedures, personnel training, and reliable detection and safety equipment in connection with the handling of oil and hazardous-material spills in marine areas.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR WATER POLLUTION ASSESSMENT, BY AGENCY

(in thousands of dollars)

	Operations		Relevant research		Total	
	FY72	FY73	FY72	FY73	FY72	FY73
Commerce			5,820	8,218	5,820	8,218
Defense ..	665	540	6,238	6,826	6,903	7,366
Transportation ...	1,369	1,218	3,940	6,374	5,309	7,592
AEC			6,149	6,048	6,149	6,048
EPA	5,922	6,323	3,734	4,384	9,656	10,707
NASA			226	250	226	250
NSF			150	250	150	250
Total	7,956	8,081	26,257	32,350	34,213	40,431

The U.S. Geological Survey (USGS) of the Department of the Interior coordinates activities with EPA to meet needs for basic data on water quality. About 55 stations are operated near the heads of estuaries in the conterminous States under fund transfer from EPA. In addition, at a number of stations in Puerto Rico, samples of water and sediment are taken biannually for pesticide determination. Temperature, conductance, and the concentration of common ions are generally measured at more than 200 USGS stations. These provide data to the Basic MAREP Service on streamflow into

coastal waters. At a small number of these stations, turbidity, pH, nutrients, dissolved oxygen, coliforms, and biochemical oxygen demands are observed. There are 35 water-quality stations operated by USGS in estuaries and canals; and, at most of these stations, only temperature, conductance, common ions, and pH are being measured.

Selected U.S. Coast Guard vessels, equipped with salinity-temperature-depth (STD) sensors and sampling devices, are used in a variety of in-house and cooperative programs for the analysis of various parameters. Properties of coastal waters are measured by fixed-station sensors. In FY 1972, the Coast Guard sponsored an expanded monitoring service in support of the MAREP Service for Water Pollution Assessment. The Coastal Zone Pollution Baselines and Monitoring Project, costing $1,983,000, contributed to the national quest for knowledge on this critical zone; the Project made use of the multimission facilities of the Coast Guard that are strategically located in the coastal zone. Funds are being used to provide airborne and *in situ* sensors and operational personnel.

The Department of Defense conducted a comprehensive assessment of the environmental impact of past Deep Water Dump operations involving conventional munitions cargos in FY 1972. Two representative disposal sites were surveyed at a cost of $573,950. An assessment of the environmental impact of past dumping operations off New Jersey, involving primarily chemical munitions cargos, is being planned for the final quarter of FY 1972 and the first half of FY 1973. An initial cost estimate for this operation is $400,000.

In response to Executive Order 11057, a U.S. Navy-wide program has been established for the prevention, control, and abatement of air and water pollution ashore and afloat as well as the development of methods for the prediction and enhancement of environmental quality. While a majority of the present Navy programs are oriented toward the development and installation of equipment to eliminate pollutants at their source, several programs are directly linked to environmental measurement and are being pursued both independently and in concert with other Federal agencies. An environmental data base program has been established to assess the present waste discharges and the measures being taken to reduce water pollution. New instrumentation, analytical methods, and operational procedures for monitoring the environment are being developed. A pilot monitoring program, now underway for Pearl Harbor, Hawaii, should provide the basic test for subsequent routine monitoring procedures. To assess the environmental impact of past bulk disposal of obsolete munitions at sea, a survey of representative past dump sites is being conducted. Future monitoring requirements are being developed as a result of measurements taken in FY 1972. The Navy is in close coordination with EPA efforts to assess the fate and effects of known hazardous substances.

From 1966 to 1969, the U.S. Army Corps of Engineers conducted studies and investigations in the Great Lakes to improve water quality by developing technology for the containment of polluted dredge spoil into selected deposit areas. This program is now operational and the Corps is in the process of obtaining spoil-disposal sites.

The *National Oil and Hazardous Substances Pollution Contingency Plan* has been developed in compliance with the Federal Water Pollution Control Act, as amended. The Plan is effective for all U.S. navigable waters, their tributaries, and adjoining shorelines. Coverage of the Plan includes the inland rivers, the Great Lakes, the coastal territorial waters, the contiguous zone, and the high seas where there exists a threat to U.S. waters, shoreface, or shelf bottom.

The objectives of the Plan are to provide for efficient, coordinated, and effective action to minimize damage from oil and hazardous substance discharges, including containment, dispersal, and removal. It establishes a pattern of coordinated and integrated response by Federal departments and agencies to protect the environment from the damaging effects of pollution spills. The Plan also promotes the coordination and direction of Federal, State, and local response systems and encourages the development of local government and private capabilities to handle such pollution spills. Federal agencies have responsibilites established by Statute, Executive Order, or Presidential Directive which bear on the Federal response to a pollution spill. The Plan promotes the expeditious and harmonious discharge of these responsibilities by those Federal agencies having the most appropriate capability to act in each specific situation. Responsibilities of the several Federal agencies relevant to the control of pollution spills are:

- ☐ The Council on Environmental Quality (CEQ) is responsible for the preparation, publication, revision, or amendment of the Plan in accordance with Executive Order 11548. The CEQ will receive the advice of the National Response Team (NRT) and will insure that disagreements arising among members of the NRT are settled expeditiously.

- The Department of Commerce provides support to the NRT, to the Regional Response Team (RRT), and to the On-Scene Coordinator (OSC) with respect to marine environmental data; living marine resources; current and predicted meteorologic, hydrologic, and oceanographic conditions for the high seas, coastal, and inland waters; design, construction, and operation of merchant ships; and maps and charts, including those for tides and currents of coastal and territorial waters and of the Great Lakes.

- The Department of Health, Education, and Welfare is responsible for providing expert advice and assistance relative to those spills or potential spills that constitute or may constitute a threat to public health and safety.

- The Department of Defense, consistent with its operational requirements, may provide assistance in critical pollution spills, in the maintenance of navigation channels, and in the salvage and removal of navigation obstructions.

- The Department of the Interior supplies expertise in the fields of oil drilling, production, handling, and pipeline transportation. Also, Interior has access to and supervision over continuously manned facilities which can be used for the command, control, and surveillance of spills occurring from operations conducted under the Outer Continental Shelf Lands Act. Additionally, Interior will provide, through its Regional Coordinators, technical expertise to the OSC and RRT with respect to land, to fish and wildlife, and to other resources for which it is responsible. The Department is also responsible for the administration of American Samoa and the U.S. Trust Territory of the Pacific Islands.

- The Department of Transportation provides expertise regarding all modes of movement for oil and hazardous substances. Through the Coast Guard, a Department representative serves as vice chairman of NRT; Transportation also supplies support and expertise in the domestic and international fields of port safety and security, marine law enforcement, navigation, and in the construction, manning operation, and safety of vessels and marine facilities. Additionally, the Coast Guard maintains continuously manned facilities that are capable of command, control, and surveillance for spills occurring in the U.S. navigable waters or on the high seas. The Coast Guard can also be responsible for the chairmanship of RRT and for the implementation, development, and revision, as necessary, of regional plans for those areas in which it has been assigned the responsibility to furnish or to provide for OSCs. EPA will provide guidance to and coordination with Transportation regarding pollution control and protection of the environment in the preparation of such plans.

- The Environmental Protection Agency (EPA) has the responsibility to chair the NRT. In this capacity, EPA will assure that the Plan is effectively and efficiently implemented with optimum coordination among Federal agencies; the Agency will recommend changes in the Plan to CEQ, as deemed necessary. The EPA can also be responsible for the chairmanship of RRT and for the development, revision, and implementation, as necessary, of regional plans for those areas in which it has been assigned the responsibility to furnish or to provide for OSCs. Through the resources of the Office of Water Programs, EPA will provide technical expertise to the NRT and RRTs relative to environmental pollution-control techniques, including the assessment of damages and environmental restoration.

- The Department of Justice can supply expert legal advice to deal with complicated judicial questions arising from spills and from Federal agency responses.

- The Office of Emergency Preparedness (OEP) will maintain an awareness of pollution incidents as they develop. Normal OEP procedures will be followed in the evaluation of any request for a major disaster declaration received from a Governor of a State. If the President declares that a pollution spill constitutes a major disaster under Public Law 91–606, the Director of OEP will provide coordination and direction of the Federal response in accordance with OEP policies and procedures.

- The Department of State can provide assistance and coordination whenever a pollution spill transects international boundaries or involves foreign-flag vessels.

PLANS FOR SERVICE IMPROVEMENT

Within the Department of Defense, efforts in water pollution assessment by the Navy during FY 1973 will center on the fate and effects of oil spills in the nearshore environment. In addition, the Navy plans to implement a routine monitoring pro-

gram at Pearl Harbor during the fourth quarter of FY 1973 as an extension of the pilot program now underway at that site.

In FY 1973, the Coast Guard will implement, in a limited number of coastal areas, a technique which has been developed in support of its responsibilities for monitoring oil spills. This technique will employ air-deployable surface current-measuring probes recently developed.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR LIVING MARINE RESOURCES

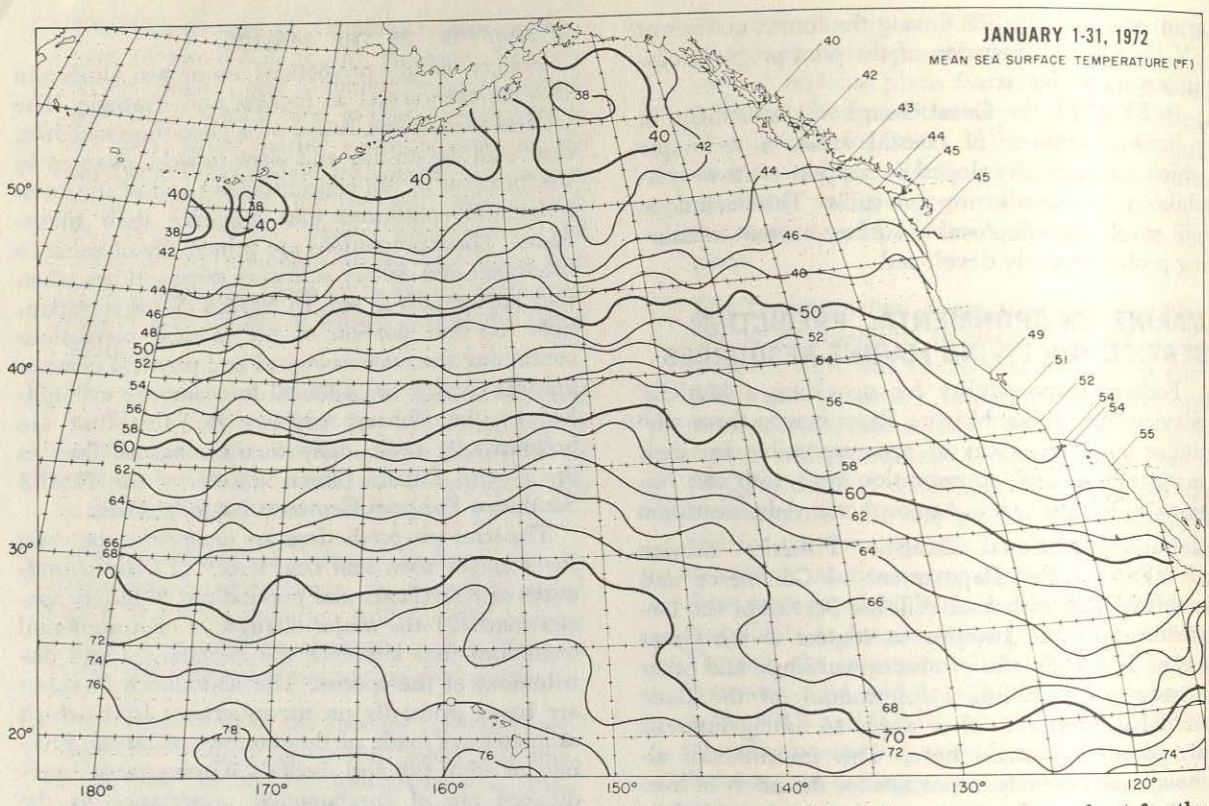
Federal responsibility for providing a MAREP Service for Living Marine Resources to those who utilize such resources or are responsible for their management and conservation rests with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) of the Department of Commerce and with the U.S. Fish and Wildlife Service of the Department of the Interior in respect to the Great Lakes. However, the products, warnings, and other broadcast or published information of the Basic MAREP Service as they apply to fishing interests are also emphasized here. This information, although particularly important for the safety of lives and the protection of property at sea, also aids fishermen in the judicious selection of areas where the fish are likely to be concentrated and where the conditions of weather and sea state will permit efficient operations.

DESCRIPTION OF THE SERVICE

Fishery biology predictions are of two kinds and may be categorized as tactical and strategic. The tactical predictions, issued on a close-time schedule, deal with day-to-day and week-to-week changes in the locations of fish concentrations and of the environmental conditions that influence their movements. These predictions are principally of value to fishermen and fishery scientists during times when they are actually at sea. In NOAA, NWS is responsible for that portion of the tactical predictions containing the meteorological and physical oceanographic conditions. Tactical forecasts are exemplified by the Fishery Advisory Bulletins that are broadcast by radio daily to the albacore fleet in the eastern Pacific Ocean waters by the NMFS Southwest Fisheries Center at La Jolla, Calif.

The strategic predictions are designed to be valid for a longer term and deal with: (1) the abundances of year classes and populations of fishery species; and (2) the major changes in environmental conditions that influence the abundances and distributions of the species. The abundance forecasts are based primarily on survey cruises from which estimates are made of the numbers of larval, juvenile, or adult fish and shellfish. These strategic predictions are of fundamental importance to the management and conservation of fishery resources.

***Albatross IV*—typical research vessel engaged in ichthyoplankton survey operations. (National Marine Fisheries Service)**



Sea-surface temperature chart for the Northeastern Pacific Ocean.

In addition, 15-day sea-surface temperature charts of the eastern Pacific are compiled from information supplied by the U.S. Navy, by the U.S. Coast Guard, by the NWS, and by the fishing industry. These charts, now in the ninth year of publication, are distributed to assist fishermen in selecting optimum fishing areas. An example of one of these charts is shown in the accompanying figure.

Strategic predictions by NMFS, some in cooperation with international commissions and various States, are made on the abundances of shrimp in the Gulf of Mexico, of several groundfish species and sea scallops off the New England coast, of menhaden off the U.S. east coast, of red and pink salmon and halibut in the Pacific Northwest fisheries area, of dungeness crabs off the California coast, of sardines off Baja California, and of skipjack tuna in Hawaiian waters.

The NMFS advises the States, which receive Federal aid under Public Laws 88–309 and 89–304, in implementing the various projects concerned with research, development, conservation, and management of commercial and sport fishing resources; NMFS also cooperates with the States and with international commissions in determining the abundance and distribution forecasts of fish and shellfish stocks. Twelve major installations and 10 ships that are involved in coastal and offshore research are also employed in these activities.

The Coast Guard conducts monthly flights over the Continental Shelf off the east coast to record

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR LIVING MARINE RESOURCES, BY AGENCY

(in thousands of dollars)

	Operations		Relevant research		Total	
	FY72	FY73	FY72	FY73	FY72	FY73
Commerce	7,367	6,902	14,907	19,910	22,274	26,812
Defense ..	100	103	705	825	805	828
Interior	5	6	313	331	318	337
Transportation ...	724	828			724	828
NASA			275	100	275	100
Total	8,196	7,839	16,200	21,165	24,396	29,004

sea-surface temperatures and surface-swimming animals. A similar program is conducted by the Coast Guard on the west coast in cooperation with the NMFS Tiburon (Calif.) Coastal Fisheries Research Laboratory of NOAA. Charts of sea-surface temperatures are prepared and mailed monthly to fishermen, various institutions, and other potential users. Through its Oceanographic Unit, the Coast Guard conducts spring and autumn oceanographic surveys of the Northwest Atlantic fisheries area as part of its coastal monitoring and studies effort. These surveys, funded at $171,000 for FY 1972, include Nansen and STD casts and analyses for inorganic nutrients.

A major new program, initiated in FY 1972 by NMFS, is the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program. The overall objectives of this Program are to:

- Develop techniques for obtaining accurate measures of the abundance and geographic distribution of living marine resources available to the United States.
- Monitor seasonal and annual fluctuations in the distribution and abundance of the various life stages of pelagic and demersal fishery resources and relate them to environmental factors and exploitation by man.
- Assess the productive capacity of these resources on a sustained yield basis and develop models for predicting future yields.
- Establish a comprehensive description of the marine ecosystem in terms of the distribution, composition, and interrelation of biological communities.

To achieve these MARMAP objectives will require:

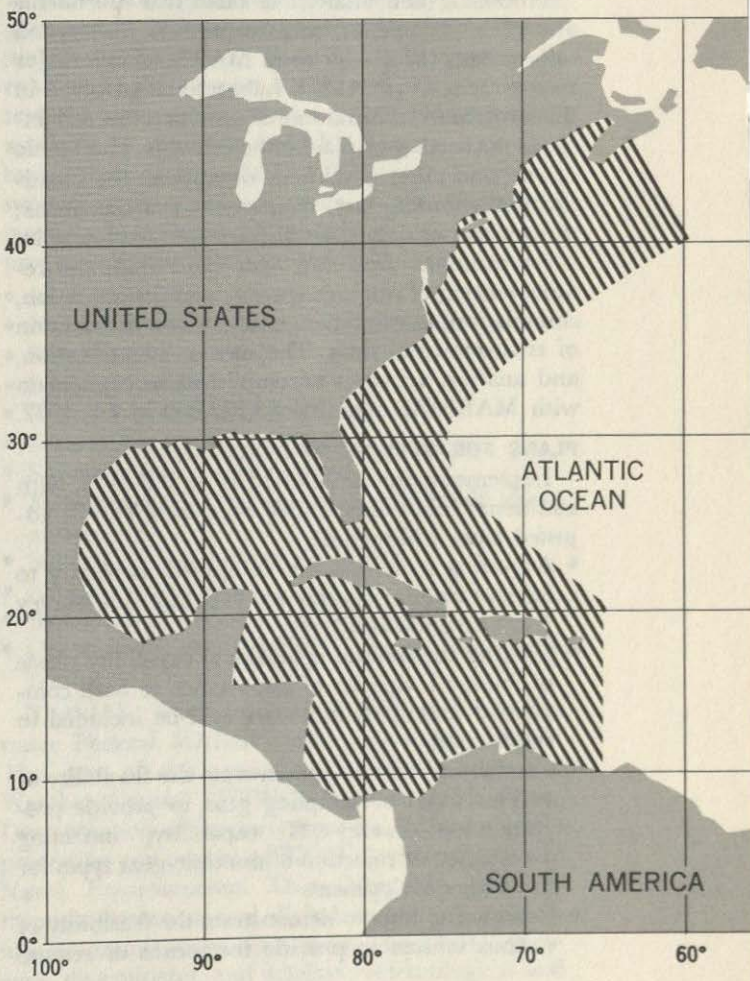
- Conducting continuing surveys of the major biological communities of living marine resources in sufficient geographical and temporary detail for assessment and prediction purposes.
- Obtaining the environmental data necessary to formulate models of the large-scale relations between physical environmental factors and biological communities, with emphasis on distribution and abundance of the resource species.
- Acquiring information from special studies to clarify specific biological and environmental relations within marine ecosystems.
- Developing an integrated national system for acquisition, compilation, analysis, and dissemination of information on the resource populations and their environment.

The MARMAP initiative involves three kinds of surveys: (1) ichthyoplankton, (2) groundfish, and (3) pelagic fish. These surveys differ principally in the method of sampling and in the techniques of data analysis. Simultaneously with the biological sampling, a variety of physical and chemical variables of the environment are measured. The surveys are performed aboard ships of the NOAA fleet, together with those of the Coast Guard, cooperating States, laboratories, and private organizations. Supplemental data will be obtained from buoys, satellites, and ships of opportunity.

The accompanying chart shows the Atlantic portion of the MARMAP area to be surveyed in FY 1973.

The overall MARMAP service Program in FY 1972 cost $5,147,000 and concentrated on: (1) the establishment of MARMAP operational control;

Marine Resources Monitoring, Assessment, and Prediction (MARMAP) survey coverage in the Atlantic, FY 1973; Survey I— ichthyoplankton. (National Marine Fisheries Service)



(2) the development of detailed survey plans for the ichthyoplankton and groundfish surveys; (3) the initiation of a substantial portion of the ichthyoplankton survey; (4) the continuation of ongoing components of groundfish and pelagic fish surveys; and (5) the development of a system to make full use of the diverse environmental data and information that is made available from numerous Federal, State, private, and international organizations. The technology thrust of MARMAP falls broadly into three categories: (1) development of ship-based systems for monitoring the living marine resources and the environment; (2) development of aircraft and satellite-based remote-sensing systems for similiar use; and (3) development of information extraction systems.

Data-acquisition activities in FY 1972 for MARMAP involved giving support to the biological and environmental data-acquisition phases of ichthyoplankton surveys off the east and west coasts and developing plans for acquisition of additional data and information at a total cost of $1,632,000.

Processing and analysis of biological speciments and of environmental data to produce the needed information (or products) of MARMAP is a major requirement at all NMFS Laboratories involved in the Program. Information or products needed include the sorting of planktonic fish eggs, planktonic larvae, and other planktonic organisms; the identification, counting, and measurement of specimens; the analysis of data derived from specimen samples —for example, sizes and ages—and from the remote sensing of resource species; and the reduction, compilation, interrelation, analysis, and distribution of environmental data. The sorting, identification, and analysis activities accomplished in connection with MARMAP required $3,722,000 in FY 1972.

PLANS FOR SERVICE IMPROVEMENT

Implementation of MARMAP in FY 1973, with additional funds of $821,000 over the FY 1972 adjusted base, will include:

- Acquiring materials and equipment necessary to achieve interim operational capability for Survey I (ichthyoplankton).
- Starting the interim operational capability phase of Survey I. Species of importance to both commercial and sport fishermen will be included in the Survey.
- Conducting tests to demonstrate the feasibility of various types of sampling gear to provide program-wide Survey II capability, including acceptance or rejection of multiple-gear types for full-scale development.
- Conducting tests to demonstrate the feasibility of various sensors to provide the means of remote underwater assessment of benthic and demersal sport and commercial species (Survey II), including acceptance or rejection of some sensors for full-scale development.
- Conducting tests to demonstrate the feasibility of various direct-sampling and remote-sampling methods for surveys of pelagic fish (Survey III).
- Entering into cooperative contracts with Federal, State, and private institutions for the processing, analysis, and production of the formatted output of ichthyoplankton and environmental data obtained during MARMAP survey cruises.
- Training of personnel in the sorting and identification of iththyoplankton.
- Acquiring equipment for environmental processing and analysis groups.
- Bringing together and integrating historical oceanographic data and analyses from all relevant sources to support the interim operational capability phase of Survey I. The analytical work is detailed under research in physical oceanography in the section, Research Relevant to Marine Environmental Prediction.
- Expanding the staff of the MARMAP Program Manager and adding personnel for field coordination of surveys.

MARMAP surveys are planned to reach full operational status by 1976.

The National Environmental Satellite Service (NESS) of NOAA will assist MARMAP by providing specialized environmental products—especially sea-surface temperature maps.

In addition to MARMAP, there are plans underway for the Basic MAREP Service to increase the number of expendable bathythermograph observations from fishing vessels and from ships of opportunity in the Cooperative Merchant-Ship Observational Program. These data will be used by NMFS in its analyses and mathematical models that relate fish concentrations and distributions to ocean-temperature conditions and will also contribute to the enhancement of the data base for the Basic MAREP Service.

The activities performed by the Bureau of Sport Fisheries and Wildlife of the Department of the Interior are described under research in biological oceanography in the section, Research Relevant to Marine Environmental Prediction.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR MINERAL EXPLORATION

No Federal agency operational programs are specifically directed toward the MAREP Service for Mineral Exploration, although most facets of the Basic MAREP Service are applicable. Of particu-

lar relevance to this Specialized MAREP Service are forecasts and warnings of tropical and extratropical storms, sea-and-swell, storm surges, tsunamis, ocean currents, and sea ice.

Two research projects, designed to support this Service uniquely, are discussed in the section, Research Relevant to Marine Environmental Prediction, of this Plan. One of these projects is conducted by the Marine Minerals Technology Center (MMTC) of the Environmental Research Laboratories (ERL) of NOAA, with the objective of developing techniques to predict the effects of marine mining on the environment. The other project is conducted by the U.S. Army Corps of Engineers, with the objective of assessing offshore deposits of sand and gravel for use in beach nourishment.

In addition, the U.S. Navy Ocean Engineering Program includes major research and development programs in undersea search and rescue, construction, and oceanographic instrumentation. The assessment of the severity and variability of the environment associated with these engineering projects as well as the advances in technology are applicable to the development of the MAREP Service for Mineral Exploration.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR NATIONAL SECURITY

There are special requirements of the Department of Defense for a wide range of MAREP Services which do not serve other user groups. The diversity and specialization of these Services are reflected in the many kinds of platforms, sensor, weapon systems, and vehicles operated by Defense throughout the total marine environment.

DESCRIPTION OF THE SERVICE

Defense activities involving a need for specialized marine environmental knowledge include search, rescue, and salvage; antisubmarine warfare (ASW); amphibious operations; mine warfare; polar operations; and ocean and coastal engineering. In addition, routine fleet operations require a large volume of marine information and predictions not otherwise obtainable in the Basic MAREP Service. To meet these Service requirements, Defense allocated $42,160,000 in FY 1972, representing the largest share and 19.9 percent of the Federal MAREP program.

Examples of marine environmental parameters, in addition to weather conditions, forecast for special defense matters include: sea, surf, and swell; sea-surface temperature; thermocline depth; subsurface thermal structure; subsurface current vectors; special factors related to underwater sound; sea-ice cover; optimum conditions for ship routing; and biological factors such as false targets, deep-scattering layer, and organisms producing reverberation.

Much of the Defense effort in MAREP is applied in support of various ASW systems. This support is essential because the propagation of underwater sound is central to most aspects of ASW and because the behavior of sound in sea water is strongly influenced by marine environmental factors. As more understanding is gained of the complexity and variability of the ocean, it is evident that the controlling environmental conditions must be monitored and projected into the future on a broad basis for ASW purposes.

The MAREP Service for National Security is the only Specialized MAREP Service containing all elements of the basic MAREP systems concept, that is, data-acquisition platforms, data collection and communications, data-processing functions, and product dissemination media. In some cases, the MAREP Service for National Security of the Department of Defense complements and provides essential support for the Basic MAREP Service. An example of this support is the hundreds of ship observations and scores of aircraft observations made available to the Basic MAREP Service on a daily basis. Most Defense MAREP activities, however, support unique defense needs of the Nation. In meeting these needs, the Department has developed programs in the following MAREP areas:

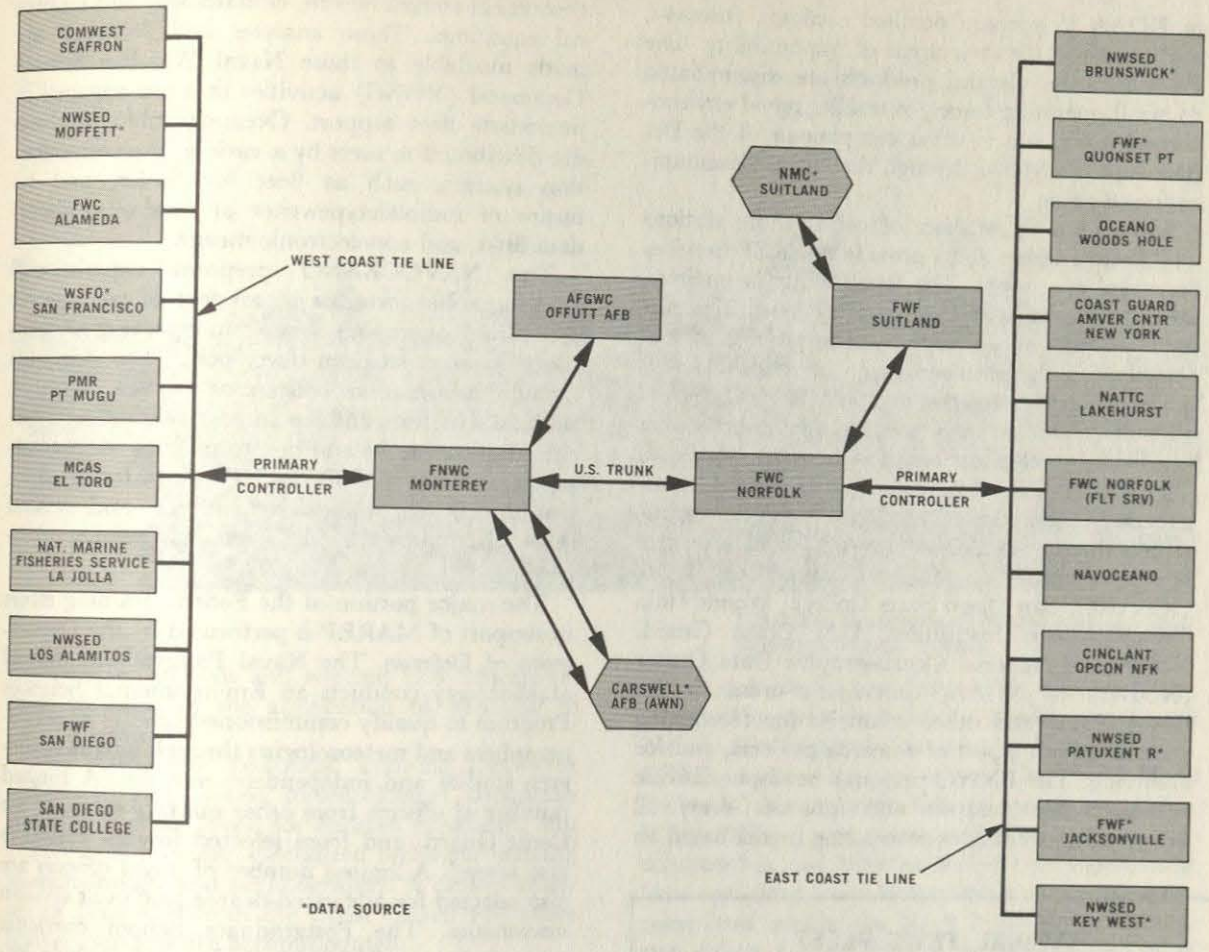
- Ice Forecasting
- Hurricane and typhoon reconnaissance
- Ship routing
- Surf forecasting
- Typhoon and hurricane evasion
- Sea-surface temperature fields
- Sea conditions (wave heights)
- Meteorological forecasts over worldwide ocean areas
- Subsurface ocean-water properties
- Acoustic conditions
- Biological effects on acoustics
- Ocean-floor characteristics and beach conditions.

The U.S. Navy operates a full-service, wide-range Federal MAREP system for defense needs. The core of this system is the Fleet Numerical Weather Central (FNWC) located at Monterey. Dissemination of products from the main computer processing component of FNWC is provided by the Naval Environmental Data Network (NEDN) through interconnected digital computers and on-line communications equipment. The FNWC processes, disseminates, and displays meteorological and

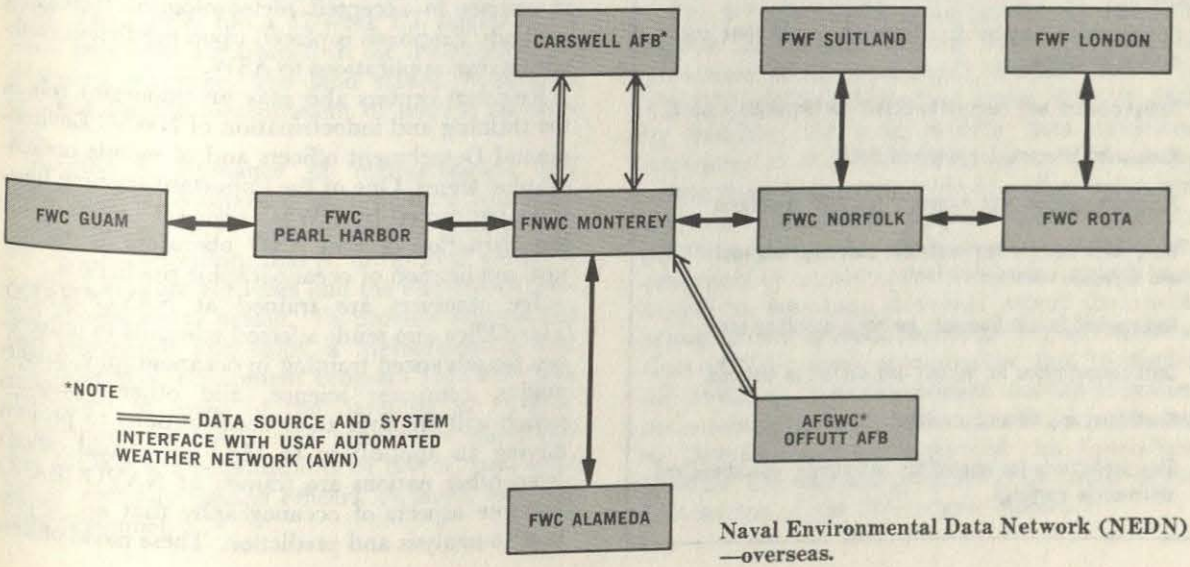
DEPARTMENT OF DEFENSE MAREP PRODUCTS OF THE NAVAL WEATHER SERVICE COMMAND

Title	Product	Cycle
1. General weather forecast	Synoptic analysis/forecast	
a. Waves—direction, period, and height		Daily
b. Swell—direction, period, and height		Daily
c. Combined sea height		Daily
d. Surface currents		Daily
e. Surface weather factors—such as wind, temperature, fog, and precipitation		Daily
f. Cloud coverage		As requested
g. Oceanic fronts		As requested
h. Oceanic dispersion		As requested
i. Air-ocean heat exchange		As available
j. Gale, hurricane, and storm warnings		
2. Optimum Track Ship Routing (OTSR) and weather advisories	Individual forecast	As requested
3. Search and rescue drift forecast	Individual forecast	As requested
4. Marine Climatic Atlas	Book (series)	As available
5. Ocean-Area Observations	Book (series)	As available
6. Sea-surface temperature	Synoptic analysis/forecast	Daily
7. Mixed-layer depth	Synoptic analysis/forecast	Daily
8. Below layer gradient	Synoptic analysis/forecast	Daily
9. Upper sound channels	Synoptic analysis/forecast	On request
10. Probability of transients (thermal gradients)	Synoptic analysis/forecast	On request
11. Bathythermograph and sound-velocity profiles	Synoptic analysis/forecast	On request
12. Acoustic Sensor Range Prediction (ASRAP)	Individual forecast	On request
13. Ship-Helicopter Acoustic Range Prediction System (SHARPS)	Individual forecast	On request
14. Detailed propagation loss	Individual forecast	On request
15. SHARPS-horizontal-range depictions	Synoptic analysis/forecast	On request
16. ASW Oceanographic Environmental Services (NWS 3360/1)	Booklet	As available
17. Oceanographic Outlooks	Booklet (series)	Quarterly

oceanographic analyses and forecasts on a hemispheric basis to meet Defense needs. Through the facilities of FNWC, real-time products are continually updated and tailored to fleet and other requirements of Defense. The FNWC products are distributed through NEDN to Fleet Weather Centrals and Facilities strategically located throughout the world. The accompanying charts show NEDN terminals. The FNWC is the master center for collecting and processing worldwide data inputs of meteorological and oceanographic parameters. Responsibilities for providing fleet support throughout the oceanic regions of the world are shared by Fleet Weather Centrals at Guam, Pearl Harbor, Norfolk, and Rota, Spain. Computers at these Centrals receive processed data fields from FNWC, augment these fields with the latest observed data, and produce environmental support products tailored to naval forces at sea and ashore. The Centrals use the broad-scale products from FNWC and, where available and applicable, the products from the National Meteorological Center (NMC)



Naval Environmental Data Network (NEDN) —conterminous United States.



Naval Environmental Data Network (NEDN) —overseas.

of NOAA to prepare detailed analyses, forecasts, and warnings for their areas of responsibility. The Fleet Weather Central products are disseminated to naval operating forces, to smaller naval environmental units, and to other components of the Department of Defense through the Naval Communications System.

More than 60 weather offices at shore stations and aboard larger ships provide MAREP Services for naval operations. The focal point for environmental support is at the operating level. The primary purpose of this support is to provide meteorological and oceanographic information and advice to operational commanders. Briefings generally are conducted in person, but they may also be provided by telephone or closed-circuit television.

Oceanographic observations are collected by regional centers and are edited, cataloged, and transmitted through NEDN to FNWC for hemispheric analyses. Data are also forwarded to NAVOCEANO, San Diego State College, Woods Hole Oceanographic Institution, U.S. Coast Guard, NMFS and National Oceanographic Data Center (NODC) of NOAA, Canadian Forces, British Royal Navy, and other countries for forecasting purposes, for support of research projects, and for archiving. The FNWC performs hemispheric-scale oceanographic analyses and forecasts every 12 hours, using a complex forecasting model based on theoretical considerations, climatology, and empirical equations. These analyses and forecasts are made available to those Naval Weather Service Command (NWSC) activities that are engaged in immediate fleet support. Oceanographic products are distributed to users by a variety of communication systems, such as fleet broadcasts, and by means of radioteletypewriter or facsimile, digital data links, and nonelectronic means.

The NAVOCEANO prepares experimental oceanographic forecasts in support of complex or specialized operations where an operational technique has not yet been developed. These forecasts include information concerning waves, currents, thermal structure, and ice and are tailored to a specific application. In addition to specialized forecasting activities, NAVOCEANO prepares oceanographic charts, publications, atlases, and related materials required by the fleet and Defense planners.

The major portion of the Federal training effort in support of MAREP is performed by the Department of Defense. The Naval Postgraduate School at Monterey conducts an Environmental Sciences Program to qualify commissioned officers as oceanographers and meteorologists through advanced-degree studies and independent research. A limited number of officers from other military services, the Coast Guard, and from selected foreign countries also attend. A limited number of naval officers are also selected for advanced-degree studies at civilian universities. The Postgraduate School curricula cover at least a 24-month period and include lecture and laboratory courses in air-sea interaction and its use in forecasting ocean currents, sea, swell, sea temperature, and acoustical parameters as well as courses in accepted meteorological forecasting methods. Emphasis is placed upon prediction methods having applications to ASW.

Regional centers also play an important role in the training and indoctrination of NWSC Environmental Detachment officers and of mobile oceanographic teams. One of the important training functions performed by NWSC regional centers is the indoctrination of fleet ASW operators in the tactical application of oceanographic predictions.

Ice observers are trained at NAVOCEANO. This Office also sends selected scientists to universities for advanced training in oceanography, mathematics, computer science, and other disciplines which will enhance their contributions to projects having an application to MAREP. Naval officers from other nations are trained at NAVOCEANO in those aspects of oceanography that are important to analysis and prediction. These naval officers

TYPICAL FNWC FLEET SUPPORT SERVICES

1. Numerical weather and oceanographic analysis and forecast charts for fleet facsimile broadcast.
2. Edited data summaries for channel 8 of the fleet multichannel broadcast.
3. Ballistic wind and density forecasts for strategic support.
4. Route-wind forecasts for long-haul airlift.
5. Sound-propagation loss forecasts for ASW operations.
6. Wave forecasts for replenishment planning, long-haul OTSR, and high-seas warnings.
7. Radiological fallout forecasts for naval operating areas.
8. Drift computations for vessels and aircraft in distress.
9. Swell forecasts for surf prediction.
10. Tide predictions for amphibious and logistic operations and storm-surge warnings.

U.S. Naval Postgraduate School oceanographic Research Vessel, *Acania.*

from foreign nations and selected U.S. officers receive training on the application of MAREP to naval operations.

The Naval Air Technical Training Center at Lakehurst, N.J., offers meteorological technician training at three levels for enlisted personnel; this Center also provides specialized technical training in meteorology and oceanography. A limited number of personnel from the Coast Guard and other military services are accommodated.

A Meteorological and Oceanographic Equipment Maintenance (MOCEM) course for Electronics Technician (ET) personnel was established at the Naval Air Technical Training Center in 1969. The Center has a 17-week ET school where naval personnel are trained in the maintenance of shipboard, airborne, and land station equipment designed for the measurement of marine parameters.

Routine maintenance of meteorological and oceanographic equipment in the Navy is a command responsibility; maintenance is provided by the local organization, that is, the ground electronics shops at shore activities and the electronics division aboard naval vessels. To provide support for field commands and ships, a Meteorological and Oceanographic Equipment Program (MOEP) was established to assist in the handling of chronic maintenance problems and installation planning. The MOEP is a responsibility of NWSC and consists of specially trained officers, civilians, and enlisted personnel.

Internal support activities within Navy include: technical support provided by NWSC and by the Naval Air Systems Command (NAVAIRSYSCOM); engineering support provided by the Naval Industrial Management Offices and by the Public Works Offices; and management, supervision, administration, and logistical support provided at the local operating level. Management above the operating level within the Navy is provided through staff efforts at the Office of the Oceanographer of the Navy, at the NWSC, at the NAVAIRSYSCOM, and at the NAVOCEANO.

PLANS FOR SERVICE IMPROVEMENT

The FY 1973 Defense budget for the MAREP Service for National Security is $44,401,000. Improvement of this Specialized MAREP Service in FY 1973 will be achieved, at a cost of $2,241,000, by installing the most modern data-acquisition equipment in additional naval ships, by providing temperature-sensor support to new observation vessels, and by expanding computer facilities and support of oceanographic analysis and forecasting. Development of an automated shipboard system forecasting for command ships will permit the combination of local synoptic bathythermograph observations with historical ocean-station data to display the predicted three-dimensional thermal structure. An extensive research program will be conducted by Defense for improvement of this Specialized MAREP Service; this program is discussed in the final section of the Plan which follows.

Research Relevant to Marine Environmental Prediction

Descriptions of the Basic and Specialized Marine Environmental Prediction (MAREP) Services and of the plans by the Federal agencies for improving these Services are contained in the preceding sections of this Plan. The Basic MAREP Service provides the foundation for the Specialized MAREP Services, which include those designed for maritime navigation, water pollution assessment, living marine resources, mineral exploration, and national security. Relevant research programs, including development efforts, supported by Federal agencies that will contribute to the future improvements in MAREP Services are presented in this section.

INTRODUCTION

Federal funds spent in FY 1972 and planned for expenditure in FY 1973 in relevant MAREP research are summarized in the table, "Federal Plan for Marine Environmental Prediction, by Agency," in a preceding section of the Plan, Summary of Fiscal Data. Federal agency funds spent for relevant research in support of the several MAREP functions are shown in the accompanying table, "Agency Relevant Research Costs, by Function." Because many research projects do not contribute *per se* to these functions, a separate heading in the table gives information on funding which supports those research projects that are expected ultimately to contribute to MAREP through a better understanding of the basic environmental processes. Expenses incurred by Federal agencies through administrative support of research projects have been supplied by some agencies and are included in the table. Funding information on research in support of the Basic MAREP Service and of the several Specialized MAREP Services is contained in separate tables under the respective Services in the preceding sections of this Plan.

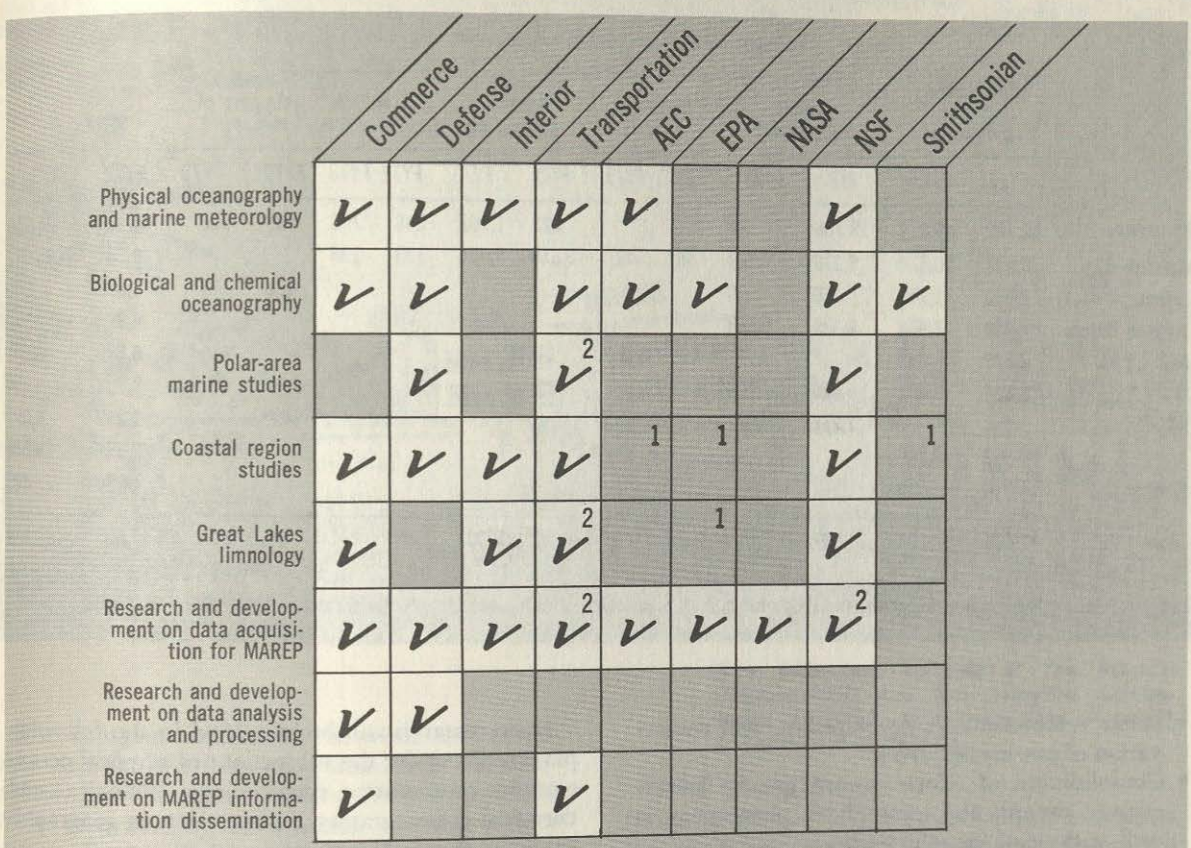
Major research efforts by Federal agencies relevant to improvements in MAREP Services are described in the following paragraphs. The presentation will discuss these research program efforts under the following categories: research necessary for the understanding of the basic marine processes and research for the improvement of functions which constitute a MAREP system.

RESEARCH FOR UNDERSTANDING BASIC MARINE PROCESSES

The National Science Foundation (NSF), the Department of Commerce, and the Department of Defense support a large variety of research programs directed toward an understanding of basic marine processes that are considered important to MAREP. Basic marine research programs relevant to MAREP are funded at lower levels by the Departments of Transportation and the Interior, the Environmental Protection Agency (EPA), and the Smithsonian Institution.

The NSF provides funds for the accomplishment of fundamental research projects in marine sciences through a number of different procedures, attempting to provide an attack on problems over a broad front that ranges from immediate to long-range concern. From unsolicited proposals submitted by individual investigators, the Oceanography Section of the Foundation selects, through a process of review by peers, those programs of the highest quality. For the Antarctic program, unsolicited proposals are selected through a review by peers and on a review of their compatibility with available logistics and of their contribution to international objectives. A slightly varied procedure is followed by NSF on the International Decade of Ocean Exploration (IDOE) and on Arctic programs; specific research efforts are selected, and most programs involve teams of investigators from different institutions. The IDOE program is designed to support selected oceanographic research efforts that will contribute to a better understanding of the ocean environment, an understanding that would not generally be expected through unsolicited individual studies in comparable time periods.

RESEARCH RELEVANT TO MARINE ENVIRONMENTAL PREDICTION IN SEVERAL CATEGORIES PERFORMED BY FEDERAL AGENCIES



1 The research programs in this area are discussed under biological and chemical oceanography.

2 Includes ship operation support.

Another procedure, initiated recently by NSF under the newly created Office of the Assistant Director for Research Applications, focuses on selected projects of national concern. The program, Research Applied to National Needs (RANN), provides support for highly coordinated and directed efforts by scientists in various disciplines and institutions. Often the interdisciplinary aspects of these RANN programs make it difficult to categorize them into science disciplines. The marine sciences are most heavily involved in programs designed either to manage the regional systems in the coastal areas or to measure the effects of trace contaminants in the environment.

The Department of Defense supports the Navy Ocean Science Program which includes a large variety of research projects covering the broad disciplines of physical, chemical, and biological oceanography as well as marine geology and geophysics. Although designed to meet specific military requirements, projects of Defense elements provide considerable benefit to the civilian sector. For example, the U.S. Navy's development of ice forecasting techniques and establishment of an extensive ice observational program in support of the resupply of Arctic stations have benefited industrial and other civilian operations in the Arctic. Research in basic processes of concern to MAREP is also conducted by Defense through the U.S. Army Corps of Engineers and by the Advanced Research Projects Agency.

The National Oceanic and Atmospheric Administration (NOAA) was created within the Department of Commerce to be a national focus for:

- A unified approach to the problems of the oceans and atmosphere.

AGENCY RELEVANT RESEARCH COSTS, BY FUNCTION

(in thousands of dollars)

	Understanding basic processes		Research directed toward improvement of: Data acquisition		Communications		Data processing		Information dissemination		Agency support of research [1]		Total	
	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73	FY72	FY73
Commerce ...	31,782	41,811	15,368	17,134			523	1,703	558	758	108	108	48,339	61,514
Defense	10,221	10,874	9,173	9,829	487	487	3,618	3,704	133	133			23,631	25,027
Interior	1,680	1,719	50	50							193	197	1,923	1,966
Transportation	2,759	3,903	4,139	5,855									6,898	9,758
AEC	6,679	6,048											6,679	6,048
EPA	3,314	3,684	420	700									3,734	4,384
NASA			2,212	4,027									2,212	4,027
NSF	20,399	18,840											20,399	18,840
Smithsonian .	250	425											250	425
Total	77,084	87,304	31,361	37,595	487	487	4,141	5,407	691	891	301	305	114,605	131,989

[1] Where figures are not given, the funds for agency support of research are included under other functional categories.

- Better understanding, development, and conservation of marine resources.
- Consolidation of efforts toward greater knowledge of oceanic and atmospheric phenomena as well as those of the solid earth.
- A balanced Federal program toward more effective environmental monitoring control.

The NOAA Environmental Research Laboratories (ERL) are organized to conduct a portion of the basic research in fulfilling these responsibilities. The ERL provide a comprehensive study of man's environment, ranging from the solid earth and oceans to the atmosphere and near space. Research by ERL contributes in particular to our knowledge and understanding of the physical marine environment. Marine research, designed to meet these NOAA responsibilities, is also conducted by other major components of NOAA including the National Marine Fisheries Service (NMFS) and the National Ocean Survey (NOS). In addition, the Office of Sea Grant of NOAA supports research projects in marine sciences at institutions throughout the United States in much the same manner as NSF, but the Office focuses its support on the applied aspects of marine resource development, conservation, protection, training, and management. Much of the research effort is relevant to improvement of MAREP.

Basic research will be identified in the following paragraphs under the subsections of physical oceanography and marine meteorology, biological and chemical oceanography, and projects in geographical areas of special interest.

PHYSICAL OCEANOGRAPHY AND MARINE METEOROLOGY

Physical oceanography within the Navy Ocean Science Program is concerned with the physical processes of the sea and their direct and indirect effects on naval operations. To understand, exploit, and predict the capabilities of these processes, the U.S. Navy needs to understand the structure of the sound-speed profile in the ocean from surface to bottom, the temporal and spatial variability of this structure, the nature of the surface and of the bottom, and the effect of all of these factors on sound.

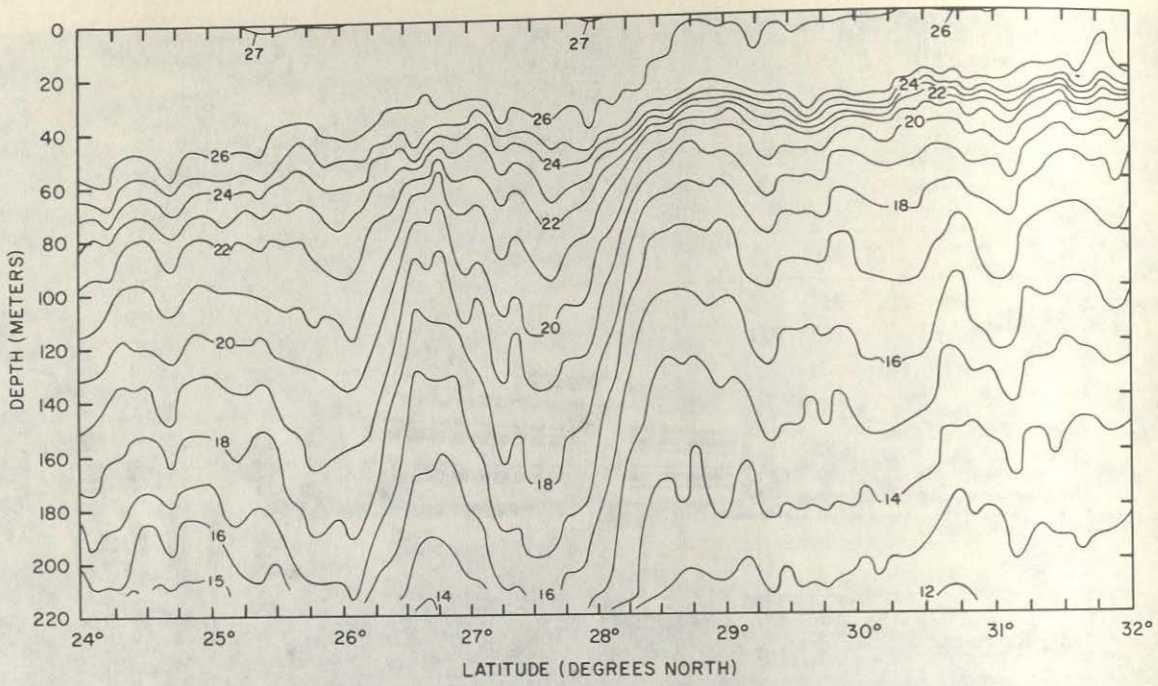
The general inaccessibility of much of the ocean makes it impossible at the present time to gather enough physical data for a synoptic analysis of the state of the ocean as the meteorologists are doing with the atmosphere. As long as it is necessary to depend on sparse sampling at sea, it is mandatory that the Navy understand the cause-and-effect relations between solar and atmospheric driving forces and air-sea response well enough to extrapolate the relatively small data samples over wide areas and to extend these analyses by reasonable prediction.

New laboratory building of the Atlantic Oceanographic and Meteorological Laboratories (AOML). (Environmental Research Laboratories of NOAA)

The complex interaction between the atmosphere and the sea frequently dominates the near-surface antisubmarine warfare (ASW) problem. Waves generated by the wind stir the near-surface waters, altering their sound-speed structure. The same wind sets the surface water in motion as a wind-driven surface current, causing the waves to scatter sound at the surface. Air-sea interaction studies, a major part of the Navy physical oceanography program, are advancing our understanding of the physical and chemical processes involved in these interactions. All scales of activity, ranging from molecular to global and from instantaneous to climatic, are embraced. Specific objectives are to understand and to describe the parameters involved in the processes of energy exchange through the sea surface, to determine the air-sea exchange rates, and to understand the atmospheric influences upon the sea and the oceanic influence upon the atmosphere sufficiently to make accurate predictions.

The Navy presently sponsors a large-scale air-sea interaction study in the North Pacific. The study, initiated by the Scripps Institution of Oceanography, is concerned with the premise that large-scale changes in the circulation of the atmosphere and ocean are closely coupled. Scripps' scientists have established the existence of huge anomalous pools of water in the North Pacific. Under Office of Naval Research (ONR) sponsorship, the relation between these anomalies in the upper region of the North Pacific and climatic anomalies over North America has been demonstrated. Research to date indicates the probability of scientific breakthroughs in the state of the art dealing with the prediction of oceanographic and global weather conditions. Future plans call for the expansion of this effort under Navy (ONR) and NSF (IDOE) management. Phase One of the expanded effort is a 9-year program during which time a massive increase in data buoy stations will be initiated. Plans also include the use of the international oceanographic data transmission frequency bands for communications. Anticipated funding for the project is $6 to $10 million per year. Procurement and operations of the buoy system will be coordinated with the National Data Buoy Center (NDBC) of NOS.

Theoretical modeling of general ocean circulation, including major current systems, has reached the stage at which the need for experimental verification of theory is comparable to the need for adequate theory to account for the observation. Laboratory models of time-dependent flows in rotating basins can now predict the gross features of general circulation.



Thermal structure of the surface layer of the ocean (in degrees Celsius), important in understanding sound propagation. (U.S. Navy)

Specific Navy objectives on small-scale water motion studies are to develop techniques for measuring the internal motions and to determine the oceanwide distribution of energy spectra and classes of motion. The scales of motion are of particular importance to undersea vehicles and research submersibles because the associated changes in density of sea water affect the vehicle buoyancy.

The physical oceanography program of the U.S. Army is related to its Civil Works missions for maintaining navigational channels, controlling beach erosion, and providing protection from natural disasters. This program is concerned with the physical processes and their interactions insofar as they affect man and his environment. The purpose of this activity is the understanding of forces and their impact on engineering design and the resultant interaction on the environment.

The Department of Defense carries out geology and geophysics research on phenomena which affect marine environmental predictions of naval interest. These studies are concerned with the morphology and physical properties of the sea floor and with the natural processes which are active there.

The obvious effects of the sea floor on surface wave motion have been studied for a long time. Incorporation of these effects into operable prediction schemes remains, however, as the goal of a substantial research effort. In the nearshore area, the characteristics of sea, surf, and swell are critically dependent upon the nature of the bottom. In turn, wave motion influences longshore currents, beach formation, and rip tides; the sea floor itself is influenced through wave erosion and by transportation and deposition of sediments.

The prediction of acoustic behavior must take into account the roughness and composition of the bottom and of the acoustic properties of sediments. Accordingly, much Navy research is directed toward understanding sea floor morphology, sediment distribution, and physical properties of sediments. Studies range from those of the dynamic tectonic and sedimentary processes to the minute examination of sediment porosity and grain size. A large number of seismic profiles, samples, soundings, and bottom photographs have been accumulated in support of this as well as other activities.

As we proceed into a decade of increased subsurface ocean operations, it is likely that the importance of marine geological research for environmental prediction purposes will increase. It may become important, for example, to predict the occurrence of turbidity currents to conduct safe deep submersible operations along the continental margins. The Army Corps of Engineers has developed a related research program which, although

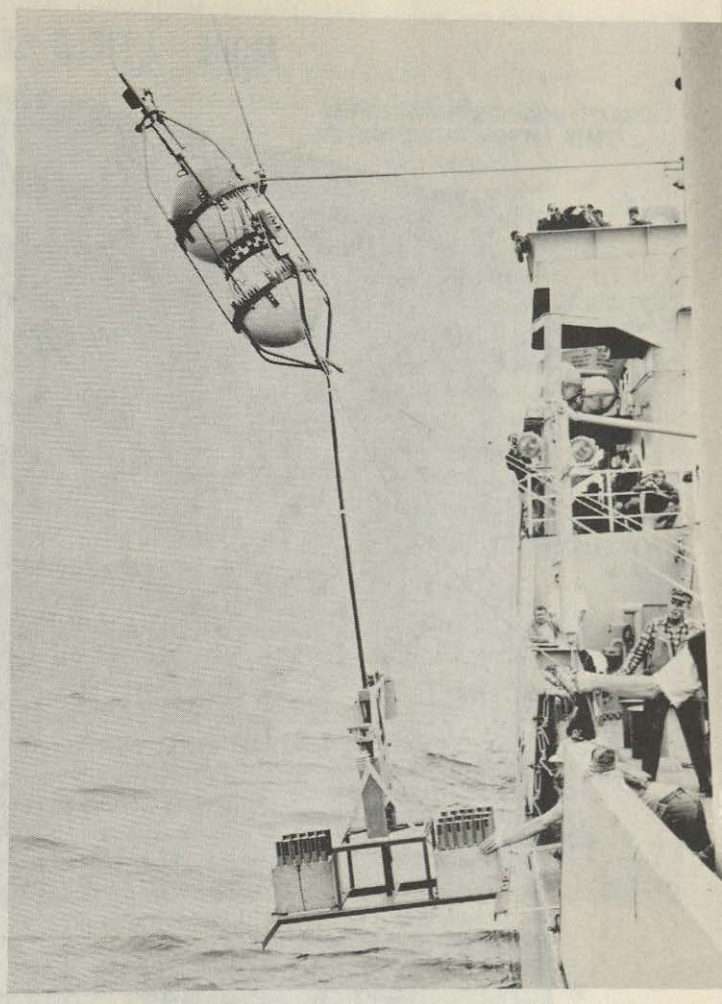
aimed at locating offshore sand and gravel deposits for beach nourishment, may have important economic and environmental aspects. Navy-oriented research into the occurrence of manganese nodules promises similar future economic benefits.

The Oceanography Section of NSF focuses on individual scientific studies of processes occurring in the ocean. These include the physical processes that maintain the sea in motion, dynamics of coastal processes, and scales of oceanographic turbulence. Both the Oceanography and Atmospheric Sciences Sections support research studies on the ocean-atmosphere interface and on theoretical fluid dynamics. A considerable number of interaction studies are involved in the Global Atmospheric Research Program (GARP), an international long-term study to increase our knowledge of the general circulation of the atmosphere and of the physical basis of climate through an improved understanding of the air-ocean linkage. In FY 1973, support will include the numerical modeling of tropical and general circulations and the continued analysis of data resulting from the Barbados Oceanographic and Meteorological Experiment (BOMEX) completed in 1969.

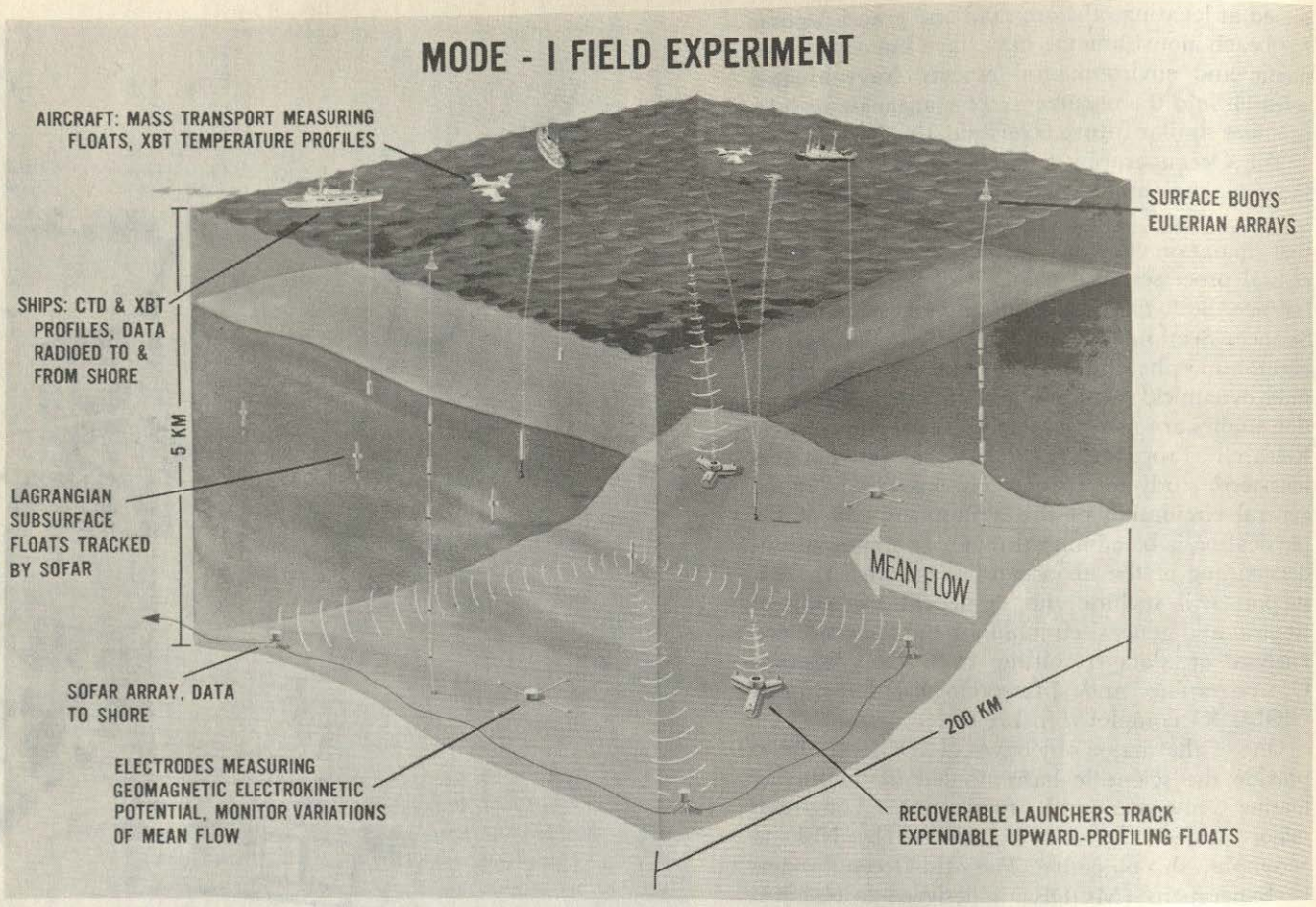
One of the major objectives of IDOE will be to provide the scientific basis needed for improving marine environmental forecasting. Long-term major projects have been selected by NSF to accomplish this objective. The Mid-Ocean Dynamics Experiment (MODE) is designed to obtain a better understanding of middle-scale dynamic processes such as geostrophic eddies and to elucidate their role in ocean circulation and in global climate. The MODE will be carried out in the Atlantic Ocean between Bermuda and the United States, with efforts in FY 1973 devoted to planning, testing of numerical models, and development of instruments. As noted, the Navy's study of large-scale air-sea interaction in the North Pacific, will be expanded as a joint program of ONR and IDOE. The aim of these programs and the others to follow in IDOE will be to support improved forecasting of the marine environment.

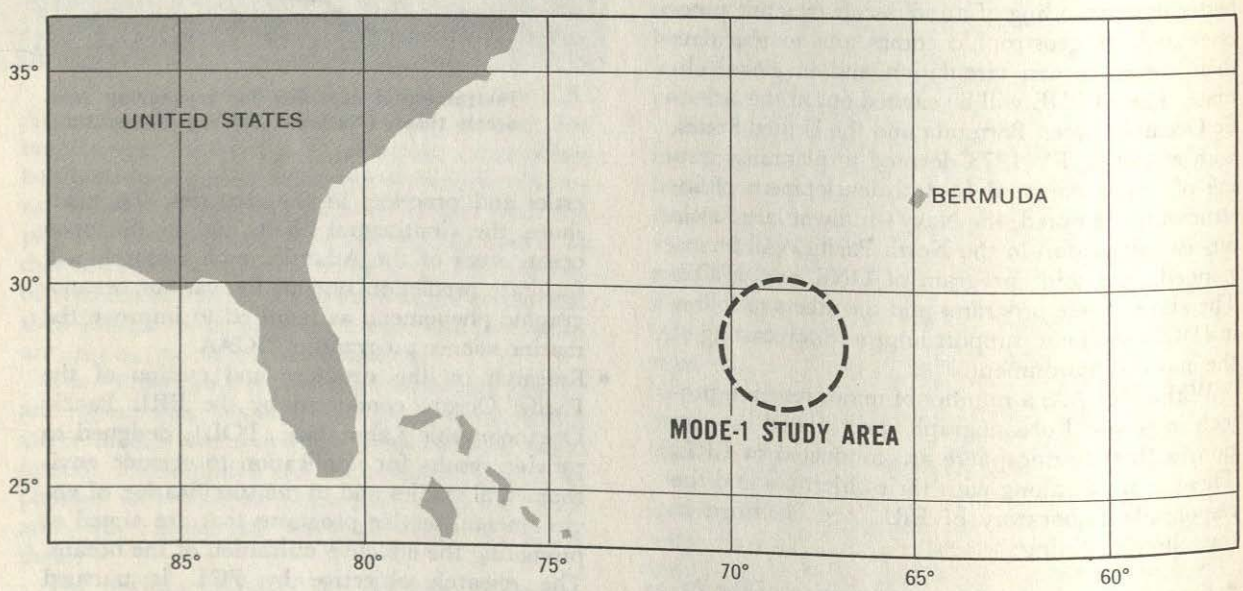
Within NOAA, a number of major research projects in physical oceanography and related interactions with the atmosphere are conducted by ERL. These projects, along with their objectives and the responsible Laboratory of ERL, are identified in the following listing:

- Research on the structure and motion of the Atlantic Ocean, conducted by the ERL Atlantic Oceanographic and Meteorological Laboratories (AOML), designed to increase the understanding of the physical, chemical, and dynamic properties and processes in the estuaries, the nearshore, the Continental Shelf, and in the open ocean areas of the Atlantic; such research will facilitate prediction systems for various oceanographic phenomena as required to improve the marine science programs of NOAA.
- Research on the structure and motion of the Pacific Ocean, conducted by the ERL Pacific Oceanographic Laboratory (POL), designed to provide results for application to oceanic environmental studies and to the specification of environmental service programs that are aimed at promoting the effective utilization of the oceans. The research objective by POL is pursued through carefully designed field experiments and through exploratory field studies that are designed to relate to significant features of ocean dynamics.



Instrumented capsules for measuring mid-ocean tides. (National Science Foundation)





Configuration for the Mid-Ocean Dynamics Experiment (MODE).

- Participation by AOML in MODE to obtain an understanding of the interactions of large-scale flow patterns and the complex smaller scales of motion in ocean circulation.
- Operations of the Sea-Air Interaction Laboratory (SAIL) of AOML that will provide field experiments necessary for the development of models of the energy exchange processes between the ocean and atmosphere, leading to an improved understanding and prediction of oceanic and atmospheric conditions.
- Dynamic oceanographic and seismological studies by POL to increase understanding of the generation, propagation, and runup mechanisms of tsunamis which will provide basic knowledge and improve tsunami prediction techniques.
- Computer modeling research in dynamic oceanography and meteorology by the ERL Geophysical Fluid Dynamics Laboratory (GFDL) to develop a comprehensive theory of the large-scale circulation of the ocean. The successful incorporation of the theory in the form of numerical models will be useful for pollution studies of large water bodies, for long-range forecasting of sea-surface temperature, and for joint air-sea model studies of sensitivity of the earth's climate to large-scale atmospheric pollution.
- Research projects conducted by POL, including investigations of near-surface circulations in response to time-dependent wind stress, of experimental and theoretical studies of wave interactions on beaches, and of open-ocean measurements of tsunamis.
- Continued reduction and analysis of NOAA data from BOMEX by the Center for Experiment Design and Data Analysis (CEDDA). Reduction of BOMEX data obtained by ship, aircraft, and island subsystems is largely completed. Initial analyses have been oriented toward scientific computation formation; data quality, noise, and error evaluation; subsystem intercomparison; and specification of edit windows, filters, lag corrections, and calibrations to system standards. In FY 1973, analysis of the core experiment data will be completed, findings will be published, and the data will be transferred to permanent archives.

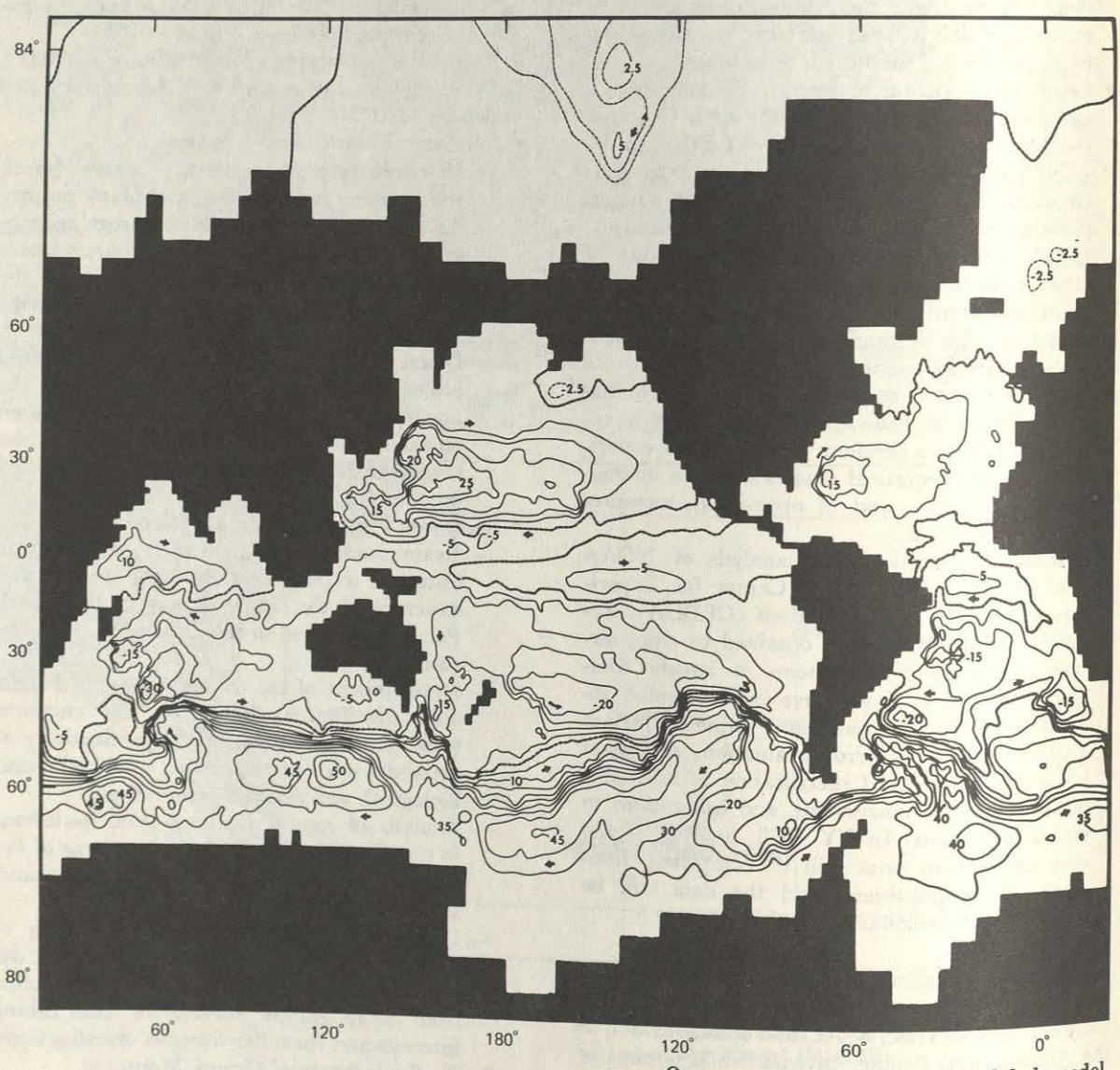
Physical oceanography work in NMFS is conducted largely from the Fishery Centers in Seattle, La Jolla, Woods Hole, Mass., and Miami as well as the Atlantic and Pacific Environmental Groups of the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program in Washington and Monterey. This work is directed toward understanding bioenvironmental relations in those areas where the living marine resources are of importance to the United States. Oceanographic conditions of major significance are: (1) variations in the location and properties of water masses as they influence the distribution and reproduction of species; (2) variations in the location and strength of currents as they influence the migrations of fish and the distribution of planktonic organisms, especially the eggs and larvae of resource species; and (3) current divergences, surface gyres, and wind-stress transport as the driving forces of upwelling and the resulting nutrient enrichment, primary biological productivity, and production of forage organisms of resource species.

Physical oceanographic investigations at NMFS facilities include the following which are funded under the MARMAP Program:

- Northwest Fishery Center, Seattle.
  - — Determination of currents, oceanic fronts, water-mass characteristics, and plankton production in the Pacific subarctic from oceanographic surveys, calculated wind-stress transports, and current drifters in relation to the migration and abundance of the Pacific salmon.
  - — Description and forecasting of flow and ecology in the groundfish area along the northwest coast of the United States, based on examination of the shifting location of the nearshore divergence zone of the zooplankton populations.
- Southwest Fishery Center, La Jolla.
  - — Examination of sea-air interactions, based on historical records in establishing the thermal structure of the upper waters in the North Pacific in relation to the distribution of albacore tuna.
  - — Development of the means to predict Pacific tuna distributions based on the currents, water masses, and biological productivity as derived from oceanographic, meteorological, biological, and fisheries observations.
  - — Analysis of long-term, large-scale variations in the thermal and circulation patterns of the North Pacific from participating merchantship observations.
  - — Description of the currents, distribution of their properties, and examination of the dynamics of island wakes in the central Pacific from oceanographic surveys for tuna fishing interests and for other fisheries investigations.
- Pacific Environmental Group, Monterey.
  - — Relation of upwelling of the California coast to variations in wind-stress transport.

— Development of a hydrodynamic numerical circulation model for the eastern North Pacific.

- Southeast Fishery Center, Miami.
  — Determination of surface currents in the Caribbean Sea, based primarily on drift bottle data from a collaborative project in the Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR) Program.
  — Development of the dynamical oceanography of the tropical Atlantic, based on survey data from the International Cooperative Investigations of the Tropical Atlantic (ICITA).
- Atlantic Environmental Group, Washington.
  — Determination of the Continental Shelf circulation off the U.S. Atlantic coast. The analyses are based principally on the historical data files of the NOAA Environmental Data Service (EDS) and on the data information from research and surveys of the U.S. Coast Guard, the U.S. Navy, the National Environmental Satellite Service (NESS), the National Weather Service (NWS), and from the MARMAP surveys of NMFS. Variable driving forces considered are: (1) the strength of the Gulf Stream and its distance



Ocean currents predicted by global model, assuming homogeneous ocean and actual-bottom topography. (Geophysical Fluid Dynamics Laboratory, Environmental Research Laboratories of NOAA)

from the Shelf; (2) eddy production by the Gulf Stream; (3) wind-stress transport; (4) coastal runoff; and (5) annual temperature cycle.

— Development of the mechanics of circulation of the Gulf of Mexico, based principally on analysis of 2 years of detailed oceanographic survey data from NMFS vessels and of anticipated data from the Engineering Experimental Phase (EEP) buoys, placed in the Gulf during 1972.

Responsibility for coordinating U.S. multiagency participation in the GARP Atlantic Tropical Experiment (GATE) has been assigned to the Department of Commerce; other participants include Defense, Transportation, Atomic Energy Commission (AEC), National Aeronautics and Space Administration (NASA), and NSF. The GATE project is designed to study the meteorology of the tropical oceans, with the objectives to gain a better understanding of the general circulation of the atmosphere and to increase the ability of meteorologists to model and predict weather for extended periods into the future. An international array of ships will be placed in the tropical Atlantic (from latitudes 10°S. to 20°N. and from longitudes 40°E. to 90°W.) from mid-June through September 1974 to measure the parameters required to achieve these objectives.

In addition to the meteorology program, an oceanographic program will be conducted. The U.S. portion of the GATE oceanographic program is being developed by a task group of the National Academy of Sciences Ocean Affairs Board.

A GATE project office has been established at NOAA, and scientists have been identified at universities and other laboratories to assume the specific responsibilities for developing the detailed scientific plans for GATE. The United States will continue to provide long leadtime on production hardware items and will pursue the development of computer programs. A U.S. trial-field program will be conducted during the winter of 1972–73 to test hardware and computer programs. In the late summer of 1973, an international trial-field program is planned to assure that items such as platforms, hardware, and observing techniques to be employed by the participating nations are compatible for the conduct of the principal observational phase during the summer of 1974. Procurement of production hardware will be accomplished, and computer programming will continue in FY 1973.

The Coast Guard basic research program in physical oceanography includes investigations of the Arctic water masses and coastal studies. In support of the International Ice Patrol, research is being conducted on water-mass exchange and on currents affecting the occurrence and distribution of icebergs and sea ice in Baffin Bay and in the Grand Banks off Newfoundland. Another Coast Guard research and development program, designed to improve its capabilities to perform search and rescue (SAR) missions, involves the investigation at sea of the response of various boat hulls, rafts, and lifesaving devices to wind, waves, and currents. In addition to these leeway studies, an intensive research effort is being conducted to improve the ability to predict ocean surface currents. An operational system has been developed under a Coast Guard research and development program which permits surface current and volume transport determination from aircraft. This system will have application in pollution monitoring, SAR efforts, and iceberg movement studies. Numerical prediction models will be developed for surface currents in simple and complex regimes of marine environments. Existing prediction models can be "tuned" or updated with the operational airborne-measuring system.

The AEC supports research related to MAREP through the development of a capability to document, evaluate, and understand explosion-generated water waves resulting from nuclear detonations at or near the surface of the ocean. Ongoing efforts include theoretical studies on the shoaling phenomenology of such waves and investigations required to predict and to document the effects of a water wave resulting from seismic activity caused by a nuclear explosion.

BIOLOGICAL AND CHEMICAL OCEANOGRAPHY

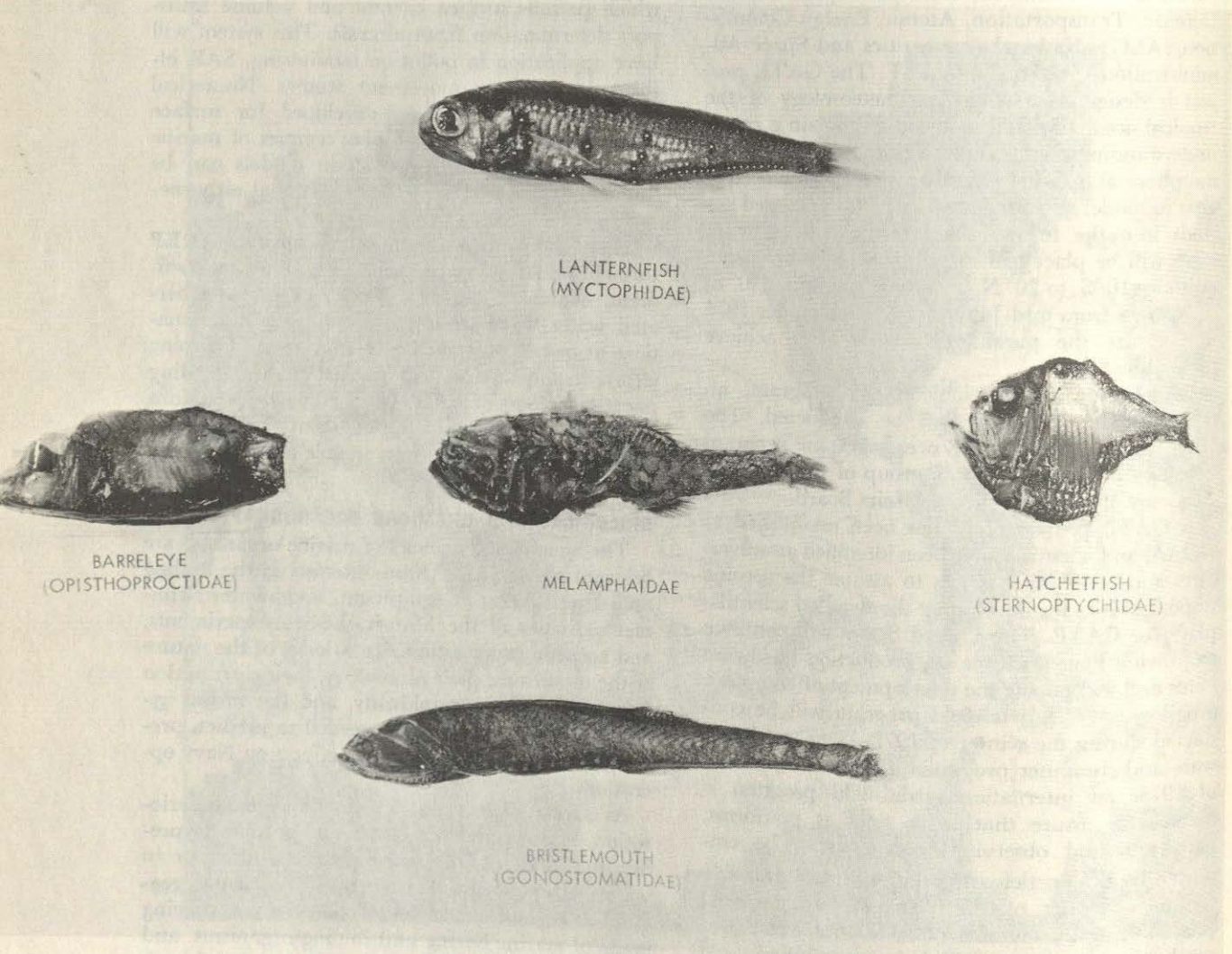
The biology and ecology of marine organisms are relevant to such U.S. Navy interests as the fouling and deterioration of equipment, underwater swimmer activities of the Man-in-the-Sea experiments, and acoustic propagation. Knowledge of the nature of the organisms, their physiology, their distribution seasonally and geographically, and the means required for their control are needed to predict, prevent, or minimize their adverse effects on Navy operations.

As a result of investigations on biological deterioration, fouling, and corrosion, it is possible to predict the kinds of infestations which will occur in waters of known properties and in particular geographic regions. Worldwide collections are being made of marine boring and fouling organisms, and their characteristics are being studied and archived. Active and destructive boring organisms appear abundant, even to depths of 2,000 meters.

A major program is being conducted on the acoustical properties and behavior of marine organisms that actively or passively alter the operational efficiency of the Navy acoustic systems. The active members are those organisms that contribute to background noise by their own acoustic-signal emissions. The passive components are the large mammals, schools of fish, and plankton that scatter sound, appearing as false targets or background reverberation or attenuating the acoustic signal.

Oceanic biologists record and analyze sounds produced by marine animals, their geographic and temporal distribution, and their behavior as it relates to sound production. A concentrated effort has been made to identify sounds of biological origin. An example is a recently published account of a comprehensive 15-year study on underwater sounds of biological origin. The research involves 206 species in 54 families of fish along the U.S. Atlantic coast and off the islands of the Caribbean Sea.

The objectives of the Navy research in chemical oceanography are to determine the chemical constituents of sea water and to elucidate ways in which they react in the marine environment. The diverse program in chemical oceanography includes studies of organic and inorganic chemical composition, geochemistry, trace-element chemistry, physical chemistry, radioactive-isotope chemistry, and exchange of chemicals at the air-sea surface.



Representatives of five families of swim bladder-bearing fishes which are important sound scatterers.

In FY 1973, the Navy has proposed research on the fate and effect of open-ocean disposal of biodegradable shipboard wastes. Efforts are continuing to relate parameters being measured for military purposes to environmental indexes of water quality. Thermal and chemical gradients suitable for remote detection and quantification will be explored in the FY 1973 to FY 1975 timeframe.

The necessity to evaluate fully the impact of construction and dredging operations on the environment has impelled the Department of the Army to develop a comprehensive research program which evaluates the impact of construction activities on the ecosystem. This program includes evaluation of techniques for disposal of dredge spoil, creation of manmade marshlands from unpolluted spoil, and impact of protective structures on the ecosystem. Also related to this effort is the study of nitrogen saturation and its impact on the estuaries.

The NSF, through its Oceanography Section, awards grants for research on the biota of the sea and their interaction with the marine environment. Such studies include the distribution, abundance, nutrition, and behavior of living organisms as well as the metabolism of marine organisms involving respiration, nutrient uptake of plants, feeding habits of animals, and elemental cycling rates.

U.S. Coast Guard efforts in chemical oceanography are programmed toward oil pollution in the marine enviornment. Top priority has been devoted to oil pollution baseline studies and to the development of analytical capability that will help the Coast Guard establish a monitoring system for pollutants. Emphasis has been placed on shipboard analysis, although in-house laboratory capability development is underway to support this and contract efforts. Current Coast Guard research and development projects include investigation of natural oil seeps, utilization of Ocean Station Vessels (OSV) for pollution data collection, and construction of a harbor oil-pollution index.

The AEC supports oceanographic research that is directed toward determining those environmental factors which influence the movement of radioelements through the marine environment, possible radiation effects on marine biota and biotic processes, and possible means and rates of return for radioactivity to man through the marine food chain and the basic ecological processes. Within this broad research program are studies on problems related to operational activities such as the impact of waste heat from nuclear power stations on the ecology of the adjacent area at such sites.

The Commission has identified certain areas within its marine research program which will be accelerated during the next several years. These areas include expanded research efforts in understanding the impact of thermal additions to the aquatic environment, in increasing information on the biogeochemical behavior of plutonium in both freshwater and marine environments, and in preparing ecological studies associated with the siting of nuclear powerplants.

The AEC thermal research program will cover a broad spectrum of topics, ranging from the effects of temperature changes on the biochemical and physiological responses of organisms to the effects on social behavior and predator-prey interactions. Studies include both laboratory and field investigations. Studies on the behavior of plutonium in the aquatic enviornment will be intensified, adding to the understanding of the major processes that affect its fate and transport in these regimes. Study sites will include the major oceans, Great Lakes, Columbia River, and former testing sites in the Pacific. Broad-based ecological and radioecological studies will be conducted at existing and planned powerplant sites.

In addition, the AEC supports research conducted by other Federal agencies as follows: the U.S. Geological Survey (USGS) of the Department of the Interior in FY 1972 completed a study on the ultimate fate of radionuclides in the Columbia River estuary as part of its own activities to predict better the time-space distribution of substances in estuaries that have large flows and turnovers of water; the NMFS Atlantic Estuarine Fisheries Center of NOAA at Beaufort, N.C., is studying the cycling of trace elements in an estuarine environment, the energy relations in estuarine ecosystems, and the influence of environmental factors on the radiation response of estuarine organisms; and the NMFS Middle Atlantic Coastal Fisheries Center at Sandy Hook, N.J., is investigating the sublethal effects of thermal additions on marine ecosystems, the effects of temperature and photo-period on fish spawning, and the effect of temperature on activity rhythms.

The Office of Water Programs in the EPA has projects in water-quality control technology and in water-quality requirements research that are intended to supply the description and prediction of the types, concentrations, and movements of pollutants in coastal waters and of the effects of pollutants on life.

Within NOAA, NMFS conducts a variety of research directed toward understanding the basic requirements of species in commercial and recreational fisheries and identifying the impact of overfishing on the stock. This research involves studies

Double plankton-sampling array used to collect fish eggs and larvae to determine the distribution and abundance of living marine resources. (National Marine Fisheries Service)

to: (1) enumerate and identify the animal and plant life present in different ecosystems and geographical areas; (2) determine the population dynamics and life histories of marine and anadromous species of sport and commercial importance; and (3) identify the physiological processes of these animals and ascertain their environmental requirements for reproduction, growth, and survival. Research also involves studies of the behavior of commercial and recreational species in relation to each other, to their environment, and to the gear man uses to capture the species. These data are used in conjunction with resource survey data to correlate the results of assessment work and to make predictions of future abundance of different species of fish. Examples of studies underway are: (1) the identification of races of stocks to ascertain geographic distribution; (2) the identification of living marine resources in the New York Bight, San Francisco Bay, Northeastern Gulf of Mexico, Puget Sound, and Valdez Bay; (3) the characterization of the life histories of organisms; (4) the physiological processes and requirements of organisms; and (5) the characterization of the behavior of porpoises and menhaden to fishing gear and of sport and commercial fishes to fixed platforms and artificial reefs. This research, at a cost of $10,313,000 in FY 1972, was carried out in laboratories dispersed along the Atlantic Ocean and Gulf of Mexico in a coastal geographic distribution from Boothbay Harbor, Maine, to Port Aransas, Tex.; along the Pacific coast from Kodiak, Alaska, to La Jolla; and across the central Pacific to Honolulu. Major vessels are assigned in support of research. An additional $2,345,000 was used for the operation and maintenance of NMFS research vessels.

In FY 1973, an additional $1,650,000 will be required for ship operations. The funds include: (1) $700,000 for reactivation of the *Miller Freeman* and installation of bow thruster; (2) $474,000 to restore to full-time operation the *Charles H. Gilbert* and *Delaware II;* and (3) $476,000 for major maintenance of other active vessels.

The NMFS is also conducting ecological research to determine the effects of natural and man-induced changes in the estuarine and marine environment. At a cost of $3,562,000 in FY 1972, efforts were made to: (1) develop the baseline information on the amount and rate of accumulation of stable pollutants such as polychlorobyphenyls (PCB), pesticides, and heavy metals; (2) identify the pathways and rates of accumulation of contaminants in the various components of the ecosystem; (3) understand the basic physiological implications of man-induced pollutants; and (4) understand the cause and prevention of red tide outbreaks. The research data accrued are collated to develop an understanding of the impact of contaminants on the dynamic processes that operate in marine ecosystems and to determine how adverse impacts can be prevented or mitigated. The research was concentrated in nearshore waters of the coastal zone and on sport and commercial species that spend most or some of their life cycle in these waters. Included are: (1) studies to develop corrective action in the New York Bight where for years there have been massive dumpings of pollutants such as sludge, chemical wastes, and munitions; (2) studies

in the Gulf of Mexico which concentrate on the impact of water resources demands, for example, irrigation, dredge, and fill activities; and (3) studies in the Pacific Northwest which focus on the impact of oil spillage, mining effluent, lumbering, and pulpmill wastes.

In FY 1973, the NMFS will require an additional $649,000 for further ecological investigations of the New York Bight as part of the NOAA Marine Ecosystem Analysis (MESA) Program. These investigations will be on the establishment of ecological baselines to define the composition, abundance, and distribution of aquatic species and to correlate these with nutrient levels, contaminants, plant-animal life compositions, and other environmental factors in the area. Of equal importance will be the assessment of effects of stress on aquatic ecosystems through field observations and laboratory experiments to determine the physiological changes caused by contaminants. Stresses from ocean dumping in the New York Bight in relation to disease problems will receive particularly critical examination. Studies to achieve these assessments will center on intensive biological surveys and on other biological aspects of the ecosystem such as life histories, population dynamics, food-chain relations, and contaminant levels in the living and nonliving segments of the system.

NMFS, in addition to its contribution to MESA, conducts a program on control of contaminants in marine fishery products with the objective of protecting the fishing industry and the consumer.

To achieve this objective, the following program goals are defined: to delineate and monitor the nature and extent of marine contamination in fish and shellfish; to determine the feasibility of removing contaminants from fishery products; and to define the consumption patterns of fishery products. Program components include: (1) a survey of over 90 species of commercial and sport fish to determine as many as 16 toxic trace elements; (2) a survey of 40 fishery products to determine five trace elements (essentially completed); (3) more detailed surveys on specific species where potential contamination problems are indicated; (4) specific surveys for PCB and dichlorodiphenyltrichloroethane (DDT) contamination; (5) development of analytical methodology; (6) studies to determine the consumption patterns of major fishery products in relation to the development of realistic regulatory guidelines; (7) monitoring the increase or decrease of contaminant levels in fishery products; (8) studies to determine the chemical form of contaminants in fishery products and their availability to humans; and (9) establishment of a national data bank. These activities were funded in FY 1972 at a level of approximately $500,000.

The NMFS also helps support a large variety of State investigations of the fish and fisheries of the coastal and estuarine waters of the United States as well as those of the Great Lakes. This grant-in-aid support, on a cost-sharing basis, is part of the State-Federal fisheries management program; the Federal Government enters into partnership with the States in a coordinated effort for the conservation, management, and development of the Nation's fishery resources and the supporting aquatic environment.

Of the total grant-in-aid program, about $1,820,000 is used to develop basic understanding of the living marine resources and their environment.

NOAA's Office of Sea Grant supports a number of activities in the biological and chemical oceanography category, designed to improve capabilities in marine organism assessment at various institutions around the country.

Research, contributing ultimately to long timescale predictions of the MAREP Services, is sponsored in estuarine ecology and tropical marine ecology by the Smithsonian Institution. These investigations are conducted at the Museum of Natural History, at the Chesapeake Bay Center for Environmental Studies, and at the Smithsonian Tropical Research Institute. In its effort to examine the impact of man on the environment, the Smithsonian will expand the research program at the Museum and the Chesapeake Bay Center. In addition, the program at the Smithsonian Tropical Research Institute will be increased to assess the potential consequences of building a sea-level canal to provide a ship-transit route between the Atlantic and Pacific Oceans.

PROJECTS IN GEOGRAPHICAL AREAS OF SPECIAL INTEREST

Research activities are traditionally categorized either by disciplines or by scientific objectives, but deviations from these divisions are frequently necessary to cover areas of special or unusual interest or to cover areas requiring special approaches. The polar regions and the coastal zone require special approaches; the former is concerned with the behavior of ice and the extreme conditions of high latitude, while the latter involves a multidisciplinary approach to understand the coastal processes. Interest in other special areas, such as the Great Lakes, develops because of economic importance, crises, or unusual opportunity. For these reasons, separate attention has been given to these areas over many years.

The Arctic

For many years, the U.S. Navy has emphasized research in the Arctic, first as one of the great unexplored regions of the world and later as one of strategic importance. More recently, the potential of the Alaskan North Slope oil discoveries has prompted increased activity as the need to know, understand, and predict this hostile environment becomes greater. The Navy mission to protect U.S. interests on the high seas has taken on a new dimension with the successful passage of a structurally reinforced commercial oil supertanker through the Northwest Passage.

Arctic Ocean science shares the basic objectives common to the Navy and to the national interests in all oceans. The principal Navy objective is to acquire a comprehensive body of scientific and engineering knowledge essential to naval operations in the Arctic Ocean and its approaches. Physical, chemical, and biological interrelations of the ocean, atmosphere, and maritime lands provide a framework for investigations leading to knowledge that will permit effective use of the Arctic. Such use requires an understanding of the characteristics unique to polar seas, such as the perennial ice pack and its contiguous areas of seasonal ice, the perennially frozen ground of peripheral lands, and the pronounced ionospheric disturbances exemplified by the aurora borealis. Development of all-weather logistic techniques and training of personnel for arctic living and operations constitute a continuing objective.

The Naval Arctic Research Laboratory (NARL) is a research facility located about 4 miles north of Barrow, Alaska. Today as at its inception in 1941, NARL is the only U.S. laboratory devoted to full-time support of research in the Arctic. Its position on the shores of the Arctic Ocean at the northernmost limit of the United States presents unique opportunities to attain arctic research objectives.

From NARL, the Navy operates several field stations including research stations on ice islands. Research at these stations encompasses programs in gravity, magnetics, underwater acoustics, seismology, micrometeorology, physical and chemical oceanography, sediment-coring and heat-flow measurements, ice physics, and ice drift. These programs have been supplemented by airborne studies on the distributions and dynamics of pack ice.

The Advanced Research Projects Agency funds research conducted by the Naval Oceanographic Office (NAVOCEANO) in environmental properties of the arctic marginal sea-ice zone and in remote sensing by laser techniques of the surface characteristics of arctic sea ice.

Naval Arctic Research Laboratory, Barrow, Alaska.

A special case of air-sea interaction arises in polar regions where ice cover is present, either permanently or intermittently. The energy-exchange relation between the sea and ice and between ice and the atmosphere is under investigation as a part of the Navy arctic program in ocean science; research on the relation will provide a data base for reliable prediction and forecast. The USGS participates in this program through support of some data collection and by mathematical analysis of ice movement and fracturing.

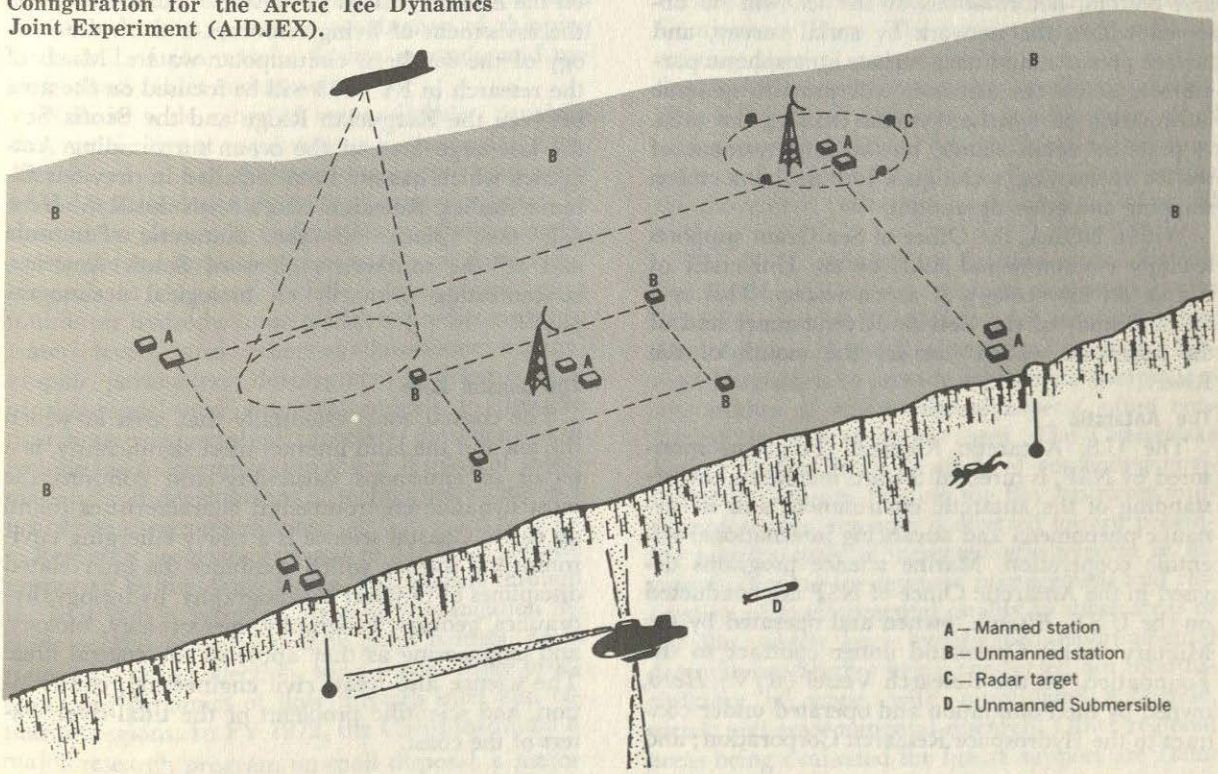
These and other arctic programs have made significant contributions to knowledge of the Arctic Basin geology and crustal structure; of the rate of ice formation, dissipation, deformation, and drift; and of underwater acoustics. The arctic investigations by the Navy have produced many practical applications, including improved survival techniques, aircraft landings on ice, use of ice for camp construction, over-the-ice vehicular movements, ice breaking, ice forecasting, ice penetration by submarines, and bathymetric charts of the Arctic Ocean.

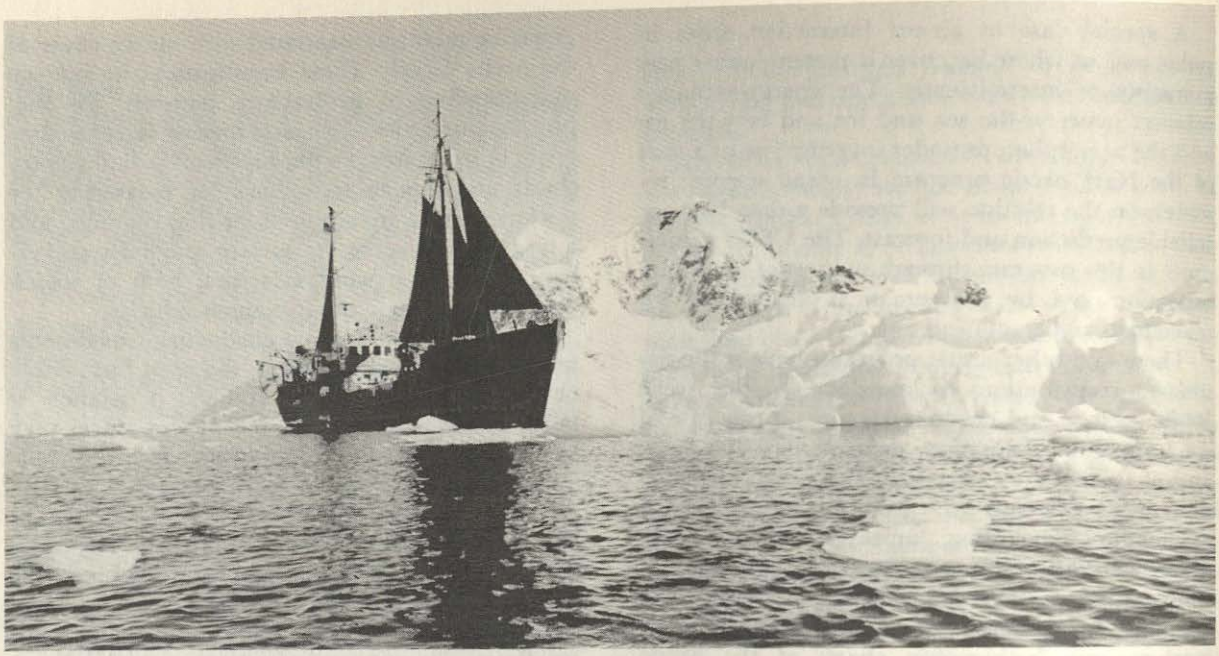
The U.S. Army Corps of Engineers, through its Cold Regions Research and Engineering Laboratory (CRREL) at Hanover, N.H., investigates engineering problems associated with the ice cover of the Arctic Ocean. These investigations include an understanding of ice-fracture patterns, ice fog, physical properties of ice, and driving forces as they relate to structures; an improvement in bathymetry charts and remote techniques for measuring ice thicknesses that are required for ship routings; and a means for detecting ice-surface roughness and effects of extreme wind velocities, both of which affect the operation of air-cushion vehicles.

The U.S. Coast Guard is conducting experiments to classify ice pressure ridges, the most formidable obstacles to arctic transportation. A relation is being sought whereby the thickness of ridges may be estimated from the height of the sail portion.

The arctic program in marine research of NSF will be concentrated in FY 1973 on the Arctic Ice Dynamics Joint Experiment (AIDJEX). The AIDJEX Project is a cooperative venture between the United States, Canada, and Japan, with several U.S. agencies contributing both scientific and logistic efforts. The principal objectives of AIDJEX are to relate sea-ice dynamics and deformation to wind and current stresses and to advance the knowledge on the heat budget of the Arctic Ocean. In this Project, five major research stations, forming a closed area of about 100 kilometers on the side, will be established as a network in the ice north of Alaska. These manned stations will be supple-

Configuration for the Arctic Ice Dynamics Joint Experiment (AIDJEX).





Research Vessel *Hero* in Antarctic waters. (National Science Foundation)

mented by instrumented automatic buoy stations for additional atmospheric and oceanographic information. The full-scale field project is planned from March 1974 to August 1975. During this period, stresses on the ice will be measured at the top and bottom, deformations of the ice will be observed within the network by aerial survey, and surface pressures and near-surface atmospheric parameters across the network will provide synoptic information on weather systems crossing the area. A practical result should be the improvement of sea-ice forecasting techniques for use in northern shipping and other operations.

Within NOAA, the Office of Sea Grant supports a major environmental study by the University of Alaska on the ecology of arctic waters. This is a baseline study of the Colville River estuary and of the nearshore waters just off the mouth of the River.

The Antarctic

The U.S. Antarctic Research Program, sponsored by NSF, is directed toward increasing understanding of the antarctic environment and its dynamic phenomena and advancing international scientific cooperation. Marine science programs devised in the Antarctic Office of NSF are conducted on the U.S.S. *Eltanin,* owned and operated by the Military Sealift Command under contract to the Foundation; on the Research Vessel (R/V) *Hero,* owned by the Foundation and operated under contract to the Hydrospace Research Corporation; and on icebreakers operated by the Coast Guard. Participants in these research programs include scientists from universities and Federal agencies. Studies on the *Eltanin* related to MAREP include those on the assessment of living resources and on the ecology of the southern circumpolar waters. Much of the research in FY 1973 will be focused on the area between the Kerguelan Ridge and the Scotia Sea, the last large area of the ocean surrounding Antarctica which has not been included in previous *Eltanin* studies. Research efforts with the R/V *Hero* will take place off the Antarctic Peninsula and off the southern regions of South America, concentrating primarily on biological oceanography.

The Coastal Zone

The coastal zone, essentially that area at which the sea and the land interact most significantly, is a sector of enormous variability and contains the most dynamic environmental characteristics found on earth. Coastal science is a newly emerging environmental science which combines the interrelated disciplines of physical oceanography, hydrology, hydraulics, geology, geography, meteorology, biology, and engineering as they apply to the coastal area. The science also treats civil engineering, conservation, and scientific problems of the tidal-river waters of the coast.

The Department of Defense is concerned with a highly specialized type of riverine warfare that has resulted from the war in Vietnam. The geographic area is generally defined as a network of rivers, canals, streams, irrigation ditches, rice paddies, and swamps. It includes heavily forested areas as well as flat, open land. Of particular interest in riverine operations is navigational information—water depth, currents, and tidal effects—and meteorological predictions of storms, sea state, swell, winds, and surf in the immediate coastal regions.

Search, salvage, and recovery operations form an integral part of the naval activities. Usually these activities occur within the coastal zone and require special considerations if they are to be executed successfully. Environmental data about the prospective search area must be obtained: actual and predicted weather conditions; surface waves; magnetic conditions; bottom composition and topography; type of beach, land, and land cover; underwater visibility; marine growth; temperature, salinity, and density of sea water; tidal data; and distance to available port facilities. These data are necessary to select search strategies, equipment, and effectiveness probabilities.

Construction on the Continental Shelf necessarily involves detailed knowledge of the areas under consideration—prevailing weather, currents and tides, bearing capacities, earthquake and fault zones, sediments, presence or absence of shipping lanes and of commercial fishing grounds, and underground cables and moorings.

With its wide range of responsibilities, capabilities, and stringent requirements in the coastal zone, the Navy is one of the most demanding consumers of the practical and theoretical coastal science. To meet these demands, various Navy offices contribute to the accumulation of coastal zone data. Navy research in the area includes development of a multilayer hydrodynamic model to predict currents, water levels, and other shallow-water oceanographic parameters; development and verification of theoretical and empirical models to describe nearshore oceanographic processes; development of techniques to permit a simplified display of information; and development of techniques to improve nearshore survey operations.

Research programs relevant to MAREP are also supported by the Army Corps of Engineers through its Civil Works Program. Areas of investigation include coastal ecology, aquatic plant control, environmental data collection, wind waves, shore processes, and dynamics of flow through inlet and estuarine regions. In FY 1972, the Corps instituted a major research program on spoil disposal, a major problem in the maintenance of navigable streams. Recognition that waste water had been polluting the environment and contaminating the sediments that were to be dredged led the Corps to initiate studies in FY 1971 to correct this deficiency.

The Corps is serving as the lead agency in the development of a comprehensive resource study of Chesapeake Bay. This study includes the design and development of a scaled physical model and shelter to be located in Maryland. In addition, the Corps is conducting environmental studies on the Chesapeake and Delaware Canal, San Francisco Bay, and Trinity Bay, utilizing physical models to evaluate the impact of sedimentation and other changes on the ecosystem of each environment. The Corps has been serving as the lead agency for an interagency committee of field elements studying the Louisiana coast.

The Coast Guard Office of Research and Development is conducting experiments to measure the advection and diffusion of floating or suspended pollutants in the shelf waters adjacent to U.S. coastlines. Wind-induced surface water drifts will be studied using dye techniques and aerial observations. The significant mixing mechanisms to be measured are the Ekman circulation, Langmuir circulation, and thermohaline instability. In addition, water movement information will be provided for various major harbors to enhance Harbor Pollution Contingency Plans. The project involves collating existing physical oceanographic data and making field measurements to develop prediction models. The leeway and diffusion of various types of oil under varying wind and sea conditions will be studied to enhance the Coast Guard's ability to predict the movement (advection and diffusion) of an oil spill.

The NSF, through its Environmental Systems and Resources Division, sponsors two programs on MAREP research in coastal and estuarine areas. The objective of the Regional Environmental Systems Program is to provide support for comprehensive studies of environmental aspects, often conflicting, in several major areas. The Chesapeake Bay study-area is an example of conflicting environmental aspects. Because the Bay has many multi-purpose uses, research is directed toward providing benefits such as increased effectiveness in regional planning for resource management and restoration of environmental quality in those areas of the Bay which have experienced environmental degradation. Studies being conducted are interdisciplinary in scope, with interrelated economic, social, and environmental research. Other regional areas being evaluated for future support are Dela-

ware Bay, San Francisco Bay, and Long Island Sound.

Another program by the NSF Environmental Systems and Resources Division is directed toward environmental aspects of trace contaminants, with a broad aim of assessing the effects of contaminants on the environment and of providing a basis for the development of methods for their control. Some estuaries and coastal areas, behaving as closed systems, provide good opportunities to study trace contaminants. These areas are often important as sources of human food and as breeding grounds for commercially valuable marine species.

Another major program sponsored by NSF under the IDOE is the Coastal Upwelling Experiment (CUE), a study of processes involved in the generation of coastal upwelling. The field experiments will be conducted off the coast of Oregon and will involve aircraft, moored arrays, and research vessels. This CUE program will be augmented in later years by the inclusion of chemical and biological efforts.

The Department of Commerce initiated research activities in estuaries and the coastal zone during FY 1972. Research projects, conducted by NOS, NMFS, and ERL of NOAA, include research on estuarine flushing, on the physical processes occurring along the coastlines and in estuaries, and on the dynamics and ecology of estuarine and coastal waters with respect to living resources.

A major new initiative of NOAA is the Marine Ecosystem Analysis (MESA) Program. A NOAA Plan for MESA has been developed to provide a concerted effort in key coastal areas by Federal agencies, State agencies, and the academic community to develop information necessary for the rational management of the coastal zone. The objectives of this Plan are:

- To describe, understand, and monitor the physical, chemical, and biological processes of marine environments.
- To provide information and expertise required for the effective management of marine areas and for the rational use of their associated resources.
- To analyze the impact of natural phenomena or manmade alterations on marine ecosystems.

The MESA Program will incorporate the facilities, capabilities, and resources of most of the elements within NOAA as a means of permitting a more effective and coordinated approach to generation of knowledge and understanding of marine environmental processes. The Program will provide comprehensive sampling and measurement of circulation patterns, tides, estuarine flushings, water-mass exchanges, physical and chemical properties, and sediments as they relate to the understanding, maintenance, and enhancement of the marine environment. The basic concept of MESA is its focus on discrete marine areas which are in need of immediate attention either because the marine environment has already been seriously damaged or because it is threatened by projected uses. The New York Bight, an area of increasing degradation, has been selected as the first regional project area. Data searches and project designs are scheduled for Puget Sound, Delaware Bay, and off southeastern Florida in FY 1973; these are scheduled as regional projects in FY 1974. The regional project in New York Bight is to be accomplished in four phases: systems analysis and design to determine the origin and fate of pollutants will be completed during the FY 1973 to FY 1975 timeframe; early warning systems will be established during the FY 1974 to FY 1975 period; models for use in predicting modification of the environment will be completed during the FY 1974 to FY 1976 timeframe; and activities will be undertaken to stimulate regional and State participation and assumption of responsibility for programs in their areas of jurisdiction during the period FY 1973 to FY 1976.

The NOS since 1968 has conducted a pilot study on the estuarine circulation in Penobscot Bay of Maine as part of a study program to develop predictions of the flushing rate of estuarine waters. A prediction model under development will be evaluated as part of the program for conducting circulation studies in other estuaries.

A research project of the ERL Marine Minerals Technology Center (MMTC) of NOAA has the objective of developing prediction techniques to assess the effects of marine mining on the environment. Such capability will provide the technical foundation to establish guidelines for operational criteria and to recommend regulations for offshore mining. Current efforts involve primarily state-of-the-art studies and laboratory research aimed at the most fundamental aspects of the prediction problem—the effect on marine life of turbidity and the associated particulate matter dispersed as a result of mining. An expanded program in FY 1973 will permit field tests at the site of an active sand and gravel mining operation off the coast of Massachusetts. Studies will be conducted on the interaction that will be expected with time upon all three elements of a marine mine—material being mined, surrounding water mass, and marine life—which will follow from the most likely type of mining operations. Research will be started on the development of preliminary dynamic simulation models for

the prediction of this interaction over the economic life of the operating mines.

The Office of Sea Grant within NOAA is currently supporting at academic institutions a number of MAREP-related projects that involve research in the coastal zone and estuarine regions on both coasts of the United States, in the Gulf of Mexico, and in Alaskan and Hawaiian waters.

The Department of the Interior sponsors research relevant to MAREP through the USGS which conducts investigations and research in-house, in cooperation with the States and other Federal agencies, and through outside contracts. This research work includes estuarine hydraulics, changes in water quality, sediment transport and deposition, thermal dispersion and its effects, use of remote-sensing techniques, salt-water intrusion and underground encroachment, tidal discharges, relation of streamflow to salinity, and effects and distributions of wastes introduced into coastal water bodies. Current field studies are largely completed in the Port Royal Sound of South Carolina and in the lower Columbia River; enlarged activity, including mathematical modeling, will be continued in a cooperative study of Tampa Bay in Florida and in selected prototype estuaries.

The Great Lakes

The NOS Lake Survey Center of NOAA conducts limnological studies on water motion, water characteristics, water quantity, hydrology, and ice and snow associated with the Great Lakes. The primary objective of this research is to establish the present conditions of the Lakes and to define and quantify the complex interrelations of the natural processes occurring in the water masses and at the air-water and water-sediment interfaces. Understanding of these relations forms the basis for forecasting the trends and for determining the effects of manmade changes. Research consists of the data acquisition surveys, data processing, analysis, model formulations, and information dissemination through publication of reports and papers. Since 1967, Lake Survey Center scientists have published over 50 reports and research papers describing the results of these studies. Emphasis in FY 1972 and FY 1973 will be placed on support of projects of the International Field Year for the Great Lakes (IFYGL).

The IFYGL is a joint United States-Canadian study of Lake Ontario within the framework of the International Hydrological Decade. The broad goal is to gain knowledge of the available freshwater supply for widely diverse purposes such as domestic and industrial usage, navigation, power, and recreation. The primary objective of IFYGL is to investigate problems associated with hydrology, meteorology, physical limnology, and geology of a large lake.

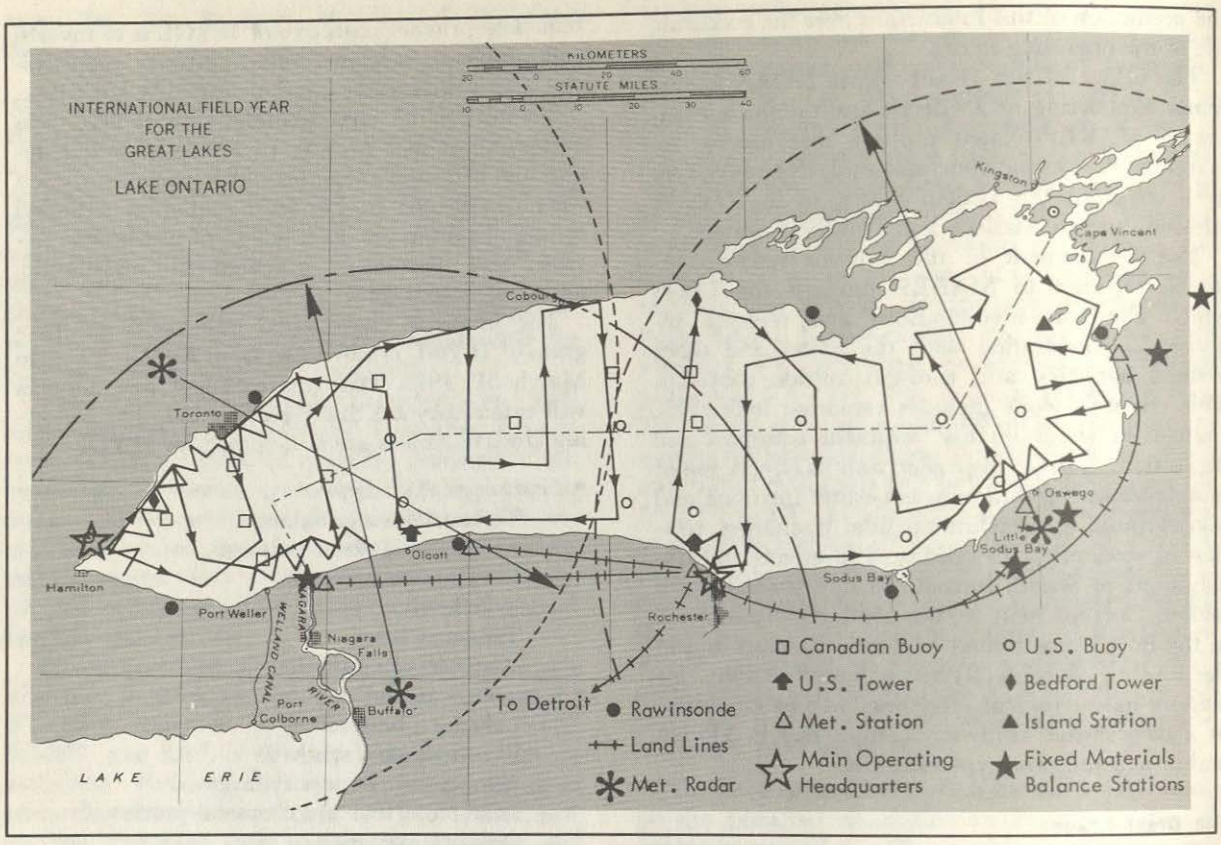
Completion of final planning for IFYGL was accomplished in FY 1970. In FY 1971, initial design and procurement of prototype instrumentation were completed; in FY 1972, activities included testing of prototypes, final design of instrument systems, and instrument procurement, installation, and intercomparisons.

The intensive coordinated data-collection program of IFYGL is scheduled from April 1, 1972, to March 31, 1973. Data management and analysis will extend beyond this 1-year period. The following kinds of studies are anticipated for IFYGL:

- Hydrological studies—
  - — Terrestrial water balance
  - — Atmospheric water balance
  - — Evaporation synthesis
  - — Lake levels
  - — Tributary levels
  - — Water-level simulation
- Limnological studies—
  - — Lake heat budget
  - — Flow-transport synthesis
  - — Atmospheric boundary layer
  - — Lake biological and chemical processes
  - — Coastal circulation
  - — Tributary streamflow and diffusion
  - — Materials balance—lake and selected tributaries
  - — Lake circulation and diffusion
  - — Lake biological and chemical status
  - — Fish populations
  - — Coastal biological and chemical status and processes
  - — Tributary biological and chemical status and processes
  - — Simulation of biological and chemical processes
- Special studies—
  - — Surface waves
  - — Coastal levels—surges and seiches
  - — Lake-ice processes
  - — Lake-effect storms.

Many of these research projects will be conducted by university investigators under contracts funded by Federal agencies.

NOAA has been designated the U.S. lead agency for IFYGL. Also participating are the Departments of Defense, the Interior, and Transportation, and EPA and NSF. The latter agency is contributing to IFYGL through support of university scientists and use of aircraft from the National Center for Atmos-



Locations of data collection stations and proposed ship tracks for the International Field Year for the Great Lakes (IFYGL).

pheric Research which are flying special missions over Lake Ontario during the Field Year.

As part of IFYGL, EPA is responsible for project planning; field surveys and monitoring programs; model development; and data management, analysis, and interpretation in connection with the chemical and biological program. Grants will be initiated in FY 1972 to sponsor specific projects in biomass and chemistry monitoring, nutrients cycling, data analysis, and model verification.

In the Department of the Interior, the Bureau of Sport Fisheries and Wildlife conducts a research program on fish population assessment and limnological characteristics of the Great Lakes. The objectives of this research are:

- To determine changes in fish stocks in various areas of each Great Lake, particularly changes in abundance, size, composition, and age, and to monitor fish stocks annually in different parts of each Lake.
- To study seasonal, annual, and long-term changes in major fish-producing environments of the Great Lakes through continued and intensive sampling of physical, chemical, and biological conditions.

The first survey of the Great Lakes fisheries was made in 1871–72; subsequent surveys were conducted under the direction of the U.S. Fish Commission and the Fish and Wildlife Service. Programs in the Great Lakes were transferred from the Bureau of Commercial Fisheries to the Bureau of Sport Fisheries and Wildlife in October 1970.

The Office of Sea Grant within NOAA also supports Great Lakes research programs of relevance to MAREP at the University of Wisconsin, the University of Michigan, and the State University of New York.

In the Great Lakes, the Coast Guard has been or is presently conducting research programs connected with extension of the navigation season. These experiments deal with ice navigation, icebreaker design, ice formation, and ice reconnaissance. Individual projects include:

- Instrumenting icebreakers with strain gages to measure ice forces on ships' hulls.
- Measuring physical properties of lake ice, including ice strength, thickness, temperature, snow cover, snow friction, and windrow formation.

- Developing a follow-the-wire navigation system for ships entering narrow ice-infested channels. This technique incorporates an energized electrical cable on the lake bottom and associated sensing apparatus on the vessel.

RESEARCH FOR IMPROVEMENT OF MAREP FUNCTIONS

Those functions necessary to the operation of a total MAREP program are data acquisition, communications, processing, and dissemination. Research programs directed specifically toward the improvement of these functions are grouped in the following discussion under two subsections—data acquisition and collection and information processing and dissemination.

RESEARCH FOR IMPROVEMENT OF MAREP DATA ACQUISITION AND COLLECTION

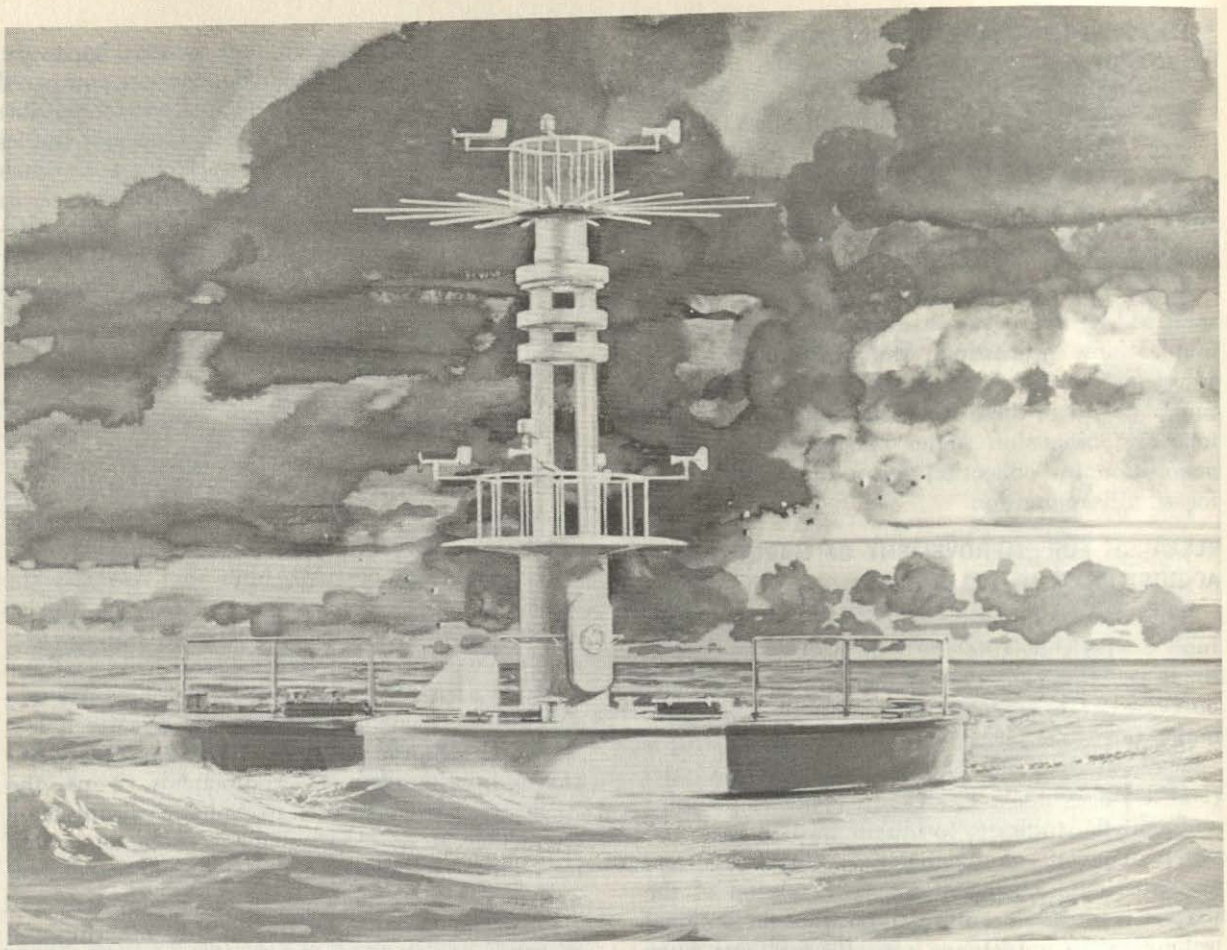
The National Data Buoy Project (NDBP), funded at $13,800,000 for FY 1973, is the largest single research and development program in support of MAREP. The NDBP, established originally under the direction of the U.S. Coast Guard, is now directed by the National Data Buoy Center (NDBC) of NOAA. The Center conducts planning and analytic studies to formulate mission goals and systems concepts and designs, develops, tests, and evaluates data buoy systems. The mission of the Project is to develop and demonstrate the national technology to implement cost-effective data buoy systems. The basic concept involves the use of instrumented, unattended buoys of one or more types, moored and drifting, on the high seas, in the coastal zone, and in inland water areas to collect and to relay, in a timely manner, data on the marine environment to meet national needs.

A total "operational system capability" is being developed for demonstration. This includes not only hardware *per se,* but the necessary handling facilities, material logistics, trained maintenance and operating personnel, and deployment. The development plan is based on an evolutionary or sequential strategy, designed so that knowledge gained in each phase will influence decisions in subsequent phases. The demonstration of the feasibility and utility of data buoy systems will be accomplished by deployment of a prototype pilot network of data buoys in the late 1970's. The principal current activities include mission analysis, experimental hardware, and technology development programs.

The NDBC approach to mission analysis is twofold. Optional developmental and operational configurations are examined and systems hardware, support facilities, and methodologies are compared to arrive at the most cost-effective systems possible under projected funding. Mission-analysis studies are conducted for a large number of reasons, such as to convert subjectively expressed user data needs into objective requirements that can be used by design engineers, to compare alternative systems for performing required tasks so that the optimal system is developed and used, and to insure that the benefits from a system exceed the cost to develop, deploy, and operate the system.

A number of buoy configurations are either under test or in development by NDBC. The Experimental Environmental Reporting Buoy (XERB–1), an existing 40-foot discus buoy, has been operating experimentally 125 miles east of Norfolk since 1970. Six Engineering Experimental Phase (EEP) buoys with hulls that resemble the XERB–1 will be deployed in the Gulf of Mexico beginning in the spring of 1972. Operation, test, and evaluation of the EEP network will continue through early 1974. Improved environmental sensors will be used on EEP buoys and, as technical development progresses, the platforms can be retrofitted with advanced components. Thus, the EEP program can be used to evaluate existing buoy technology, to develop systematic engineering data for high-capability sensing systems and buoy design, and to provide experience in the deployment and servicing of buoys as well as in the gathering and handling of environmental data.

Limited Capability Buoys (LCB) under development are designed to accommodate requirements for scientific activities such as GATE, which is scheduled to begin in the summer of 1974. Potential applications for LCBs include: oceanic networks in combination with other buoy configurations; operational and research networks in limited-size bodies of water and estuaries; networks deployed temporarily to investigate and report seasonal phenomena; tactical deployment in the vicinity of storms to measure critical environmental conditions; and other research programs involving air-sea interaction and atmospheric and oceanic processes. In addition, the LCBs will provide a baseline from which capabilities may be scaled upward to a "medium"-capability buoy or downward. The LCBs are to be optimized for communications with satellites over ultra-high frequency bands; however, early versions will use high-frequency communications for test and evaluation in 1972 before commencement of the operation of the Geostationary Operational Environmental Satellite (GOES) System.



Engineering Experimental Phase (EEP) buoy. (National Ocean Survey)

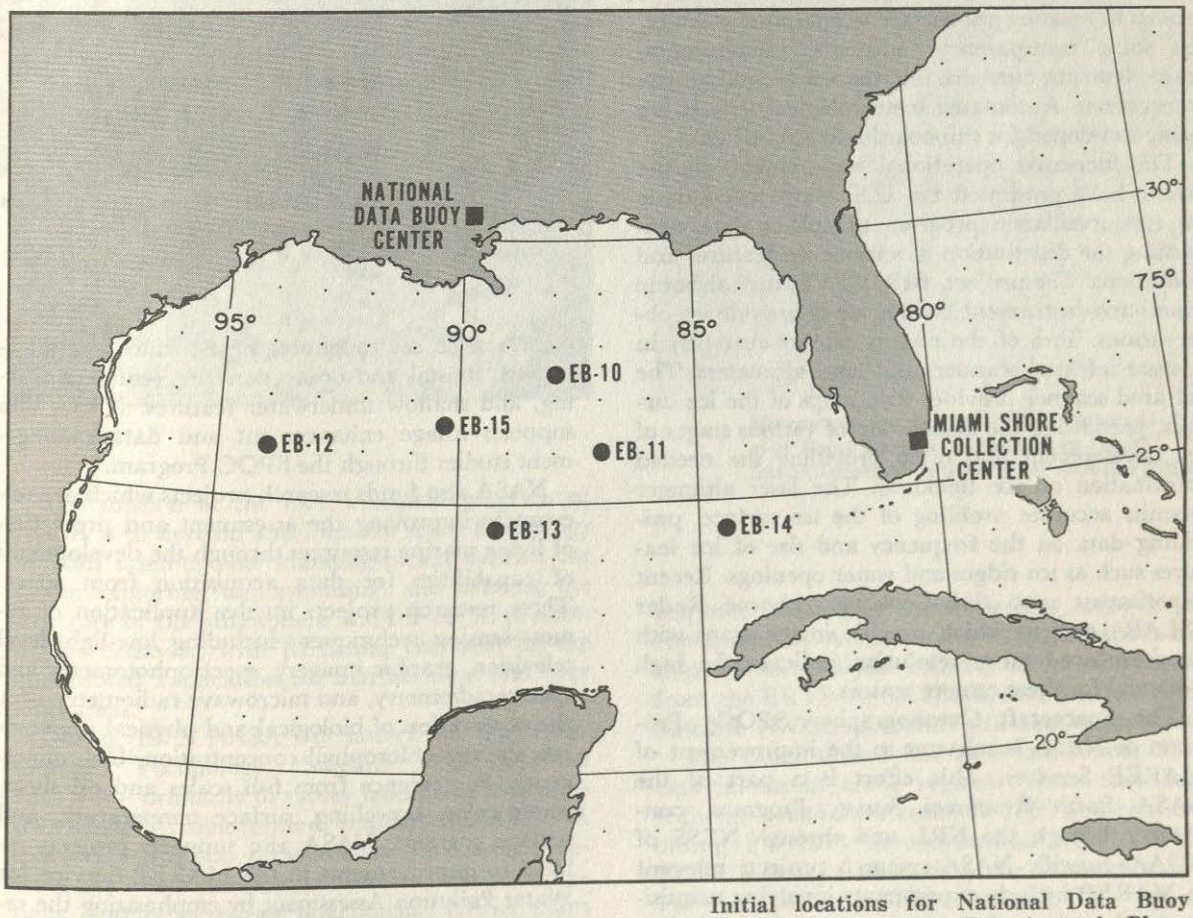
In spite of major advances in the ability to collect and to transmit marine data automatically from the far reaches of the ocean, there is a lack of complete understanding on the adverse affects of the marine environment on oceanic-telemetering data buoys and on the interrelations between the environment and the buoy, its sensors, and mooring. For this reason, the development of data buoys in certain areas still requires further research and development. The technology for telecommunications, data handling, and shore support appears to be sufficiently advanced for application to data buoys without extensive research and development. The development of reliable sensor, moorings, and buoy-handling capabilities poses the greatest technological challenge. Principal developments underway to improve buoy technology by NDBC include: two different sets of oceanographic instruments which incorporate the latest technology; an experimental arctic data buoy; liquid-fuel thermoelectric generator; position-locating devices; lowest special-capability buoys; and full-scale hull and mooring tests. Other studies, laboratory tests, and experiments being conducted include: an analytical mooring-model investigation; scale-model buoy tow-tank tests; sensor surveys; and high-frequency and satellite communication studies.

In FY 1972, at a cost of $141,000, NMFS is developing specialized equipment in support of MARMAP data acquisition: (1) the Remote Underwater Fish Assessment System (RUFAS), an instrument towed from aboard ship to detect subsurface fish and shellfish concentrations; (2) remote sensors for use on ships, aircraft, and satellites to detect surface concentrations of fish and shellfish; and (3) an undulating, continuous plankton recorder with associated environmental sensors and data-recording system. An increase of $1,100,000 in FY 1973 will be used for conducting tests to demonstrate the feasibility of various types of sampling gear to provide a survey capability and to acquire Survey II type hydroacoustic samples. Tests will be

conducted on various types of bottom and midwater trawls to determine their efficiency in the assessment of groundfish (including both crustacean and finfish) and pelagic resources. Such data are basic to resource assessment objectives. The development of the hardware required for these tests will be accomplished under contract, for which $800,000 is requested. Increased funds in FY 1973 will also be used for conducting tests to demonstrate the feasibility of various sensors to provide the means for remote underwater assessment of sport and commercial species. These tests will provide an evaluation of an advanced RUFAS II, employing hydroacoustic (sonar) techniques to detect and to assess fish stocks. This advanced System improves the detection range and operational depth of present systems. Tests also are planned for another new hydroacoustic assessment system, for example, one with both a vertical- and lateral-scanning capability. The combination of the RUFAS II and the advanced systems will provide a capability to assess midwater and bottom-dwelling fish stocks by remote-sensing means. The development of the hardware required for these tests will be accomplished under contract, for which $300,000 is requested.

Other research and development projects supported by NOAA for the improvement of MAREP data acquisition and collection include the following:

- Development of vertical- and horizontal-ranging acoustical devices by NMFS and by the University of Washington, under a Sea Grant, to provide qualitative and quantitative data on marine organisms, thus reducing the time, effort, and cost of conducting resource surveys with traditional fishing gear.
- Initiation of experimental studies by ERL on the use of high-frequency backscatter from the sea surface to determine the wave height, direction, and velocity in real-time over thousands of square miles of ocean surface.
- Improvement of the understanding of the gener-



Initial locations for National Data Buoy Project Engineering Experimental Phase (EEP) buoys in the Gulf of Mexico.

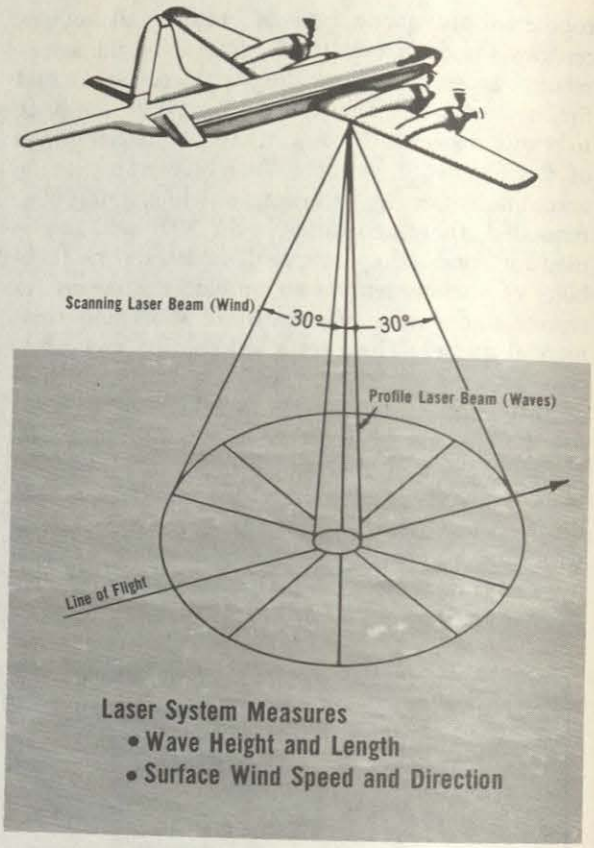
ation, propagation, and runup mechanics of tsunamis by ERL through the deployment of prototype tsunami gages linked with satellite telemetry.

- Development, procurement, operation, and maintenance of instrumentation by AOML of ERL in support of oceanographic research projects and tropical meteorological research.
- Acquisition and installation of a data acquisition system by NOS in connection with an expanded estuarine dynamics program in which the basic data inputs are obtained from an observational network that meets the measurement specifications adequate to describe a given area.

In data acquisition, the U.S. Navy plans to develop a modularized system for collecting salinity, temperature, bathymetry, and subbottom profiles. In remote sensing, a new effort has been initiated at the Naval Research Laboratory (NRL) in Washington to use remote-sensing techniques for military applications. This involves the use of aircraft or satellite microwave, infrared, and radar sensors to measure sea-surface temperature, salinity, sea state, transparency, nutrients, radioisotopes, trace elements, currents, internal waves, and air-sea interactions. Automated meteorological sensors are being developed for shipboard and aircraft use.

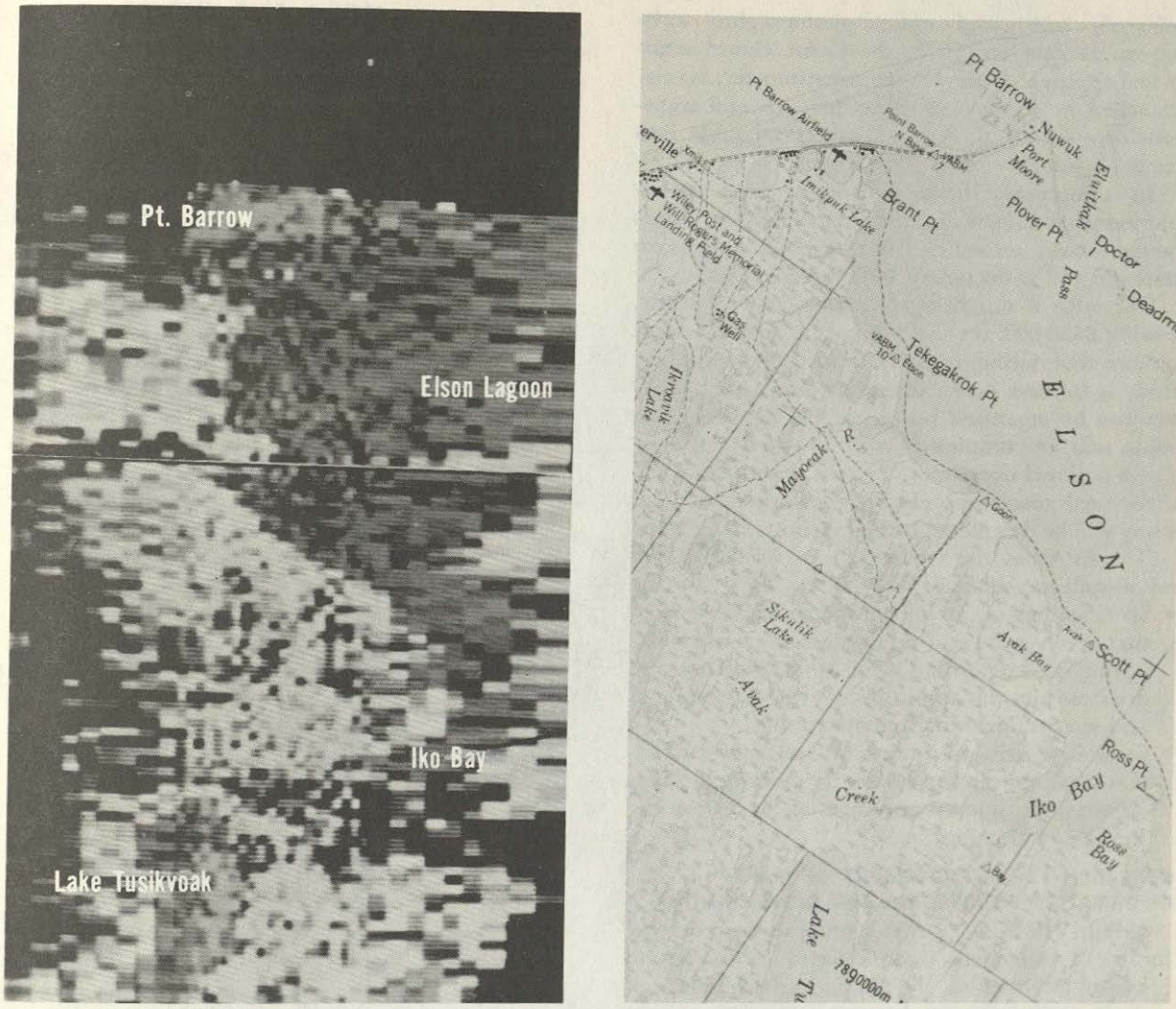
The increased operational requirements in the Arctic have prompted the U.S. Navy to continue an ice-surveillance program to collect data concerning the distribution of various ice features and conditions. The project, BIRDSEYE, uses airborne visual-and-instrument techniques to provide ice observations. Two of the remote sensors currently in use are infrared scanners and laser altimeters. The infrared scanner provides strip maps of the ice surface, permitting the delineation of various stages of ice development and often providing the needed information on ice thickness. The laser altimeter permits accurate profiling of the ice surface, providing data on the frequency and size of ice features such as ice ridges and water openings. Recent experiments with Side-Looking Airborne Radar (SLAR) systems which provide image maps with good surface-feature resolution indicate the high potential for these remote sensors.

The Spacecraft Oceanography (SPOC) Program of NASA is relevant to the improvement of MAREP Services. This effort is a part of the NASA Earth Resources Survey Program, conducted through the NRL and through NESS of NOAA. Specific NASA research projects relevant to MAREP include experiments involving acquisition and analysis of remote-sensor and correlative-surface data for sea-surface temperature, ocean color, sea ice, sea roughness, near-surface wind conditions, coastal and ocean currents, sediment tracing, and shallow underwater features. NASA also supports image enhancement and data management studies through the SPOC Program.



Aircraft ocean-surface-measuring system under development by the U.S. Navy.

NASA also funds research projects which are relevant to improving the assessment and prediction of living marine resources through the development of capabilities for data acquisition from space. These research projects involve application of remote-sensing techniques—including low-light-level television, graphic imagery, spectrophotometry and spectroradiometry, and microwave radiometry—for the observation of biological and physical phenomena such as chlorophyll concentration, bioluminescence, fluorescence from fish scales and oil slicks, water color, upwelling, surface temperature, and surface currents. NASA also supports projects related to improvements in the MAREP Service for Water Pollution Assessment by emphasizing the remote sensing of river effluents, water quality, and sediment transport.



Microwave image (left) from aircraft flight over Point Barrow, Alaska, area (right). (National Aeronautics and Space Administration)

The mission of the meteorological program of NASA is to develop and improve space technology in both satellite and sounding-rocket systems for use in exploring, understanding, and defining the structure of the atmosphere and for use in predicting its behavior, with particular emphasis on the operational application for marine areas and over land areas.

During 1972, NASA will launch an Earth Resources Technology Satellite (ERTS)—the ERTS-A—primarily to survey land areas with multiwavelength-visible remote sensors; the ERTS–A spacecraft will also provide data on coastal processes, shallow-water bottom features, sea-ice conditions, and other ocean phenomena. NASA plans call for inaugurating a worldwide ocean-survey satellite mission in 1974–75. In FY 1973, NASA will continue research on remote sensing, using NASA, Navy, and NOAA aircraft and surface-truth from ships; data analysis techniques for information from the ERTS–A, SKYLAB, and Earth Orbiting Satellite (EOS) spacecraft will also be broadened.

The Coast Guard has been conducting SLAR experiments in arctic regions. These tests began with the *Manhattan* cruise in 1969 and continued during FY 1971 in conjunction with AIDJEX. SLAR is being evaluated by the International Ice Patrol as an iceberg-detection tool. The object of these experiments is to develop a remote-sensing capability to observe ice conditions, using SLAR,

infrared, laser, and optical-photographic techniques. During FY 1972, the Coast Guard completed research on the sea-ice penetrometer, an air-launched projectile that penetrates ice and transmits deceleration data which are translatable into ice thicknesses.

In connection with its research program on explosion-generated water waves, the AEC is developing sensor, recording, and readout systems to measure and to document such waves.

The EPA is supporting a major contract study, costing $420,000, for the design of a coastal water-quality monitoring network. The purpose of the study is to show how existent monitoring capabilities can be organized into a unified network. The study will be completed in three specific phases: (1) a national overview; (2) case studies; and (3) a national coastal-monitoring network plan. This study will be completed by September 1972.

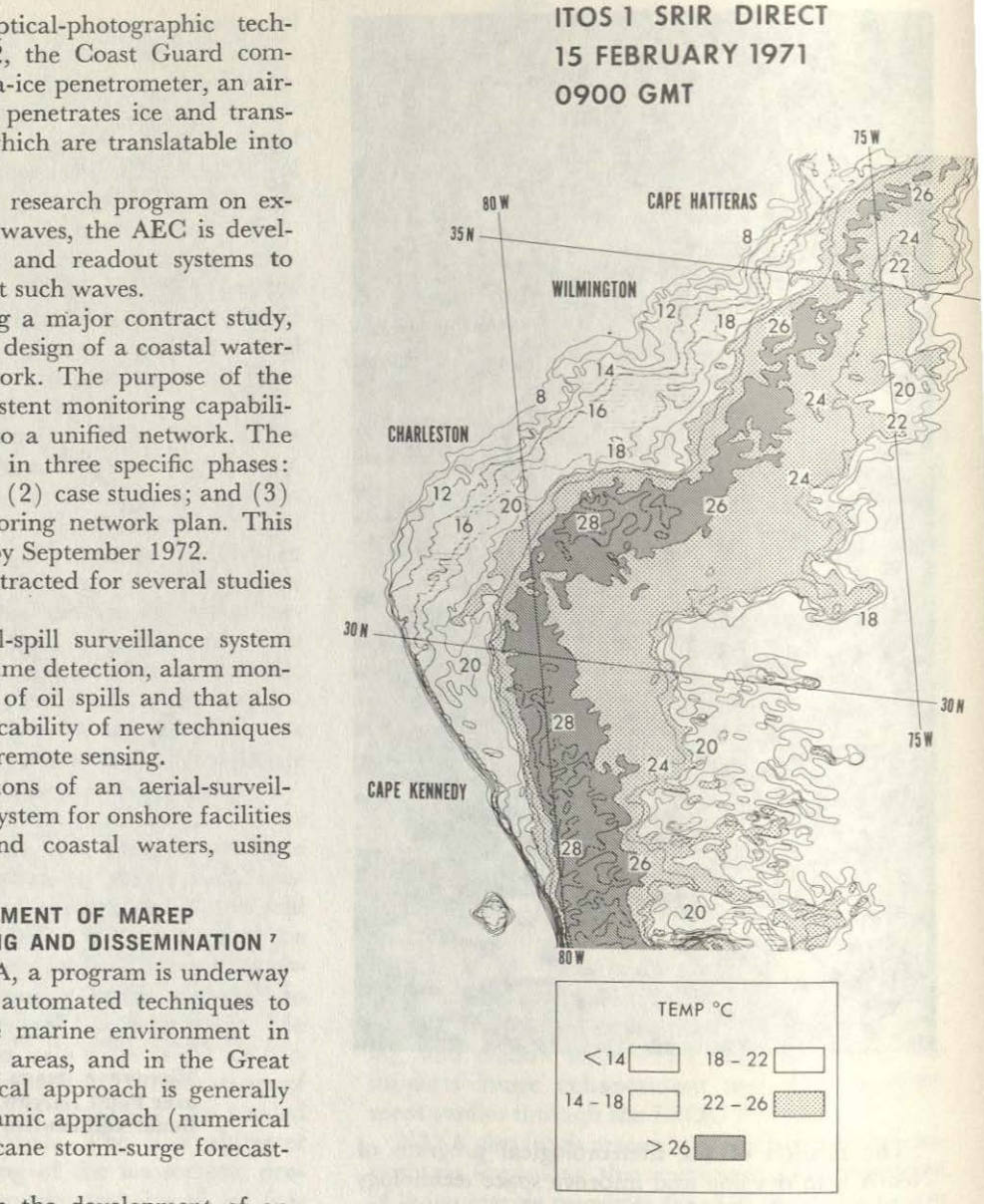
The EPA has also contracted for several studies on oil-spill surveillance:

- Specification of an oil-spill surveillance system that involves the real-time detection, alarm monitoring, and recording of oil spills and that also demonstrates the applicability of new techniques and sensors, including remote sensing.
- Feasibility demonstrations of an aerial-surveillance spill-prevention system for onshore facilities adjacent to inland and coastal waters, using available technology.

RESEARCH FOR IMPROVEMENT OF MAREP INFORMATION PROCESSING AND DISSEMINATION [7]

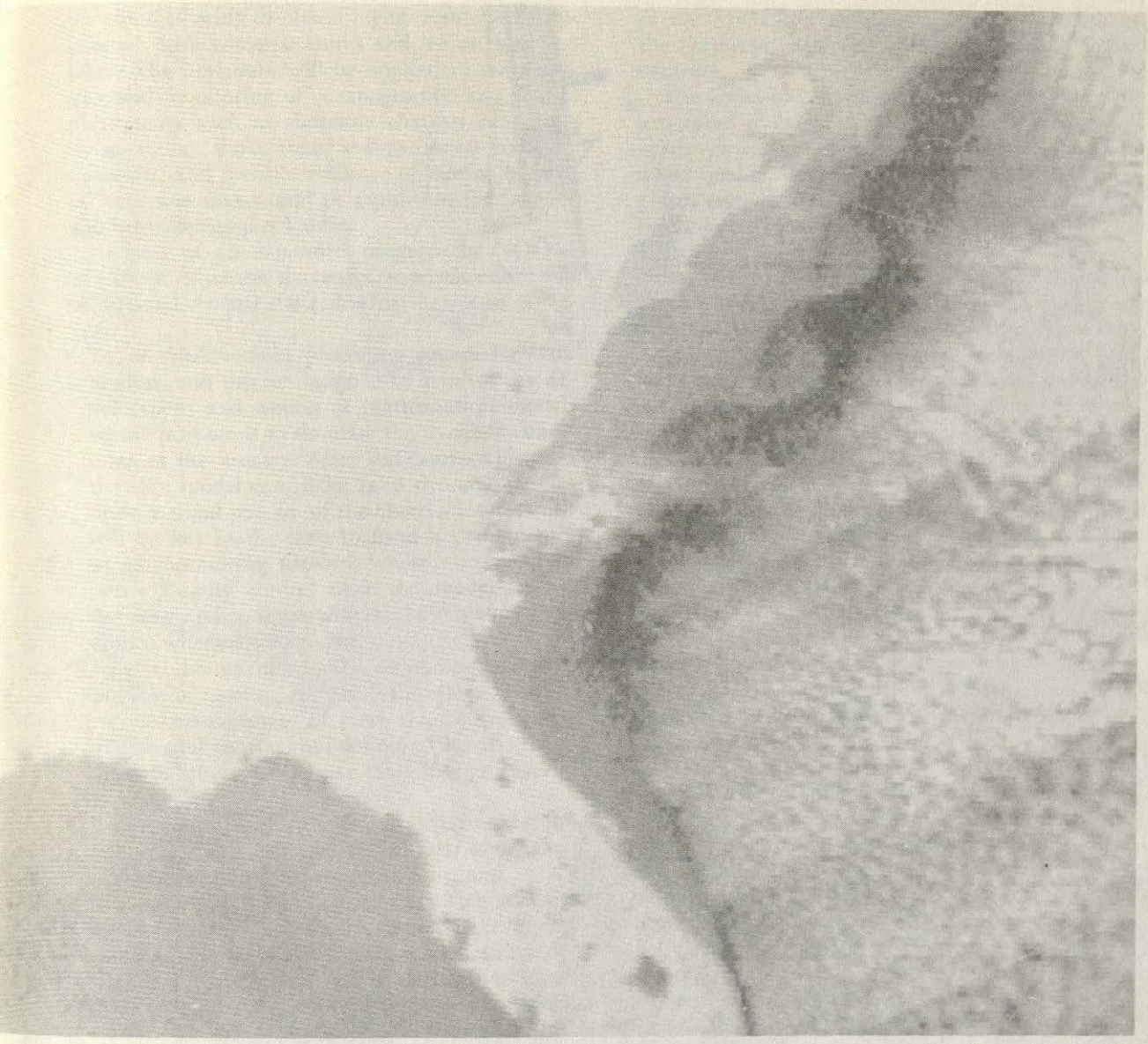
Within NWS of NOAA, a program is underway for the development of automated techniques to produce forecasts of the marine environment in oceanic areas, in coastal areas, and in the Great Lakes. A physical-statistical approach is generally followed, although a dynamic approach (numerical model) is used for hurricane storm-surge forecasting.

Work is proceeding on the development of an improved method of wind forecasting for application to wave forecasting over oceanic areas. For the Great Lakes, a wave climatology was compiled; and wind forecast techniques are being derived for Lakes Superior, Michigan, and Huron. In coastal areas, the numerical model SPLASH—Special Program to List Amplitudes of Surges from Hurricanes—has been developed for forecasting the hurricane storm surges along the U.S. gulf and east coasts; SPLASH is in experimental use at the National Hurricane Center (NHC). Equations have been derived for forecasting extratropical storm surges at eight east coast cities.



In FY 1972, wind-forecast techniques for Lakes Superior, Michigan, and Huron will be completed and made operational. A wave-forecasting technique for the Great Lakes will be developed and implemented. Further improvements will be made to the hurricane storm-surge forecasting model at NHC. Contract studies on a breaker-forecasting

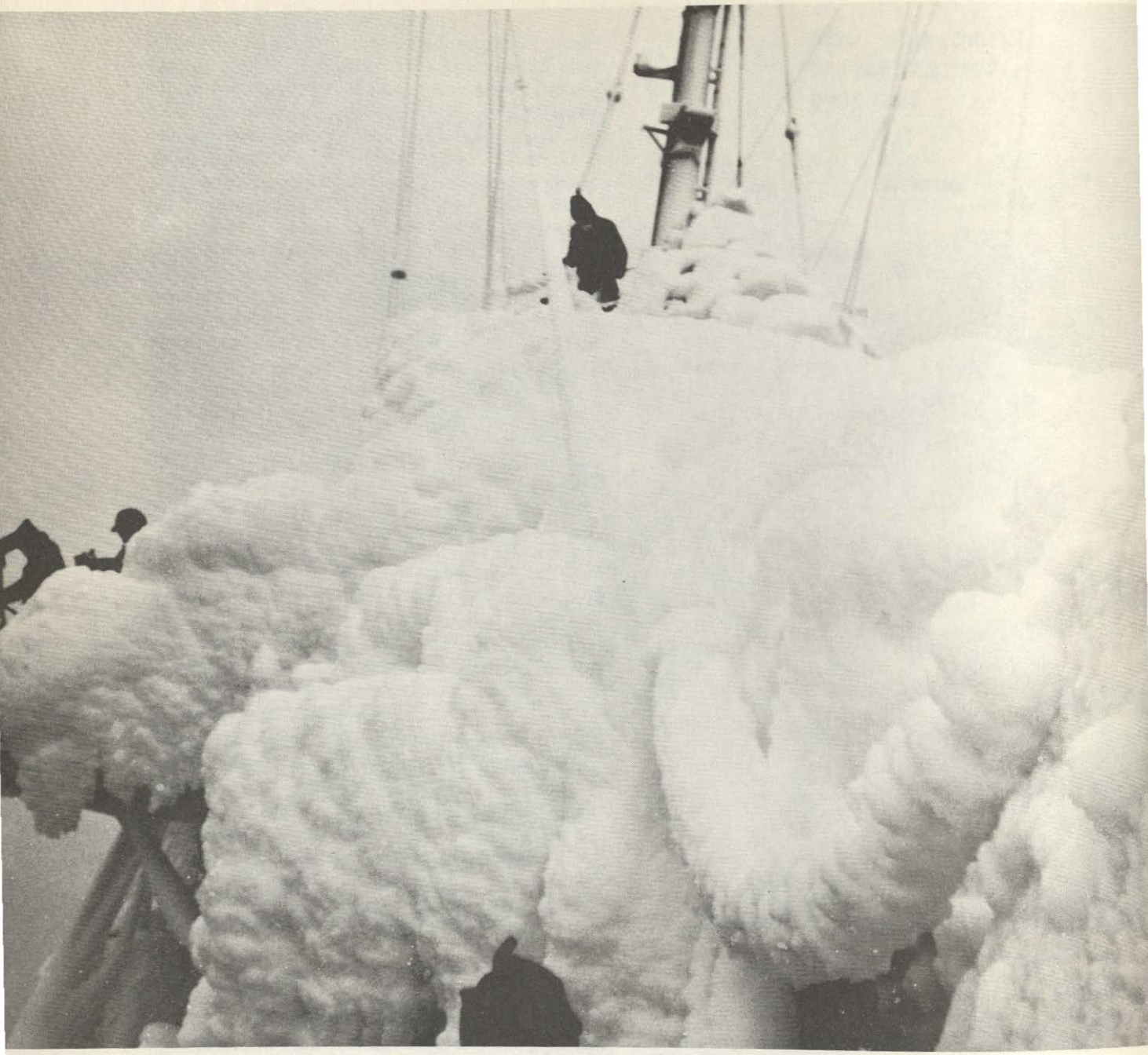
[7] The specialized, long-range "Plan for Improvement of Marine Environmental Prediction Techniques," being developed by ICMAREP, will include an appendix with an extensive review of current agency research programs directed toward the development of new or improved prediction tchniques.



Sea-surface temperature map for the Atlantic Ocean off Southeastern United States (left), derived from thermal imagery obtained from satellite radiometer (right). (National Environmental Satellite Service)

technique and on investigation of hazardous-wave conditions over bars at the mouth of the Columbia River will be completed. In FY 1973, efforts will continue to improve those techniques developed earlier. In addition, the scope of techniques development work will be expanded to include sea-surface temperature, vertical-temperature structure, and ice forecasting.

The NESS of NOAA is developing techniques for using satellite observational data in marine environmental monitoring and prediction. A histogram technique, developed to derive sea-surface temperature from satellite data, has been used with the infrared data of the Improved TIROS Operational Satellite (ITOS) to generate experimental surface-temperature maps. Comparison with available data from conventional sources showed root-mean-square differences of about 2°C. The technique has been applied to produce special temperature charts over small areas of particular signifi-



Ice accretion hampers operations at sea.

cance to fishery and oceanographic investigations. Techniques for mapping sea ice, developed for use with satellite picture data, are being extended for use with satellite infrared data. Increased emphasis on these techniques is planned during FY 1973 because the infrared data permit mapping of sea ice during periods of polar darkness.

Program expansion proposed by NESS in FY 1973 will include developing applications of very high resolution and multispectral data from new satellite sensors planned for orbiting spacecraft in 1972 and 1973. These sensors offer new possibilities

for cloud filtering to obtain higher resolution mapping of surface temperatures and ice on seas and lakes. The new data will be applied to the detection and monitoring of oceanographic and coastal phenomena such as shoreline changes caused by storm action, shoal areas, sediment and pollution transport, and possible evidence of marine biological processes that would be significant for fisheries and for water-quality studies.

As part of an expanded program by NOS of NOAA in estuarine dynamics, research effort will be directed toward the following long-term objectives:

- To establish a data processing system for data analysis and interpretation that involves the development and testing of mathematical models whose purpose is to simulate the dynamic conditions of the estuary. After sufficient verification that the model can make valid dynamic predictions, a small portion of the observation network will be left in the area to form a permanently based monitoring network whose purpose is to assure quality control over the model-derived forecasts and to sense abnormal circulatory conditions whenever they arise.
- To establish an information dissemination system capable of meeting the needs for effective multiple-use management of more than 40 estuarine and coastal areas within the next 10 years.

Potential users will receive two different *types of service products:*

- Real-time alerts of unfavorable estuarine circulation conditions, followed by forecasts of the rates of disappearance of these conditions; and,
- Data atlases, historical records, and technical and scientific reports for studies aimed at an understanding of the long-term rate processes underlying the natural phenomena occurring in estuaries and coastal areas and at a determination of engineering design criteria for waterfront structures, offshore permanent structures, offshore engineering projects, and vessels.

In FY 1972 at a cost of $100,000, the NMFS is developing two items of specialized equipment in support of MARMAP data processing: (1) an automated plankton sorter; and (2) automated scale-reading equipment for determining ages of fish. An increase of $200,000 in FY 1973 will be used for development of the automated egg- and larvae-sorting system. This automated system will eliminate time-consuming handsorting, thereby enabling more efficient use of personnel. Such a system will contribute materially to our capability to manage data and will permit rapid movement into data processing, analysis, and dissemination areas of the MARMAP Program. The development of the hardware required will be accomplished under contract.

The Office of Seat Grant of NOAA is supporting a number of institutional research projects to develop environmental prediction models in marine water quality, living resource assessment, and integrated regional development. The Office also funds information dissemination activities in support of fisheries.

In the U.S. Navy, a development effort is underway for predicting and modeling dynamic oceanographic and marine meteorological conditions. Parameters of interest to the military include divergent items such as sea-ice conditions, waves and surf, winds, currents, ocean-thermal structure, and tropical storms. Development of improved or new prediction techniques and models are being conducted at the Naval Oceanographic Office (NAVOCEANO), the Environmental Prediction Research Facility, and the Fleet Numerical Weather Central (FNWC). Models cover the physical state of coastal waters, estuaries, and the deep ocean. Numerical environmental prediction models are being updated to maximize utilization of satellite input data. Integration of the multilayer hydrodynamic ocean model with the atmospheric model to produce an interactive hydrodynamic air-ocean model is planned at FNWC.

As part of the research effort by the Navy in marine pollution, computerized hydrodynamic models are being adapted to additional coastal areas with the goal of providing real-time assistance for predicting distribution in the event of an inadvertent discharge of pollutants in estuarine or restricted water bodies.

In conjunction with its research efforts on the Great Lakes, the U.S. Coast Guard has established an ice information and reconnaissance center in Cleveland. Here, ice information is collected and disseminated to shipping interests, to SAR units, and to NWS.

The Coast Guard initiated a research program in FY 1972 in support of a requirement to monitor pollution by hazardous materials. This effort is directed toward the development of a national pollution-response center and the provision for a rapid-response investigative team on hazardous materials.

The EPA has awarded a contract for compilation of a handbook on field-oriented procedures and techniques. This publication is intended to assist users in the rapid detection, analysis, identification, and monitoring of spilled oil and hazardous materials and in the assessment of damages to the aquatic environment and adjacent shorelines.

Appendix

GLOSSARY

The following is a glossary of acronyms and abbreviations used in this Plan. The list is arranged alphabetically by acronym or abbreviation.

AEC	Atomic Energy Commission
AFB	Air Force Base
AFGWC	Air Force Global Weather Central
AIDJEX	Arctic Ice Dynamics Joint Experiment
AM/SSB	Amplitude Modulation/Single Sideband
AOML	Atlantic Oceanographic and Meteorological Laboratories
ASW	Antisubmarine Warfare
AWN	Automated Weather Network
BOMEX	Barbados Oceanographic and Meteorological Experiment
CEDDA	Center for Experiment Design and Data Analysis
CEQ	Council on Environmental Quality
CICAR	Cooperative Investigation of the Caribbean and Adjacent Regions
CINECA	Cooperative Investigation of the Northern part of the Eastern Central Atlantic
CRREL	Cold Regions Research and Engineering Laboratory
CTD	Conductivity-Temperature-Depth
CUE	Coastal Upwelling Experiment
CW	Continuous Wave
EDS	Environmental Data Service
EEP	Engineering Experimental Phase buoy
EOS	Earth Observatory Satellite
EPA	Environmental Protection Agency
ERL	Environmental Research Laboratories
ERTS	Earth Resources Technology Satellite
ET	Electronics Technician
FAA	Federal Aviation Administration
FAO	Food and Agriculture Organization (United Nations)
FNWC	Fleet Numerical Weather Central
FWC	Fleet Weather Central
FWF	Fleet Weather Facility
GARP	Global Atmospheric Research Program
GATE	GARP Atlantic Tropical Experiment
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution
GFDL	Geophysical Fluid Dynamics Laboratory
GIPME	Global Investigation of Pollution in the Marine Environment
GIPSY	Generalized Information Processing System
GOES	Geostationary Operational Environmental Satellite
ICES	International Council for Exploration of the Sea
ICG	International Coordination Group
ICMAREP	Interagency Committee for Marine Environmental Prediction
ICSU	International Council of Scientific Unions
IDOE	International Decade of Ocean Exploration
IFYGL	International Field Year for the Great Lakes

IGOSS	Integrated Global Ocean Station System
IMCO	Inter-Governmental Maritime Consultative Organization
IOC	Intergovernmental Oceanographic Commission
ITOS	Improved TIROS Operational Satellite
LEPOR	Long-Term and Expanded Program of Oceanic Exploration and Research
MAREP	Marine Environmental Prediction
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MESA	Marine Ecosystem Analysis Program
MMTC	Marine Minerals Technology Center
MOCEM	Meteorological and Oceanographic Equipment Maintenance
MODE	Mid-Ocean Dynamics Experiment
MOEP	Meteorological and Oceanographic Equipment Program
NARL	Naval Arctic Research Laboratory
NASA	National Aeronautics and Space Administration
NAVAIR-SYSCOM	Naval Air Systems Command
NAVOCEANO	Naval Oceanographic Office
NCC	National Climatic Center
NDBC	National Data Buoy Center
NDBP	National Data Buoy Project
NDBS	National Data Buoy System
NEDN	Naval Environmental Data Network
NESS	National Environmental Satellite Service
NHC	National Hurricane Center
NMC	National Meteorological Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOIC	National Oceanographic Instrumentation Center
NOMAD	Navy Oceanographic/Meteorological Automatic Devices
NOS	National Ocean Survey
NRL	Naval Research Laboratory
NRT	National Response Team
NSF	National Science Foundation
NSRT	Near-Surface Reference Temperature
NSSFC	National Severe Storms Forecast Center
NWS	National Weather Service
NWSC	Naval Weather Service Command
OEP	Office of Emergency Preparedness
OMB	Office of Management and Budget
OSC	On-Scene Coordinator
OST	Office of Science and Technology
OSV	Ocean Station Vessel
OTSR	Optimum Track Ship Routing Program
POL	Pacific Oceanographic Laboratory
RANN	Research Applied to National Needs
RAWARC	Radar Report and Warning Coordination System
RRT	Regional Response Team
RUFAS	Remote Underwater Fish Assessment System
SAIL	Sea-Air Interaction Laboratory
SAR	Search and Rescue

SC/B	Subgroup on Buoys (ICMAREP)
SC/IGOSS	Subcommittee on the Integrated Global Ocean Station System (ICMAREP)
SC/MBM	Subcommittee on Marine Baselines and Monitoring (ICMAREP)
SLAR	Side-Looking Airborne Radar
SOFAR	Sound Fixing and Ranging
SOLAS	Safety Of Life At Sea (International Convention)
SOSC	Smithsonian Oceanographic Sorting Center
SPLASH	Special Program to List Amplitudes of Surges from Hurricanes
SPOC	Spacecraft Oceanography Project
STD	Salinity-Temperature-Depth
STORET	Storage and Retrieval System
TG/CED	Task Group for Collection, Exchange, and Dissemination of Real-time MAREP Data (ICMAREP)
TG/MTD	Task Group for MAREP Techniques Development (ICMAREP)
TIROS	Television Infrared Observation Satellite
TWX	Teletypewriter Exchange Service
UJNR	United States-Japanese Cooperative Program in National Resources Development
UN	United Nations
USGS	United States Geological Survey
VHF/FM	Very High Frequency/Frequency Modulation
WMO	World Meteorological Organization
WSFO	Weather Service Forecast Office
XBT	Expendable Bathythermograph

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