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RESEARCH AND DEVELOPMENT PROGRAMS OF THE
NATIONAL OCEANIC AND ATMOSPHERIC
ADMINISTRATION

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HEARINGS
BEFORE THE
SUBCOMMITTEE ON
NATURAL RESOURCES AND ENVIRONMENT
OF THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-SIXTH CONGRESS
FIRST SESSION

NOVEMBER 13, 14, 1979

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Committee on Science and Technology



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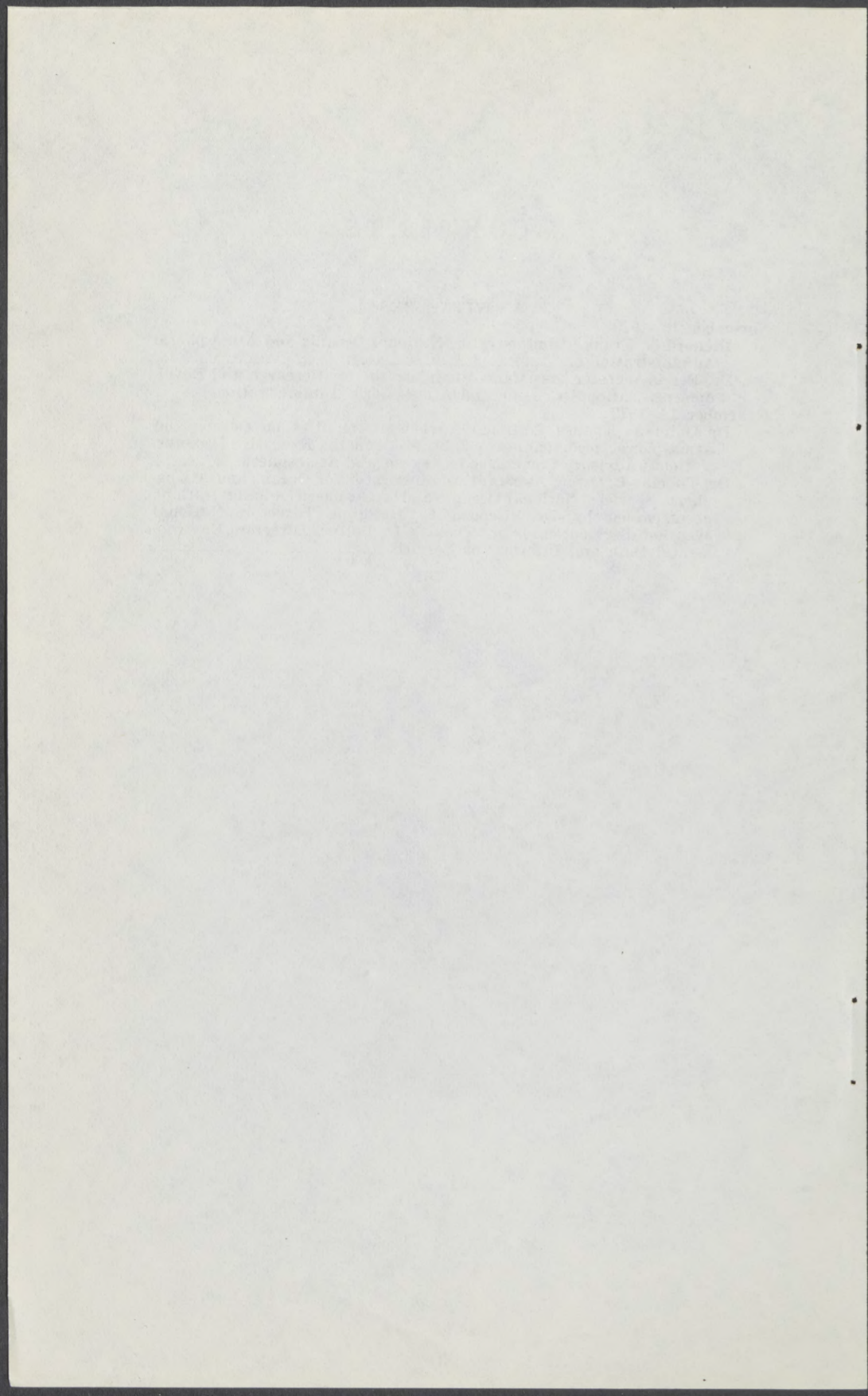
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RESEARCH AND DEVELOPMENT PROGRAMS OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINIS- TRATION

NOVEMBER 13, 1979

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON NATURAL RESOURCES AND ENVIRONMENT,
Washington, D.C.

The committee met, pursuant to notice, at 2 p.m., in room 2325, Rayburn House Office Building, Hon. George E. Brown, Jr., presiding.

Mr. BROWN. The subcommittee will be in order.

May I invite the witnesses from NOAA to come to the table, all of them that can find room up there, and we will proceed here on a relatively informal basis.

I have a brief opening statement which I will subject you to, if you don't mind.

Today the Subcommittee on Natural Resources and Environment is holding the first of a series of hearings to receive testimony on environmental research programs within the National Oceanic and Atmospheric Administration. These hearings will focus primarily on atmospheric research and services programs, for which NOAA has lead responsibility within the Federal Government.

The subcommittee will also be holding hearings later this week on the National Climate Program, a matter of specific concern to NOAA.

What we would like to do today is examine the basic research programs conducted by NOAA's Environmental Research Laboratories. Tomorrow we will attempt to follow the process through the application of this research in the operational programs of the National Weather Service. Finally, we will look at dissemination of information to the scientific community by NOAA's Environmental Data and Information Service. We will also hear tomorrow from the National Advisory Committee on Oceans and Atmosphere on their perceptions of the NOAA program as a whole and other matters relevant to that program.

By following the process in this way, there are several things we hope to achieve in holding these hearings. First of all, we would like to get a partial overview of the research programs underway and planned by NOAA, not only in the research labs but in the operational services areas as well.

Second, we are interested in seeing how priorities are determined among the variety of deserving programs. This subcommittee has had a longstanding interest in assuring that Federal research programs

are planned in such a way as to provide a sound base for the nonresearch missions of the agency.

We will therefore be particularly interested in hearing about the mechanisms that exist to coordinate the emphasis of the research agenda with the needs of other NOAA components.

Finally, as you are probably aware, the subcommittee is likely to be considering organic legislation for NOAA in coming months and our hearings this week will provide useful background information for those hearings as well as for our annual budget review of NOAA programs. And I stress the importance of what we are doing today in developing this background as a contributing factor to these other activities I have mentioned which we have to go through. We may be able to reduce our demands for your time in the period ahead when we go into the authorization process.

We are pleased to welcome as our first witness today the Administrator of NOAA, Hon. Richard Frank. Mr. Frank is accompanied by Dr. Ferris Webster, NOAA Assistant Administrator for Research and Development; Dr. Wilnot Hess, Director of the Environmental Research Laboratories; and Dr. George Benton, NOAA, Associate Administrator.

You may proceed with your statement, Mr. Frank, and handle it in any way as you wish.

STATEMENT OF RICHARD A. FRANK, ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Mr. FRANK. Mr. Chairman, thank you.

It is a great pleasure to be here today as we have been in past hearings to discuss NOAA's overall research activities.

I am going to present if I may today a statement on generalized research subjects, and then Dr. Webster and Dr. Owen will discuss in more detail research programs under their respective jurisdictions.

These hearings in the past have been very useful to us in forcing us to focus on our research, and the important elements of it. We would like to be as responsive as we can to you today as these hearings proceed this week. We would be happy to "zero in" on any subjects you would like to talk about, more than we have elaborated in the prepared statement, and to skim briefly over those subjects which you feel are already covered, or have been covered in the past.

As you know, NOAA's research and development activities cover the full spectrum of the agency's functions and are carried out by virtually all components of NOAA. We do have an Environmental Research Laboratories unit, and while it has several laboratories located throughout the country, it is only part of our research effort. The National Weather Service, the Environmental Data and Information Service, the National Marine Fisheries Service, the Office of Sea Grant, the National Ocean Survey, the National Environmental Satellite Service, and the Office of Coastal Zone Management all are actively involved in research and development activities either through inhouse work or through grants or contract work.

Our annual budget for research and development activities this fiscal year is approximately \$200 million, and that does not include additional funds which come to us from other agencies.

I would like to spend a few minutes giving you some sense of the range and variety of our activities.

The atmospheric sciences are continuing to stress the development of Doppler radars to improve our short-term weather forecasting and warning capability. The Doppler radar facility is presently set up in Norman, Okla., and if any members of the committee are interested in discussing that further and in fact seeing that system operate, we would be happy to discuss it with them.

We are building on our work in the development of remote sensing instruments to create a Prototype Regional Observing and Forecasting Service, called PROFES, which will provide greatly improved local weather services. Not only will it greatly improve local weather services, but it will be a weather service of a substantially different character. That is, we will be focusing in PROFES, and I think in many of our weather services in the future, on short-range forecasting and communication systems, which will allow the public to get more information in a more timely fashion.

We are proceeding with the Severe Storms and Mesoscale Experiment called SESAME, to improve our ability to understand and predict severe thunderstorms and related phenomena, such as tornadoes. Our early experiments in this area have shown that, in fact, they will produce a substantial improvement.

We are seeking to understand better the role of the ocean in influencing interannual climate fluctuations through the Equatorial Pacific Ocean Climate Studies program which is called EPOCS. This year, we are intensifying our efforts to investigate the increasing level of carbon dioxide in the atmosphere and the impact of this phenomenon on global climate.

Our marine programs are equally ambitious. Our Marine Ecosystems Analysis program, MESA, which we have described to you, is continuing to examine the impact of various pollutants on the marine environment.

As you are aware, MESA is organized around regional studies, which in the past have involved the New York Bight and Puget Sound, and which have been extended this year to the Gulf of Mexico. In fiscal year 1979, a major effort in marine environmental assessment continued to be the Deep-Ocean Mining Environmental Study, DOMES. This project has become all the more relevant as we move closer to enactment of deep-sea mining legislation.

You may know that NOAA has been assigned the responsibility of lead agency in the area of deep-sea mining; and because of the studies and research that have gone forth, we will be better able to develop regulations and to know the environmental impact of these activities so that industry need not be delayed in proceeding to mine.

We are examining such issues as the impact of offshore drilling activities on coral reefs, which will enable us not only to provide advice to EPA for its permit policy, but will also allow us to make better programmatic decisions on possible marine sanctuaries under the Marine Sanctuaries Act.

Let me focus for a moment on a few specific areas of importance, over the last year.

NOAA as you know has a history of efforts in the marine pollution research and development area. This area is receiving increased attention as a result of new statutory responsibilities, such as those under the National Ocean Pollution Research and Development and Monitoring Planning Act of 1978, and the Outer Continental Shelf Lands Act Amendments of 1978. Moreover, recent events, such as the Campeche spill, have helped to galvanize our marine pollution activity.

As the committee is aware, the National Ocean Pollution Research and Development and Monitoring Planning Act of 1978 provides for greater coordination of Federal ocean pollution research and development and monitoring efforts. It gives NOAA the lead role in developing a 5-year Federal plan for such activities. We have completed, and have just obtained administration approval of our plan. We have proposed the establishment of an Office of Marine Pollution Assessment to carry out the mandates of the act for NOAA's own programs, both directly and through coordination with other components of the agency.

I might say that I consider this act very important from the point of view of ocean pollution, because through it, Congress has stimulated the first thorough look by the Government at all of its ocean pollution programs.

NOAA continues to devote significant efforts to the Outer Continental Shelf Environmental Assessment Program, the program in which NOAA, in cooperation with the Bureau of Land Management, seeks to coordinate all Federal Alaska marine environmental assessment activities relating to oil and gas development.

Finally, in response to the oil spill from the IXTOC-I well in the Bay of Campeche, NOAA assembled a team of more than 50 scientists, and did so very quickly to evaluate the impacts of this catastrophic incident. Our efforts thus far have cost over a million dollars. It is our hope, in the end, to have a damage assessment model and to know what damage this oil spill has caused.

Let me turn for a moment to ocean services.

In recent years there has been a steady increase in activities in coastal and offshore ocean areas. These include such activities as fishing, energy development, recreational boating, and marine transportation. Thus, the ocean services which NOAA provides have become increasingly important. We must rely on a wide variety of research and development efforts to improve our ability to supply these essential ocean services and have developed several initiatives in these areas.

First, for example, we are developing airborne laser hydrography. We are using now a swath sonar system to survey and map deeper ocean bottoms more efficiently. In addition we will be initiating an expanded effort in cooperation with the Navy for obtaining surface observations from government-supplied instrument packages placed on commercial vessels.

This will result not only in our supplying increased services but also will produce some cost efficiency for example in the swath sonar area. One can just look at the difference between the way soundings were done in the past and the way they are being done now. Originally they were performed with a plumb line from a vessel which stopped each

time to take a sounding. Now vessels can proceed at many knots with the swath sonar that takes soundings over a wider area of the ocean bottom and not just below the ship.

The future of R. & D. in the area of ocean services also holds promise. We are now looking at expanded application of ocean-directed satellite observations to determining ocean surface characteristics. We are already taking limited satellite measurements of sea surface temperatures and ice conditions. Major new initiatives in this area might include global observations of sea state, surface wind field, surface temperature under all weather conditions, the abundance of matter on which fish feed, and turbidity. These in turn could provide significant improvement in the warnings and other information on environmental conditions which are becoming more important for the users of our Nation's ocean and coastal areas.

As you are aware, Mr. Chairman, Seasat is no longer in operation but I feel fairly confident that there will be an experimental follow-on to Seasat and NOAA will be playing a major role in that effort along with the Department of Defense and NASA. It is my hope that someday we will have an operational system, that is an operational satellite performing similar functions to those that Seasat performed, so that we will not only have a Landsat but also a Seasat.

In the area of climate, the National Climate Program Act, with which you are very familiar, mandated that NOAA, working with other involved Federal agencies, develop a 5-year climate plan that establishes the goals and priorities of the climate program and that such plan should detail a comprehensive and coordinated program for research, forecasting, data collection, monitoring, information dissemination, and international and intergovernmental cooperation.

On July 10, 1979, Associate Administrator George Benton presented the committee with our preliminary 5-year plan and described NOAA's efforts to satisfy the statutory mandate.

We are now in the process of preparing the final plan incorporating suggestions made by Members of the Congress and in particular by you, Congressman Brown, governmental agencies, and other interested persons. We are aware of your particular concern in connection with this subject and we hope to accommodate those concerns to the extent we can.

In the fisheries area, NOAA received a substantial new responsibility with the passage of the Fishery Conservation and Management Act, a responsibility which quantitatively and qualitatively differs from others we have had with fisheries. We have come to realize that if we are to meet the mandate of the FCMA to insure full utilization of U.S. fisheries, we must insure that fishing and fish habitats are protected. NOAA is directing substantial resources to research into understanding and protecting these vital habitats.

In the area of weather modification, NOAA and its predecessor agencies have conducted weather modification research since 1948. Our Environmental Research Laboratories conduct a wide range of relevant laboratory experiments and studies, field experiments, and computer modeling activities. NOAA's Office of Oceanic and Atmospheric Services is the primary source within the Federal Government of the observations, data and information essential to weather modification

field programs and evaluations. And NOAA, in concert with the Department of State, provides Federal leadership in connection with those multinational organizations, experiments, and negotiations involving weather modification.

We will deliver this week, to the Congress, the Secretary of Commerce's report on national weather modification programs and policies, which is the result of several years of study of the issues with the assistance of a distinguished public Weather Modification Advisory Board. This study has confirmed that modification of the weather is scientifically possible, and that if it can be done reliably and with predictable results, society will benefit substantially, both economically and by the saving of lives. These potential benefits justify the Federal Government in undertaking a sound research and development program built around a coherent long-term research plan to resolve the outstanding scientific issues.

The administration has favored, in testimony before Congress, the passage of legislation on this subject and also increased funding.

As a result of this study, the administration has decided to establish a Weather Modification Subcommittee under the Committee on Atmosphere and Oceans, which I chair. The committee will be led by a NOAA official, and will be charged with developing a 5- to 10-year Federal research plan that emphasizes fundamental research on cloud microphysics and mesoscale meteorology. The subcommittee will also provide a coordinating mechanism for the conduct of the plan. We have not had, I might add, such a coordinating mechanism at all in the Federal Government in connection with weather modification.

We welcome this new initiative and we believe that NOAA is well equipped to take the lead in performing the necessary research and development.

As I mentioned earlier, we are favoring legislation which I hope this committee will focus on at the right time, and we are also favoring an increase in funding.

Let me talk if I may for a minute about the framework for decisions on research and development issues.

We obviously have a number of rather generic decisions in connection with R. & D. which sometimes are difficult to assess, and to implement.

For example, a major factor in deciding what research and development should be undertaken is the existence of a significant need in a particular area. These needs may be determined from several sources. A primary basis for establishing need is statutory requirement. A need may also be created by Presidential directive. Or in some cases our scientists may identify specific scientific questions which beg for answers. Needs may be related to the operations of NOAA in carrying out its functions, or they may be those identified in the course of, and for the benefit of, research and development activities generated by other agencies.

A second issue which we focus on is the need and potential for innovation. It is a factor which affects NOAA's research and development policies. Obviously, we do not wish to undertake activities in areas where it is clear that we will be unable to obtain results. Rather, we look for areas where there is the greatest potential for benefits com-

pared to the resources to be invested. For example, NOAA is moving forward in the development of a Prototype Regional Observing and Forecasting Service to provide weather information on a local and immediate scale. We are doing so because a known capability exists and because it may be possible to realize substantial benefit at a reasonable cost.

A third factor which influences NOAA decisions is our capability in a given area. NOAA possesses a reservoir of expertise in a wide variety of disciplines, ranging from geologists to ocean engineers to biologists to meteorologists, and has a substantial resource in experience. We seek to apply our efforts in areas where this capability can be realized and utilized in the most effective way.

We also look at the capability of other agencies in allocating our own research and development resources. In the area of satellites, for example, we work closely with NASA, and that relationship has been a very beneficial one, not leading to any redundancy or inefficiency. We work well together with NOAA as an operating agency and NASA as the agency involved in satellite procurement and research.

Our relationship with NASA has been very productive and demonstrates the viability of interagency research and development efforts. It is not only our agency's capability toward that end that we consider. We also consider what is available in the university research community and if that capability is better than ours. I will discuss that subject a bit later in this testimony.

There are a number of additional factors which affect decisions on research and development. For example, some of NOAA's efforts are conducted on a reimbursable basis for other agencies. Examples include OCSEAP, air pollution meteorology efforts for EPA, a solar radiation observing network for DOE, and an acid rain network to be provided for EPA and the Department of Agriculture. In undertaking such efforts, we must consider the benefits and costs of additional resources received in these arrangements.

While such additional resources are important for accomplishing certain NOAA research and development efforts, we also believe NOAA must maintain a minimum core of control over its own resources. This is necessary to provide some stability in operating our own laboratories, retain competent people in the agency, maintain reasonable control over and coherence in our programs over time, and plan for the future. While we seek to strike this balance, of course we continue to make decisions in the context of the factors I have mentioned—need, potential for innovation and NOAA capability.

In the area of outside contracting, OMB Circular No. A-76 which sets forth policies for acquiring commercial or industrial products and services needed by the government, presently is undergoing scrutiny within the executive branch with respect to its application to research and development activities. I suggest, by the way, that the committee may wish to oversee our response to OMB Circular A-76 since it will impact a number of issues of concern to you. The purpose of this review is to develop guidance for assuring consistency in determining and justifying what is appropriately a governmental function, that is, what "core capability" should be retained within an agency, and what efforts should be obtained from outside contractors in accord

with the Government's general policy of relying on the private sector for goods and services. Meanwhile, NOAA is examining this issue on a project-by-project basis and seeks outside assistance whenever possible.

We also have taken specific steps in response to some criticism, by National Academy of Science Advisory Panels and the Weather Modification Advisory Board, established by the Secretary of Commerce in 1977, that NOAA has been unduly oriented to in-house research activities.

We believe the academic and research communities can provide research of high quality and contribute significantly to NOAA missions. Indeed, some of that research is not only of high quality, but of better quality. This depends a lot on what individual scientists we have in an area and what individual scientists might be in outside institutions.

To increase our support of and reliance on these communities, I issued a policy directive in January of this year which established guidelines designed, among other matters, to increase funding for outside research, and to insure increased interaction between NOAA and academic institutions by locating NOAA facilities near such institutions, through cooperative research agreements with universities, and through more frequent consultation with the research communities. With respect to increased out-of-house funding, I have established target figures for each of NOAA's components with significant research budgets which will result in an increase in grants and contracts to universities from roughly \$10 million this year to nearly \$21 million in fiscal year 1980, and I am speaking about funds that do not include those made available by the Office of Sea Grant.

With respect to the role of government versus industry, we encounter the issue whether government should support a particular effort or whether industry should be left to address it.

There are, obviously, a number of criteria we use in making this decision and the decision is not often easy. For example, we asked ourselves whether industry will develop the technology without government help. If it won't, can government realistically attract human resources and move the bureaucratic mountains to solve the problems?

If not, should government provide the funds, and the academic or industrial community provide the work?

And are budget constraints such that, in the end, no government program will be significant?

One area of research and development in which this issue has been particularly troublesome is ocean engineering. NOAA spends in excess of \$20 million annually, and devotes the efforts of 152 full-time employees, to marine engineering activities throughout its Offices of Research and Development, Oceanic and Atmospheric Services, and Fisheries. Most of these activities are designed to carry out NOAA's statutory missions, and are not framed to carry out a broader role of advancing fundamental ocean technology for the Nation.

I must admit these activities do not fulfill the hopes and expectations of many in the ocean community. From the Stratton Commission in 1969 to the National Advisory Committee on Oceans and Atmosphere in 1974 to the Marine Board of the National Academy of

Engineering today, many groups have concluded that the Nation needs a governmental program to act as a catalyst for private industry's development of advanced ocean engineering technologies. However, private industry has made some notable marine engineering advances on its own, and no consensus has developed within the Federal Government as to the appropriate roles of Government and private industry in the area.

As a result, NOAA has undertaken an intensive internal review of its future role in the field. We have concluded that, in view of this lack of consensus, and the general budgetary and personnel constraints to which the entire Federal Government is subject, NOAA must continue to focus primarily on carrying out its own basic engineering requirements, however much it would like to be able to carry out a broader role.

I will be making a policy statement in some depth on this subject within a couple of days, Mr. Chairman, and I would like to send you that statement because it is announcing something that I think some people will be saddened with—namely of our inability under present guidance, laws, and budgetary constraints to carry out the broader role which many individuals would like us to carry out. It is simply in my view a recognition of the reality as it exists.

Finally we have the issue of short-term versus long-term needs. It is a subject which every manager of resources grapples with. We hope that we are satisfying our short-term needs and at the same time are not placing undue resources in them at the expense of the long-term needs. We do commit ourselves toward identifying long-term needs and sticking to them to the extent we can.

You mentioned earlier the subject of coordination among our units. I think the questions along those lines should be addressed to Drs. Owen and Webster but let me first say, one of the reasons those two individuals exist is to have the coordination that is necessary for the transfer of technology between research and development and services in NOAA. That is, prior to our reorganization 2 years ago, no one in NOAA was responsible for research and development, and no one was responsible for services, but we now have one person in each category, and they are responsible for the technology transfer between them. If it does not take place, we know to whom to look.

I thank the Committee for the opportunity to testify today and I would be happy to answer any questions now or after you have heard from all of our witnesses if you would like. Thank you.

Mr. BROWN. Thank you very much. Can you conveniently remain for a little bit longer? Do you have some constraints on your time?

Mr. FRANK. I would have to leave about 3:15 to attend another meeting in the other House.

Mr. BROWN. I would prefer to go ahead with our additional witness if it is satisfactory and I think we can expedite the full proceeding, if you have no objections, and we will try and get you through by 3:15.

Mr. FRANK. Would you like me to stay now or would you like—

Mr. BROWN. I would like to have you remain at the table.

Mr. FRANK. It would be my pleasure.

Mr. BROWN. Do you have a separate statement, Dr. Benton?

Dr. BENTON. No; I do not.

Mr. BROWN. Dr. Webster, would you proceed then with your statement?

**STATEMENT OF FERRIS WEBSTER, ASSISTANT ADMINISTRATOR
FOR RESEARCH AND DEVELOPMENT, NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION**

Dr. WEBSTER. Thank you, Mr. Chairman.

I appreciate the opportunity to be with you here today to testify on research and development programs and NOAA.

As Mr. Frank mentioned, I am accompanied by Dr. Wilmot Hess, the Director of the Environmental Research Laboratories, and I would like to follow up on Mr. Frank's opening remarks by first providing you with a perception of the R. & D. programs that are conducted in the Office of Research and Development, and second by giving you details of the R. & D. programs in the Environmental Research Laboratories as your subcommittee has requested.

I have prepared a formal statement, Mr. Chairman, which you have. I would like to submit that for the record.

Mr. BROWN. Without objection the full text of your statement and Mr. Frank's will be made a part of the record at this point.

[The prepared statement of Dr. Webster follows:]

STATEMENT BY
 DR. FERRIS WEBSTER
 ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
 UNITED STATES DEPARTMENT OF COMMERCE
 TO THE
 SUBCOMMITTEE ON NATURAL RESOURCES AND ENVIRONMENT
 COMMITTEE ON SCIENCE AND TECHNOLOGY
 OVERSIGHT HEARINGS ON NOAA'S RESEARCH AND DEVELOPMENT PROGRAM
 NOVEMBER 13, 1979

Mr. Chairman and Members of the subcommittee:

I appreciate the opportunity to testify before you on the research and development programs of the National Oceanic and Atmospheric Administration.

I would like to follow up on Mr. Frank's opening remarks by providing you with an overview of the NOAA R&D programs conducted by the Office of Research and Development, with emphasis on the R&D programs of the Environmental Research Laboratories as requested by your subcommittee.

There are five major elements in NOAA's Office of Research and Development that are responsible for managing R&D programs to meet the needs of other components of NOAA, the needs of other Federal agencies, and national needs within the NOAA mission.

The Office of Marine Pollution Assessment

The National Ocean Pollution Research and Development and Monitoring Planning Act of 1978 (the Act) (P.L. 95-273) assigns NOAA as the lead agency to develop, with other federal agency cooperation, a comprehensive five-year plan for ocean pollution research and development. The Federal Five-Year Marine Pollution Plan No. 1 has been prepared and is currently being reviewed by the Interagency Committee on Ocean Pollution Research and Development and Monitoring.

The Act also directs NOAA to establish within the Administration a comprehensive ocean pollution research and development and monitoring program to implement the Five-Year Plan. A new Office of Marine Pollution Assessment has been proposed by NOAA, which would be charged with this responsibility, and would serve as the focal point for NOAA's marine pollution research and development activities, such as the Marine Ecosystems Analysis (MESA) Program and the Outer Continental Shelf Environmental Assessment Program (OCSEAP). The OMPA would also direct the Hazardous Materials Response Project which provides scientific support to the on-scene Coordinator in cases of offshore and coastal spills of oils and other hazardous materials. An example of such an event is the recent crisis caused by the IXTOC 1 blowout in the Bay of Campeche.

In support of our marine program, for example, NOAA is supporting applied research at the University of Rhode Island through which we expect to develop an advanced system for automated zooplankton processing through the use of image analysis and pattern recognition, which would improve considerably the timely availability of information important to fishery resource assessment. In the area of marine pollution, a potentially significant advance is the development of a miniature, low-cost sensor for measuring dissolved oxygen, an important indicator of the ocean's health.

Global Atmospheric-Research Program

The objective of the Global Atmospheric Research Program (GARP) is to improve the range and accuracy of weather forecasts and obtain a better understanding of the physical basis of climate. It does this through regional and global projects to acquire and analyze observational data and to develop physical--mathematical models.

The Global Weather Experiment of GARP will soon conclude a successful operational year-long experiment ending on November 30, 1979. A total of 149 countries contributed their support during this observation phase of the experiment. The United States contributions of observing systems included: operational and research satellites, aircraft operations, ships, tropical constant level balloons, special temporary island stations, drifting buoys,

automated data collection systems on commercial aircraft, and other systems for the various regional experiments. Data management and research plans are already being implemented. Although the observational phase is over, the analysis of the data will intensify during later phases of the program.

Office of Ocean Engineering

The effective performance of NOAA's service and scientific investigations requires intimate knowledge of the ocean and its boundaries--its properties, characteristics, and movements. The acquisition of such knowledge is dependent upon the availability of proper tools, facilities, techniques, and data acquisition systems. The Office of Ocean Engineering is working to provide improvements in our capabilities to perform NOAA's missions effectively through the development of advanced technologies.

In support of our marine programs, for example, the Office is supporting applied research at the University of Rhode Island through which we expect to develop an advanced system for automated zooplankton processing through the use of image analysis and pattern recognition, which would improve considerably the timely availability of information important to fishery resource assessment. In the area of marine pollution, a potentially significant advance is the development of a miniature, low-cost sensor for measuring dissolved oxygen, an important indicator of the ocean's health.

The office is also initiating activities to examine the application of remotely operated vehicles in support of NOAA's observation and measurement requirements. In this area, the office is working with others in the field and last month, for example, the office cosponsored with NASA a workshop with industrial, academic, Navy, and other Government participants. One example of our effort, still in its infancy, but which appears to offer considerable potential, is the work being sponsored by the Office at the University of Georgia for developing techniques of sediment retrieval from a moving ship to provide continuous analysis for trace metals and other constituents in bottom sediments.

For the climate program, we are working to extend the capability of our highly successful drifting data buoys that were deployed in the Global Weather Experiment. The developed air drop capability for these buoys and its potential for adding additional sensors is expected to provide an invaluable tool not otherwise available.

In other activities, the Office of Ocean Engineering is developing a program of regional facilities to improve manned underwater capability in support of NOAA's missions. An example is the Hydrolab underwater laboratory at St. Croix, which has been operating since May 1978.

Office of Sea Grant

The major objectives of the Sea Grant program are to increase the Nation's capability for development, utilization, and conservation of its ocean and coastal resources by promoting, via a partnership with the Nation's universities, and in concert with the States and industry, a strong educational base, a relevant dynamic research program, and a responsive technology transfer and information dissemination network.

During 1979, the 13th Sea Grant college, Louisiana State University, was designated. The many research accomplishments included isolation of a new substance from a Caribbean sea fan which has shown great promise as an anticancer agent, and use of a Sea Grant developed hydroacoustic system to determine the extent of the rejuvenation of a Pacific herring fishery whose dockside value climbed to nearly \$5,000,000 this year.

The Environmental Research Laboratories

I would like now to discuss the mission of the Environmental Research Laboratories (ERL) and some recent program highlights from within the laboratories.

The Environmental Research Laboratories conduct geophysical and environmental research on a broad set of problems ranging from forecasting solar flares to research on weather and climate to assessing the potential effects of ocean pollution. These laboratories carry out a broad program of research and technology development within their mission areas.

I would like to comment briefly on three basic functions of the laboratories as we see them, illustrating each function by an example.

1. R&D Support relevant to NOAA's Service functions.

The Joint Doppler Operational Project is an excellent example of technology transfer in NOAA. This technology defined the feasibility of using a single Doppler radar to improve tornado detection and warning. It resulted from research and technology developments particularly at the National Severe Storms Laboratory in Norman, Oklahoma. Since the project also involved the Department of Defense and the Federal Aviation Administration, it will have benefits across the Federal Government and potential for the private sector. The new technology has been transferred to the National Weather Service to form a part of the Next Generation of Weather Radars (NEXRAD) for operational purposes.

2. Direct public services in selected areas.

The Space Environment Services Center, a part of the Space Environment Laboratory in Boulder, Colorado, provides real-time data, forecasts, and warnings of solar terrestrial phenomena, such as solar flares, to a wide range of users. When solar events impinge on the near-Earth environment, they disturb the Earth's atmosphere and thus have potential to affect man's activities such as satellite communications, powerlines, and geophysical exploration.

3. Conduct of research on national problems.

There are many research areas where environmental information is needed for public decisions. One example is the National Climate Program, for which ERL is making global observations and performing analyses of carbon dioxide levels in the atmosphere which may have potential climatic effects.

Now, I would like to highlight a few of the areas of ERL research.

SOLAR-TERRESTRIAL SERVICES AND RESEARCH

The Space Environment Services Center, of the Space Environment Laboratory has already been cited as an example of a direct public service of ERL. The work of this unit provides real-time data concerning the impingement of solar events on the near-earth environment, affecting man's activities such as satellite communications, electric power distribution, and geophysical exploration. As we approach the maximum in the eleven-year solar cycle, these solar events should reach a peak in the coming year. During the last few weeks of the life of Skylab, NASA and the Air Force used NOAA predictions of solar activity, made 27 days in advance, to predict the Skylab re-entry date. Long-term prediction of sunspot numbers, made by NOAA in 1977, brought an early awareness of re-entry problems associated with Skylab. These predictions appear to be verifying almost exactly.

In research on the interplanetary medium a new, more realistic, three-dimensional model of the solar atmosphere was developed, permitting a better estimate of how solar disturbances travel through the sun's atmosphere and out into interplanetary space. Observed variations in the brightness of the distant planet Neptune, and Saturn's moon, Titan, were found to be controlled by variations in either ultraviolet or energetic particle emissions from the sun.

Research on the Earth's magnetosphere, using data from the International Sun-Earth Explorer satellites, launched in 1977, has resulted in the first direct measurements of the motion of the magnetopause, the outer boundary surface of the Earth's magnetic field, and the existence of waves on this boundary. A new model of the generation of electric fields aligned along the Earth's magnetic field in the auroral zone explains observations of auroral characteristics in a consistent but simple manner.

WEATHER RELATED RESEARCH

The efforts in atmospheric science are oriented strongly toward providing the understanding and developing the techniques and technologies that will be the basis for future improvements in the nation's weather services. I would like to discuss a number of these developments. Mesoscale or regional meteorology is the term used to define weather processes and phenomena that develop within areas of 10 to 1000 kilometers. These processes and phenomena encompass all major forms of severe weather that affect the U.S. including hurricanes, flash floods, severe winds and thunderstorms including tornadoes, heavy snow storm and hail as well as clear air turbulence affecting aviation. Because of the importance and effects of these phenomena on the lives and business of the American people, and because of recent advances in science and technology, such as Doppler radar and high speed computers for data processing and numerical modeling, we are focusing a great deal of attention on mesoscale research, development, and transfer in order to improve regional weather data, forecasts, warnings and dissemination.

Prototype Regional Observing and Forecasting Service (PROFS)

For several years, scientists from the Wave Propagation Laboratory have been developing remote sensing instruments to measure the properties of the atmosphere from the ground. These studies have progressed far enough that some of them are now ready to be tested for incorporation into operational services. This year, a new project has been started called the

Prototype Regional Observing and Forecasting Service (PROFS), The objective of the project is to develop a considerably improved local weather service for the future by incorporating recent advances in remote sensing, mesoscale modeling, data processing, analysis and dissemination, and communication technology into an integrated system.

We intend to design and build an experimental development facility (EDF) that will be similar to an operational Weather Service Forecast Office (WSFO) but with many recent technologies being used. The EDF will be operated in Boulder, Colorado. It will have a new Automated Forecast and Observing System (AFOS) unit like operating WSFO's and will get new satellite data products from employees of the National Environmental Satellite Service who will be working at Colorado State University and the University of Wisconsin. An example of a new product is an integrated overlay on the same map of a satellite cloud picture and a ground-based radar picture of those same clouds. New kinds of data display and dissemination systems will be tested. Schemes for producing automatic maps of weather parameters for T.V. screens and for showing the motion of weather fronts and severe storms will be incorporated. All appropriate new remote sensing techniques will be used in the EDF. One which has special importance is called the profiler.

Profiler

Various instruments have been developed over the last several years to measure vertical profiles of temperature, humidity, and winds from the ground. The system for measuring both temperature and humidity will be a multi-channel passive microwave radiometer. This system is much like that used in satellites for temperature sounding. It will detect natural

emissions from water vapor molecules in the air and measure how much water vapor there is. It also will detect the emissions from oxygen molecules at different frequencies. These data can be used to infer temperatures in the air at different altitudes. An example of data taken with this system compared with atmospheric temperature and humidity measured by instruments on a balloon is shown in Fig. 2.

Winds aloft, one of the most important parameters for numerical weather prediction models, can be measured by appropriate Doppler radar; one such radar sending out pulses at 50 Mhz is shown in Figure 3 . By using the Doppler effect and by measuring radar waves scattered back to the transmitter from different directions, and from different heights in the atmosphere, one can deduce both the horizontal and vertical winds. A series of wind profiles measured this way are given in Figure 4 .

One important feature of the information collected by this temperature-humidity-wind profiler is that the data is available continuously with new profiles available every few minutes. The present scheme of the National Weather Service (NWS) for getting upper air data involves the release of balloons every 12 hours from stations roughly 200 miles apart. Since the present NWS data are available infrequently and with wide spacing, these data are not adequate to understand events on the mesoscale. That is to say, squall lines and severe thunderstorms may slip through the present network of upper air soundings taken by the National Weather Service because they are so widely spaced in distance and time. Such events could be captured by continuous soundings at measuring stations. To develop a good future local weather service, continuous soundings from ground-based remote sensors will be necessary.

Mesoscale Modelling

In developing future local weather service, almost certainly a new kind of numerical model will be important. The present large numerical models used by the National Weather Service typically cover an entire hemisphere of the Earth and have grid points roughly 100 miles apart. For local weather services it is necessary to have models covering a domain of about 200 miles from side to side with grid points perhaps every 10 miles. Using this kind of mesoscale model, one can develop a quantitative picture of the classes of problems that occur on this scale, e.g., flash floods and squall lines. Mathematical models will be incorporated in PROFS when they are refined sufficiently to be useful operationally.

In addition to its mesoscale modelling, the Atmospheric Physics and Chemistry Laboratory has completed a climatology of flash flood events and detailed diagnostic analysis of the flash flood near Johnstown, Pennsylvania in 1977 utilizing all available data from radar, satellites, ground and upper air systems. The laboratory will complete two other detailed analyses of the flash floods in central Texas and in southern California during 1978. These techniques are being transferred to operations through training courses with NWS forecasters.

Other Remote Sensing Projects

It has long been recognized that the relative strength of thunderstorms can be estimated by well-calibrated weather radars. However, current

operational weather radars measure only the distribution of precipitation, and cannot detect damaging winds and tornadoes accurately and dependably.

Since 1970, scientists and technicians at NOAA's National Severe Storms Laboratory (NSSL) in Oklahoma have been developing 10 cm Doppler radar techniques to improve storm warnings and to advance knowledge of thunderstorm processes. In research, two or more Doppler radars are used to detect two-dimensional or three-dimensional movement within a storm. NSSL scientists found that Doppler radar could be used to detect and track accurately the mesocyclone circulations that are first observed in the middle levels of a severe thunderstorm and usually precede tornado touchdown by one-half hour or more. NSSL scientists also were able to use single Doppler radar to identify a small-scale signature for the tornado itself in the Doppler-derived winds.

The Joint Doppler Operations Project (JDOP), established in 1976 among the Environmental Research Laboratories, and the National Weather Service (NWS) in NOAA, the Air Force Geophysics Laboratory, the Air Weather Service (AWS) and the Federal Aviation Administration (FAA) to evaluate the operational usefulness of Doppler radar as a tool for improving warnings of severe weather, especially tornadoes, was completed in 1979. The program consists of developing techniques for detecting

tornadic signatures in an operational environment and of testing the feasibility of these techniques in a real-time environment. A team of three meteorologists from NESL, AWS, and NWS issued telephone advisories on storm severity and expected tornado formation to NWS and AWS forecast offices. Figure 5 shows the JDOP team analyzing the newly developed color display of Doppler reflectivity and a multi-moment display of detailed wind vectors:

Results indicate that Doppler velocity data can provide significant information to forecasters in real time not available in the current warning system. In particular, the probability of detection of severe weather is higher with Doppler than it is with conventional radar with a false alarm rate of less than half that in the current warning system. Average lead time before tornado occurrence was increased from zero to about 20 minutes. The National Weather Service is using the results from this project as the basis for engineering development leading to eventual procurement of a national system of Doppler radars.

An exciting new idea in remote sensing is the possibility of measuring global winds using a Doppler mounted lidar in satellites. Fig. 6 shows an artist's conception of a lidar mounted in a space shuttle platform. A lidar produces a light beam which would be reflected by dust particles in the atmosphere with their motion inferred from the Doppler effect. An analysis of this technique has shown that a Doppler lidar should measure winds with an accuracy of 1 meter per second in 1 kilometer vertical slices of the atmosphere all the way from the ground up to the lower stratosphere. A map of the expected wind field from this lidar technique is shown in Fig. 7.

We have recently purchased a new laser to start measuring winds using this technique from the ground. If all goes well, we will attempt our first satellite borne instrument using the shuttle in about 1986.

Other Mesoscale Research

The Severe Storms and Mesoscale Experiment (SESAME) is a program to improve understanding and prediction capabilities for severe thunderstorms and their related phenomena such as tornadoes. The SESAME 1979 Field Project was executed through a cooperative pooling of existing resources and proved to be a landmark in acquisition of data for regional-scale numerical model development and a variety of stormscale objectives. The success of SESAME '79 was due in large part to the cooperation of 17 universities, 14 departments or agencies of the federal government including four military services, National Guard units from three states, research councils of the United States and Canada, a private contractor, and the National Center for Atmospheric Research. Host for the project was NOAA's National Severe Storms Laboratory in Oklahoma.

The best instrumented severe storm field program ever carried out was done in the central U.S. from 10 April to 11 June this year. Fig. 8 shows the 43 radiosonde stations that were used to send balloons aloft every three hours on selected days. Six Doppler radars and eight instrumented aircraft also provided upper air data. Eighty ground stations continuously collected meteorological data. Massive data sets were collected on thirteen days with more limited operations on an additional 21 days. Phenomena observed in detail included evolution of the pre-convective boundary layer, short wavelength upper atmospheric disturbances, low-level jets, cumulus through cumulonimbus stages of convection (some with tornadoes) and several intense rainfall events.

During 1980, the National Hurricane and Experimental Meteorology Laboratory (NHEML) will initiate the Hurricane STRIKE program to improve the short term forecasting of hurricane landfall and intensity. Unique data sets from the newly instrumented WP-3D aircraft will be used for real-time monitoring and reporting to the National Hurricane Center of short-term changes in hurricane path or intensity, and for the purpose of developing and testing techniques to substantially improve hurricane prediction and warning skill. The aircraft radar (Fig. 9) and precision navigation system allow detailed and accurate monitoring of the hurricane's position and storm track over the previous several hours. In addition, the aircraft radar systems allow quantified measurements of rainfall intensity over a large horizontal area of a hurricane striking the U.S. coast, while aircraft wind sensors fully map the hurricane windfield in horizontal space and time. Fig. 10 shows the real time display of wind and pressure measured during a flight through Hurricane Anita in 1977. The first such high density aircraft data sets were obtained on the destructive Hurricanes "David" and "Frederic" of this year.

Quantified forecasts of storm surge, wind, and flooding potentials will start as much as 48 hours prior to landfall, and then be continually updated and refined for the duty forecasters as the point of hurricane landfall is narrowed down. Such a procedure will not only make the issuance of hurricane strike warnings more timely and accurate, it will greatly reduce the time and costs of adequate public preparation.

The Hurricane STRIKE Program is complementary [to Project STORMFURY, which I will discuss shortly. Much will be learned about the convective structure and natural variability of the hurricane, along with detecting and forecasting rapid changes in intensity and track.

WEATHER MODIFICATION

The Environmental Research Laboratories, through the Weather Modification Program Office, National Hurricane and Experimental Meteorology Laboratory (NHEML) in Miami, Florida, and the Research Facilities Center (RFC) in Miami, Florida, is involved in two weather modification activities: Project STORMFURY and the Florida Area Cumulus Experiment.

Project STORMFURY is designed to test the hypothesis that the maximum surface winds in hurricanes can be reduced by 10 to 20% if proper clouds in specified areas of the storm are seeded with freezing nuclei. Since the force of the wind varies as the square of the wind speeds, reductions of 20 to 40% in the force of the wind will result. Damage due to the winds is expected to be decreased by an even larger factor than is the force of the wind.

The status of this project is that we (1) have completed the necessary operational improvements (e.g., modernization of RFC aircraft);

(2) are preparing to conduct one seeding experiment in the western Atlantic during 1980; and (3) are carrying on international negotiations (e.g., with Government of Australia thru the Department of State) to allow the experiment to proceed in the western South Pacific where the frequency of seedable storms is greater than in the western Atlantic. Fig. 11 shows areas off the coast of Australia where seeding might occur.

The Florida Area Cumulus Experiment (FACE) is designed to develop and test a technology for enhancing the precipitation output of cumulus clouds over a large area using dynamic seeding. Earlier experiments have shown that dynamic seeding increases the sizes and lifetimes of individual cumulus clouds and enhances rainfall by nearly a factor of three. The present experiment was designed to increase precipitation over an extensive area ($= 1.3 \times 10^4$ square kilometers) in southern Florida, as shown in Figure 21, by promoting larger and better organized cloud systems than would evolve naturally.

The initial results, based on the analyses of 75 days of randomized experimentation since 1970 (39 seed days and 36 control days), indicate that dynamic seeding produced up to 50% more rainfall from systems of cumulus clouds and from 20 to 25% more rainfall over the entire experimental area than no seeding would have produced. Additional measurements and analyses of the cloud processes involved have produced strong evidence that dynamic seeding does increase the growth rate of clouds and induce the merger of clouds into even larger systems. Also, using satellite rainfall analysis, mentioned previously, no downwind effects were apparent. A confirmatory field experiment has been conducted during

the last two years in Florida in response to recommendations from the scientific community and the third field season will be conducted during July-August 1980.

The midwestern United States is an area where meteorological conditions appear to be suitable for dynamic seeding as used in the FACE program and agricultural yield could benefit from increased rainfall during many years. In FY 80 NOAA will receive \$400K to explore this possibility. These funds will be used to undertake the necessary background studies to assess the suitability of midwestern clouds for increased rain stimulation and to design the experimental modification phases.

NOAA's FY 80 budget also provides funding to develop nationally applicable evaluation technologies for two types of operational weather modification projects -- summertime rain enhancement and wintertime snowpack augmentation -- based on the on-going North Dakota and Utah state-sponsored operational projects. NOAA has let a contract with Colorado State University to accomplish the first task of this effort; namely, to review the operations and recommend evaluation designs for the North Dakota and Utah project. These results will form the basis for a national evaluation design for the conduct of actual evaluations.

IV. CLIMATE RESEARCH

The Environmental Research Laboratories are continuing to play a major part in NOAA's climate program. I would like to relate to you a few of the highlights of ERL's recent climate-related research activities and briefly mention some of our plans for the future.

Ocean/Atmosphere Studies

ERL has completed its first year of research in the Equatorial Pacific Ocean Climate Studies (EPOCS) program. The principal purpose of EPOCS is to understand better the role of the ocean in influencing year-to-year climate fluctuations. The central importance of the ocean is based on: (1) its enormous capacity to store and transport thermal energy, and (2) the influence of its surface temperature in regulating the behavior of the atmosphere. Initially, this program is concentrating on the large thermal anomalies in the eastern equatorial Pacific Ocean where interannual sea-surface temperature fluctuations of 4-6°C extending over thousands of kilometers are not uncommon. It is hypothesized that these thermal anomalies alter the geographic pattern of heat input into the tropical atmosphere, thereby influencing the mid-latitude circulation and interannual climate fluctuations in the United States. Fig. 12 shows the complex instrumentation layout for the oceanographic experiment in the Eastern Pacific Ocean.

During this initial year of EPOCS, detailed oceanographic measurements have been taken on the equator 110°W to obtain a better picture of the complex current system present in this region. Three deep-ocean

moorings, each containing a vertical distribution of current meters from near the surface down to 3,000 meters, have been successfully deployed and retrieved. These observations were supplemented by the use of surface drifting buoys and hydrographic measurements from NOAA ships. Analysis of these data, as well as atmospheric measurements obtained by aircraft and satellite, will continue into next year.

Atmospheric Variability

In this fiscal year, ERL will be embarking on a new atmospheric climate research program to investigate the increasing level of carbon dioxide in the atmosphere and the variability of the sun's energy output. Fig. 13 shows the measured atmospheric CO₂ concentration at the NOAA baseline station at Mauna Loa, HA. Using information from the expanded U.S. program of carbon dioxide measurements, NOAA is accelerating its research on exchange processes of the carbon cycle. Primary emphasis in the new program will be on the analysis of the partitioning of carbon dioxide and radiocarbon isotopes among the major global carbon reservoirs, and on the further development of global models to predict future carbon dioxide levels in the atmosphere and oceans and their potential effect on climate. An augmented program is also being implemented on solar ultraviolet and visible radiation intensities. The need to observe and analyze solar behavior results from mounting evidence that indices of solar variations (such as sunspots and geomagnetic disturbances) are statistically correlated with certain weather and climate changes on

earth. These statistical correlations involve such diverse relationships as the phase of the 22-year magnetic cycle of the sun and extent of drought in the western United States, and between long-term variations of the average level of solar activity and historical climate variations. With regard to each of these apparent relationships, we are almost totally ignorant of the physical processes that are responsible for the correlated terrestrial climatic effects. Precise measurements of the solar output is, therefore, required to determine what the sun is doing that may be the source of these observed changes in climate and to enable the specific cause-effect linkage to be determined.

Climate Modelling

The Geophysical Fluid Dynamics Laboratory is continuing to improve its mathematical modelling of the global climate in order to examine the impact of the increase of carbon dioxide in the atmosphere. Some recent results have been obtained from a mathematical model in which the atmospheric concentration of carbon dioxide is four times the present level. The mathematical model consists of a general circulation model of the atmosphere coupled to a simple ocean model with a static isothermal water layer of uniform thickness and provision for sea ice. The model has realistic geography and for the computation of solar and terrestrial radiation, the distribution of ozone and cloud cover are prescribed beforehand.

Figure 14 shows the seasonal variation of the difference of zonal near surface air temperature resulting from the quadrupling of CO_2 .

The difference in zonal near-surface air temperatures arising from a quadrupling of CO_2 is large in low latitudes and varies markedly with seasons, particularly in the Northern Hemisphere. The poleward retreat of highly reflective snow cover and sea ice is mainly responsible for the relatively large warming in high latitudes (Fig. 15). This model predicts that the pack ice in the Arctic ocean would melt in the summer months and then refreeze in winter. If this should happen there would be considerable climate changes.

The model results also show that the average warming of the Northern Hemisphere (i.e., 4.5°C) is significantly larger than that of the Southern Hemisphere (i.e., 3.6°C).

In view of the assumptions of fixed cloudiness and various simplifications contained in the sea ice modelling, the quantitative aspect of these results should be received with caution. However, this investigation suggests that the warming of the atmosphere in response to an increase in CO_2 will have significant seasonal and interhemispheric asymmetries.

Stratospheric Research

We have continued direct sampling of the stratosphere by means of balloon-borne samplers which are parachuted to Earth and analyzed in the laboratory. Measurements of methane, water vapor, and ozone have been added to those of nitrous oxide and the halocarbons F-11 and F-12.

Routine flights made in Brazil as well as Wyoming and Antarctica, provide the most complete geographical and seasonal picture yet available for these important constituents. A new instrument for the measurement of stratospheric water vapor was successfully developed and flown. This instrument provided the first observational evidence of the longstanding hypothesis that water vapor enters the stratosphere through ascending motion in the equatorial regions. Fig. 16 shows the balloon-borne equipment used for measuring stratospheric water vapor, while Fig. 17 shows a typical vertical profile of stratospheric water vapor.

Measurements have continued with the simple spectroscopic technique developed to measure stratospheric nitrogen dioxide from the ground. It was found that dramatic changes in stratospheric nitrogen dioxide abundance accompany stratospheric sudden warming events. The spectroscopic technique used has been adapted to measure nitrogen trioxide as well and the first measurements of this important intermediate species were made. The existence of nitrogen trioxide had been suggested from theory but had not been observed prior to these measurements.

Laboratory measurements of the reaction rates of important stratospheric neutral constituents have extended our knowledge of the reaction of HO_2 with NO by measuring its temperature dependence and by measuring the rate of reaction of HO_2 with ozone and chlorine oxide. When these additional measurements were incorporated into models, the calculation of ozone destruction predicted from the release of halocarbons into the atmosphere increased even more than was believed a year ago. These new calculations also show that stratospheric aircraft emissions will not play a significant role in ozone destruction.

Very sensitive Doppler radars operating in Colorado have demonstrated that these radars can monitor continuously the altitude of the tropopause, an important piece of information in numerical weather prediction. The initial results from the new Doppler radar being constructed in Alaska has already produced the best results ever obtained on atmospheric tidal motions at 80 to 90 km altitudes even though the radar is operating currently at only one thousandth of its eventual power.

MARINE PROGRAMS

Up until FY 1979, a large portion of the resources of the Atlantic Oceanographic and Meteorological Laboratories (AOML) and Pacific Marine Environmental Laboratory (PMEL) were used in support of marine programs related to activities of the Marine Ecosystem Analysis program and of the Outer Continental Shelf Environmental Assessment Program in Alaska, which NOAA plans and manages for the Department of Interior. In FY 1979, in addition to the marine environmental assessment studies, we expanded our efforts into two other areas of national interest: Ocean Climate and Ocean Services Research. All three will be discussed below.

Marine Environmental Assessment

Marine environmental assessment activities center around regional studies such as the New York Bight and the Puget Sound Projects. New projects for FY 1979 include the Gulf of Mexico and Coastal Enrichment programs, both of which will be managed by the Office of Marine Pollution Assessment as I discussed earlier.

A. Atlantic Oceanographic and Meteorological Laboratory (AOML)

Field activities for the New York Bight Project of the MESA Program were completed in 1979. All cruise data from previous years were prepared for reporting and archival, and papers have been prepared for publication of interpretive and diagnostic results of this investigation. For example Fig. 18 shows a map of the measured distribution of coprostenol, a constituent of human waste. This chemical is a unique, non-degradable, tracer of sewage sludge.

As field efforts are being completed in the New York Bight, they are being increased in the Gulf of Mexico. Efforts in the Gulf are focused on developing systems to test the effect of natural organic chelation of trace metals on marine productivity. This has required development of trace metal "clean" systems for sampling and for measuring size specific productivity as well as for isolation of natural organic chelating compounds. One cruise was conducted through the Gulf to investigate the chemical and microbial weathering of oil spilled by the IXTOC-I Bay of Campeche oil well blowout as well as the effects of this oil on lower trophic level marine organisms.

Research in cooperation with the NOAA Ocean Dumping Research and Monitoring Program on the disposition of pharmaceutical wastes dumped off the north coast of Puerto Rico continued. Chemical tracer techniques were developed using one constituent of the dumped waste, dimethyl aniline. These techniques allowed tracking of the waste for as long as 26 hours and provided essential "ground truth" information to acoustical tracking experiments conducted at the same time.

During the 1979 field season, scientists reported the discovery of an oil-rich layer of water hundreds of miles long, hundreds of feet beneath the surface of the southwestern North Atlantic (see Fig. 19), estimated to contain at least a million tons of crude oil apparently from a natural oil-seep in the ocean floor. Shipboard analysis of water samples, and subsequent analysis made at the Atlantic Oceanographic and Meteorological Laboratories (AOML) as well as at the Woods Hole Oceanographic Institution and Scripps Institution of Oceanography confirmed the hydrocarbon was crude oil in an "accommodated

state"--a kind of chemical middle ground between being dissolved and in droplet form.

Other tests indicated that the oil was a biochemically weathered crude that had not lost any constituents to evaporation, indicating it had never surfaced at sea. Comparisons between the characteristics of sunken tars and the subsurface oil indicated the oil had weathered underwater for one to two years before the NOAA scientists found it.

The average oil concentration of six milligrams per liter was five to ten times that found in "polluted" waters. Most organisms would be sickened or killed by this level of oil contamination.

Boundary layer sensing systems, mounted on the seafloor, continuously measure sediment movement from the bottom to one meter above the ocean floor. Information on sediment transport rates relate to problems of installing seafloor structures. If a sewage outfall or oilfield pipeline is laid on the seafloor, the extent to which it will be buried or scoured depends on the rate of horizontal sand movement. The extent to which dredge spoil at dumpsites will disperse also depends on the rate of sand flow. Such studies are thus important from a pollutant and engineering aspect and aid in making decisions regarding siting.

Plans for FY 1980 include the participation of AQML in a cooperative program with the Environmental Protection Agency to help determine the impact of offshore drilling activities on a unique coral reef ecosystem in the northwestern Gulf of Mexico.

The Texas Flower Gardens are two fragile reefs located 100 NM from Galveston, Texas, among tracts of ocean that have been or will be leased for oil and gas drilling. The purpose of the EPA project is to assess the exposure of the Texas Flower Gardens to pollutants from drilling operations and to aid EPA in guiding NPDES Permit policy regarding leasing around the reef.

AOML plans to address the following :

1. Establish the dimensional characteristics of the particulate plume from the drilling platforms.

2. Determine the fate of the particulate matter.

1 and 2 will utilize the unique acoustical tracking device at AOML.

3. Identify the chemical species that can be measured to demonstrate/prove that the particulate plume detected by acoustic backscatter techniques does originate from the drilling platform.

B. Pacific Marine Environmental Laboratory (PMEL)

Research in marine environmental assessment constitutes the major area of activity for over half of the PMEL staff. Emphasis is on understanding the complex physical, biological, and geochemical processes that determine the extent of man's impact on the marine environment. The geographic focus of these studies has been: 1) Pacific Northwest and Alaskan coastal and estuarine waters and 2) the test site for manganese mining in the eastern tropical Pacific.

In the Strait of Juan de Fuca, the emphasis has been on transport mechanisms that might affect the distribution of spilled oil and the potential impacts on the biota. During FY 1979, field studies for the MESA program were continued in the eastern Strait of Juan de Fuca to describe the dominant circulation modes and relate them to various forcing parameters. A new program was begun in conjunction with Canadian scientists to examine the seasonal and spatial distribution of currents near the mouth of the Strait.

In Puget Sound proper, the emphasis has been on understanding the Sound's ability to accommodate discharged wastewater. From collected data it appears that the deep water can transit the main basin in 1-2 weeks, significantly faster than previous estimates. A new program under MESA was begun to examine the relationship between estuarine circulation and transport of particulate matter and its burden of natural and anthropogenic substances in various embayments of Puget Sound.

As part of the NOAA program to study the long-term effects of pollutants, field and laboratory studies were initiated to determine the reactivity of trace metals in estuarine and coastal waters. Preliminary studies indicate that the effluents from sewage disposal systems enhances the flocculation of trace metals in a stratified estuary.

Research in Alaska, primarily under OCSEAP sponsorship, has focused on defining the environmental conditions potentially affecting or affected by future petroleum exploration and development on the outer continental shelf. During FY 1979, much of the PMEL effort was devoted to the analysis of data from the intensive field programs conducted during the past three years. A brief description of the efforts follows:

- A variety of instruments have helped define the circulation regime of the northwest Gulf of Alaska and estimate the volume transport of the Alaska stream.
- In Lower Cook Inlet, a rich fisheries area has been the subject of intensive study by PMEL physical, chemical and biological oceanographers.
- Hydrocarbon field work was continued in Norton Sound, where previous studies had located a deep-seated gas seep of thermogenic origin. Only transient evidence of the seep was found this year in the distribution of low-molecular-weight aliphatic compounds.
- Data from a large number of current meter and pressure gauge stations on the Bering Sea Shelf have been analyzed to describe the tidal propagation across the shelf. Complementary theoretical research has resulted in a series of models designed to test the data.

A major effort in marine environmental assessment during FY 1979 continued to be the Deep Ocean Mining Environmental Study (DOMES), managed by the DOMES Project Office within PMEL. In November 1978 a pilot-scale manganese nodule mining test conducted by Ocean Mining Associates was monitored in the tropical North Pacific. Observations made before mining and during an 18-hour mining period indicated the surface plume was detectable to a distance of 7-8 km from the ship and was confined to the upper 40 m. Particulate levels returned to ambient concentration after about 35 hours of dispersion. Shading by particulates in plume water may reduce primary production by as much as 40% but there is no significant effect on zooplankton.

Nitrous oxide, a trace atmospheric component, represents an indirect sink for stratospheric ozone. Human activities such as broad-scale application of fertilizers and burning of fossil fuel contribute nitrous oxide to the environment, however little is known regarding the role the oceans play in the global budget. Ongoing research at PMEL seeks to define the mechanisms by which nitrous oxide is produced in and removed from the ocean.

Plans - FY 80

Efforts in the Puget Sound area will continue as part of the NOAA Marine Pollution program via both project support and in-house programs. Studies of flushing processes in the main basin of the Sound will focus on determining residence times. Combined physical transport/geochemical

studies will continue in selected Puget Sound embayments as part of the MESA project. Field work will be initiated to assess the fate and transport of volatile and suspended organics in the Duwamish-Elliott Bay system.

Much of the Alaska OCSEAP work will be synthesized during FY 1980 into special reports and contributions to a book on Bering Sea oceanography.

The DOMES project final report will be completed in FY 1980. A new project to examine the environmental effects of sand mining off the Virgin Islands will be developed.

C. Great Lakes Environmental Research Laboratory (GLERL)

The Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan, was established to conduct research directed toward better understanding of environmental processes in the Great Lakes and their watershed and to assist in the solution of environmental problems related to resource management and in the improvement of environmental services on the Great Lakes.

The highlights of the GLERL program in 1979 have included:

- 1) the initiation of a substantive research program on the cycling of toxic organic compounds in the Great Lakes aimed at determining the transport, dynamics, and fate of these pollutants (Fig. 20 shows the observed distribution of MIREX in Lake Ontario and the simulated distribution assuming sources at the Niagara River and Oswego, New York;

- 2) the application and testing of GLERL ecosystem models using Lake Ontario data on biological, chemical, and physical parameters;
- 3) the development and application of a model to predict the movement of oil and other hazardous materials spills in the Great Lakes. This model has been used in support of the Regional Response Team action after shipping accidents in the lakes;
- 4) the application of the phosphorus model developed at GLERL to support the International Joint Commission (IJC) efforts to determine the phosphorus loads that could be assimilated by the lakes and still meet the water quality criteria contained in the 1978 U.S.-Canada Water Quality Agreement for the Great Lakes;
- 5) completion of a study of the present and future consumptive use of water in the Great Lakes in support of the International Joint Commission's efforts to review the Great Lakes Regulation Plan;
- 6) the implementation by NWS of the storm-surge prediction model for Lake Erie developed by GLERL; and
- 7) the application of the GLERL St. Lawrence hydraulic transient model by the U.S. Corps of Engineers and the St. Lawrence Seaway Development Corporation to evaluate the impact of winter navigation through ice booms on the level of Lake Ontario and the levels and flows in the St. Lawrence River.

Plans for 1980 include: 1) completion of a field program initiated in 1979 and data analysis on Lake Erie circulation in support of the International Joint Commission's Lake Erie Surveillance Plan; 2) development and application of Great Lakes Basin rainfall-runoff models to improve the forecasting and simulation of water supplies to the Great Lakes; 3) initiation of a program to develop an Atlas of Great Lakes Eutrophication; 4) testing, jointly with NWS, of a storm-surge model for Lake Huron; 5) determination of toxic organic compound loading into Lake Michigan in cooperation with EPA; and 6) printing and distribution of the Atlas of Lake Ontario physical properties.

Through these advances, GLERL is providing a much needed service to the many decision-makers in the Great Lakes who need environmental input for the solution of problems.

RESEARCH AIRCRAFT SYSTEM

ERL's Research Facilities Center (RFC) in Miami, Florida, operates two P-3 (Fig. 21) and one C-130B aircraft which provide unique capabilities to acquire, process and display meteorological and oceanographic data in real time. Figure 22 shows the major data collection systems of the P-3 aircraft, including three radar systems, Omega dropsonde and Airborne Experiment Bathythermograph launch and data collection systems.

In FY 1979, ERL's research aircraft logged more than 2,000 flight hours. This is substantially more than the previous year and included over 1,500 hours that were funded on a reimbursable basis to support the Global Weather Experiment (GWE) and the Monsoon Experiment (MONEX).

In support of a variety of research programs, the RFC carried out research missions in the Pacific, Australian waters, the Indian Ocean, the Bay of Bengal and the Arabian and South China Seas. Despite the long deployments to foreign territories, poor maintenance facilities, engine failures, and daily flight schedules, the RFC carried out more than 92% of its missions with outstanding research system performance. Considering the fact that nearly all of these programs involved multi-national participation, the RFC has brought most favorable attention and credit to this country throughout the world and has made outstanding contributions to science via the unique and excellent data collected in support of these programs.

The RFC also flew both research missions and operational missions in Hurricane David and Hurricane Frederick.

This ends my statement. I would like to thank you for this opportunity to appear before the subcommittee and will try to answer any questions that you may have.

Dr. WEBSTER. Thank you, Mr. Chairman.

I would like to, then, focus my remarks on selected areas that are mentioned in my testimony.

There are five major elements in NOAA's Office of Research and Development in NOAA. These are the Office of Marine Pollution Assessment, the Global Atmospheric Research Program Office, the Office of Ocean Engineering, the Office of Sea Grant, and the Environmental Research Labs. I may begin by giving you a few comments about all five Offices, so you can understand what the Environmental Research Labs activities are. These Offices collectively are responsible for managing research and development programs to meet the needs of other components of NOAA, the needs of other Federal agencies, and national needs within the NOAA mission.

First of all, the Office of Marine Pollution Assessment will be designated as the focal point for coordination of NOAA's marine activities.

The National Ocean Pollution Research and Development and Monitoring Planning Act, Public Law 95-273, assigns NOAA as the lead agency to develop, with other Federal agency cooperation, a comprehensive 5-year plan for ocean pollution research and development. The Federal Five-Year Marine Pollution Plan No. 1 has been prepared and is currently being reviewed by the Interagency Committee on Ocean Pollution Research and Development and Monitoring.

One example of the kind of activity going on in this Office is that recently NOAA's Dr. Lawrence Swanson testified before the public hearing of this subcommittee on the Long Island Sound dredge spoil dumping proposals of the Corps of Engineers. This testimony drew on the research activities of NOAA's Marine Ecosystem Analysis, MESA program in the New York Bight and of NOAA's Northeast Fisheries Center. A MESA program is underway in Puget Sound and a Gulf of Mexico program is under consideration. The hazardous materials response project, another component of the OMPA, provides scientific support to the onscene coordinator in cases of offshore and coastal spills of oils and other hazardous materials. The most recent example is the crisis caused by the IXTOC-1 blowout in the Gulf of Mexico.

The next Office I would like to mention is that of the Global Atmospheric Research Program.

This is a multiyear activity to improve the time, range and accuracy of weather forecasts and obtain a better understanding of the physical basis of climate. The GARP office in the Office of Research and Development has overall responsibility for the international program. It does this through regional and global projects to acquire and analyze observational data and to develop physical mathematical models.

The global weather experiment of GARP will soon conclude a year-long experiment on November 30, 1979. A total of 149 countries contributed their support during this observational phase of the experiment. When this phase is over, the analysis of data will intensify during the later phases of the program.

The Office of Ocean Engineering is responsible for the development of engineering technologies to support NOAA's activities in ocean and coastal zone management. Let me give you a few examples of some of the work carried out by this Office.

In the marine area, for example, the Office is supporting the development of an automated zooplankton processing system through the use of image analysis and pattern recognition. If we are successful in this effort, it should considerably improve the timely availability of information important to fishery resource assessment.

Another example of the work in the marine pollution field is the development of miniature sensors for measuring dissolved oxygen, which is an important indicator of the ocean's health.

The Office is also examining the application of remotely operated vehicles in support of NOAA's observation and measurement requirements. One example which appears to offer considerable potential is work being sponsored by the Office at the University of Georgia for developing techniques for sediment retrieval from a moving ship to provide continuous analysis for trace metals and other constituents in bottom sediments.

To support the climate program, the Office is working to extend the capability of our highly successful drifting data buoys that were deployed in the global weather experiment. These buoys can be dropped from aircraft and thus provide an invaluable tool not otherwise available.

In other activities, the Office of Ocean Engineering is developing a program of regional facilities to improve manned underwater capability in support of NOAA's missions. An example is the Hydrolab Underwater Laboratory at St. Croix, which has been operating since May 1978. Finally, Congress provided funding in this year to produce an operational radar for measuring surface currents based on experimental designs of NOAA's Environmental Research Laboratories.

The Office of Sea Grant is responsible for developing national marine resources by providing support to research, education, and advisory service ocean programs. The aim to improve the Nation's capability for development, utilization and conservation of its ocean and coastal resources. It does this via a partnership with the Nation's universities in concert with the States and industry. It has a strong educational base, a relevant dynamic research program, and a responsive technology transfer and information dissemination network.

In this past year the 13th Sea Grant college, Louisiana State University, was designated.

Finally, the Environmental Research Laboratories carry out an extensive program of applied research and technology development of a broad scope of geophysical and environmental problems.

I would like now to discuss that function and give you recent highlights of their work.

The programs in the Environmental Research Laboratories range from forecasting solar flares, to research on weather and climate, to assessing the potential effects of ocean pollution. These laboratories carry out a broad program of research and technology development within their mission areas.

Let me comment first briefly on three basic functions of the laboratories.

These are, first, research and development in support of NOAA's services; second, direct public services; and third, research and development on national problems.

Let me illustrate each of those by an example.

First, research and development support relevant to NOAA's service functions.

An example of this is the Joint Doppler Operations Project which is carried out to examine the feasibility of using single Doppler radar to improve tornado detection and warning. This program resulted from research and technology developments, particularly at the National Severe Storms Laboratory in Norman, Okla. Since the project also involved the Department of Defense and the Federal Aviation Administration, it will have benefits across the Federal Government and potential for the private sector. The new technology has been transferred to the National Weather Service to form a part of the Next Generation of Weather Radars, NEXRAD, for operational purposes.

The second role is direct public services in selected areas.

An example I would like to give is the Space Environment Services Center which is part of the Space Environment Laboratory in Boulder, Colo. It provides real-time data, forecasts, and warnings of solar terrestrial phenomena, such as solar flares, to a wide range of users. When solar events impinge on the near-Earth environment, they disturb the Earth's atmosphere and thus have potential to affect man's activities such as satellite communications, powerlines, and geophysical exploration.

The third role in our laboratories is that of conducting research on national problems.

Examples of this function include the national climate and marine pollution programs, where, for example, ERL is making global observations and performing analyses of carbon dioxide levels in the atmosphere which may have potential climatic effects. There are many such research areas where environmental information and research is needed for public decisions.

Work for other Federal agencies is a part of our total effort, and is an indication of the relevancy of our work to national problems across the Federal establishment.

Mr. Frank already mentioned to some extent the criteria we use for the establishing of reimbursable work.

Let me restate that by giving it in terms of the criteria used by the Environmental Research Laboratories. There are a number of these.

First of all, we want to make NOAA's missions—in particular, oceanography and solar-terrestrial physics—available to other Federal agencies where compatible with NOAA's missions. In particular, OMB Circular A-62 encourages use of NOAA capabilities in meteorology by Federal agencies for reasons of effectiveness and economy; for example, the solar radiation measurement network or air pollution meteorology in the Air Resources Laboratories.

We engage in reimbursable work in order to participate in cooperative projects with other agencies toward mutual goals and operating efficiencies. As an example, the Severe Storms and Mesoscale Experiment, SESAME, hosted by the National Severe Storms Laboratory involved funding and/or participation by NOAA, the National Science Foundation, the National Aeronautics and Space Administration, the Federal Aviation Administration, the Department of Energy,

the Department of Defense, the National Center for Atmospheric Research and a number of university scientists.

The third area where we carry out reimbursable work is to accelerate progress in NOAA programs by utilizing additional resources from other agencies where mutual benefits can be achieved; for example, initiation of expanded CO₂ measurements with the Department of Energy.

Fourth, increase the benefits or utilization of NOAA research by applying this research to the related missions of other Federal agencies, for example, the Joint Doppler Observational Project to test the feasibility of single Doppler radar to improve tornado detection and warnings.

Let me now highlight a few areas of research in the Environmental Research Laboratories. I will do this by areas of investigation.

First, the Solar Terrestrial Services area.

I mentioned already the activities of the Space Environment Services Center of the Space Environment Laboratory. This is an example of direct public service. The work of this unit, as we approach the maximum in the 11-year solar cycle, should reach a peak in the coming year.

In weather-related research, our activities are oriented toward providing an understanding and developing the techniques for future improvements in the Nation's weather services. I would like to discuss a number of these activities.

First of all, mesoscale or regional meteorology is the term used to define weather processes and phenomena that develop within areas of 10 to 1,000 kilometers. These phenomena encompass all major forms of severe weather that affect the United States including hurricanes, flash floods, severe winds, thunderstorms, tornadoes, heavy snowstorms and hailstorms, as well as clear air turbulence affecting aviation. These phenomena have a strong impact on the lives and business of the American people. Recent advances in science and technology, such as Doppler radar and high-speed computers for data processing and numerical modeling, have stimulated us to focus attention on mesoscale research, development, and technology transfer to improve regional and local weather data, forecasts, warnings, and dissemination.

Mr. Frank already mentioned a couple of times one of our major efforts in this area which is Prototype Regional Observing and Forecasting Service.

For several years, scientists at the Wave Propagation Laboratory have been developing remote-sensing instruments to measure the properties of the atmosphere from the ground. These studies have progressed far enough that some of them are now ready to be incorporated into operational services. This year, a new project has been started called the Prototype Regional Observing and Forecasting Service. The objective of the project is to develop a considerably improved local weather service for the future by incorporating recent advances in remote sensing, mesoscale modeling, data processing, analysis and dissemination, and communication technology into an integrated system.

We intend to design and build an experimental development facility that will be similar to a operational Weather Service Forecast Office—

WSFO—but with many recently developed technologies being used. The experimental facility will be operated in Boulder, Colo. It will have a new Automated Forecast and Observing System (AFOS), unit-like operational WFSO's, and will receive satellite data products from National Environmental Satellite Service units at Colorado State University and the University of Wisconsin.

Various instruments have been developed over the last several years to measure vertical profiles of temperature, humidity, and wind from the ground. The PROFS system for measuring both temperature and humidity will be a multichannel passive microwave radiometer. This system is much like that used in satellites for temperature sounding.

One important feature of the information collected by this temperature-humidity-wind profiler is that the data are available continuously with new profiles available every few minutes.

The present scheme of the National Weather Service, NWS, for getting such profile data involves the release of balloons every 12 hours from stations roughly 200 miles apart. Since the present NWS data are available infrequently and with wide spacing, these data are not adequate to understand events on the mesoscale. That is to say, squall lines and severe thunderstorms may slip through the present network of upper air soundings taken by the NWS because they are so widely spaced in distance and time.

Such events should be captured by continuous sounding at these sites. To develop a good future local weather service, continuous soundings from ground-based remote sensors will be necessary.

The Joint Doppler Operations Project, JDOP, was established among the Environmental Research Laboratories, and the National Weather Service in NOAA, the Air Force Geophysics Laboratory, the Air Weather Service, and the Federal Aviation Administration.

It is intended to evaluate the operational usefulness of Doppler radar as a tool for improving warnings of severe weather, especially tornadoes. The program consists of developing techniques for detecting tornadic signatures in an operational environment and of testing the feasibility of these techniques in a real-time environment.

Results indicate that Doppler velocity data can provide significant information to forecasters in real time not available in the current warning system. In particular, the probability of detection of severe weather is higher with Doppler than it is with conventional radar. The false alarm rate is less than half that in the current warning system. Average leadtime before tornado occurrence was increased from zero to about 20 minutes. The National Weather Service is using the results from the project as the basis for engineering development leading to eventual procurement of a national system of Doppler radars.

In the field of climate research, the Environmental Research Laboratories are continuing to play a major part in NOAA's climate program.

I would like to relate to you a few of the highlights of ERL's recent climate-related research activities and briefly mention some of our plans for the future.

In the ocean/atmosphere studies, ERL has completed its first year of research in the Equatorial Pacific Ocean Climate Studies (EPOCS) program. The principal purpose of EPOCS is to understand better the role of the ocean by this temperature-humidity-wind profiler in that the data are available continuously with new profiles available every few minutes.

The program consists of developing techniques for detecting tornado-influencing, year-to-year climate fluctuations. The central importance of the ocean is based on: (1) Its enormous capacity to store and transport thermal energy, and (2) the influence of its surface temperature in regulating the behavior of the atmosphere.

Initially, this program is concentrating on the large thermal anomalies in the eastern equatorial Pacific Ocean where interannual sea-surface temperature fluctuations of 4 to 6° C. extending over thousands of kilometers are not uncommon. It is hypothesized that these thermal anomalies alter the geographic pattern of heat input into the tropical atmosphere, thereby influencing the midlatitude circulation and year-to-year climate fluctuations in the United States.

This year, ERL will embark on a new atmospheric climate research program to investigate the increasing level of carbon dioxide in the atmosphere and the variability of the Sun's energy output. Using information from the expanded U.S. program of carbon dioxide measurements, NOAA is accelerating its research on exchange processes of the carbon cycle. Primary emphasis in the new program will be on the analysis of the partitioning of carbon dioxide and the radiocarbon isotopes among the major global carbon reservoirs, and on the further development of global models to predict future carbon dioxide levels in the atmosphere and oceans, and their potential effect on climate.

Let me conclude by giving a few comments on our marine programs.

First of all, in the area of marine environmental assessment, this centers around regional studies such as the New York Bight and the Puget Sound projects. New projects of fiscal year 1979 include the Gulf of Mexico and coastal enrichment, both of which will be managed by the Office of Marine Pollution Assessment.

As field efforts are being completed in the New York Bight, they are being increased in the Gulf of Mexico. One cruise was conducted through the Gulf to investigate the chemical and microbial weathering

of oil spilled by the IXTOC-1 oil well blowout in the Bay of Campeche, as well as the effects of this oil on lower tropic level marine organisms.

During the 1979 field season, scientists reported the discovery of an oil-rich layer of water hundreds of miles long, hundreds of feet beneath the surface of the southwestern North Atlantic, estimated to contain at least 1 million tons of crude oil apparently from a natural oil seep in the ocean floor. Shipboard analysis of water samples and subsequent lab analysis in Miami as well as at the Woods Hole Oceanographic Institution and Scripps Institution of Oceanography confirmed the hydrocarbon was crude oil in what the scientists call an accommodated state; that is, a kind of chemical middle ground between being dissolved and in droplet form.

Other tests on the oil indicated that the oil was a biochemically weathered crude that had not lost any constituents to evaporation, indicating it had never surfaced at sea. Comparisons between the characteristics of sunken tars and the subsurface oil indicated that this oil had weathered underwater for 1 to 2 years before our scientists found it.

In the Great Lakes area, we maintain the Great Lakes Environmental Research Lab in Ann Arbor, Mich. They conduct a program of research to understand environmental processes in the Great Lakes and their watershed, the purpose being to assist in the solution of environmental problems related to resource management, and works to improve environmental services on the Great Lakes.

Let me give you some examples of recent activities that are carried out in our Great Lakes program.

Scientists have begun research on the cycling of toxic organic compounds in the Great Lakes.

They have developed a model to predict the movement of oil and other hazardous materials spills in the Great Lakes. This model has been used in support of the Regional Response Team action after shipping accidents in the lakes.

We have applied a model to assist the United States-Canadian International Joint Commission in determining the phosphorous load that can be assimilated by the lakes and still meet water quality criteria.

We have evaluated the impact of winter navigation through ice booms on lake and river levels.

Through these and other activities, our scientists in the Great Lakes Lab are providing environmental support to decisionmaking in the region.

Mr. BROWN. Dr. Webster, I'm sorry to interrupt you.

I know that you are very close to the end.

Dr. WEBSTER. Yes, sir.

Mr. BROWN. I have just about 3 or 4 minutes to get over and vote.

Unfortunately, there is a series of three votes, and if I am going to keep my commitment to you, Mr. Frank, I am going to have to excuse you now, because I will not be able to be back by 3:15; it is likely to be closer to 3:30.

Can the other gentleman remain for that period of time?

I am very apologetic about that, but the timing has just worked out very poorly.

So I would hope that you will feel free to leave, Mr. Frank, and I hope that Mr. Ambro and I can both come back after this series of votes.

Mr. FRANK. Thank you, Mr. Chairman.

Mr. BROWN. The subcommittee will be in recess.

[A short recess was taken.]

Mr. BROWN. The subcommittee will resume its meeting. Let me apologize again for the disruption created by a parliamentary situation.

Dr. Webster, you had just about completed your statement. Could you go ahead and conclude with your remarks and then we will ask whatever questions we can.

Dr. WEBSTER. Thank you, Mr. Chairman.

You correctly surmised I was coming to a conclusion.

In fact, I had about two sentences left in the statement, my summary statement. I understand the parliamentary problem that caused it.

Let me just summarize by making those two statements.

I would like to say our research and development programs are directed at scientific areas related to national needs within our mission in NOAA.

I would also like to emphasize that opportunities to improve our service programs or to increase our capabilities to contribute to national needs are most important, particularly in response to new legislative responsibilities.

That was all I had planned to say, Mr. Chairman. That concludes my remarks, and I would be pleased to answer any questions you and other members here may have. Thank you.

Mr. BROWN. We appreciate that very much.

Your full statement, of course, is an extremely comprehensive description of much broader aspects of the program than you have the time to go into here, and that will, of course, make a very useful contribution to our consideration.

I'd like to ask again if Dr. Benton or Mr. Hess may have any statements that they would like to contribute at this point.

Dr. BENTON. Thank you, Mr. Chairman.

I did not plan to submit a statement today.

I attended with the Administrator. Mr. Frank, in order to be able to assist him, if possible or necessary, with regard to particular questions, and I would be delighted to participate in the discussion and answer any questions that you or others on the committee may have.

Mr. BROWN. Mr. Hess.

Mr. HESS. I have no statement, Mr. Chairman.

Mr. BROWN. All right.

I am not quite sure I know how to go about approaching the salient issues in this area.

Let me ask a simple question that may get us into something else.

When we had a blowout in the Gulf of Mexico which required the mobilization of a substantial research group—or more than a research group, I guess—how do you handle that kind of a situation?

Do you have, you might say, an emergency fund or emergency procedure that when something of this sort which cannot be planned for and cannot be forecast, happens, you are able to respond?

I am concerned with both the organizational and the resource arrangements to handle a situation, how is it triggered and how does it work?

Dr. WEBSTER. The hazardous materials response project in the Office of Marine Pollution Assessment has an annual budget which I believe for the fiscal year 1980 is something less than \$1 million.

This is intended to cover the costs of normal, whatever that may be, reaction to spills of oil and other hazardous materials. In actual fact, as you know, when major events come along, they dwarf the resources we have available, both in terms of people and in terms of dollars. The total number of people in the hazardous material response project, I am not sure exactly, but it is less than 10 full-time permanent employees, and we put 40 to 50 people into Corpus Christi for the IXTOC-1 blowout.

We did this by scrounging people whatever way was possible. There was a considerable amount of university involvement. There was involvement by all areas of NOAA, not just the Office of R. & D., but the Office of Fisheries and the Office of Oceanic and Atmospheric Services, such as the Environmental Data Information Service.

As for dollars, we used funds that were part of the marine pollution program and at least in some cases, temporarily put resources into responding to the spill with the feeling that this is the most important thing we could do with the money and we better take advantage of the opportunity rather than wait and try to get salvage support funding. We are still trying to pick up the pieces.

I think if I had to do it again, I would do it the same way.

I'd like to just add one other comment, Mr. Chairman.

You used the word "research."

Our primary role in something like the IXTOC-1 blowout is not research. Our first role is science support to the on-scene coordinator to answer questions such as what is the impact likely to be if this hits such a beach, which way is the oil likely to go, what is the trajectory of the oil under the influence of winds and so forth.

This is not research, as such. This is the application of previous research results to a particular emergency.

There is a role for research and we are going into that now particularly since it involves damage assessment that will be based in part on the results of the cruise, mentioned in my testimony to investigate the effects of oil weathering.

But our first response and the one that we are legislatively, or maybe legislatively is the wrong word, our first mandate is to be there to provide the science support for the on-scene coordinator and that takes precedence over all else.

Mr. BROWN. I understand that. I am not trying to quibble over the definition of research, although it has been my position, expressed in previous hearings, that the fortuitous, or unfortuitous accidents of this sort do provide opportunities for accumulating information which we might not otherwise be able to obtain.

And while much of this in the nature of impact analysis, as you have indicated, I see no reason to differentiate that from other forms of research when we do not have an adequate base of knowledge as to say how the effects of that disaster are transmitted to the ocean or

the atmosphere and what the effects will be of the whole series of things that we haven't experienced before.

That is all valuable information. While it perhaps doesn't break new ground scientifically it is useful to have.

Am I incorrect in this?

Mr. WEBSTER. You are quite correct, Mr. Chairman.

I have to confess to a personal sensitivity on this point that comes from an academic background. Many of my ex-colleagues will say to me that the research you are doing down there at IXTOC isn't first rate. When we look into it we find out, our mandate primarily isn't to do the kind of research that might be done at a university, but to provide the support that is needed.

Research may come later and it may be of a quality that universities do, but our first responsibility isn't to do that. I must confess, Mr. Chairman, I have been sensitized to this by my colleagues and I have been defending our role here because I think it is an important national role and I think we have to do it.

Mr. BROWN. I have difficulty distinguishing, and maybe you can help me, between a spill of this sort in the ocean, a few million gallons of oil, its impact on society, and the spill in which a few million tons of carbon dioxide produced by our industrial society is spilled in the atmosphere.

Where does the line stop between the research that you are doing on one and on the other, or am I being too harsh?

Mr. WEBSTER. I don't think you are being too harsh at all.

I think the analogy is there.

We have to recognize the first thing that happens in something like the IXTOC-1 blowout is to define what the problem is, and to take steps to control the problem.

The carbon dioxide example you mentioned, the first step you do is to define what the problem is.

Although we haven't moved on to the step of trying to control the problem in the sense of having NOAA play a coordinating role to other agencies of the Government which have a mandate to take steps. I hope to see, Mr. Chairman, that we mature in our carbon dioxide understanding to the point where the analogy can be fulfilled.

I would like to add if you look at the impact on the United States, maybe other kinds of hazardous materials in the ocean or in the Great Lakes which are far more pervasive and have greater impact on the people of the United States than something like the IXTOC blowout that tend not to get the attention. These, too, are things that we are required under the ocean pollution law to look into.

Mr. BROWN. Well, the real point I am trying to emphasize is that we have a spectrum of interventions in the environment by human activity, and it seems that we don't know enough about any of them.

I am concerned really about the system that we have for evaluating, determining, and reacting to those things, and I see each one as an opportunity to build a better system capability here.

What I am trying to get at is where the present weaknesses in the framework we have for doing this are.

You can move from something that occurs in a very brief period of time and has a very little impact to something like acid rain or CO₂

which goes on over years and has impacts that we don't understand yet.

The question is, do we have a system for comprehending man's intervention in the environment and reacting adequately to it? I think we are weak in impact assessment in practically every area that I look at, and it is a major difficulty.

Dr. BENTON. Mr. Chairman, I think you are absolutely right in your comparison.

I believe when something like this happens, such as the IXTOC spill, we tend to look at the immediate problem, which is how we get control of the spill and the immediate damage resulting from it.

But it is entirely true of course as you emphasized that there is a broader problem; namely, the overall impact not of this one spill, but of many like it, which generalizes the problem of petroleum spillage which is changing the nature of our environment and, of course, the still broader problem of how does this fit into the still broader pollution problem. I am afraid, Mr. Chairman, that we are probably as an agency and as a government devoting too much attention to the smaller scale problems and not really enough attention to the very broad scale look at man's influence on his environment.

Mr. BROWN. We haven't found a good way to change that focus, but we are looking for it.

May I yield to my distinguished colleague, Mr. Ambro, the chairman of the subcommittee, and see if he has any questions?

Mr. AMBRO. Just one line of questioning, Mr. Chairman, to round out the record.

On page 7 you talk about the transfer of single Doppler radar to improve tornado detection and warning to the National Weather Service.

How many of the weather stations have received these radar?

Dr. BENTON. Perhaps I can answer that, Mr. Chairman.

The Doppler weather radar has been developed experimentally as was indicated in testimony of Mr. Frank and also of Dr. Webster, by the National Severe Storms Laboratory which has an experimental Doppler radar which has been explored very carefully with regard to its capability.

Based on what we have learned here through a cooperative joint project with the Federal Aviation Administration, the Department of Defense, and NASA, we have been planning through the Federal Coordinator for Meteorological Services and Supporting Research, a coordinated interagency program to develop a next-generation radar for installation operationally throughout the country.

This program is called NEXRAD and it is an interagency effort. We hope to be able to come forward to the Congress very soon with a plan for the nationwide installation of this advanced weather radar.

This is a major acquisition. Doppler radars are expensive and a program of this sort which takes Doppler radar from the experimental state to the operational state on a national scale needs very careful interagency planning which is now going forward.

Mr. AMBRO. So the sentence that says, new technology has been transferred to the National Weather Service to form a part of NEXRAD for operational purposes is not needed. There are now weather stations using single Doppler radar, is that correct?

Dr. BENTON. That is correct.

[Note.—Subsequent to the hearings, information was provided by NOAA to the effect that an Interagency Group is developing a next-generation weather radar for nationwide operation using in part the technology developed by the National Severe Storms Laboratory and that the radar systems have not as yet been deployed.]

Mr. AMBRO. All right.

I would rather defer, then, Mr. Chairman, the rest of these questions for written response because I must say that while this is fascinating and I would like to spend an awful lot of time, I am developing other lines of questions.

We do have a briefing by the Secretary of State at 4 o'clock on the Iranian situation, and I hope you don't feel slighted by having me say that we are all very interested in that.

I would just as soon defer.

Mr. BROWN. I would like to ask Mr. Walker if he has any questions?

Mr. WALKER. Thank you, Mr. Chairman, I too will be brief but just a couple of things I would like to follow up on.

I wasn't here for the important testimony to cover this, I apologize.

The first is kind of a parochial interest. I am wondering what you are doing, what you have in mind in the acid rain problem as it affects Pennsylvania. In particular I wanted to mention to you that evidently there is some jurisdictional squabble and I am a little dismayed by it over whether the Federal Government really has any authority or power to look into the fact that we are having interstate problems with regard to where the pollutants are developed and where they finally come down.

There seems to be a question as to whether Federal law will allow us to take not only regulatory action but even research action, and I'd like for you to comment on that particular problem and what NOAA has in mind in this area. What are you presently doing?

Dr. HESS. Let me try to partially answer the question and maybe my colleagues will handle the rest of this.

First, what are we doing in the acid rain problem from a research viewpoint?

We have operated 10 stations countrywide for several years in collecting data on the acid rain problem.

This is part of the national network. There is now a coordinating committee chaired by CEQ that involves NOAA, the Department of Agriculture, Department of Energy and I think others, all of whom are helping to collect information on this subject.

I recently have seen a redrawn map of the average annual precipitation in the Northeast United States as of last year which makes the problem even worse than it was when we looked at it 3 or 4 years ago.

We are now looking fairly seriously not only at the pH but at the chemical constituents and we will shortly bring on line some instruments which continuously look at the chemistry of the acidity of the rainfall.

In the Northeast the major constituent as you are probably aware is sulphuric acid which is produced mainly by SO_2 which probably comes mainly from powerplants.

Mr. WALKER. Let me follow up if can.

Are you doing any of the atmospheric monitoring with regard to drift of the pollutants?

Dr. HESS. We don't measure drift per se. We measure the concentrations at 10 stations countrywide.

Mr. WALKER. But you are not measuring the——

Dr. HESS. Trajectories of air masses?

Mr. WALKER. Yes.

Dr. HESS. We do that sometimes in connection with research projects in the field. But we don't have any orderly process for doing that specifically connected to acid rain.

Mr. WALKER. Isn't the problem that we are facing or seem to be facing throughout the Northeast a result evidently of trajectory which comes up from the Southeast or at least from the Ohio River Valley? Wouldn't that seem to indicate we need to have some kind of look at that to find out whether or not there are interstate problems here that are going to have to be resolved with more than just one base applications of pollutant standards?

Dr. HESS. I think it is clear to say that there are interstate problems.

Certainly, the air mass goes from one State to the next State. Maybe my colleagues would like to address the policy matters.

Dr. BENTON. Perhaps I can answer that a little bit, Mr. Walker.

The problem of tracking effluents through the atmosphere and actually making trajectories is one that has been studied in the atmospheric sciences for many years, and we have a major capability here.

This first developed many, many years ago in connection with efforts to track nuclear releases in the atmosphere to determine exactly where they went following a release.

We have this capability, but in the case of acid rain, the chemical contamination of the atmosphere occurs from a very, very broad area and from many, many sources, so that it is not exactly the simple problem of tracing a pollutant on a particular track.

For example, the fact that the winds are from the South in connection with most times of precipitation means that the pollutants that occur along the East that are put into the atmosphere in the Central and Eastern United States tend to move toward the North, giving tremendous problems in the Northern United States and in Canada, as you know.

Mr. WALKER. Would you agree with me, for instance, that the western Pennsylvania problem which has recently come into focus is not a problem which is being primarily developed in western Pennsylvania?

Dr. BENTON. I would say that the problems of the Northeast United States and of Canada are problems which have a very broad origin, and that part of our problem goes back to the issue that Mr. Brown raised earlier, that we simply are not looking at a large enough scale and with sufficient care at the very broad scale problems of what man is doing to his environment.

Mr. WALKER. In other words, we are going to have to find out where the effluents come from before we can do any kind of regulating to clear up some of the problems. Basically, is that a logical assumption?

Dr. BENTON. That is correct.

But this will require broad identification of area input rather than pinpointing individual plants.

Mr. WALKER. That goes back, and I don't want to delay this either, because I, too, want to allow the committee to go down to discuss the Iranian situation, but as I understand it, that is where the problem lies. There is evidently some interpretation that there is no authority to take a look at these things on an areawide basis. Is that your assumption?

Dr. HESS. That in no way has impeded our business of trying to monitor the problems or work on the chemistry of the problem.

Mr. WALKER. So that sounds like more of a regulatory problem than a research problem?

Dr. HESS. Yes.

Dr. BENTON. I believe the regulatory issues here are not primarily within NOAA's area of responsibility.

We have attempted to focus more on the tracking problem and on the evaluation of the extent of the problem.

Mr. WALKER. You don't see it as a research problem in terms of trying to find out where the areas are that we are developing the acid rain problem and then tracking it? In other words, if you had the resources available, you don't think there would be anything in the law right now to prevent you from carrying on those kinds of studies?

Dr. BENTON. Not from the atmospheric point of view as far as I can see.

I believe that from the regulatory point of view, if you want to try to solve the problem, you may have a different situation, but that is beyond my competence and particular responsibilities of NOAA.

Mr. WALKER. If Congress were to authorize such a study would you be prepared to begin almost immediately on it?

Dr. BENTON. Yes, we could do so.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. BROWN. I, of course, I think it should be pointed out that as you gentlemen know, you have an overlapping area of jurisdiction with the Environmental Protection Agency. EPA has made a number of studies of air mass movement using balloons and airplanes and what-not, and as long as each of you is doing what seems to be needed and is within the competence of your Agency, there is no problem unless the total effort is inadequate or there is not adequate coordination. I think we can assume the total effort is inadequate, but I hope the coordination is OK.

Dr. BENTON. The President, as I believe you know, Mr. Chairman, has formed an interagency committee to coordinate an interagency effort here, and this committee is still very new, but I believe that we look to it to provide the coordination that is required.

Mr. BROWN. Well, gentlemen, I think you are aware of the problems that face us.

Let me ask one additional question.

One of our colleagues is concerned about the colocation of the Environmental Research Lab at Ann Arbor with the Great Lakes Marine Water Center at the University of Michigan. I would assume that everybody in that region is probably concerned about it. There is no effort to be critical, but a desire to be kept informed as to the progress of that effort. Could we ask you to provide the committee with timely information about your action in that area?

Dr. WEBSTER. Yes, Mr. Chairman. We would be pleased to do that. As Mr. Frank indicated, we feel very strongly about it.

Mr. BROWN. All right.

There are several other lines of questioning that we will not have time to explore. May we ask you to respond in writing to some of those?

Dr. BENTON. Certainly, Mr. Chairman.

[Additional material submitted subsequent to the hearing in response to subcommittee questions follows:]



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852

JAN 31 1980

RD1:DH

Honorable Jerome A. Ambro
Chairman, Subcommittee on
Natural Resources and Environment
Committee on Science and Technology
U. S. House of Representatives
Washington, D.C. 20515

Dear Chairman Ambro:

In connection with my testimony of November 13, 1979, before the Subcommittee on Natural Resources and Environment of the House Committee on Science and Technology, I am enclosing answers to the questions which you raised in your letter of December 4, 1979.

In addition, I also enclose, in accordance with my agreement during testimony, information on the question of collocation of the Great Lakes Environmental Research Laboratory at Ann Arbor, Michigan with the University of Michigan's Great Lakes Marine Water Center.

I appreciate the opportunity to provide these extensions to my testimony before the Subcommittee. Please let me know if I can be of further assistance.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "Ferris Webster".

Ferris Webster
Assistant Administrator
for Research and Development

Enclosures (2)

ADDITIONAL QUESTIONS AND ANSWERS FOR THE RECORD
 TESTIMONY OF DR. FERRIS WEBSTER
 ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
 U.S. DEPARTMENT OF COMMERCE
 November 13, 1979

1. General Direction of Environmental Research Laboratories (ERL)

Question 1(a)

Could you briefly describe the process by which research priorities within ERL are developed? To what extent are future programs determined by researchers, as opposed to the Office of Research and Development?

Answer

The process for developing programs and setting priorities within The Office of Research and Development (RD) consists of both top-down and bottom-up actions. RD holds a planning meeting early in the program cycle to exchange views among its top managers, laboratory directors and key scientists. This occurred in September 1979 for the FY 82 budget. In parallel with this, the Assistant Administrator for Research and Development (AA/RD) discusses program requirements with the other NOAA AA's and has inputs on R&D requirements from other sources, such as Congress, other agencies and the public. Following these meetings and discussions, the AA/RD provides guidance on program areas that need attention or priority. As a result of this guidance, various planning meetings then take place within and among the RD program elements and with other NOAA components, e.g., National Weather Service (NWS), National Ocean Service (NOS), National Marine Fisheries Service (NMFS), to define specific programs and resource requirements. The AA/RD then meets with key managers to assign priorities to base program activities and new program initiatives.

Inside ERL, priorities are set using criteria as shown in Attachment A. This RD program then is presented to NOAA management for review and for further priority setting.

Question 1(a) (continued)

What input do NWS and other operational components of NOAA have in identifying their long-term needs to ERL? Is such input solicited by ERL?

Answer

In general, the functions of the National Weather Service are widely known within ERL. NWS R&D needs are directly communicated to ERL both in a formal and informal fashion.

Periodically, applied research requirements are identified and communicated to ERL as formal statements of R&D needs. Informally, very specific, applied research needs are identified and articulated by in-house NWS elements who are closely identified with the operations, and these groups in turn seek advice and assistance from ERL persons with appropriate expertise.

The formal and informal means for determining research relevant to operational needs have included:

Meetings between the Director of ERL and the Directors of other MPE's (e.g., NWS) to solicit operational needs.

Personal contact between ERL scientists, research managers and operational personnel to solicit operational needs. The joint doppler project was formulated in this way.

Planning workshops consisting of research and operational personnel in which operational needs are clarified for researchers.

Meetings called by AA's on areas requiring R&D.

Seminars, talks and training courses between research and operational elements. (For example, ERL scientists teach a forecaster training course at the NWS Training Center in Kansas City.)

In addition to the above mechanisms, the AA/RD and the Assistant Administrator for Oceanic and Atmospheric Services (AA/OAS) are exploring ways to put the identification of operational needs for R&D on a more formal basis.

Question 1(a)(continued)

A 1979 GAO report on Severe Storms Research indicated that there was "no systematic procedure within NOAA to assure that severe storms research needs are identified from a NWS perspective and met." GAO notes that in the USAF and NASA, needs for improvements in weather forecasting operations are documented to researchers through formal mechanisms. Would such a mechanism be useful for NOAA?

Answer

It is not clear how much more useful a documented mechanism for identifying operational needs for R&D will be than the current process. A number of efforts in the past few years has indicated that the informal system produces relevant and valuable R&D, e.g., Joint Doppler Operational Program (JDOP), Prototype Regional Observation and Forecasting System (PROFS), Severe Environmental Storms and Mesoscale Experiment (SESAME), flash flood studies, and stratospheric ozone.

Question 1(b)

In determining "needs" for research and development you note the "primary basis" for establishing R&D needs to be "statutory requirements" followed by Presidential directives and as a distant third, "scientific questions which beg for answers." Do you think it wise to allow Congress to legislate your R&D priorities?

Answer

Within NOAA's "statutory requirements", there are many ongoing programs, such as weather services and climate, that require R&D for improved service delivery or for improved management decisions. These programs provide the basis for identifying and defining the needs for R&D. We believe that R&D priorities reflect the needs of these programs and the contributions that R&D can make to improve these programs.

Congress, from its national perspective, can best identify areas of program emphasis within NOAA's statutory requirements that need priority attention, e.g., improvement in severe storm warnings. Individual NOAA R&D program priorities would then be related to these program priorities since R&D is a means to meet national problems and is not an end in itself.

Question 1(b)(continued)

What is the role of NACOA or OSTP? What should be their role?

Answer

NACOA addresses issues and offers recommendations on a number of ocean and atmosphere problems. These recommendations provide general guidance to the Federal government and, in many instances, provide specific guidance to NOAA. OSTP, as a part of the executive branch, can identify programs to which NOAA can contribute and can coordinate among agencies where appropriate.

Question 1(b)(continued)

How are these priorities determined considering related programs in EPA, DOE, etc.?

Answer

In light of its statutory requirements and Congressional appropriations, NOAA's R&D priorities must reflect the missions assigned to it. In areas where appropriations are approved to assist other agencies, NOAA can develop an R&D program. Otherwise, other agencies that request NOAA's support for R&D must be expected to share the cost.

2. Organization of ERL Research

Question 2

Atmospheric research at ERL often seems to be organized around interests of individual researchers and capabilities of particular laboratories, rather than around specific problems. Thus one sees a fragmented effort on certain questions: for example, research on detection of atmospheric water vapor is carried out by the Aeronomy Lab, the Atmospheric Physics and Chemistry Lab, and two subgroups of the Wave Propagation Lab. What is your philosophy concerning organization of research resources around specific problems?

Answer

Atmospheric water vapor is an important field of research due to the ubiquitous and critical role of water vapor in controlling the behavior of the stratosphere, troposphere, and planetary boundary layer. The study of atmospheric water vapor is not an area around which to organize a research program or to form a laboratory since it cuts across many problem areas, such as weather forecasting, stratospheric ozone, weather modification, and climate and constitutes only one aspect of research on these problems. Therefore, NOAA has chosen to organize around problem areas or major facilities, and not around particular scientific disciplines or parameters, e.g., atmospheric water vapor.

Primarily the laboratories are focussed on major problem areas, such as the National Severe Storms Laboratory (NSSL) on tornadoes and severe thunderstorms or the National Hurricane and Experimental Meteorology Laboratory (NHEML) on hurricanes.

Two laboratories cross cut a number of problem areas due to facility and resource considerations. These are:

Geophysical Fluid Dynamics Laboratory (GFDL) -- which does geophysical modeling and numerical simulation related to weather, climate and ocean prediction due to the need for a large and expensive computing facility, and

Wave Propagation Laboratory (WPL) -- which does atmospheric and ocean remote sensing due to the need for expensive equipment and the desirability of having cross-fertilization among scientists and engineers representing a broad spectrum of electromagnetic and acoustic technologies.

Question 2 (continued)

When research on a given problem has progressed, is it typical for NOAA RSD managers to effect a pooling of resources in order to mount a more concentrated attack on a given problem (e.g., modeling of hurricanes)?

Answer

Yes. This can occur in several ways: (1) Transfer of resources--(An example is the centralization of lightning research in 1978 in NSSL and the transfer of staff from WPL and APCL); (2) Changing emphasis of research programs--(The Aeronomy Laboratory has changed its major field of emphasis from ionospheric physics and chemistry related to radio propagation in the 1950's and 1960's to stratospheric chemistry and dynamics related to the stratospheric ozone and climate problems of the 1970's and 1980's); and (3) Reorganizing programs--(RD has recommended establishing the Office of Marine Pollution Assessment to provide a pooling of resources and attention on marine pollution problems.)

NOAA is also studying organizational changes to streamline its research on mesoscale meteorology, weather modification and air quality research.

Question 2 (continued)

Do the operational components of NOAA have input into such redirection of research efforts?

Answer

In the past, changes have been made in consultation with top NOAA management to bring R&D in line with new directions in NOAA.

ERL managers frequently consult with appropriate operational managers concerning relevant research efforts (e.g., Director of National Hurricane and Experimental Meteorology Laboratory with Director, National Hurricane Center on the hurricane STRIKE project; and the PROFS manager with NWS and NESS officials. In specified cases such as PROFS or the national flood warning project a formal mechanism for redirecting ERL decisions on research efforts may be established on an ad hoc basis.

Question 3(a)

It is our understanding that the PROFS system will incorporate technological advances such as Doppler radar into a local, automated weather observing and predicting system. ERL seems to be in the forefront of developing the ground-based remote sensing technology required for such a system. Who is developing the processing and display components for this system? How is ERL interacting with the NWS, NESS and others in designing a system that is convenient to the non-researcher at the local level?

Answer

The PROFS Exploratory Development Facility (EDF) for testing and integrating new weather service subsystems and techniques will develop the extensive data processing and display capability. The EDF processor and display capability is intended to support exploratory development of operational systems and is therefore expected to be more powerful than the operational designs that will be tested and integrated later. The operational designs will be developed by consultation with private industry and the operational weather service community (government and private).

A number of operational organizations will be providing direct support to PROFS. NWS will have at least two full-time meteorologists working with the PROFS EDF in Boulder in the near future. NESS will establish a team of satellite meteorologists at Colorado State University in support of PROFS, and NASA is providing one person for 6 months.

A formal management structure has been designed for agencywide management and review of PROFS. Through this mechanism, NWS has made continuing input to the designing of the program to meet the operational needs of the non-researcher at the local level.

Question 4(a)

Could you describe the efforts being made to clarify local liabilities resulting from potential domestic hurricane modification experiments?

Answer

NOAA and other agencies have sponsored a number of legal studies addressing this question. In general such studies reveal that:

Legal liability for hurricane seeding has never been litigated nor subjected to statutory or treaty provision.

However, there have been a number of lawsuits which have involved efforts to obtain damages for or injunctive relief from weather modification activities. They have for the most part failed because of inability to prove the causal relationship which the law requires between the seeding and harm to complainants. Although the cases have involved seeding for precipitation enhancement or hail suppression, they indicate that proof of causation in hurricane seeding loss claims would also be difficult to prove.

The federal government is immune from legal liability to individuals under domestic law, except to the extent it has waived that immunity by the Federal Tort Claims Act. Interpretation of the FTCA suggests that the United States would not be liable for design and planning of projects because that is a "discretionary function," an activity for which immunity has not been waived. There may, however, be liability for operational-level errors if negligence can be proven.

The United States may also be subject to claims under international law from nations which have been harmed by our hurricane seeding. As in the case of domestic law, a causal relationship between the seeding and the harm is likely to be difficult to prove. Failing diplomatic settlement of such a claim, a nation may resort to arbitration or litigation procedures to prove the loss and causal relationship, and to obtain an award assessing against the United States responsibility to pay for the actual damages caused.

Question 4(a) --continued

Would it be wise to pursue a large program of hurricane seeding in the Western Pacific before these problems are clarified?

Answer

NOAA is no longer pursuing a program of hurricane seeding experiments in the Western Pacific, but rather is hoping to conduct such experiments from Australia. Scientific discussions have been completed with Australian scientists and have resulted in the Australian Cabinet deciding in principle to support a Stormfury-Australia Program. The next step is the negotiation, through the Department of State, of a formal Memorandum of Understanding (MOU) addressing all aspects of such a program, including the issue of liability in terms of the United States, Australia and third countries.

Question 4(b)

The NOAA Research Facilities Center (RFC) in Miami is equipped with one C-130 and two P-3 aircraft for use in atmospheric research and hurricane modification. The P-3s were outfitted with sophisticated atmospheric research equipment at a cost of nearly \$30 million. What percentage of flight time is presently devoted to atmospheric research and to hurricane research? Given the legal and logistical problems surrounding the hurricane modification research program, have these aircraft been fully utilized in the past? What use will be made of them in future hurricane modification experiments?

Answer

Although the anticipated level of use for hurricane modification research has not materialized, the RFC aircraft have been extensively utilized in support of atmospheric, oceanographic, climate and hurricane research to the limit allowed by available funding for operations, i.e., 550 flight hours in 1979 and 800 flight hours in 1980. In addition, in FY 1979, all three aircraft were used for the First GARP Global Experiment (FGGE), a reimbursable project in which 1500 hours were flown for the GARP Monsoon Experiments for hurricane reconnaissance.

Of the base-funded hours allocated for FY 1980, approximately 25% are devoted to atmospheric research and 35% to hurricane modification research. The remainder of the hours are allocated for the Equatorial Pacific Ocean Climate Study (EPOCS) ocean climate research, Great Lakes and coastal ocean wave studies, and for RFC crew training and instrument calibration.

These aircraft are indispensable to the hurricane modification effort, and when future seeding experiments take place, they will be the critical element for both seeding and data collection.

Question 5(a)

Doppler radar has been widely acclaimed for its potential in predicting tornadoes and other atmospheric disturbances. Tornadoes are, of course, a national rather than regional occurrence. How many Doppler radar installations would be required to provide the country with an adequate network of tornado detectors?

Answer

Weather radar is the principal tool for detecting and warning of tornadoes, severe thunderstorms, and flash floods. NOAA, the U.S. Air Force and the Federal Aviation Administration have operated a joint project since 1977 to explore the potential application of the Doppler principle to weather radar. The joint program has clearly demonstrated the concept of

Doppler weather radars and established that such radars will make dramatic improvements in warning timeliness and accuracy. Results obtained with laboratory Doppler radar equipment show that warning lead times of 20 minutes or more are possible for large tornadoes compared to average lead times of a minute or so with present conventional weather radars. Similarly, false alarms from unnecessary warnings are reduced by two-thirds from more than 50 percent to less than 20 percent.

As a result of the successful joint R&D program, NOAA, DOD and FAA have proposed a national system of Doppler radars that will make this new technology available to meet public, aviation, and military needs at the lowest possible cost. A joint systems project has been established to plan such a national system, manage the final development work, and procure and install the radars. Current planning calls for operational system definition to be completed in 1981, competitive development by industry in 1982 and 1983, limited production to begin in 1985 and full-scale production in 1986. The entire national system would be completed by the end of 1989.

With the joint R&D program having already demonstrated the concept, a recent multiagency review concluded that even though considerable development work remained to transfer this new technology to an operational system suitable for use by civil and military operating units, there was very little technological risk involved. The hardware technology is well established and most components are available "off the shelf." Computer programs that will reduce the radar data to signature identifications are the major development step remaining.

The new Doppler radar sites will be determined as part of the system planning and definition phase in 1980 and 1981. The new radars would supplant aging civil and military conventional weather radars in a carefully designed system that would meet most civil and military requirements in a cost-effective way. Considerations such as severe thunderstorm threat and locations of metropolitan areas, communities, and civil and military airfields will go into the analyses of siting tradeoffs.

The proposed national system of Doppler weather radars is under review by the Office of Management and Budget as a new program start in the FY 1981 budget with funds requested for initiation of final development. As proposed by DOD, DOD and FAA, there would be subsequent decision points in FY 1982 when added funding would be required to initiate competitive development by industry, in FY 1984 when funding would be required for full-scale development and limited production, and in FY 1986 when full funding for production and installation would be requested.

The national system, according to preliminary estimates of the agencies involved, would require between 100 and 128 radars in the 48 contiguous States and DOD needs 32 more for its overseas bases.

Question 5(a)--continued

What is the estimated cost of such a system (in 1979 dollars and in real dollars, at time of installation)?

Answer

Preliminary estimates of the agencies involved in the joint program at this early stage before system definition and competitive development by industry is completed are that full-scale production costs at time of installation are expected to be about \$1.5 million each installed with spares and training for operators and technicians. The estimated system cost in 1979 dollars is about \$250 million, including costs of development, software, first year spare parts, maintenance, training and program management. Dollar costs at time of installation can not be estimated at this time.

Question 5 (b)

In general, how is intergroup communication maintained between the researchers involved in modeling, observation and modification of hurricanes?

Answer

There are several mechanisms within and outside of NOAA for communications relating to hurricane research, including:

- Ad hoc NOAA committee on operational hurricane modeling,
- Contact between principal scientists within the NOAA organization including attendance at program reviews,
- NOAA/DOD committee on operational hurricane reconnaissance (this has implications on hurricane operations),
- Scientific meetings at which NOAA and outside researchers discuss the results and needs for hurricane research, and
- Direct funding of NMC by NHEML under the Hurricane STRIKE program.

It should be noted that only NHEML conducts an observational and modification program for hurricanes.

Question 5(b)--continued

Several hurricane models seem to exist within NOAA. How does the model at the Geophysical Fluid Dynamics Lab (GFDL) compare with that at the National Meteorological Center (NMC/NWS) and with that of the Strike Group at the National Hurricane and Experimental Meteorology Lab (NHEML)?

Answer

Because of the conditions in hurricane modification as well as hurricane prediction research, NHEML has focussed its attention on developing a model which provides high resolution of the hurricane's inner core in order to understand and develop seeding hypotheses and evaluation procedures for the modification of hurricane structure and dynamics (i.e., to lower peak windfield). The emphasis in the Hurricane STRIKE program in FY 80 is based on the opportunity to use this model along with the new NOAA aircraft to improve the prediction of hurricane track and intensity.

The NMC activities are designed primarily to refine the present operational forecast model which predicts the path of a hurricane and its central pressure. Due to operational considerations these models use coarser spatial resolution and more approximations to the explicit physics than do the NHEML and GFDL models. Many techniques developed in detail at NHEML and GFDL are later incorporated or approximated in NMC models.

The main distinction between the ERL and NMC models deals with their intended use. The ERL models are research oriented while the NMC model is designed to support operational requirements.

Research models have large computational requirements and are designed to study basic questions concerning cumulus-hurricane small-scale interactions and focus on studies aimed at revealing the quantitative explanations behind hurricane development. The NHEML model has an additional and complex goal of understanding and predicting the impact of cloud seeding on hurricane evolution.

The operational model being developed at NMC involves the interaction between large-scale steering flows and hurricane vortices which more directly impact the day-to-day forecast of hurricane movement and landfall. NMC operates under very tight computer time constraints because of the heavy operational requirements placed on their computer facility and the requirement to provide timely forecasts and warnings. Because the NMC model deals with large-scale details, the computer computations can be much more simplified. Consequently, the operational model computational requirements are 5 to 10 times less than the research models to permit accommodation within the current NMC computer time constraints.

The GFDL modeling effort is more basic than that at NHEML and seeks to model the entire storm evolution, from wave disturbance to decaying tropical depression.

Formal coordination has been ongoing between NMC, NHEML, and GFDL in the development of these models. The total NOAA modeling activities can be viewed as a hierarchy of efforts from the near operational through short, medium, and long range R&D.

Question 5(c)

How does ERL interact with NOAA's Office of Marine Pollution Assessment (OMPA) in developing plans for marine pollution research under P.L. 95-273, the National Ocean Pollution Research and Development and Monitoring Planning Act of 1978?

Answer

ERL scientists and managers participate in marine pollution planning meetings conducted by OMPA. In addition, ERL prepares its own marine pollution study initiatives. These are forwarded to OMPA and the Office of R&D for review and, if approved, are integrated into the proposed NOAA marine pollution budget package.

Question 5(c)--continued

What does ERL see as areas where additional marine pollution research will be needed in the 1980's?

Answer

The following are some research areas in which ERL expects to participate in the next decade:

1. Toxic organics and coastal enrichment--It is evident that the existing research effort can only scratch the surface of such a complex problem and significant human and monetary resources will be required on this problem during the 1980's.

2. Ocean waste disposal--Prior to designation of disposal sites, certain questions must be answered, including: (a) What chemicals should be disposed of together; (b) What chemicals will need to be containerized until technology advances to a state of dealing with such toxic substances; and (c) Which ocean sites are best suited to assimilate specific inputs and in what quantities.

3. Ocean resources--Expanded utilization of the ocean in the next decade will include: energy production (conventional and alternative), mineral withdrawal, desalinization, expanded commercial offshore development and possibly residential sites. All such utilization involves concomitant environmental problems that must be addressed and balanced with economic benefits.

Question 5 (d)

Regarding the Campeche oil spill, you note that it has helped to "galvanize" NOAA's marine pollution activities. Could you be more specific?

Answer

All that I meant to say here was that the Campeche spill stimulated further interest and concern within the agency regarding the suite of NOAA's marine pollution activities. We re-examined the focus of our response capabilities in terms of current programs, funding levels, dedicated personnel, etc. The Campeche incident was a further test of NOAA's management capabilities for large-scale scientific efforts involving a number of NOAA elements, other Federal and state agencies and the academic community.

Question 5 (e)

In your OCSEAP (Outer Continental Shelf Environmental Assessment Program) you speak of collaboration with the Department of the Interior regarding Alaskan assessment related to oil and gas activities. Are you conducting other assessment programs such as in the Gulf of Mexico or the Baltimore Canyon and Georgia Banks areas in the Atlantic? If not, why not?

Answer

NOAA is not conducting any other OCSEAP - like assessment studies. The Bureau of Land Management is already conducting such studies for the other U.S. coastal areas under consideration for oil and gas development.

NOAA is, however, participating in research that is in direct support to such assessment efforts. There is a DOE-sponsored NOAA effort in the Gulf of Mexico which studies the environmental effects of disposal of brine from salt dome caverns proposed for petroleum storage. Also, NOAA has been conducting, with EPA pass-through funds, environmental assessment studies in the Gulf of Mexico, specifically in the Buccaneer oil field and the Flower Gardens reef area.

Attachment A									
PROPOSED PROGRAMS									
Prospects for Progress									
Is the field ripe for breakthrough?									
Are the investigators good? (or obtainable?)									
Relevance									
-- to NOAA mission									
-- to achievement of specific goals									
-- to progress in other scientific fields									
-- to societal needs (food, safety, world harmony)									
-- to critical national problems (energy, balance of payments)									
Consequences									
of success (can it be exploited) (what does it commit NOAA to)									
of failure (can it be afforded)									
Cost									
Overall index of opportunity									

Collocation of Great Lakes Environmental Research Laboratory (GLERL)
in Ann Arbor with the University of Michigan's Great Lakes Marine
Water Center

The problem of permanent housing for the NOAA Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor has reached the critical stage both programmatically and administratively. The lack of research facilities is seriously impeding the work and the growth of this laboratory. A permanent resolution of this facility problem is essential.

NOAA and the University of Michigan have jointly prepared a program statement, "Development of a NOAA Facility on the North Campus" that identifies many of the mutual advantages to collocate GLERL with the University of Michigan. NOAA and GSA Region 5 (Chicago) staff have discussed the need to collocate the NOAA and the University staff and laboratory facilities; and NOAA's critical need to develop this special purpose research facility on the University campus. NOAA was encouraged from this GSA interaction and submitted a formal request to the GSA Region 5 Administrator from the NOAA Assistant Administrator For Management and Budget to designate this research laboratory "Special Purpose Space" for the intent and meaning of sub-part 101-18.104 of the Federal Property Regulations and that GSA delegate to the Administrator of NOAA the following authorities:

1. Specific authority to acquire by lease research facilities for the NOAA Great Lakes Environmental Research Laboratory on the campus of the University of Michigan.
2. Specific authority to enter into long-term leases not in excess of 20 years when deemed to be in the interest of the Government and necessary for the accommodation of this NOAA research laboratory for buildings and improvements which are in existence or to be erected by the University.

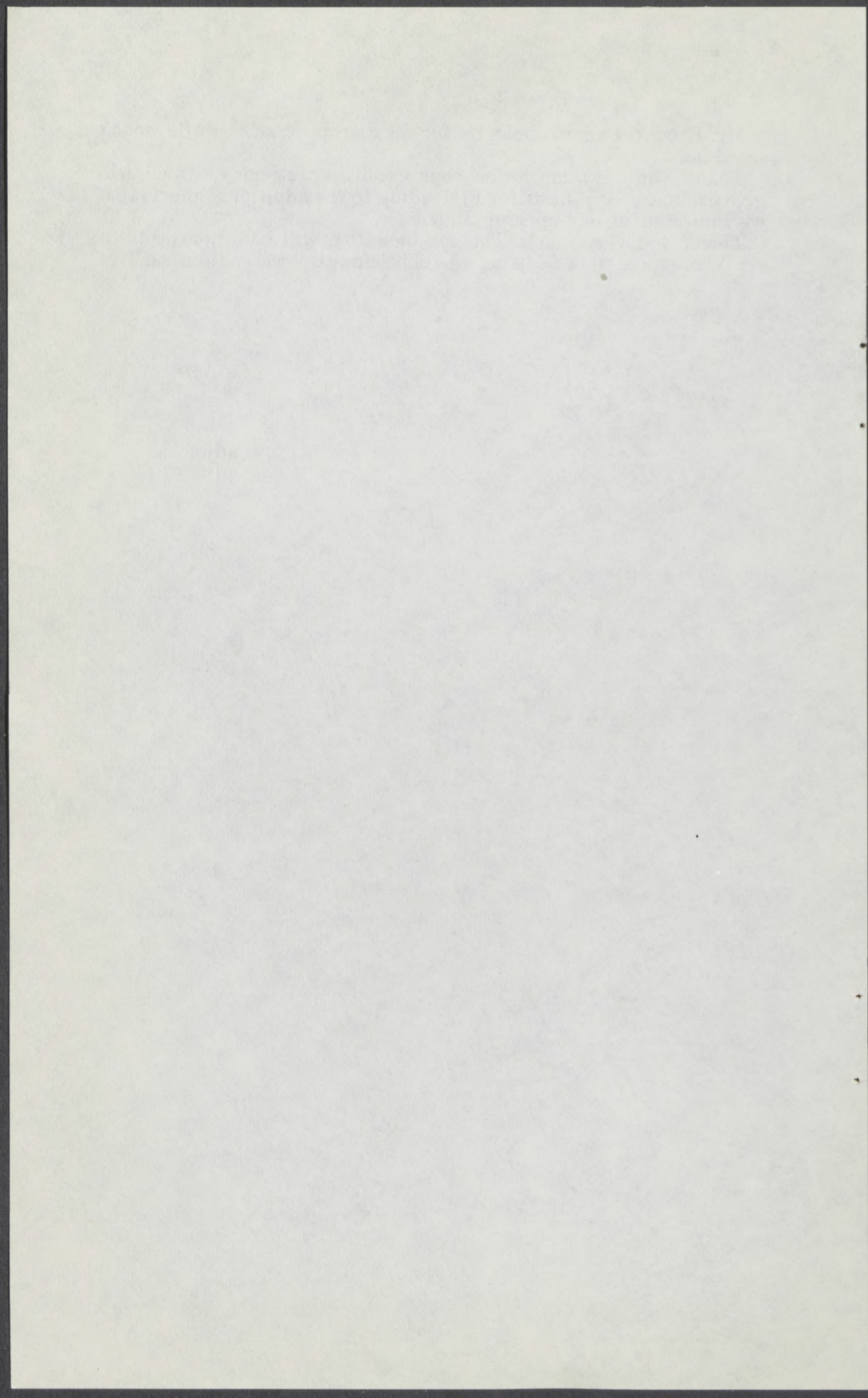
A number of NOAA research laboratories are currently located on campuses of major universities. Such collocation has furthered the interaction of NOAA scientists and the academic community and has strengthened the research programs of these laboratories. This request to GSA is consistent with policy of the NOAA Administrator to enhance relationships between NOAA and the academic research community and the recommendation of a recent major report of the National Research Council, "The Quality of NOAA Research and Development Program - An Evaluation".

NOAA is awaiting a decision by the GSA on collocation of GLERL with the University of Michigan. It is our understanding that the GSA Region 5 Administrator has recommended approval and has forwarded our request to GSA, Washington for decision.

Mr. BROWN. I again apologize for the disruption of this afternoon's schedule.

Thank you very much for your excellent testimony, which will give us an excellent basis for proceeding to the additional efforts that we indicated in our opening statement.

Thank you very much. The subcommittee will be adjourned.
[Whereupon, at 4:05 p.m., the subcommittee was adjourned.]



RESEARCH AND DEVELOPMENT PROGRAMS OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINIS- TRATION

WEDNESDAY, NOVEMBER 14, 1979

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON NATURAL RESOURCES
AND ENVIRONMENT,
Washington, D.C.

The subcommittee met, pursuant to recess, at 2 p.m. in room 2325, Rayburn House Office Building, Hon. Jerome A. Ambro (chairman of the subcommittee) presiding.

Mr. AMBRO. I would like to open this hearing on research and development programs in NOAA.

Today the Subcommittee on Natural Resources and Environment will continue hearings to receive testimony on research and development programs within the National Oceanic and Atmospheric Administration. We heard yesterday from the Administrator of NOAA, the Honorable Richard Frank, and from the NOAA Office of Research and Development on their programs of basic research being conducted at the Environmental Research Laboratories. Today we will hear from the primary users of that research in two of NOAA's operational services divisions, the National Weather Service and the Environmental Data and Information Service.

It is our hope that the information provided at these hearings will be useful in the subcommittee's efforts to assure that research and operational programs are coordinated to achieve the best possible return on the research dollar. Not only will this information be helpful in preparing for our annual budget review of NOAA programs, but it will also be most important in the context of subcommittee action on organic legislation for NOAA later in this Congress.

We are pleased to welcome as our first witness today Dr. John A. Knauss, National Advisory Committee on Oceans and Atmosphere. If you will, Dr. Knauss. We will include any written testimony you have in the record in toto, and you may proceed as you deem most appropriate.

Dr. KNAUSS. I think since my statement is rather brief, Mr. Chairman, I might as well just quote from that statement.

I would like to note that with me today are three members of the staff of NACOA, including its Executive Director, Mr. Connolly; and with their help, I think we're prepared to answer any questions you might have.

STATEMENT OF JOHN A. KNAUSS, NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE, ACCOMPANIED BY JOHN W. CONNOLLY, EXECUTIVE DIRECTOR, NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE

Dr. KNAUSS. I would like to thank you for your invitation to the National Advisory Committee on Oceans and Atmosphere. Dr. Evelyn Murphy, NACOA Chairperson, asked me to appear on behalf of the committee.

I am an oceanographer by profession, and have been a member of NACOA since it was reestablished in 1977. I would like to comment on some of our recommendations on NOAA programs in oceanic, coastal zone, and atmospheric matters. To put these recommendations in proper perspective, I would first like to make a few remarks about the **NACOA mandate.**

The National Advisory Committee on Oceans and Atmosphere Act of 1977 calls for a "continuing review, on a selective basis, of national ocean policy, coastal zone management, and the status of the marine and atmospheric science and service programs of the United States; and * * * advise the Secretary of Commerce with respect to the carrying out of the programs administered by the National Oceanic and Atmospheric Administration." In other words, sir, our mandate is to advise Congress and the President on the status of the entire marine and atmospheric program of which NOAA is one part.

The "new" NACOA, established in 1977, differs from the former committee established in 1971 in several respects:

1. There are 18 members instead of 25.
2. There is a prerequisite for expertise in oceanic and/or atmospheric affairs.
3. The former committee published an annual report with its recommendation; the present committee tries to be more responsive and timely with its advice. The annual report now is essentially a compilation of the year's activities.

Our former chairman, the late Donald McKernan, stated during the NACOA reauthorization hearings earlier this year before the House Subcommittee on Oceanography that NACOA believes that by being selective on issues and specific in its recommendations, it more effectively serves Congress and the President. This philosophy of selectivity is as best we see it the sense of the Congress. It is in that context that we undertake our mandate.

During the past 15 months, NACOA has testified before Congress a number of times on matters related directly or indirectly to NOAA programs. The committee also has reviewed and commented on specific policy and program plans, such as the Coastal Zone Management Act, the national ocean pollution research and development and monitoring plan, the preliminary 5-year national climate program plan, the NOAA/USDA Federal plan for agricultural weather services, fisheries, oilspill liability, and a NOAA Organic Act. NACOA also sponsored two workshops on Federal reorganization efforts in oceanic and atmospheric affairs; and, as I believe you are well aware, Mr. Chairman, another one to assist the former House Subcommittee on the Environment and the Atmosphere on issues relating to the future of the

National Weather Service and weather services provided by the private sector. We have provided your staff with a collection of the relevant NACOA letters and testimony concerning NOAA or NOAA programs. I would like to go briefly through a few of these programs.

I'll start with the climate program.

NACOA stressed in its annual reports such topics as the relationships between climate and food production, climate and fuel consumption, and the role of the oceans in climatic changes. NACOA also recommended that historical weather and ocean records be preserved for future work in climate. During the 95th Congress, it forwarded recommendations to Congress and prepared a reconciliation of the different climate bills in the House and Senate for use by Congress. After enactment of the National Climate Program Act, NACOA reviewed the preliminary 5-year national climate program plan prepared by the National Climate Program Office in NOAA and forwarded its comments to the Director of the Office. NACOA will continue to monitor the climate program.

WEATHER MODIFICATION

A national weather modification policy and program have been advocated by NACOA from its first annual report in June 1972.

NACOA testified before the Senate Subcommittee on Science, Technology and Space on October 24, 1979, on two bills concerning weather modification, S. 1644, and S. 829. In its testimony NACOA outlined the present status of weather modification technology and recommended that the legislation under consideration include provisions for stabilized funding, a continuing research program including carefully designed cloud seeding efforts, and continuing studies on the societal impacts of an effective technology. Because of the apparent lack of enthusiasm within NOAA for this program NACOA is not prepared to recommend NOAA for the lead agency for weather modification at this time. NACOA believed a coordinating body at the level of the Office of Science and Technology would be more effective at present.

WEATHER SERVICES

NACOA has addressed a number of other NOAA atmospheric programs. It has stressed the need to increase priorities for systematic design and data collection analysis, dissemination, and of forecasts relating to small-scale meteorological phenomena, particularly the issuance of observations and warning of such small-scale weather as severe thunderstorms, flash floods, and tornadoes.

NACOA prepared a special report, at the request of the NOAA Administrator, in 1972 on the floods caused by Tropical Storm Agnes. This was an independent evaluation of the Nation's weather and flood forecasting, warning and dissemination systems.

The provision of weather services to the public by the Federal Government and by the public sector also has been addressed, and is currently being addressed by NACOA. As I mentioned earlier, NACOA sponsored a workshop earlier this year to focus on some of these issues to assist your subcommittee in the deliberations. Weather services to

aviation safety were addressed by NACOA in its earlier years; more recently NACOA has reviewed a draft plan prepared by NOAA and the Department of Agriculture for an agricultural weather services program.

OCEAN ENGINEERING

NACOA has been concerned with the U.S. position in civil ocean engineering. In 1974, NACOA made a special study at the request of the Secretary of Commerce of this subject. A NACOA report, "Engineering in the Oceans," was sent to the Secretary. Amongst the recommendations was that NOAA establish an Institute for Engineering Research in the Oceans.

More recently NACOA's review of the Federal ocean research and development program, undertaken in the broad Federal reorganization study by NACOA in 1978, also revealed deficiencies in civil engineering and technology. In the background papers of that project and in a report sent directly to the Administrator of NOAA, we summarized the various issues that should be considered in the establishment of a strong and competitive civil engineering and technological capability in the United States. A copy of this study is included in the material given to your staff.

FISHERIES

NACOA's first annual report outlined six steps for NOAA's National Marine Fisheries Service to develop a comprehensive plan to assess, develop, and manage fish stocks to rehabilitate the U.S. fishing industry. In the years following, NACOA continued to comment on and make recommendations concerning the management of fishery resources.

Passage of the Fishery Conservation and Management Act of 1976 had a dramatic impact on fishery resource management and use in offshore U.S. waters. In its sixth annual report, of June 30, 1977, NACOA made specific recommendations on limited entry, membership in regional fishery management councils, and the tuna-porpoise conflict that was coupled with marine mammal management. In testimony before the Senate Committee on Commerce, Science, and Transportation in 1978, NACOA identified problems in the implementation of the FCMA based on its early experience. In addition, NACOA has forwarded to OMB and the Congress comments relating to the U.S. fishery development policy announced on May 23, 1979.

The need for prompt action to resolve coastal zone management problem was addressed in the 1969 Stratton Commission report; NACOA further emphasized the need for immediate coastal zone legislation in its first annual report. After passage of the Coastal Zone Management Act of 1972, NACOA reviewed the act and made suggestions for improvements in NOAA activities and funding levels. In response to invitations from the Senate and House of Representatives, NACOA has testified on the issues of the State role in environmental protection and the resolution of multiple-use conflicts, the coastal energy impact fund, and the "Federal consistency" provision of the act. Knowing the coastal zone management program was coming up for reauthorization this year, NACOA in 1978 invited knowledgeable

persons in the Federal Government, industry, public interest groups, and State CZM programs to write position papers and participate in NACOA meetings and a workshop. In a report to the President and Congress in January 1979, NACOA concluded that the Coastal Zone Management Act is falling short of its original objectives and that the Nation's coastline is more threatened by adverse developments today than in 1972. The committee made specific recommendations to encourage greater State participation. These include an intensive third phase of coastal zone management to further insure attention to the national interests. The recommendations contain draft legislative language worded to accomplish these changes.

SEA GRANT

NACOA published a special report on the sea grant program in November 1976. NACOA found the program to be responsive to its legislative charter—one that in 10 years had already contributed significantly to the Nation's marine effort—and saw a continuing need for the services the program provides. NACOA identified ways in which it believes the program could be improved and made a number of specific recommendations concerning policy, management, and funding. Several policy recommendations were addressed to the Administrator of NOAA concerning clarification of the goals and role of sea grant, the role of the advisory panel, and the coordination with other Federal activities. On management, the recommendations were directed primarily to the Director of the Office of Sea Grant. These concerned relations between that Office and the participating institutions, the proposal review process, and other aspects of operating the program. The recommendations on funding were addressed to NOAA, the Department of Commerce, OMB, and the Oversight and Appropriations Committees in Congress.

POLLUTION PLAN

NACOA forwarded recommendations and comments on May 11, 1979, on the initial draft of the Report of the Interagency Committee for Ocean Pollution Research, Development, and Monitoring, fiscal years 1979-83. In a letter of September 13, 1979, commenting on the final report, we stated that while there are particular concerns regarding the plan, we find the document to be a useful one upon which to build the Federal effort and wish to support it.

RESEARCH AND DEVELOPMENT

As you can see from the foregoing, NACOA has primarily addressed the research and development activities incorporated in specific programs.

We have not undertaken an overall evaluation of the total NOAA R. & D. efforts. However, in its recommendations of February 13, 1979, on the subject of NOAA's R & D. objectives and procedures—and contained in our eighth annual report dated June 1979—NACOA recommended that NOAA should continue to operate with a mix of project-oriented and discipline-oriented projects. More specifically, we recommended that:

1. NOAA should consolidate and maintain data bases that can be used to effectively design programs for oceanic development and protection. These data would be of great value in the formulation of effective relevant regulations and laws. NACOA envisions this effort as assisting in the process of conflict resolution.

2. We also recommend that NOAA should develop a program aimed at expanding the foundation for ocean technology to open up new opportunities for industry or to lay foundations for new industries.

3. NOAA should take the lead in developing jointly with Government, the universities, and industry an R. & D. program to address specific industrial deficiencies and long-term opportunities.

In conclusion, I would like to note that NACOA is now planning to undertake a major task—that of determining a series of well-defined, broadly supported, quantifiable goals and objectives to provide the necessary coherence and focus to our national ocean programs. We hope to work with Congress and the administration in this effort.

In conclusion, Mr. Chairman, I would note that the material that I've addressed here in terms of detailed recommendations either has been made available to your staff or can be made available to you. Thank you.

Mr. AMBRO. Thank you very much, Dr. Knauss. I appreciate your testimony, as do other members of the subcommittee.

I wonder if there would be any objection—I talked to my friend, Mr. Brown, earlier about this—if we just interrupted this line of questioning as a followup to your testimony and got the attention of Dr. Owen, Dr. Hallgren, and Dr. Potter for a couple of relevant and pertinent questions that would come from our friend and colleague from Mississippi, Mr. Bowen.

Dr. KNAUSS. Not at all.

Mr. AMBRO. Gentlemen, why don't you sit in the audience? Mr. Bowen will ask a couple of questions, and those who can answer them, if you would come to the microphone and do so, we would appreciate it.

Mr. BOWEN. Thank you, Mr. Chairman. I'm most grateful for your willingness to allow me to participate in your process this afternoon, and I would like to thank Mr. Brown as well.

I would just like to take a moment and ask a question or two of the witness from the National Weather Service about some of the coverage in the southeastern part of the country.

In the State of Mississippi, where we happen, unfortunately, to lead the Nation in terms of having the most fatalities from tornadoes, that is, the most fatalities per million population, we have had great difficulty in getting the sort of assistance we believe we need. The National Weather Service did send a team to Mississippi following a major flood we had earlier this year—that was in April—and they had promised a report on their findings. It was due in July, but our communications have been that they have been unable to prepare it.

We are, of course, vitally concerned with the Doppler radar as a possibility to cover this sort of radar void, which involves a huge area in the northern part of the State and in the neighboring States. That, of course, is one which would be of great benefit to the region.

Speaking as a member of the Agriculture Committee, where I am also the chairman of the Cotton Subcommittee, I would also like to

ask about Now Cast, which many farmers feel gives them the kind of hourly weather information which they need for crop planning and maintenance, and which they feel is really more effective than Operation Green Thumb.

I'm not a technical expert on these matters, but I'm simply reporting on some of the observations made by the farmers who have contacted me.

So I'm very deeply concerned about two things. First is tornado deaths and inadequate coverage, which could be improved either through a radar system or updating of NOAA weather radio ground transmitters; and second is Now Cast.

I would just like to preface my remarks to you by saying that it is my impression that the National Weather Service has been very cooperative with officials at the State, regional, and national levels, and has been sympathetic, but the indications have been that no one has, in effect, clamped down on any cooperation or assistance, and I would like to ask you for a response, if I might.

Thank you, Mr. Chairman.

Mr. AMBRO. Thank you, Mr. Bowen.

Who would like to comment on that?

Dr. OWEN. May I respond first, Mr. Chairman, and then I will ask Dr. Hallgren to respond.

Mr. Chairman, members of the committee and Mr. Bowen, I am Dr. Thomas B. Owen, Assistant Administrator of the National Oceanic and Atmospheric Administration, responsible for oceanic and atmospheric services.

You raised four points in your questions, Mr. Bowen, and I would like to respond initially and then turn to Dr. Hallgren for a more detailed response.

With regard to NOAA weather radio, I do, very frankly, regret and apologize for the delay encountered in responding to your queries that started last spring.

Dr. Hallgren informs me that equipment has been shipped to Mississippi, including a new transmitter that will take care of the transmission problem associated with the NOAA weather radio mounted on the towers that have not been giving appropriate area coverage. He will expand on that.

Second, with regard to the flood report in Mississippi, I believe you're referring to the floods on the Pearl River?

Mr. BOWEN. Yes.

Dr. OWEN. We are required after a major disaster such as occurred in Mississippi to make what we call a disaster survey, and I had a team under the direction of Dr. Martineau, my deputy, visit the area, with a team that included a hydrologist, an independent adviser, to assess our performance in reacting to that flood situation. The report is in preparation. Dr. Martineau only last week finished the final draft. It will be prepared and forthcoming for review—I can't give you an exact date—but in the fairly near future, sir.

You indicated you had a question concerning Now Cast versus Green Thumb. And with regard to agricultural services provided by the Weather Service in the area, I would turn to Dr. Hallgren.

You did mention the problem of radar coverage in Mississippi. We are familiar with the problem, particularly in the area of Tupelo and

in the general vicinity. As I recall, having looked at our radar coverage in the area, there are three radars, not in Tupelo certainly, but so located such that we have felt that Tupelo did get coverage.

I realize the situation with regard to severe storms and tornadoes, and our program that I will discuss during my testimony hopefully will provide us with an enhanced capability to locate and to determine the severity of a storm, and to issue appropriate warnings.

With regard to Now Cast and the agricultural services I would like to ask Dr. Hallgren, Director of the Weather Service, to comment.

Mr. BOWEN. Thank you.

Dr. HALLGREN. Thank you.

With regard to the agricultural forecasts, of course, we do provide such forecasts in the State of Mississippi, and you know we operate an Environmental Science Service Center that provides support to the farmers.

The Now Casts are another story. We recognize that this is an area that we have to move more deeply into and provide up-to-date information for the very short term which is frequently referred to as Now Casts. We are doing some of that through NOAA weather radio, but until we get a far greater capability, both observationally and in terms of arrangements for disseminating the information, nowcasting will not come in the exact way that the farmer and many other citizens would like.

I might add on NOAA weather radio, as Dr. Owen indicated, the report has not been prepared. I have told the program manager to have such a report prepared in 1 week. So you should have it in 10 days or so.

But on the other hand, he has taken very definite actions. There have been new transmitters shipped for all stations. We've worked out an agreement with the officials in Mississippi for their installation. And in addition, we have shipped an additional console, which just arrived last week, so that in the northern part of the State the forecasts that are received on NOAA weather radio will be broken down into finer detail. In a sense, that helps out somewhat on the Now Cast as well.

Mr. BOWEN. I appreciate that.

Of course, there's a special sort of technological problem that we had, and I'm informed by those who are certainly more expert on the subject than I that there is a particular recent kind of tornado called the southeastern tornado, which comes in a completely different manner than the traditional Great Plains twister, one that often comes related to thick rain cloud and out of a large, low cloud bank, and it is much more difficult to see it coming.

I have a feeling that a good deal of research probably is needed on this. I don't know whether that sort of research is being conducted. I would hope so.

Dr. OWEN. Yes, Mr. Bowen, the National Severe Storms Laboratory itself is conducting research. This experimental laboratory at Norman, Okla., has the specific responsibility for engaging in research associated with severe storms and tornadoes.

We are very concerned, and we hope that our development and capitalization on the Doppler radar applications developed by that laboratory will enable us to analyze the characteristics of a storm area

much more closely in order to determine whether or not it will manifest itself in a tornado, and we think that with this new capability we will be successful.

I might say that the Environmental Research Laboratories, on which Dr. Webster testified yesterday, have carried out in that area the severe storms and what they call mesoscale experiment in company with universities. The Severe Storms Laboratory in Norman, and the people from our Severe Storms Forecasting Center, have conducted a series of experiments during tornado seasons to analyze storm characteristics and to develop and provide appropriate specifications for radar and surveillance equipment to analyze the characteristics of those storms and provide earlier warning.

So it's an ongoing program, and I certainly appreciate your interest and concern, sir.

Mr. BOWEN. Thank you. I appreciate your response today.

It sounds as though we're making some progress. As I say, the National Weather Service has always been extremely cooperative. I do realize that there have been some limitations imposed binding on NOAA. I was not able to be here yesterday for the testimony, but I do hope the word will travel up the line and reach the appropriate places.

Again, thank you, and Mr. Chairman, I want to thank you very much for allowing me to be with you today.

Mr. AMBRO. We thank everyone.

If you'll proceed, gentlemen, we would appreciate your testimony. Can we get a copy of that report being sent to Mr. Bowen? I would like to see that.

Dr. OWEN. Yes, Mr. Chairman.

[The report to be provided follows:]

NOAA WEATHER RADIO IN THE STATE OF MISSISSIPPI

(Prepared by National Weather Service, Communications Division, Silver Spring, Md.)

The NOAA Weather Radio (NWR) Program Manager visited Jackson, Mississippi during the week of April 16, 1979. Even though this was the week the Pearl River flooded the City of Jackson, there was an opportunity to talk with operational and technical personnel of the National Weather Service (NWS). An analysis was made of maintenance records and a visit was made to the Bude NWR transmitter site, which had a history of the largest number of failures.

NATURE OF THE PROBLEM

Prior to the visit, several complaints had been received from NWR listeners about frequent NWR transmitter failures with loss of service extending over long periods of time. A careful analysis of the maintenance reports for the NWR system showed that the largest number of failures occurred at six transmitters which were mounted on towers 800-1000 feet above ground. Only a few failures could be attributed to direct lightning strikes. The majority of the system failures were minor in nature, and conceivably had been caused by power-line or antenna-line transients, possibly caused by lightning induced voltages in the primary power source to the transmitter.

While the mean-time-between-failures (MTBF) in the Mississippi NWR system might be considered acceptable, the mean-time-to-repair (MTTR) NWR transmitters at the seven contractor maintained sites (six with transmitters on towers) was excessively high. The loss of NWR service was extensive in several cases, and can readily be attributed to the following factors:

1. The primary contributing factor to extensive losses of service was caused by lack of any one person or agency being responsible for the performance of

NWR transmitter maintenance. When a NWR transmitter failure occurred, NWS personnel or contract broadcast personnel had to find a service company that would perform the maintenance. This usually requires several phone calls to find a service company with a technician that was willing to climb the tower to service the transmitter which was 800-1000 feet above the ground.

2. Additional delays were caused by the fact that access to the tower was available only during the time that the access gate to the tower facility was unlocked (approximately 16 hours a day). Additionally, delays were caused by the fact that the tower could be climbed only in fair weather, during daylight hours, and when the tower elevator was not in use by others.

3. An inspection of the NWR site at Bude disclosed the fact that there was no lightning protection device installed on the primary power line coming into the site. At the transmitter level on the tower, there was no evidence of electrical bonding of the antenna transmission line or the NWR transmitter cabinet.

ACTIONS REQUIRED

From the observations and analysis made during the visit to Mississippi, it was concluded that the desired NWR system reliability could be attained by taking several steps to improve NWR transmitter performance.

These steps are:

1. Replace the low-powered single NWR transmitter on the tower with a higher-powered dual transmitter on the ground level, placing them in a housing that would permit service in any type of weather. Ideally, the transmitters could be serviced by technical personnel on duty at the site, and thereby reduce the travel time of the technician to zero.

2. Replace the present NWR antenna having exposed dipoles with one having enclosed and protected dipoles. This should minimize any system failures caused by icing of antennas in severe winter weather.

3. Provide access to an emergency power supply through an automatic transfer switch in the event of a primary power loss.

4. Install lightning-protection devices on the transmitter primary power source and on any audio control lines that extend outside the protection of the transmitter housing facility.

5. Provide an alarm system that would notify the programming office in Jackson when a NWR transmitter failure occurred.

6. Move the NWR transmitter from the Rose Hill Mississippi Authority for Educational Television (MAETV) site to the site of WTOK-TV in Meridian. This will improve service to the Meridian area and will eliminate the loss of NWR service caused by consistently faulty telephone lines used for programming the transmitter.

7. The service area of the NWR transmitter at the McHenry MAETV site considerably overlaps the service area of the Gulfport NWR station. Moving the McHenry station to a NETV site at Melba (Northwest of Hattiesburg) will provide NWR service to Hattiesburg (not now being served), Columbia and Laurel.

8. The four NWR stations serving the northern part of the state are all programmed from one console at the Jackson Weather Service Forecast Office (WSFO). This means that the entire northern half of the state receives the same weather programs and warnings. Greater flexibility in programming could be accomplished if another console were made available to Jackson.

While some of the above suggestions and recommendations could be effected without assistance from outside the National Weather Service, the siting and maintenance of NWR transmitters are the crucial problems to be solved.

ACCOMPLISHMENTS TO DATE

1. After a meeting with the engineering staff of MAETV, the National Weather Service made a proposal to them, in the form of a Cooperative Agreement, for MAETV to provide housing facilities for dual high-powered transmitters, tower space for antennas, and to provide transmitter maintenance using on-site licensed technicians. The MAETV accepted the proposal on August 29, 1979, with an effective date of October 1, 1979. Facilities and maintenance will be available for the Oxford, Bonnevill, Inverness, Bude, Ackerman and Melba NWR transmitters. Dual high-powered transmitters, with supporting spare parts,

test equipment and instruction manuals were shipped to Mississippi in September 1979. New antenna installations have been contracted for and mounting hardware has been ordered. A special training class has been scheduled for December 11-12, 1979 to train MAETV technicians in the maintenance of the NWR transmitters located at MAETV sites.

It is anticipated that six of the seven new transmitters at MAETV sites will be completely installed and operational by the end of March 1980. With good weather that is favorable to tower work, the transmitters could be placed into operation at an earlier date.

2. A dual high-powered transmitter was ordered for the Meridian site at WTOK-TV and arrangements have been made to have the transmitter installed in an auxiliary facility at the base of the antenna tower. The new and relocated NWR transmitter for Meridian probably will not be installed before the end of June 1980. A purchase order for the dual transmitter was issued in October 1979 after FY '80 funds became available. Maintenance will be provided by a contract technician residing in Meridian.

3. Emergency power sources for the Oxford, Inverness, Bude and Ackerman NWR sites will be provided by the Mississippi Civil Defense Council. Emergency power for the Jackson NWR is provided by the lessor of the privately owned site. Emergency power for the Gulfport NWR site is provided by the NWS.

4. Contracts are being prepared for the installation of the necessary power circuits, emergency power transfer switches, lighting protection, etc. for the affected sites.

5. MAETV has been asked for a proposal to provide a supervisory alarm system to notify the WSFO program offices when a transmitter failure occurs at a MAETV site.

6. Licensing approval has been received for all site changes and transmitter power increases necessary to effect the above changes.

7. A fourth NWR programming console was delivered to the Jackson WSFO in early November 1979. It should be installed and made operational by NWS technicians before the end of December 1979. It will be used to program the Inverness NWR initially. When telephone control circuits can be provided to the Ackerman NWR, the console will be used to control and program both transmitters.

8. The recommended moves of the NWR transmitters from Rose Hill to Meridian, and from McHenry to Melba will be accomplished with the installation of the new transmitters. The installations will be scheduled in such a way that there will be no loss of service to the present NWR listeners.

9. To be assured that the many separate tasks in the NWR program in Mississippi are properly coordinated with MAETV and NWS field personnel, one person in the NWR Program Office has been assigned responsibility for that coordination and timing of events.

With the completion of the changes discussed above, the NWR system in Mississippi will have increased reliability during periods of severe weather and the service will be more expansive, providing service to a larger number of citizens.

Mr. AMBRO. Dr. Knauss, if you would resume your place maybe we can chat a little bit about your testimony.

On page 7 you say you have not undertaken an overall evaluation of the total NOAA R. & D. efforts.

What do you see as the role of NACOA in establishing priorities, research priorities, with respect to NOAA?

Dr. KNAUSS. Mr. Chairman, if you look at the total mandate of NACOA, it's almost open-ended as to the kinds of things we could do and can do.

We have not taken an overall look at the NOAA R. & D. program, I suspect, for at least two reasons. One was that just prior to our reestablishment in 1977 a rather large effort had been undertaken by the National Academy of Sciences on the NOAA R. & D. program, a rather extensive review, which was forwarded to the Administrator of NOAA. It turned out that the chairman of that particular committee was a man named Ferris Webster, who was then shortly thereafter hired by NOAA and is now head of their R. & D. effort.

It seemed, given the limited amount of time and effort that we can put to anything, that it was probably not worth our effort to look once more at this time at the total NOAA R. & D. effort.

Second, I think it's fair to say that for an advisory committee like ourselves to be useful to both Congress and the executive it's helpful to give our guidance in several forms. If we're asked specifically by groups within Congress to look at some matter we, of course, will do so. If we're asked by the executive specifically to look at some efforts we will do so. Of course, we generate a number of ideas on our own, without requests from either. But in the absence of a specific request from any group, from Congress or from the administration, and given the effort that had been put forward, in 1977, it didn't seem worth our effort to look once more at the total R. & D. program. Rather, what we've done, or tried to do, is look at specific programs. That's what I think the thrust of my testimony is about. We've looked at specific programs and at the R. & D. effort with respect to those programs.

I guess that's all I can say, sir.

Mr. AMBRO. Do you consider that that response is one in line with your mandate, or your charter, which says that you will undertake a continuing review of marine and atmospheric science and service programs of the United States? Do you think you're doing that?

Dr. KNAUSS. We're doing our best.

Mr. AMBRO. You've used phrases like "we didn't think it was worth our effort."

Dr. KNAUSS. I'm sorry, sir. We've made recommendations on the R. & D. effort with respect to the Coast Guard, for example, just recently. We have made some recommendations with respect to some aspect of the R. & D. efforts of the Navy in the last 18 months.

With a limited staff and 18 essentially volunteer members, there is only so much we can do. We have to look at these things on a selective basis.

No, I think it is in our mandate, and the fact that we have not looked at the total NOAA R. & D. effort at this time is for the reasons I gave you.

Mr. AMBRO. How many members do you have on NACOA?

Dr. KNAUSS. When we're at full strength there are 18 members. We have had the usual problem. We serve for 3 years and we rotate. Therefore, a third of our members are off each year. Between two deaths and some resignations—

Mr. AMBRO. There are 10, then?

Dr. KNAUSS. I think there are eight now.

Mr. AMBRO. You have eight?

Dr. KNAUSS. I think we're down to eight.

Mr. AMBRO. That's even less than I thought. So there are 10 vacancies?

Dr. KNAUSS. That is my understanding, sir. That's what Mr. Connolly tells me.

Mr. AMBRO. We believe Mr. Connolly.

Dr. KNAUSS. I know we're short.

Mr. AMBRO. Why? Why are you short?

Dr. KNAUSS. I don't make any attempt to understand what goes on in the White House in making appointments. I know that our recom-

mendations have gone forward some time ago. If it was just up to us, I can assure you we would be up to full strength. We've made every effort to push the White House on making these appointments, but they've been slow in coming.

Mr. AMBRO. Does not being up to full strength affect your ability to meet your charter, or requirements?

Dr. KNAUSS. Absolutely.

Mr. AMBRO. I make no effort to understand what happens in the White House either. Of course we're not sitting here to do that. There is, then, a direct relationship, however, between not appointing members that should bring you up to full complement and doing the job that the enabling legislation requires you to do.

One of NOAA's major new research initiatives is something called PROFS, the Prototype Regional Observing and Forecasting Service program, which represents an attempt to incorporate recent progress in observing and forecasting methods, including ground-based remote sensing technology satellites and new data processing dissemination techniques into an integrated system to produce improved forecasts for local weather conditions.

NOAA has been criticized in the past for slow transfer of technology to operational weather groups.

What do you think about this program? Is it a good step forward in improving interaction between researchers and operational weather groups? Is it enough, for example? What about the cost of improving the Nation's local weather forecasting through the system, PROFS? Would it be cost effective? Things of that nature. Do you have any views with respect to this?

Dr. KNAUSS. No, sir, I do not have any views on this matter at this time because it's a subject which, to the best of my knowledge, NACOA has not looked into in any depth. I could be wrong.

Mr. AMBRO. How about the whole business, then, of the transfer of new technology to operational groups? Do you have any attitudes with respect to that?

Dr. KNAUSS. I'm sorry, sir?

Mr. AMBRO. The whole question of the transfer of technology to operational groups, such as the Weather Service, do you have any thoughts with respect to that, any additional mechanisms, any way to improve the transfer of technology?

Dr. KNAUSS. We have looked a little bit at the problem with respect to ocean technology and have made some recommendations to NOAA that they should develop a much stronger program of their own in ocean technology, which therefore could be utilized by ocean industry. To date NOAA has, for one reason or another, been unable to do so. We are deeply concerned about this lack of Government initiative in ocean technology.

Some years ago the Navy actually fulfilled the role of providing the base for ocean technology, for the civilian as well as the military sector. The Navy has pulled out of this, not completely, but at least in large part. NOAA as the major civilian ocean agency presumably has that mandate. NOAA has never been able to develop a total program in what you might call generic ocean engineering. It has adopted a rather piecemeal approach to this. It's a problem which we've been concerned

with for some time and made a number of recommendations to NOAA on, but as of this date we don't see NOAA making much change in their method of operation in this matter, sir.

Mr. AMBRO. Maybe they can't get anybody to fill vacancies either.

Dr. KNAUSS. That could be possible.

Mr. AMBRO. Who in the White House is your whip to push whomever into making these appointments?

Dr. KNAUSS. We have contact with the personnel office in the White House, I suppose at a fairly low level in Eizenstat's office. We have tried to use OSTP to get some movement on these matters.

Mr. AMBRO. I think that's a central question. I don't like to deal in hearings as lofty as these, dealing with so many vital questions, in considerations of personnel, but it seems to me someone should go to somebody in the executive branch to make these appointments.

I think I'll turn this over to my wiser and more eminent colleague, who could probably focus on this far better than I and follow up on these questions. My friend, Mr. Brown, from California.

Mr. BROWN. You're very kind, Mr. Ambro.

Mr. AMBRO. I try to be.

Mr. BROWN. Dr. Knauss, I think your recital of the activities of NACOA is very impressive, frankly, considering the difficulties that you have because of the shortage of appointees in your organization.

I think in the focus that you've given that you have outlined or touched on a good share of the major problems we face in this area, and I appreciate that very much.

At the present time the general political atmosphere seems to be favorable to the sort of action which I gather that you have recommended, specifically the Institute for Engineering Research on Oceans. I look on this as a way in which we can develop a much stronger base of research, both basic and applied research, toward the need for expanded operation in the ocean environment, which obviously is coming, and I note also the climate of concern for the ability of this country's industrial system to engage in programs which are innovative and increase productivity, which would be stimulated by an Institute for Engineering Research, it seems to me.

In the light of that, I would like to ask you if your recommendations have provided more detail as to the organization, the framework, the resources that would be necessary, and so forth, to move ahead with this kind of a program, or has the National Academy of Engineering given any attention to this problem?

Dr. KNAUSS. I'm told that the earlier report, which was made before I was a member of NACOA, did go into that kind of detail. Our more recent recommendations have not gone into that detail.

Mr. BROWN. So that we then would have your original report, which gave some detail, plus the more recent ones which reinforced those recommendations?

Dr. KNAUSS. That's right, sir.

Mr. BROWN. And that should provide a basis for some action.

You don't happen to recall what we're talking about roughly, in terms of annual resources, do you?

Dr. KNAUSS. If I can refer to Mr. Connolly?

We would have to furnish that material for you, sir.

Mr. BROWN. All right. It's conceivable the staff already has these reports, but if we do not have that information I would like to have it because we are considering legislation of a broader nature, aimed at facilitating the research institutes of various kinds that would couple industrial and university research more effectively.

Dr. KNAUSS. Yes, sir.

Mr. BROWN. It seems appropriate to consider something like that. [The information to be provided is as follows:]

A Report for
the Secretary of Commerce

Engineering IN THE Ocean

by the
National
Advisory
Committee on
Oceans and
Atmosphere

November 15, 1974
Washington, D.C.

OCEAN ENGINEERING PANEL

Dr. Donald B. Rice, *Chairman*
President
Rand Corporation

Mr. Charles F. Baird
Senior Vice President
International Nickel Company, Inc.

Dr. Clayton H. Clewell
Senior Vice President
Mobil Oil Corporation

Mr. Elmer P. Wheaton
Vice President
Lockheed Missiles & Space Company

Staff:

Mr. David A. Katcher
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Dr. Abraham B. Bernstein
Staff Assistant

Mr. Lincoln D. Cathers
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**NATIONAL ADVISORY COMMITTEE
ON
OCEANS AND ATMOSPHERE**
Washington, D.C. 20230

15 November 1974

HONORABLE FREDERICK B. DENT
Secretary of Commerce
Washington, D.C. 20230

Dear Mr. Secretary:

In your letter of August 21, 1973, you asked NACOA to define the national need in civilian ocean engineering, and to discuss who ought to be responsible, as between the private sector and the government, for meeting particular portions of it.

Our reply has been longer in coming than we had intended. There turned out to be no obvious consensus in the answers to the questions you have asked. Reasonable suggestions for improving the national effort have been made by many—in studies over the last decade and in the interviews staff conducted during the last year. There were persuasive arguments for developing various aspects of engineering in the oceans. But no specific applications of ocean engineering to civilian needs swept the field as critical, urgent, national in scope, yet neglected.

The panel we appointed to look into this matter consisted of Dr. Donald B. Rice, Chairman, Mr. Charles F. Baird, Dr. Dayton H. Clewell, and Mr. Elmer P. Wheaton. It reports that it found itself in a position of concluding that the paramount national civilian ocean engineering need is not a specific number of projects in ocean engineering, but rather a modest organization whose function it would be to:

- a) work on and develop standards which presently, in ocean engineering, lag other engineering;
- b) fund good ideas in meeting basic engineering needs to the point where they could generate support on their merit or fade away on their lack of it; and
- c) animate technical transfer and professional communications.

The basic needs would be concerned not so much with systems as with special materials, techniques, and engineering characteristics required for many different kinds of marine operation.

The panel came to the conclusion somewhat unwillingly that an organization rather than a specific program was needed. Its expectation had been that at least several agreed-upon ocean engineering tasks would emerge as outstanding and essential to the civilian sector. It was aware of extensive Navy work in many of the areas of interest. The panel was prepared to find that if no agreement on particular civilian applications emerged as especially significant there was no real need, national in scope, for a civilian ocean engineering program.

But that did not settle the matter. Despite the fact that no "winners" emerged, the panel also became convinced that we would all be the losers if things were allowed to drift in ocean engineering as they have over the last decade. There is need for technical alternatives to be on hand when decisions are made so as not to be trapped into expedient, possibly environmentally detrimental, actions. There are simply too many things that should be done to avoid being caught by surprise in our expanding and conflicting uses of the oceans offshore, in the coastal zone, in the depth and the breadth of the sea.

None of the needs developing from this increased activity, by themselves, make for a national program. But together they seem to require a stimulus to progress because they fall into the gap which lies between short- and long-term programs and between the responsibilities of the private and governmental sectors. The gap lies between the immediately-targeted projects of the private sector in getting on with its operations (during which engineering problems are solved as part of the project) and the lower-keyed longer-range targeting of the government sector in laying in a broad fund of knowledge upon which we can all draw as time goes on. The former is quite specific, the latter quite general. The question of the relative roles of government and of industry is involved because each, to some extent, looks to the other to cover the inbetween area. The panel speaks of this grey area in more detail in its memorandum report which I forward with this letter.

Ocean engineering is more expensive than engineering on land, the panel noted, and the benefits are often harder to assess than the costs. This open-ended uncertainty is one reason recommendations in the past to start broad programs in ocean engineering have been unpersuasive. But the panel felt it a mistake to take an all-or-nothing attitude about supporting and funding this work, especially since one reason ocean engineering is expensive is that its development is so uncoordinated.

While there are a number of ways in which this situation could be ameliorated, and it is disappointing that it has not proved practical to take full advantage for civilian purposes of the Navy's work in ocean engineering, NACOA proposes that an Institute for Engineering Research in the Oceans, with a strength of about 150 professionals,

be established as the effective way of organizing ocean engineering development without incurring large down-stream costs. To encourage the formation of a focus for marine affairs in NOAA, we believe this Institute should report to the Administrator of NOAA, who would maintain it as a distinct entity with appropriate bonds to other government agencies who have engineering tasks to perform in the oceans such as the Department of Interior, the Navy, the Coast Guard, etc. The Institute should be authorized startup funding of \$5, \$15, and \$25 million for three successive years with a mandatory reexamination and re-evaluation of the effort starting two years after day one and a major reassessment five years later. The task of this Institute would be to stimulate and support engineering research (advanced development) in the oceans to meet civilian needs by using seed money to get good work started but not supported indefinitely. *The essential task of the Institute would be to range the field rather than get bogged down in expensive demonstration programs.* It would be to support work and act as a catalyst in new areas of special materials and techniques which would serve a multiplicity of marine activities. It would have a central responsibility for improving professional communications and encouraging the development of standards.

To do this job the Institute would have to have the in-house technical capacity to be stimulated by technical problems, to help prevent falling behind in ocean technology, and to monitor the technical quality of contracts. It would need a Board of Governors representative of industry, the universities, and government to exert the pressure to keep the Institute technically competitive. It would be desirable to have a mix in funding with a major portion of the disbursed funds being used for direct out-of-house support and for fund-matching with outside sources as an earnest of effort and as a check on judgement. Thirty to forty percent should be reserved for in-house efforts or centralized facilities.

Det Norske Veritas, the highly regarded technical research and standards-setting agency in Norway which uses a mix of government, private, academic, and professional expertise on marine and offshore problems is an example of the organizational status we have in mind.

One of the National Institutes of Health with a touch of the National Bureau of Standards would be a closer analogy amongst U.S. institutions in organizational structure—more so, for example, than the Office of Naval Research or the Institutes which grew up around the Department of Defense in the fifties and sixties. The reason is that the mission of the Institute for Engineering Research in the Oceans would be to catalyze activity for many users who are dispersed throughout the nation rather than to stimulate technical activity by many suppliers for a centralized, government user. In any event we

do not propose in this writing the details of this organization. This Institute would best be formulated, NACOA believes, through the legislative process.

In brief: finding that the national purpose would be served by the establishment of a modest organization to stimulate more foresighted development of ocean technology than now occurs despite accelerating national activity in the oceans, we recommend there be established an *Institute for Engineering Research in the Oceans*

Whose function it would be to:

- Develop standards which presently, in ocean engineering, lag other fields.
- Fund good ideas in meeting basic engineering needs to the point where they could generate support on their merit or fade away on their lack of it.
- Improve technical transfer and professional communications in ocean engineering.
- Oversee the no-man's land between performing in the oceans and trying to describe and understand it.
- Provide seed money to develop good ideas (but not demonstration projects) before a certain market exists.

We suggest a size of:

- About 150 professionals with the technical competence to follow as well as lead, perform as well as monitor.

And a budget of:

- About \$5, \$15, and \$25 million per year (at full strength), more than half of which would be for outside grants and contracts.

Reporting to:

- The Administrator of NOAA as focal agent for marine affairs and Federal Coordinator for Marine Sciences and Technology.

This proposal is a step deeper into commitment to ocean engineering than was recommended in our Second Annual Report where it was suggested that a Federal Coordinator of Marine Technology Development be appointed who would at least assist in the transfer of information from the Navy into the civilian sector. Having looked into the matter with some care, the panel feels that minimum step would be insufficient even though beneficial. Another alternative—to await the effects of the stronger focus for marine affairs to be achieved by government reorganization as NACOA recommended in its Annual Report—would simply delay things, for ocean engineering efforts would have to be concentrated even there in some similar fashion.

What we propose here is not a general solution for marine affairs, but a specific one for ocean engineering. The exact form which it takes is less essential than that it pioneer in ocean engineering and scout out approaches to the civilian engineering problems which we will face tomorrow.

The memorandum we forward expresses those views in somewhat more detail and gives the general argument by which they were reached. The memorandum has been considered by the National Advisory Committee on Oceans and Atmosphere in full and approved by them. It is with pleasure that I forward it.

Sincerely,

/s/William A. Nierenberg

WILLIAM A. NIERENBERG

Chairman

Memorandum Report
by the
Ocean Engineering Panel

of the
National
Advisory
Committee on
Oceans and
Atmosphere

Engineering in the Ocean

INTRODUCTION

Modern technology is creating a dilemma for engineering by imposing on it precise demands for information on, and understanding of, complicated physical characteristics without relaxing the practical constraints of economics, schedule, and purpose. This dilemma poses especially difficult choices in the oceans where a harsh environment offers severe technical and economic limitations to gaining this technological information.

The civilian effort in ocean engineering both public and private appears to be undersupported in view of the rapid expansion of activities in the ocean and little or no reserve of technology to provide the technical alternatives to meet the requirements which thus develop. Use of the oceans is expanding faster than is the knowledge being provided to support it. While the difference in rates of growth may be temporary, it exists now, and creates a gap. That is why the lack of a conscious effort to do something about it on a national scale is troublesome.

Recognition of this gap is not new, of course, as many previous studies have testified, but almost all these reports suffered from a skeptical reception because the ocean engineering needs were defined so broadly they promised to be costly without promising any obvious results. The panel determined to avoid the general and look for the specific.

It is our purpose in this brief memorandum report to state the task as we saw it, describe our approach, recount what we found, and recommend a course of action we propose be followed.

THE TASK FROM THE SECRETARY

The task suggested by the Secretary of Commerce * was to survey the national civilian needs in ocean engineering, define the specific applications which should be undertaken, suggest the relative roles of industry and government, and recommend how government effort might be applied if other than is now the case.

* See Attachment A, Letter to Chairman, NACOA, from the Secretary of Commerce, 21 Aug '73.

THE APPROACH BY THE PANEL

Studies already undertaken were reviewed. Staff interviewed many active practitioners in marine affairs in government, in industry, in the oceanographic research community, and at universities, and reported to the panel on what they had been told. This memorandum has been prepared on the basis of what was learned.

FINDINGS: Introduction

The panel learned that there are many specific tasks necessary to the development of ocean engineering which need doing but no general agreement exists as to what, specifically, ought to be done first. No area of ocean technology stands out as critical yet totally neglected.

This could be interpreted as reassuring evidence of normal progress. But the panel feels there is a contributory cause to this drift which is not normal. The contributory cause is the expense of working in the ocean which occurs partly because of the nature of ocean engineering, partly because of the way we go about doing it. The inherent reasons are straightforward but worth noting. You can't leave something on the ocean's surface without mooring it; then, how long it remains there is uncertain. You can't put something on the bottom and find it easily when you come back. It is difficult in the ocean to see and touch what you work with. In addition to the extremes of weather over water, the physical, chemical, and biological effects of water on materials, instruments, and constructions are in general so much more extreme than they are on land, it costs extra even for impermanence. Furthermore gear can't exist except as part of a "system" which means that every upward adjustment in requirements balloons through a whole chain of inter-connected parts. Fighting cost, reliability, and weight at the same time means something has to give. It is usually all three. To top off the expensiveness brought on by the nature of the work, we characteristically add expense unnecessarily by a cut-and-try approach to complex system development in which we fail to work on components separately in advance and suffer further disadvantage in the use of otherwise suitable materials because of marine fouling, stress corrosion, etc.

This matter of cost has a major influence on what can or cannot get done. Further, it involves the important side effect of making it tempting to let someone else do it—or at least pay for it. Working out all the details in advance is expensive and time consuming and so rather more risk is accepted in groping forward. Or one looks to someone else to work things out. In any event many things which people or organizations would normally do for themselves are put on a wish list instead.

The panel's hope was to find a consensus on several critical needs, that is, several items on everybody's wish list, the lack of whose fulfillment was choking progress, and then ascertain whether government support had a role to play and suggest how it might be done.

FINDINGS: Sector Viewpoints

We had expected that government, industry, and the research community would exhibit needs common to their own sector but reflect separate sector interests, and their viewpoints would therefore be somewhat different. They are, and we will attempt to describe them briefly (despite the obvious danger of generalizing about specifics) because these viewpoints illuminate differing approaches to the specific tasks mentioned.

- (a) *Government* tasks are so endless, the requirements for program and budget justification so detailed, it was not surprising that ready-made plans exist to take ocean engineering one more step in about any direction named. The price however is a somewhat sluggish responsiveness to new problems and there seems not yet to have emerged forward-looking definition of what needs to be done, in the offshore zone in particular, with regard to ocean engineering aspects of multiple use, regulation, safety, environmental protection, and the like.
- (b) *Industry* exhibited a wider range and greater diversity of approaches on what needed doing than did the other sectors. This was reflected especially in the differences of opinion on what industry would like government to do, and what it wishes to reserve to itself. The oil industry has the incentive and the wherewithal to tackle brute-force almost any ocean problem it runs into, but it needs better environmental data. People who build submersibles, on the other hand, would like to see Government programs which use submersibles, even if the direct results are somewhat intangible. Government responsibility is apt to be defined broadly by most as the need for a technological basis—materials research, for example, or general investigations in soil mechanics, or structure loading, or sub-surface nuclear power, or in waste-management in coastal areas. But the economics of it look somewhat different from different vantage points.
- (c) The research sector, to lump the oceanographic and university ocean engineering communities, are more of one mind. With only minor variations they stress the theme of continuity, facility support, and receptiveness to a longer view than immediate applicability.

What is common to all sectors then is the judgement that not enough ocean technology is on the shelf, that learning as you go may be the only way to get things done now, but that it is not the best way because it means re-inventing the wheel or basing decisions on expediency which comes back to haunt you later. A little foresight would help a lot in many areas.

FINDINGS: Civilian Ocean Engineering Needs

We did not cover the entire field of ocean engineering in detail for we had neither the resources nor the desire to make a complete survey. We did not seek to find out why U.S. fishing vessels buy Swedish sonars, or why Japanese build bigger tankers. We accepted the judgment that American oil technology is the reserve on which all the world draws, that the U.S. Navy deep submergence capability is unparalleled, and that this won't keep on forever if we simply rest on our laurels. We felt that if we sought specifics where we could find them, a strong common trend would probably show up even in a partial sample if it existed.*

Attachment B samples the extensive collections of specifics collected by others. We did not try to compete with these studies. The specifics we did find independently were, in general, not very different from the rather more thorough surveys sampled in the attachment. As with these studies, we found no consensus or major imperatives. Unwillingness to invest effort in anything unless it is immediately needed—at which point it is often too late—seemed to be a root cause of many of the problems but that isn't new. Systems failed because the components had not been thoroughly tested. There was no time—or taste—for a disciplined engineering approach.

Engineering needs exist in such areas as offshore pipelaying, underwater storage tanks, mooring systems, oil spill prevention, dredging, resource recovery, environmental studies, and *adequate component testing of ocean engineering systems before deployment to lower the failure rate, which is high.*

For specific applications the panel's attention was drawn to the need for reliable underwater connectors, subsurface bench marks, non-fouling transducers, and meso-scale current measurements.

* Special thanks are due to the Sea Floor Engineering Committee of the Marine Board of the National Academy of Engineering for its courtesy in welcoming staff to its deliberations. They are still in progress, in the course of a two-year effort supported by the National Science Foundation, to define the precision with which characteristics of the sea floor and structures within and upon it are known, and the precision with which they should be known. This effort differs from being merely another tabulation in that it is more quantitative and is a step in the direction of standardization.

In all instances, the panel pressed for priority. "What would you do first?" In response to this, specific goals (not specific ocean engineering applications) were usually offered: The panel was offered not priorities, but selection schemes to find them. Criteria such as urgency, responsibility, return vs cost, multiplier effect, and impact were suggested. The relation to energy was offered as a selection device which would imply emphasis on exploration, surveying, offshore federal expertise in drilling and harvesting, information to get offshore plants on line faster, power-plant siting, subsurface soil mechanics, loading factors on structures from wind, wave, and current, and energy sources (oil, wind, wave, current).

Instrumentation was another area to draw attention, in particular monitoring gear, satisfactory subsurface instrumentation, instruments for tidal measurements, wave heights, and surveys. Suggestions were made that user needs would indicate priority, such as those for shipping, petroleum, minerals, construction, recreation, national security, and ocean sciences. Bold pilot projects in energy discovery were suggested from which ocean engineering priorities would develop—and so forth.

A persuasive case was made for the critical importance of materials research, especially as materials are affected by fatigue under cyclical loading, and in stress corrosion where the chemical action of seawater affects materials in an unusual way.

Nevertheless, the common trend did not turn out to be a specific high priority application. Instead it was the apparent inability to choose what ought to be done first. Despite an almost universal if poorly defined distress at not doing things that ought to be done there was instead a helter-skelter looking in all different directions and reaching for schemes to pick winners. Specific application of ocean engineering to civilian needs appeared trivial as candidates for a national effort, yet the more general suggestions for enhancement of ocean engineering capability sounded poorly thought out, open-ended in cost, and groping for support.

It was also evident that there is no natural government sponsor for the general support of civilian ocean engineering needs. Of the government agencies with direct interest in the oceans, only the Navy has responsibility for pursuing advanced technology directly; other agencies, such as the Department of Interior, NOAA, the Coast Guard, etc. relate the ocean engineering needs to their service requirements and so no one has a broad oversight.

FINDINGS: Summary

The marine implications of the over-riding need for the U.S. to decrease its dependence on other nations for what is critical to its own existence are too important for the United States to let drift.

There is an "ocean engineering problem"—it won't go away even though general goals are unconvincing because their costs are too open-ended and separate specific goals don't win enough votes.

Complaints from those with whom the panel made contact proved to be less along the line of specific technological deficiencies than they were organizational in nature. There was concern for the lack of understanding of the need for ocean engineering until it proved late and expensive to correct what foresight might have prevented. There was concern for the lack of continuity in ocean engineering development which meant inefficient, stop-start investigations. There was concern for the lack of meso-scale activity mid-range in size, mid-range in time, and mid-range in money. There was concern about the lack of timely communication of data that did exist.

The panel's findings were:

- The ground has been well-ploughed.
- There is no question but that there are things to do in ocean engineering but too many to do all at once.
- There is no general agreement on what projects or programs ought to be done first.
- This may be because no one thing ought to be worked on first and many ought to be worked on simultaneously.
- Drifting along until we hit a snag seems hardly the useful way to go.

On the relative roles of government and industry in ocean engineering—there seems to be agreement in principle. It is: The cost of ocean-engineering research and development is to be borne by those who would benefit from it. If the development is for a specific operation with specific users, the costs should be assumed by the operator and reflected in the price of the product or charge for service, or, if there are many and disparate operations by whose use the public is generally benefited, the cost should be borne by the general taxpayer and requests for funding must compete with other and unrelated demands.

The hitch comes in deciding whether a particular development fits one definition or the other. The ambiguities seem to arise in three ways: (1) when the direct benefits are hard to figure, (2) when the benefits are twice-removed, i.e., when the direct results might stimulate benefits but their nature is not directly foreseeable, and (3) when differing conception of the detail, the risks, and the time-to-payoff raises the argument of who should pay for the middle stages. This is especially complex because the expenditure of government funds in the early high-risk stages of development leads to a government interest in later stages where industry would otherwise prefer to go it alone. It is

the implication of continued government involvement (in addition to the normal divergence of opinion on regulation and monitoring) which leads to such differences of opinion by industry on government's role in a new field. It seems to depend a lot on how much is available to be put at risk in the early stages.

The panel sees no way out except by deciding each case on its own merits, for industry is not uniform in its attitudes and its needs; its relationships with government vary.

CONCLUSION AND RECOMMENDATIONS

Short-range ocean engineering problems and applications are being attacked and solved by industry if they otherwise would block operations, but the solutions are often expedient and expensive in the long run because they have been worked out in a hurry. A long-range program for supplying background information on the oceans exists in NOAA, though it is bound to fall short of satisfying everybody's requirements because it is expensive in the detail and the precise characteristics sufficient to keep everybody happy.

But the extensive lists of engineering to be done in the oceans include whole classes of problems in materials, techniques, engineering characteristics, and instrumentation whose solutions, if anticipated, could save time, and money, and possible environmental strain, if tackled now. They seem ripe for government encouragement if only of a limited sort. Since the candidates for support are so numerous, as are the selection schemes themselves, the panel came to the conclusion that what is needed is wide-ranging stimulation of the field to provide technical alternatives, with demonstration technology left to others once particular ideas prove out.

This conclusion was not independent or isolated. Two organizational examples of what kind of organization people in ocean engineering would like to see active kept cropping up: (1) the Office of Naval Research through its twenty-five years history and the role it has played in providing continuity to the support of basic research and in paving the way for the National Science Foundation, and (2) the National Advisory Committee on Aeronautics and the role it played in welding research, industrial, and governmental efforts in aeronautical engineering. Both were outstanding in stimulating progress in highly technical areas—the one in basic and the other in applied science. The heart of the matter is that support was offered for good ideas, not for predictable results.

However, neither the ONR nor the NACA concepts apply to ocean engineering today. ONR was launched to preserve the Navy-University relationship at the end of the vigorous fast-moving and successful

cooperation in research for weapon systems induced by World War II. And money was available. The NACA helped bring on the age of the airplane, it was an integrating device to harness what otherwise was scattered or partial. The conditions which made these agencies so singularly appropriate do not exist for ocean engineering today. A relationship has to be established outside of the Navy, not preserved. The analogy between the atmosphere's heights and the ocean's depths for those to whom ocean program seemed as impelling as a space program has been spectacularly unconvincing. And no war-end millions (with which ONR was launched) are there to be used.

But, if a catalyst to stimulate engineering in the oceans is needed since a programmatic solution does not seem sensible, there is no good reason why results similar to those produced by ONR and NACA could not be achieved, albeit in a somewhat different way. An organization is therefore proposed whose function it would be to provide technology-gathering and technology transfer, to stimulate industrial efficiency and development in the oceans, to work on the ocean's problems a few years ahead, to back good people and good ideas, and to set standards for and back-up the regulators and the issuers of permits and safety certifications in the oceans.

The panel therefore recommends an Institute for Engineering Research in the Oceans reporting to the Administrator of NOAA as the proper focus for marine affairs, but independent of the mainline components in that agency as too limiting, too confining for an organization which is to serve users in a broad range of government, industry, and research.

There are a number of government agencies whose need for ocean engineering expertise make them possible hosts for such an Institute such as the Department of Interior, the Navy, the Coast Guard, EPA, the National Science Foundation, the National Bureau of Standards, NASA, etc. But as we stated earlier, none of the civilian agencies presently has a responsibility for *general* oversight of national ocean engineering needs. NOAA, as the focus for marine affairs, is the most appropriate agency to hold in trust, so to speak, an Institute which would be geared to encourage needed progress in ocean engineering activities.

This Institute could not easily be part of the Sea Grant Program for it is essential that this Institute work with all types of organizations and individual practitioners and that it conduct its own in-house research. It must also be in a position to develop the special relationship with the Navy which would facilitate transfer of what can and should be transferred to the civilian sector from the Navy's extensive store of ocean engineering expertise. An organization close in its management of research in support of standard-setting functions in ocean engineering

to that suggested for the Institute is Det Norske Veritas, a Norwegian entity that certifies shipping (and offshore platforms) and is most highly regarded for its professional competence and the manner in which its setting of standards is backed by research. This organization is funded by those whom it services.

An Institute similar to one of the National Institutes of Health would be a closer U.S. analogy in its manner of operations to what the panel has in mind than the organization which grew up to serve the Department of Defense in the fifties and sixties. The DOD institutes gathered technical expertise from all over the country to assist one or two government-agency users. The Institute of Engineering Research in the Ocean would have the purpose of stimulating and contributing to activity in ocean engineering of interest to users dispersed throughout the nation—industry, federal, state, and local government, research institutions, etc. The customer is he who must work in the ocean, not a government agency.

The goal of the Institute would be to stimulate useful activities of others, which means it must possess the competence to judge what seems right for the field and have the dollars to back its judgement. It must have a necessary technical competence of its own, and be in a position to offer support directly or use matching funds to take advantage of local judgement on priority of importance. Some form of recovery of portions of the matching funds, on the basis of performance, or of results, could be offered as incentive (similar to the practice of the Defense Department in stimulating independent R&D along lines of DOD interest). The form and nature of the arrangement would clearly have to be worked out carefully with the utmost regard for keeping the Institute responsive, catalytic, technically aggressive, but reasonably controlled in the amount and the support it can offer. An essential function would be to improve timely technical publications and communication which is distressingly poor in ocean engineering today. A Board of Governors, representative of industry, the universities, and government is necessary to oversee the general course taken by the Institute and to provide a powerful means for keeping the Institute sensitive to changing national requirements and for keeping it technically competitive.

The panel estimates that for such an Institute to develop recognized technical excellence in ocean engineering, it must grow to about 150 professionals. To develop input from the nation at large and impact on the field it should disburse out-of-house at least one and a half times the funds it uses itself. This implies a start-up schedule for funding the first three years of \$5 and \$15 million to level off at \$25 million per annum although the nature of the facilities which would be required or used would have significant bearing on the rate of growth.

The panel is under the impression that the creation of such an Institute could best be accomplished by the legislative process during which the details of its composition, procedure for operation, and immediate tasks would be worked out in detail as a result of the broadest possible input from interested parties. It believes that the legislation should provide for an early review starting two years after startup to monitor the course the Institute is taking and a major review in five years to ascertain the Institute's contribution and the value of continuing it. The panel sees no conflict between its requirement for excellence and its suggestion that it come up to speed in a few years. Five years is a long time in which to make a case.

Recapitulation

To the Secretary's Question: What specific civilian ocean engineering applications to meet national requirements are not now being pursued? No major area seems to be without some attention, but it is less a question of specifics than of sluggishness in response to a whole category of mid-range problems in materials, techniques, and engineering characteristics, many having to do with responding forcefully to questions regarding environmental factors.

To the Secretary's Question: What are the relative roles of government and industry? Broad stimulation of the field by the former and specific development by the latter. If, as a nation, our development of technology in the oceans seems to be lagging (for which there is evidence, it is said, in the more rapid progress being made by other nations), it is not unreasonable to charge the Federal Government with trying to do something about it.

To the Secretary's Question: What do you recommend be done about it? We recommend the establishment of an Institute for Engineering Research in the Oceans, to report to the Administrator of NOAA, whose mission it would be to catalyze activity in the mid-range term 3 to 5 years ahead. This is not the only beneficial step which might be taken, but we believe it to be that most promising in effectiveness.

An Institute for Engineering Research with modest funds to expend in- and out-of-house should prove its own usefulness in about five years or rightfully sink out of sight. It would not be a sluice for funds nor would it have to wait on agreement on stated national goals and objectives—it would take off on those implicitly agreed to.

Attachments

Attachment A



THE SECRETARY OF COMMERCE
Washington, D.C. 20230

August 21, 1973

DR. WILLIAM A. NIERENBERG
Chairman, National Advisory Committee
on Oceans and Atmosphere
Washington, D.C. 20230

Dear Dr. Nierenberg:

The National Advisory Committee on Oceans and Atmosphere (NACOA) has commented extensively on the Nation's civil ocean engineering program in its second annual report. It has made recommendations for improved coordination of the Nation's ocean engineering activities and has suggested a number of areas for emphasis.

I believe that ocean engineering is one of the important elements in the Nation's future posture in ocean affairs. What is needed is an analysis and documentation of the requirements for an ocean engineering effort by the civil agencies of the Federal Government. There are many key questions about a civil ocean engineering program that need answers, such as:

- (a) What specific ocean engineering applications should be addressed by a Federal program to meet national requirements and what are these requirements?
- (b) What are the benefits that can be expected from Federal investments in specific types of ocean engineering?
- (c) To what extent should the Federal Government engage in and support civil ocean engineering activities?
- (d) How should such support be provided in those instances where Federal Government effort is clearly warranted?
- (e) What should be the relative roles of private industry and the Federal Government in fostering ocean engineering?

The above are all key questions, answers to which would be valuable in planning a civil ocean engineering effort.

The National Advisory Committee on Oceans and Atmosphere could be of great help to the Federal Government in organizing and carrying out an analysis directed at answering the types of questions that I have listed above. These questions should not be regarded as the only ones that are pertinent but only typical of those that require answers.

Accordingly, I am requesting that the National Advisory Committee on Oceans and Atmosphere undertake such a study and report to me on its results.

Sincerely,

/s/Frederick B. Dent

FREDERICK B. DENT

Secretary of Commerce

Attachment B

A Sampling of Civilian Ocean Engineering Needs

The Ocean Engineering panel was well aware that it was not the first group to take on an evaluation of national civilian ocean engineering needs and instructed staff to seek out previous studies with bearing on the task before it. A number of these previous studies turned out to be surprisingly explicit. A sampling from four reports covering a span of seven years is included in this attachment to demonstrate the care and detail with which ocean engineering needs have been specified. Excerpts from the Stratton Commission Report are not included partly because it is so well known, and partly because it generalized these needs into targets of national capability so that the underpinning specifics are not otherwise easily summarized.

It was the existence of reports such as these from which the attached concepts have been made which brought the panel to the early conclusion that it would not suit its own purpose to provide another set of what it would be nice to know about ocean engineering. Rather it needed to know what it would be good to do first of that which was already known.

Example I

1967

Excerpted from

"Underwater Technology Requirements for Non-Military Ocean Missions" prepared for National Council on Marine Resources and Engineering Development by Southwest Research Institute, 1967.

The manner in which this 1967 report classified the areas of underwater technology and related basic engineering, engineering components, to general systems, and operations to ocean missions is shown in Table 3.1 and Figures 3.2, and 3.3 immediately following.

Priorities and the relative roles of industry and government were also treated in Table 9.1, also attached.

Table 3.1

Areas of Underwater Technology**Basic Engineering**

- Coastal and Oceanic Hydrodynamics
 - Wave motion, force, spectra
 - Tides, seiches, surges, tsunamis
 - Reflection, refraction, diffraction
 - Currents. Turbulence and diffusion
 - Sediment erosion, transport, deposition
- Underwater Soil Mechanics
 - Physical properties; in situ and laboratory
 - Sampling. Testing. Site surveys
 - Bearing capacity. Foundation settlement
 - Anchoring. Breakout. Penetration
 - Scour. Stabilization. Slope stability
- Materials Engineering
- Structural Mechanics
- Mechanical and Electrical Sciences
- Naval Architecture and Marine Engineering

Engineering Components

- Instrumentation Systems
 - Navigation, positioning, communications
 - Observations, recording, measurements, sampling
- Power Sources
 - Batteries. Fuel cells
 - Radioisotope. Nuclear
 - Chemical dynamic. Closed cycle diesel
- Equipment, Tools, Devices
 - Motors, pumps, propulsion units, controls
 - Fittings, connectors, penetrations, seals
 - Tools: cutting, hammering, torquing, welding
 - Manipulators. Remote control systems
- Life Support Systems
 - Submersibles, habitats, divers

General Systems and Operations (multimission applications)

- Submersible Vehicles
 - Manned and unmanned
 - Tethered, untethered, towed
 - Bottom crawlers
- Mooring Systems
 - Anchor and cable
 - Dynamic anchoring

- Underwater Structures and Installations
 - Platforms
 - Petroleum production installations
 - Habitats, observatories, laboratories
 - Power generating and processing plants
- Man-in-the-Sea Operations
 - Free and hard hat diving
 - Saturation diving systems
 - Working and living underwater
- Underwater Construction Methods and Equipment
 - Dredging. Trenching
 - Piles. Caissons
 - Underwater fabrication, maintenance, inspection
 - Pipelines
 - Subaqueous tunnels

Mission-Oriented Technological Areas

- Fisheries Technology
 - Support of marine biology research
 - Location, tracking, identification
 - Concentration, control, harvesting
 - Modification of environment
 - Support of mariculture
- Petroleum Drilling and Production
 - Drilling platforms. Mobile rigs
 - Blow-out preventers. Marine conductors. Casing strings
 - Production platforms. Subsea completion systems
 - Underwater storage tanks. Gathering lines
- Ocean Mining
 - Exploration and evaluation
 - Extraction, processing, transportation
- Shoreline Modification and Island Building
 - Shoreline structures and construction methods
 - Beach erosion, transport, deposition, silting control
 - Land fills. Island building
- Underwater Technology Supporting Pollution Control and Waste Disposal
 - Standards and tolerance limits
 - Monitoring and sampling systems
 - Dispersion of wastes (industrial, mining, radioactive)
 - Removal of discharged oil
- Search and Salvage Methods and Equipment
 - Search and identification
 - Attachment, lifting, flotation
 - Recovery of cargo and equipment
 - Removal of debris

Figure 3.2
Relation of Basic Engineering and Engineering Components to
General Systems and Operations and Mission-Oriented Technological Areas

Basic Engineering and Engineering Components	General Systems and Operations and Mission-Oriented Technological Areas						
	Coastal and Oceanic Hydrodynamics	Underwater Soil Mechanics	Materials Engineering	Instrumentation Systems	Power Sources	Equipment, Tools, Devices	Life Support Systems
Submersible Vehicles			X	X	X	X	X
Mooring Systems	X	X	X		X		
UW Structures and Installations	X	X	X	X	X	X	X
Man-in-the-Sea Operations			X	X	X	X	X
Underwater Construction	X	X	X	X	X	X	X
Fisheries Technology			X	X			
Petroleum Drilling and Production	X		X	X	X	X	
Ocean Mining	X	X	X	X	X	X	
Shoreline Modification and Island Building	X	X	X				
Pollution Control, Waste Disposal	X			X			
Search and Salvage		X	X	X	X	X	

Note: All of engineering areas (basic and components) apply to a certain extent to each of the general and mission-oriented areas. The X denotes only the more important applications.

Figure 3.3
Relation of General Systems and Operations to Ocean Missions

Missions	Systems and Operations				
	Submersible Vehicles	Mooring Systems	UW Structures and Installations	Man-in-the-Sea Operations	Underwater Construction
Seafood Developments	X	X	X		X
Recovery of Petroleum	X	X	X	X	X
Recovery of Minerals and Chemicals	X	X	X	X	X
Underwater Transportation	X		X		X
Coastal Zone Development		X		X	X
Pollution Control and Waste Disposal		X			
Salvage and Recovery	X	X		X	X
Weather Prediction and Modification		X	X		
Exploration and Research	X	X	X		

Note: X denotes ocean mission for which a given system and operation will have an application in present or future developments.

Table 9.1
Areas of Underwater Technology

Area		R & D Effort Relative to Present Rate			Initiative for Developments					* Suggested Government Action	* Priorities for New Government Action		
		Greatly Accelerated	Some Increase	Present Rate Adequate	Primarily Government Primarily Industry								
Basic Engineering	1. Coastal & Oceanic Hydrodynamics	●			▼					A		1	
	2. Underwater Soil Mechanics	●			▼					A		1	
	3. Materials Engineering		●			▼				B		2	
Engineering Components	4. Instrumentation Systems Navigation, Communications, Bathymetry, Observations, Measurements, Sampling	●				▼				A		1	
	5. Power Sources	●				▼				B		1	
	6. Equipment, Tools, Devices		●				▼			B		2	
General Systems & Operations	7. Life Support Systems			●			▼				C		
	8. Submersible Vehicles	●					▼			B		2	
	9. Mooring Systems		●				▼				C		
	10. Underwater Structures & Installations		●					▼		B			3
	11. Man-in-the-Sea Operations			●				▼			C		
	12. Underwater Construction								▼		C		
	a. Dredging, Trenching			●					▼		C		
	b. Piles, Caissons			●						▼	C		
	c. Pipelines			●							▼	C	
	d. Tunnels		●					▼			B		3
Mission-Oriented Technological Areas	e. UW Fabrication, Maintenance, Inspection	●							▼		B		2
	13. Fisheries Technology					▼				B		1	
	a. Support of Marine Biological Research	●					▼				C		
	b. Harvesting, Mariculture		●					▼			C		
	14. Petroleum Drilling & Production		●						▼		C		
	15. Ocean Mining												
	a. Exploration and Evaluation	●					▼			B		1	
	b. Extraction and Processing		●						▼		C		
	16. Shoreline Modifications, Island Building	●						▼		B		2	
	17. Support of Pollution Control & Waste Disposal		●					▼		B		2	
18. Salvage Methods & Equipment		●						▼		B		3	

* Table 9.1 is a digest of the summary Chapter 9 of this report and conditions under which evaluations were made are given there with some care. The stated judgements are clear with the exceptions of symbols under government action required and priorities which may be paraphrased as follows:

A. New or greatly expanded physical facilities required.

B. Management and coordination of existing programs needs strengthening.

C. Present arrangements seem OK.

The criteria for priorities were commonality, urgency, and criticality.

Example II

1972

Excerpted from

"Toward fulfillment of a National Ocean Commitment," A Report of the Marine Board, National Academy of Engineering, Washington, D.C., 1972.

The National Academy of Engineering Report "Toward Fulfillment of a National Ocean Commitment" contains a great number of suggestions and recommendations for work in ocean engineering. The subjects covered give the shape of the Report's content and a brief paraphrase or outline is given below. In some areas the guidelines for proceeding are given in extraordinary detail.

MARINE TRANSPORTATION

Marine Speed Gap: 30 to 200 knots not now covered.

Ship Operating Problems: High cost of domestic construction; high operating costs; trade route problems; regulation and cargo preference; conferences, etc.

Ship Building: Mixed Navy and Civilian construction sub-optimal.

Merchant Marine: Underutilization of available technology; unattended power plants; unattended ships; design, coating, propulsion, anti-fouling, routing to avoid weather.

NEW VEHICLES

Hydrofoil, air cushion, semi-submersibles.

LIVING RESOURCES

Fish location; preservation aboard harvesting vessel; processing in general; aquaculture, contaminants.

NON-LIVING RESOURCES

Recovery of minerals from deep sea floor.

ENVIRONMENTAL ENHANCEMENT

Recreation, urbanization, power, coastal works, water resources.

EXPLORATION AND SURVEYING

Fish, fuels, bottoms, navigation, etc.

CONSTRUCTION AND CIVIL WORKS**Effects of the Ocean Environment on Construction**

Bottom Aspects: Littoral drift and mud slides; bottom scour; mapping and bathymetry, soil mechanics, geology, earthquakes.

Air-Sea Interface: Wind-induced waves, tsunamis, sea-ice and icebergs, tidal motions and storm surges, weather forecasting.

Sea-Water Characteristics: Pressure effects, temperature; currents, biological effects, corrosion effects, overall environmental effects.

Construction and Civil Works in the Ocean

Systems Approach: Effect on the Environment

Ports and Harbors: Future requirements, planning and design, port authorities.

*Coastal Engineering**Facility Equipment*

Offshore Construction: New land; floating platform; artificial islands; offshore platforms and submerged buoyant structures; mineral exploration and exploitation; pipelines; tunnels; and habitats.

Materials and Fabrication Methods: Material needs; fabrication methods.

Exploration and Development Programs*Instrumentation and Testing**Oceanographic Data Acquisition**Models of Ocean Environment**Construction Material and Fabrication Methods Development***VEHICLES AND PLATFORMS****Introduction***Ocean Exploration Needs**Management Responsibility**Time Scales***Study Methodology****Analysis of Tasks for Vehicles and Platforms**

Critical Task Area: Launch; operation; navigation; communication; sensing/processing; work.

*Limitation in Technology***PRINCIPAL TECHNOLOGY REQUIREMENTS**

Structure/Material: Pressure; hull; fabrication techniques; coatings.

Mechanical Interfaces: pressure hull bolted joints, exostructure connections; deep-depth emergency escape; hatch sealing at extended depth; supplemental buoyancy material.

Power Sources: Batteries; fuel cells; nuclear; waste-heat dissipation; power-source technology.

Electrical System: Connectors; conditioning equipment; hull penetration; power cables.

Machinery and Equipment: Hi-pressure seawater pumps and valves; hydraulic fluids and connectors; deep-depth ballast tank blow system; propulsion and control system; winches and cables.

Data System: Viewing; signal processing; sensing; undersea navigation; underwater communication.

Work System Technology: Manipulator systems; lock-out systems; sediment stabilization systems.

Support System: Surface tanking system; submerged support; life-support system.

Man in the Sea, Instrumentation, Navigation, and Communications

These chapters all have large lists.

Example III

1973

Excerpted from

"Report on Marine Technology" by a Panel of the
Science Research Council, London, 1973, p. 28-43.

APPENDIX 3 Recommended Research Areas by Field Reference Number

(Asterisk denotes high priority)

Field Reference 01

SHIP DESIGN - STRUCTURAL AND STRESS ANALYSIS

The response of structures to static and dynamic loads is considered in this section. Both static and dynamic behaviour is of concern especially where non-traditional materials are considered, for example, ferro-concrete. The methods of obtaining dynamic responses are of interest, where new techniques are being applied, such as the use of finite elements in propeller blade vibration calculations and in ship vibration calculations where the ship is treated as a three-dimensional stiffened plate structure instead of the usually assumed beam simplification.

A better understanding of fatigue and crack propagation as experienced by ship structures is required to provide information for efficient and safe detail design.

Methods of analysing and designing 'open-deck' ships for torsional loads are required, and these should take into account variation of cross-sectional properties along the length of the ship.

The response of ships' structures to impulsive loading is of concern from the point of view of preventing damage locally and also from the point of view of transmission of periodic forces which may cause unacceptable forced and resonant vibrations.

Recommended Topics

The design of a ferro-cement, pre-stressed concrete hull with technical and economic considerations taken into account.

The application of finite element techniques to the calculation of vibration responses of ships' hulls.

The assessment of the vibration characteristics of large marine propellers.

The assessment of structural response to impulsive loading.

A study of fatigue and crack propagation in ships' structures to provide design guidance.

The analysis and design of 'open-deck' ships under torsional load.

Field Reference 02

SHIP DESIGN - PROPULSION

The topics listed below range from the very specific to the rather general and, undoubtedly, the general ones would require specification in greater detail before they could be supported with confidence.

Apart from the very general items there appears to be very little – if any – overlap with work already underway. This is not, perhaps, very surprising as most of the undermentioned topics have been suggested by non-educational institutions.

Recommended Topics

Standby steam superheating by induction heating at normal supply frequency.

Investigation of increased steam speeds in saturated steam lines.

Effects of steam wetness on condensing heat transfer.

Design of boilers to accept rapid changes in steam demand.

Design of condensers.

Investigation of the future use of supercharged boilers in marine installations.

* The effect of fluctuating torques in the gearing of medium speed marine diesel engine systems.

Development of theoretical methods of solution for the determination of natural frequencies and normal elastic curves of heavy shaft marine propulsion systems.

Strength and vibration characteristics of main engine seats at higher powers.

Fundamental design procedure for steam bearings.

Aeration of lubricating oil in geared turbine systems.

Techno-economic studies of choice of main machinery system for factory trawlers including A.C. and D.C. electrics, hydraulics, C.P. and fixed propellers as means of transmitting power.

Production of data for, and preparation of, a series of propeller performance charts especially for (a) C.P. propellers, (b) shrouded propellers, (c) all propellers at speeds of advance associated with towing of fishing gear.

Analysis of vibration of ducted propellers.

Aerodynamic design of large 3D diffusers in gas turbine uptake and downtake systems.

Removal of waterborne salt from air in gas turbine intakes.

Coalescer filters – the effects of vibration and throughput of fuel and water.

* Air flows in confined machinery spaces containing supercharged i.c. engines, large electrical machines and men.

* The environment effects of noise in ships.

Computer drawing of pipework.

Field Reference 03**SHIP DESIGN - HYDRODYNAMICS, PERFORMANCE****Recommended Topics**

- Performance of ducted propellers with hull boundary layer interaction.
- Effect of form on the resistance and propulsion of small craft and determination of correlation factors.
- Measurement of wave pattern resistance full scale and correlation of same with model.
- Development of computational techniques in non-linear wave resistance theory.
- Measurement of drag and lateral force components for asymmetric hulls.
- Effects of viscosity on wave resistance – theoretical and experimental treatment combining boundary layer and potential theories.
- Resistance of trailing side pipes and suction heads of dredgers – variations with configuration and load on sea-bed and sea-bed materials.
- Investigation of the characteristics of turbulent wakes (fully immersed bodies).
- Study of scale effect on separation, particularly on the after-body of tanker forms.
- Laser measurements of velocity, turbulence of boundary layers and rotational wakes at both full scale and model scale.
- Physical understanding of flow patterns over different surface curvatures.
- An examination of the hydrodynamic laws governing the separation of flow at the stern of a 3D body, leading to the derivation of design rules for bodies of minimum separation.
- *Determination of the scale effect of vortices from model to ship size.
- *Finite element treatment of hydrodynamic phenomena.
- *Research on noise, especially in relation to onset of cavitation, with a view to reduction in noise output of fishing propellers, shafts, etc., in certain frequency bands.
- *Investigation of the distribution of bubble streams (generated by the bow wave) around and beneath the hull.
- *A study of the hydrodynamic and scaling laws for water currents induced by streams of air bubbles, with the aim of exploiting such currents for use in ship manoeuvring and berthing.
- *Physical understanding of skin friction for rough, smooth and chemically treated surfaces in various fluids.

Field Reference 04**SHIP DESIGN - HYDROELASTICITY (INCLUDING FOIL BEHAVIOUR)****Recommended Topics**

- Studies in propeller excited vibration.
- *Control of propeller induced vibration.
- Fundamental work on boundary layer theory to predict the distribution of wake velocity over the propeller disc.

Prediction of fluctuations in propeller blade loads due to variation of wake velocity over the propeller disc.

Torque and thrust characteristics for fixed pitch and controllable pitch propellers and interaction with hull under dynamic conditions.

Factors influencing, and control of, wave induced transient vibration.

Understanding of wave excited vibration.

Vibration of surfaces moving through fluid (eg bottom panel of ship).

Causes of cable vibration and its effect upon the drag characteristics of a towed cable both plain and faired, including vortex shedding.

Most of these suggestions emanate from non-university sources and, clearly, propeller induced vibration and wave excited vibration are the favoured areas for future work. From the data supplied it appears that only University College and Newcastle have current work in the field of hydroelasticity, but the degree of detail supplied does not enable much matching to be done with the proposed items. There is probably very little overlap. However, there is some overlap and redundancy in the proposed topics themselves and some could coalesce into single items.

Field Reference 05

SHIP DESIGN - HULL LOADS AND SHIP MOTIONS

Of interest to this section is the derivation of the forces acting on a ship's structure in a seaway. These forces are a result of the passage of waves, the ship motions, and the sloshing of liquid cargo, all of which create pressure forces and may cause impact forces. An accurate definition of these forces is necessary before full advantage can be taken of advances in stress analysis techniques.

Work on ship motions is required to help define underkeel clearance in shallow coastal waters; this is of particular concern to large tankers. The requirement is to define the ship responses of pitch, heave and roll, and the sinkage effect caused by the relative forward motion between the ship and the water. For all these, it will be necessary to take account of the proximity of the sea bottom as it will influence the hydrodynamic damping and added virtual mass associated with ship motions and will also influence the sinkage effect caused by the restricted area of flow under the keel.

Recommended Topics

General and local hydrodynamic loading on ships' structures owing to the effects of wave action, ship motion and liquid cargo.

The determination of added virtual mass and damping for ship shape forms for three-dimensional flow in deep and shallow water.

The determination of underkeel clearance for ships at various speeds in shallow water with a seaway.

The determination of propeller pressure forces and wake forces and moments.

Field Reference 06 (See Field Reference 19)

SHIP DESIGN - MANOEUVRABILITY, STABILITY AND STEERING SYSTEMS

The work of interest to this section is concerned with the manoeuvrability and directional stability of ships and boats, and also the associated optimum automatic steering system. Of immediate interest is steering and manoeuvring in shallow water at slow speeds, as typified by harbour approaches, and a longer term interest is the mathematical description of the motion of a ship with random wave disturbance.

Also considered under this section is transverse stability which requires investigation for fine ship forms travelling at speed in calm water and in a seaway. The effect of speed is to alter the righting ability of a ship and this is further modified by the passage of waves.

Recommended Topics

The development of analytical techniques for the determination, at the design stage, of manoeuvrability and directional stability properties leading to specifications for optimum automatic steering systems.

The determination of manoeuvrability and stability of hydrofoil craft and hovercraft.

The determination of ship manoeuvrability characteristics at slow speeds in shallow water and in channels.

The determination of transverse stability at speed and in a seaway.

Field Reference 07

PLATFORMS AND STRUCTURES AT SEA

Recommended Topics

Foundations

Foundations on various types of sea-bed.

Buoyant foundations.

Effect of structures on erosion and sedimentation.

*Scouring action in vicinity of fixed structures.

Erosion and sand movements around underwater pipes.

Design Loads

Wave forces on pipes and columns.

Properties of random waves and corresponding response of structures.

Full scale measurements on structures.

- Estimation of wave forces for structures under tow.
- Validity of small scale models in predicting loads on structures.

Structural Design

- Rational design criteria for marine structures.
- Design loadings for marine structures.
- Measurement and comparison of stresses in structures.
- Stress levels in 3D joint configurations.

Measuring and Monitoring Equipment

- Wave recorder to measure wave spectrum.
- Development of improved wave recorders.
- *Design of buoy system to measure currents and wave heights.
- Data recording and transmission buoys.
- Acoustic emission techniques to monitor stresses.

New Concepts

- Concrete pontoons, platforms, drilling rigs.
- Precast submerged tunnel units and erection gantries.
- Ice as a structural component.
- Design of breakwater for attachment to legs of platforms.
- Devices to protect deep water terminals from surface effects.

Field Reference 08

DESIGN AND CONSTRUCTION OF UNDERWATER PIPELINES

Recommended Topics

Design

- Improved weighting techniques less susceptible to damage than the present concrete coating.
- *Forces on pipelines due to waves and current.
- *Trenching and surface stabilising techniques.

Interaction with Sea-Bed

- Effect of structures in causing erosion and sedimentation.
- Study of erosion and sand movements and development of stabilising techniques to avoid exposure of underwater pipelines.

Field Reference 09**MATERIALS FOR MARINE APPLICATION****Recommended Topics**

Use of Composite Materials and Laminates

eg Glass reinforced plastic

Low density Epoxy

Fatigue strength – bi-axial fatigue behaviour

Toughness

Corrosion Resistant and Animal Growth Resistant Materials,

eg coated steels or naturally passivating steels.

***H.T. Steels**

Fatigue in welding details.

Stainless and Low Elongation Steels.

Hydrogen embrittlement.

***Shaft and Seals Materials**

Fundamentals of behaviour of materials of different hardness in contact
(Application to stern tube seals).

Simulation and assessment of self-lubricating bearing materials.

Gaskets

Ability to maintain sealing properties after serious distortion of mating structure.

***Fire Resistant Materials other than steel or mineral based material.**

Welded Structure in Sea Water

Fatigue.

***Fracture Toughness**

Fundamental investigations of factors mainly near welded joints in plates.

Field Reference 10**CORROSION AND ANTI-FOULING MEASURES****Recommended Topics****Anti-fouling**

Fouling of metals and plastics in coastal waters.

Influence of marine growth on flow resistance of static structures.

***Development of a rubber or plastic skin for ship plates to prevent attachment of marine growth.**

Destruction of spore of algae or prevention of sediment other than by poison,
e.g. bacteria.

Corrosion

*Corrosion fatigue in relation to off-shore structures.

Development of alternative to blast cleaning for the pre-treatment of welded areas to ensure adequate adhesion of protective coatings.

***Paints**

Inter-coat adhesion

Permeability to water and ions.

Extension of cathodic protection to splash zone.

The behaviour of metallic couples under sea-bed conditions, specifically the rate of hydrogen evolution, the rate of corrosion and the effect thereon of a covering of sediment containing decaying organic matter.

Field References 11, 12, 13, 21, 22

11 DIVING TECHNOLOGY

12 UNDERWATER HABITATS

13 UNDERWATER POWER PLANT AND TOOLS

21 UNDERWATER VIEWING, PHOTOGRAPHY AND OBJECT LOCATION

22 UNDERWATER COMMUNICATION

Recommended Topics

Improved Diver Work Capability

Development of improved life-support systems and details for shallow, medium and deep depths. These items would include the diving suits themselves (including insulation/heating), decompression chambers, personnel transfer chambers, perhaps underwater habitats (lock-out submersibles), etc. Some fundamental work on basic parameters might be of value, but any system developed must take into account the necessity for it to be economical both to build and operate.

Development of improved underwater communications system for divers between themselves and to the surface. This brings in the need for improved unscrambling devices to counteract helium speech.

Development of greatly improved lighting or other systems to improve visibility underwater, and give the diver 'eyes'. This could include the adaptation, for use underwater, of some methods at present under development for blind people.

Development of improved light-weight navigation and homing systems for divers, both for safety and for search/location/rescue.

Development of a light-weight, reasonable endurance, cheap diver transport vehicle.

Development of improved handling systems for divers, diving systems, equipment, submersibles, habitats, etc. through the air/sea interface in weather up to sea state 5/6 or higher.

*Study and analysis of diver accidents and existing safety regulations, with a view to developing better regulations, codes of practice, training standards and methods,

support and diving equipment, etc. This would require the analysis of such statistics as exist, and research into other accidents which have gone unrecorded in statistics but are available from Coroner's Court reports, insurance archives, the Factory Inspectorate, etc. This work should be done in conjunction with the Medical Research Council Decompression Panel, the Underwater Engineering Group, the Royal Naval Physiological Laboratory and any others already involved in certain parts of this work.

The use of lasers and other possible methods in the improvement of communications and viewing underwater.

The development of a 'black box' to be carried by divers, with a pressure and temperature recorder versus time, to be used in the analysis of existing work practices and the correct use of decompression schedules. This work should be done in conjunction with the Medical Research Council Decompression Panel at Newcastle (Professor Walder), which has already made some progress in the development of such a monitoring unit.

A study of the design and dimensions of the mating assemblies of one-man and large-scale decompression chambers throughout the country, including those in naval establishments, to try and find the best design and recommend standard dimensions, to permit the mating of portable chambers with the major facilities in various centres, so permitting the transfer of divers under pressure. This study should also result in the preparation of a complete list of available facilities throughout the country.

Underwater Work

Development of underwater power sources.

*Development of underwater acoustics for surveying, navigation, search and location, communications, control, etc.

Development of improved underwater television and photographic systems for control of underwater work, surveying, etc.

Development of underwater welding systems and techniques, preferably for welding in the wet, rather than in the dry. Such systems must eventually be to the standards acceptable for pipelines by the petroleum industry, or by the Registration Societies for Ships and Structures.

Development of underwater cleaning, survey, maintenance and repair systems for ships and structures. Apart from diver operated tools and units, this could include the development of floatable coffer dams or part dry docks, or special chambers in which a dry atmosphere could be provided in which surface workers could carry out the necessary repairs or other work.

Development of underwater 'cranes' using lifting bag or equivalent techniques to exploit buoyancy.

The further development of practical underwater hand tools to suit the many tasks of divers.

The further development of economical and convenient power tools, reactionless where appropriate, and pneumatic, hydraulic or electric according to the type of tool, the depth at which it has to operate, and the method shown to be the most practical for the conditions involved.

The development of compact, light-weight, safe gas generators for displacing seawater at various depths.

The development of improved designs of multi-core cables, cable handling gear and cable connectors for underwater use. These are particularly vulnerable in most present systems, and there is much room for detailed improvement.

Development of underwater demolition techniques.

Field Reference 14

MARINE ASPECTS OF PORTS PROBLEMS

Recommended Topics

Ship Movements

Speed ranges of ships moving in restricted waterways.

Effect of shallow water on motions of ships.

Motion of ships in confined waterways.

Behaviour of small ships in a seaway.

Development of equipment to determine bottom clearance of ships entering harbours.

***Berthing & Mooring**

The effect of hydrodynamic mass on berthing forces.

Collation of information on berthing forces of large ships.

Improved mooring systems.

Study of mooring and anchoring equipment for large ships – new methods of anchoring required.

Offloading of large tankers either between ships, or at offshore station.

Forces developed by anchoring systems and factors affecting them.

Exploiting currents induced by air bubbles to assist in ship manoeuvring and berthing.

Dredging Siltation

Dredging technology

Control of density – induced siltation.

Separation of river bed silt from water by mechanical processes.

Investigations of materials for hopper barges, door sealing arrangements.

Effect of estuary circulation on sedimentation.

Field Reference 15

HANDLING OF BULK MATERIALS

Recommended Topics

Manoeuvrability of trailing suction dredgers with one or two sidepipes in different fore and aft locations.

(As part of the problem of dredger positioning this is significant mainly in channel clearing (capital and maintenance) dredging rather than in sand and gravel dredging. Believed to be a profitable line to pursue in association with ship control techniques and automation. As a result of studies of dredging economics and the CIRIA survey, but depending on support offered, studies may be launched of ship-positioning systems for this and other applications. A short study (as described by heading) would, however, not be inappropriate).

Heavy lift movements within containerisation. Engineering considerations of equipment and handling methods.

*Settlement of material in hopper-dredgers-configuration of discharge pipes and mechanical settling devices.

(Settlement of dredged material in hoppers (Mechanical/hydrodynamic techniques): DTI information is that this could be significant in increasing productivity, but no study in existence; chemical (flocculant) techniques being considered currently by DTI and NPC, should be able shortly to indicate order of improvement required for a non-chemical technique to be viable).

Field Reference 16

SEA-BED INVESTIGATIONS

Recommended Topics

***Mechanisms** (This is an area in which NERC are also interested).

Investigation of mechanisms leading to ripple/dune formation. Movement of sand/gravel under action of waves and currents. Interaction of sea and sea-bed (ie sand waves, shoals, etc.). Long term research into movement of sea floor sediments. Effect of dredging on sea-bed.

Inspection Techniques

Application of nuclear techniques to sea-bed investigations.

Recorders to provide continuous indication of constitution of upper three feet of the sea-bed.

Improved coring methods for soft ground in the open sea.

Acoustic properties of sea-bed, etc. for sonar applications.

Field Reference 17

FISHING TECHNOLOGY, FISH FARMING ENGINEERING

Recommended Topics

Conventional Fisheries

Development of improved sonar systems for locating and identifying fish shoals, both for catching and for surveying the extent of resources including fish-counting.

Development of economical side-scan sonar systems to follow nets and fish shoals in the horizontal and vertical planes, as opposed to solely in the vertical plane, to improve the effectiveness of fish hunting and capture for both pelagic (free-ranging) and demersal (bottom-living) fish.

The development of improved telemetering systems from nets or gear to the fishing vessel.

On-line applications of computers on board ship.

The development of improved and more economical fish catching methods and fishing gear, together with handling methods on board the fishing vessels. This work would require an analysis of the characteristics of towed bodies and the various parts of the gear, to elucidate design parameters, with a view to seeking means of improvement in design and effectiveness.

Studies of propulsion systems and towing winches and other equipment on deck, in relation to their effects on fishing gear and catching efficiency.

Machine tools for automatic gutting, filleting, etc, and associated systems for sorting, size grading, conveying, washing, temperature conditioning etc.

Thermal insulation (freezer trawlers and cold stores).

A study of existing freezing and refrigeration systems in relation to the fish products themselves and to conditions on board ship, with a view to making improvements in operation, safety and economy.

Secondary refrigerants (a non-toxic, non-inflammable, non-corrosive liquid, mobile at minus 55°C).

Shipborne navigation systems.

A study of ship control and navigation problems, with a view to the judicious and economical application of automation to machinery surveillance and ship navigation on passage and while fishing; the object is always to reduce labour and watch-keeping.

Operations research and systems analysis.

A study of the optimum requirements for a fishing port/terminal, including its location, together with the facilities required for dealing with the catch and for servicing and maintaining the fleet in the most economical manner, and taking into account commercial, hygiene, fish quality and other related considerations. The relative merits of independent fish terminals and those closely related to commercial ports should also be studied.

A study should be made of the minimum requirements of a fish terminal to improve the handling of catch and vessels at a typical fishing village in a developing country. This should take into account the need for minimum expenditure and maximum effectiveness, in terms of improving the demand for fish and/or the price paid for it by buyers from inland or other communities.

Active training simulators for fishing skippers.

Aquaculture

A study of the water, wave and other forces on the different types of structure employed in fish farming, with a view to identifying gaps in existing information and to developing improved designs and methods.

A study of the problems involved in establishing fish farming in open water, and the gaps in existing knowledge which need to be filled before such an installation could be attempted.

A study of the engineering problems involved in maintaining the required conditions in different types of enclosures, and the identification of the instrumentation required to permit correct monitoring of the various characteristics; the development of the necessary instrumentation and equipment.

Dynamics of exploited fish populations.

Field Reference 18

INSTRUMENTATION APPLIED TO MARINE ENGINEERING

Recommended Topics

Cheap, reliable wave recorders indicating directions as well as other wave characteristics.

(This requirement has not been highlighted earlier as of great significance, but a number of offshore engineering problems and activities could be dealt with more effectively if meaningful wave data were available. The first problem is to establish what is meaningful, which may differ according to the application; we doubt whether it can be simplified as far as is suggested. NIO and other places have wave-measuring equipment and MATSU is looking into the possibility of rationalising some of the requirements. A study of the significant factors in relation to various offshore operations would be worthwhile; a number of bodies would be interested. The suggested instrumentation can, however, probably be developed from existing technology, and is perhaps not a suitable task for a University).

Data recording and transmission buoys to monitor wind/wave velocities and amplitudes, temperatures and direction.

Information on physical conditions in or surrounding a ship and its equipment.

(The new techniques likely to be needed would be mainly those involved in adapting to the marine environment. DTI are not investigating this aspect of instrumentation).

Survey of design recommendations for shipborne instruments (propulsion, navigation, cargo handling, fire protection, computers etc.) and comparison of effectiveness of equivalent land instruments, marinized-land instruments, and the need for special development.

*The development of a technique for the accurate measurement of large mass flows of cryogenic liquids and vapours. Similar measurement is also required on board ship for other fluids. The primary objective would be for use with custody transfer.

(Many methods of flow measurement exist, including recent ones using sound or light traversing the pipe at an angle; for gases or, especially, for mixed liquid/gas flows these are unlikely to give sufficiently accurate results. The problem, though not exclusively a marine one, appears difficult, interesting and well matched to university investigation).

Shipborne information systems. Study of the total information processing problem in large merchant ships with a view to incorporation of a hierarchy of computer-processors.

Field Reference 19 (See also field reference 06)**SHIP CONTROL SIMULATION****Recommended Topics**

*Adaptive and optimal control of marine gas-turbine installations with and without variable-pitch propellers.

An integrated study of yaw stability, steerability, manoeuvrability and automatic steering and engine control systems for large ships.

A study of optimum man-machine systems for the navigation, control and manoeuvring of merchant ships and submersibles.

(The topics proposed above will be included in the DTI systems and automation studies, out of which separable longer-term studies may well emerge).

Use of hybrid computers for simulating non-linear ship manoeuvres.

Investigation of ship response to hydrofoil control systems.

(To DTI knowledge, there is no great emphasis on the use of hydrofoils at present, but the proposal need not be rejected on that account).

Study of human error in Radar using simulation and ergonomic equipment.

Field Reference 20**NAVIGATION (INCLUDING SURVEYING)****Recommended Topics****Navigation**

*Study of the techno-economic factors involved in optimum ship routing and weather routing.

*Systems study of a fleet activity in relation to particular cargo-carrying or other activities, bringing in the economic and other factors involved, and isolating where possible the obstacles in present systems, both technical and commercial, to the attainment of optimum efficiency. Simulation computer programmes covering such activities would be of value.

The development of automatic and centralised control of ships from the bridge, but taking into account the paramount requirements concerning safety at sea and the observance of the Rule of the Road.

*Development of means for decelerating very large under-powered vessels such as tankers.

A study of the problems in manoeuvring large vessels in confined and shallow waters, both to negotiate channels and during berthing.

A study of existing methods of transferring at sea, and the development of improved methods, both between ships (stationary or under way) and between small supply vessels and structures such as oil rigs, lighthouses, etc.

A study of existing dynamic positioning systems, and the development of a new optimum and cheap system.

A study of the problems involved in underwater navigation and position-fixing, and the development of improved and more reliable methods, taking into account various possibilities including inertial, acoustic and other systems.

The development of automatic track-keeping systems, with special reference to the avoidance of collisions at sea.

The development of low-cost materials for Satnav to permit the facility for continuous fixing.

A study of bridge layout and the arrangement of navigational equipment and displays on ergonomic lines, to improve ship control and safety.

A study of the propagation characteristics of subsonic radiation in clear weather and in fog leading to the development of efficient equipment for generating subsonic sound, and also for its detection and sensing by direction and, if possible, distance.

The development of an under-way draught gauge for large vessels.

Surveying

Development of a wide-band true-to-scale double-side sector-scan acoustic system for bottom surveying.

Development of a surveying system incorporating automatic chart reduction.

*Development of a reliable deep water tide gauge and recording/telemetering system with the possibilities of developing an advance information system to advise approaching vessels of the tidal height.

Field Reference 21

UNDERWATER VIEWING, PHOTOGRAPHY AND OBJECT LOCATION

See Field Reference 11 et seq.

Field Reference 22

UNDERWATER COMMUNICATION

See Field Reference 11 et seq.

Field Reference 23

POLLUTION

Recommended Topics

*Handling bulk materials and pollution.

*Pollution near undersea structures.

*Effect of harbour construction on pollution.

Turbulent diffusion and marine effluent dispersal.

*Design of outfall pipes for sewage and heavy liquids, and their pollution pattern.

Marine surface diffusion as a function of wind speed.

Activation analysis techniques for estimating:

- i radioactive waste
- ii sea water pollutants
- iii dangerous trace elements in fish

Two-dimensional numerical model studies of marine pollution problems.

Design of pollution indication device for use in rivers and coastal waters.

Field Reference 24

SAFETY AT SEA

Recommended Topics

Control problems involved in compensating for ship's heave, roll, pitch and yaw when handling objects inboard and outboard, in order to reduce vertical and pendulum motions of the load.

*Systems of centralised ship-position monitoring in confined waters.

*Submerged tide recorder with telemetering to land.

*The effect of a seaway on the stability of a ship.

*The behaviour of slurries within a ship under the effects of hull vibration and/or ship movements and its effect on the stability of a ship.

Fundamental research into the basic physics and chemistry of the initiation of ignition of hydrocarbon/air mixture.

Development of a technique for the safe disposal of 100% light hydrocarbon vapours from liquefied natural gas tanker.

*Examination of marine accident statistics and their analysis according to types of accident, causative factors etc. Correlation of this information with ship type, crew training and qualifications etc.

*Ergonomic study of commonly used ships instruments and equipment such as compass, engine room telegraph, helm angle indicators etc., with the object of unifying and improving designs so as to improve accuracy in use and to reduce incidence of error at the instrument/human interface.

*Ergonomic study of ships structural features such as ladders, doors, hatches, bunks etc. with the aim of improving designs so as to reduce the risk of injury due to slipping and falling when the ship rolls and general improvement of comfort levels.

Field Reference 25

SHIP PRODUCTION AND MANUFACTURING SYSTEMS

The table below summarises the specific suggestions for research under five sub-headings.

The largest group of suggestions for further work concerns methods of improving some basic shipbuilding processes. Most of these are essentially problems in applied

mechanics and production engineering; in some of them the scale of the practical problem may present difficulties for University research.

The next largest group concerns proposals for work in applications of the computer to ship production, and in ways of reducing production costs. Both of these are receiving attention at Strathclyde and Newcastle, and at BSRA; but more needs to be done. In both areas, the practical implementation of improved methods by the shipbuilding industry remains a source of difficulty. A similar comment applies to the two studies proposed on the larger problems of shipbuilding strategy and corporate planning.

The final small group is of the kind which could well expand rapidly if non-ferrous materials come to be widely adopted for marine use. In the context of ocean engineering, these seem well worthy of further study.

Recommended Topics

Organisation and Planning

- Application of group technology techniques to shipbuilding
- Mathematical model for corporate planning in shipyards

Cost Studies

- Design for economic manufacture and costing
- Value analysis in shipbuilding
- Study of shipbuilding costs
- Design-production studies for minimum cost

Computer-Aided Production

- Automation of shipbuilding processes
- Use of graphic terminals in ship production
- Steel flow studies for N/C applications
- Dynamic modelling of assembly processes

Plant and Processes

- Methods of bending thick plates
- Techniques for defining non-developable surfaces
- Fundamentals of welding and cutting
- Devices for positioning large, heavy units
- Methods of reducing weld distortion
- Development of steelwork jiggling system

Construction Problems in New Materials

- Concrete construction for marine uses
- Concrete and GRP production problems

Example IV

1974

Excerpted from

"British National Committee on Ocean Engineering:
National Policy on Seabed Engineering," Council of
Engineering Institutions, London, May 1974.

This report is a broad policy report similar in tone and sweep to the Stratton Commission Report on which one feels it depended to some extent. The major intent of the report is to discuss management of an ocean engineering effort having established broad policy recommendations. Of particular interest to the ocean engineering panel was enclosure 17 which indicated the fields in which Navy activities could assist in other marine activities and simply indicated how broad and how deep the question of technical transfer from naval to the civilian areas might run.

Table I

Some Fields in Which Defense Experience Can Assist Other Marine Activities*N.B. Not all the items listed below presently exist at least in the form described.***I. Vessels and Craft**

- a. Warships, submarines, Royal Fleet Auxiliaries, auxiliary and harbour craft
- b. Salvage and rescue craft—tugs (ocean and harbour), lifting craft, heavy lift cranes, diving vessels, helicopters
- c. Submersibles, telechirics, habitats
- d. Hydrographic and research craft and vessels
- e. Mooring, buoy and boom defense vessels and systems

II. Engineering

- a. Propulsion systems
- b. Auxiliaries and systems, including automation
- c. Desalination
- d. Ship construction
- e. Materials, corrosion, protection

III. Electronics

- a. Communications, radio and visual
- b. Position-fixing systems for navigation and hydrography
- c. Radar
- d. Underwater acoustics—echo sounders, sonar (side-scan, doppler, etc.)
- e. Underwater communications, navigation, search and location
- f. Ship control and collision avoidance systems. Training simulator system
- g. Instrumentation
- h. Data acquisition, processing, storage, dissemination. Buoy systems
- i. Meteorological systems—weather, storm, tide prediction

IV. Other Facilities

- a. Diving and underwater work systems and techniques. HMS "Reclaim" replacement
- d. Environmental testing centres, and sea-borne "test beds"
- c. Structural, shock and vibration testing facilities
- d. Structural testing at full scale
- e. Desalination experimental station

- f. In-water survey, maintenance and repair techniques
- g. Hydrographic and oceanographic survey and chart-making systems
- h. Meteorological forecasting systems
- i. Pollution monitoring and counter-measures

V. Research and Development

- a. Procurement Executive
 - 1. Research and development establishments
 - 2. Outside contracts with industry, universities, etc.

VI. Miscellaneous

- a. Procurement of ships, equipment, services, stores
- b. Defense sales (exports)

VII. Education and Training

A Report to:

The President and The Congress

8

National
Advisory
Committee on
Oceans and
Atmosphere

Eighth Annual Report
June 30, 1979

CHAPTER V

CIVIL OCEAN ENGINEERING AND TECHNOLOGY

NACOA has been concerned for some time with the U.S. position on civil ocean engineering and technology. Previous NACOA reviews in 1973/1974 and more recent reviews in connection with the Federal ocean R&D program and Federal reorganization have called attention to serious deficiencies in the Nation's posture and performance in civil ocean engineering and technology. In the past year, NACOA examined this problem and saw the need for a thorough assessment of the national benefits which would result from a viable, technically advanced program for civil ocean engineering and technology. In addition, NACOA believes that the roles of the Federal Government in these areas must be better defined.

RECOMMENDATIONS

Because of the complexity of the issues, NACOA is not prepared to make specific program recommendations at this time. NACOA intends, however, to direct its attention to these areas of concern, and over the coming months specify actions and directions that it feels should be taken.

To serve as the basis for its recommendations, the Committee sees the need for an in-depth preliminary effort as a prerequisite to NACOA's assessments. This work (with NACOA project monitoring) should:

1. Identify and evaluate the major areas where civil ocean engineering and technology development should be actively pursued by drawing on the available literature, including the many existing studies of technology needs.
2. Identify the derived economic, social, and political benefits to the Nation that would result from a viable and technologically advanced civil ocean engineering program.
3. Explore the roles of the Federal Government in civil ocean engineering and technology.
4. Develop Federal policy alternatives for ocean engineering and technology.

A NACOA task force on civil ocean engineering and technology will then undertake to:

1. Assess and recommend the roles of the Federal Government in civil ocean engineering and technology.
2. Assess policy alternatives and make specific recommendations for Executive or Congressional actions in these areas.

BACKGROUND

Civil ocean engineering is concerned with developing the operational systems for deriving economic, social, and other benefits from the oceans, advancing our understanding of the ocean environment, and enhancing the safe development and use of the oceans and the coastal zone. Civil ocean technology links the advances in the sciences and engineering with industrially and commercially oriented ocean activities; it is a means to attain economic, social, and political goals. It covers a wide spectrum, including the adaptations of technologies from other fields of engineering, as well as the development of specific technologies. NACOA finds that developments in civil ocean engineering and ocean technology in the United States in the past decade have not been as significant or as dynamic as in a number of foreign nations. NACOA finds that a loss of momentum has occurred in the United States because:

1. Federal support for development of the foundations of ocean engineering and ocean technology, which traditionally has been carried out by the U.S. Navy, has declined substantially.
2. The governmental agencies with responsibilities for development and regulation of ocean uses have very restricted and often narrow R&D programs for ocean engineering and ocean technology which are often inadequate for their intended purposes.
3. Ocean industries have been inhibited by the uncertainties caused by Federal regulations that have constrained both industrial risk-taking and innovation and that, in many cases, have generated excessive financial costs.

NACOA believes that the Federal roles in civil ocean engineering and technology must be defined and then acted upon. The report included as Appendix V develops questions that should be considered in determining Federal actions to establish and maintain a technologically strong and competitive civil ocean engineering capability.

APPENDIX V

NACOA PROGRAM FOR THE STUDY OF THE FEDERAL ROLE IN
CIVIL OCEAN ENGINEERING AND TECHNOLOGY

NACOA has been concerned for some time with the U.S. position in civil ocean engineering. Previous NACOA reviews in 1973/74 (Ref. 1) and more recent reviews in connection with the Federal ocean research and development (R&D) program and the Federal reorganization (Ref. 2) have revealed serious deficiencies in the Nation's posture and performance in civil ocean engineering and technology. This paper summarizes the problems and the questions that NACOA feels should be considered prior to its defining the proper Federal role in civil ocean technology, and prior to its recommending actions to ensure a technologically strong and internationally competitive civil ocean engineering and technology capability. NACOA plans to establish a task group to address these issues.

Civil ocean engineering is concerned with developing the operational systems for deriving economic and other benefits from the oceans, advancing the understanding of the ocean environment, and enhancing uses of the oceans and the coastal zone. Civil ocean technology essentially links the advances in the sciences and engineering with industrially and commercially oriented ocean activities and can be a means for the attainment of economic, social, and political goals. It covers a wide spectrum including the adaptations of technologies from other fields of engineering, as well as the development of specific technologies, and focuses them on ocean applications. (A more detailed description of the scope of civil ocean engineering and technology activities is found in Attachment 1, which includes a list of technical activities that are of concern to ocean engineering).

"The Innovative Loop"

Ocean engineering and technology operate in a supply-demand regime, the elements of which include:

1. Advances in basic knowledge.
2. Development of engineering capabilities and industrial technology.
3. Improvement of existing industries and the establishment of new industries and commercial enterprises.
4. Meeting societal and economic needs.
5. Development of regulatory processes.

The societal and political decisionmaking related to items 4 and 5 provides feedback and driving force for items 1 and 2. The "supply" is provided by scientific and technical developments; and "demand" is provided by societal needs, such as food, transportation, employment, or security. Although the foregoing describes the normal steps in technological development, it

does not, however, address the issues related to hitherto unimagined capabilities. The development process, however, requires the assumption by the entrepreneur of high technological and economic risks (surely a heady exercise in our current economic climate). What is not readily apparent is that not pushing the boundaries of technology has an even higher cost, in that it tends to erode our general technological and industrial base. A far-sighted, advanced national technological capability is one of the critical pieces in increasing our productivity and in maintaining our technological and economic strength. As Treasury Secretary Michael Blumenthal has stated, "Our technological superiority is not mandated by the heavens. Unless we pay close attention to it and invest in it, it will disappear." Determining those processes that are needed to maintain this attention to our national needs in ocean technology is surely the "bottom line" of our efforts in these areas.

National and International Trends

The broad R&D program of the U.S. Navy and associated naval engineering developments did, in a sense, operate in this "loop" during the 1950s and brought the United States into a unique position of world leadership in ship research and naval architecture. It laid the foundation for U.S. ocean engineering and ocean technology in general. Oil and gas exploration and production by the private sector in the 1960s led to advances in offshore technology of marine construction and operation and to the establishment of U.S. leadership in offshore technology.

During the past decade, however, the U.S. track record is far from impressive. NACOA is of the opinion that the cause for this loss of momentum resulted from the following actions. (Ref. 3)

1. Federal support for the development of the foundations of ocean engineering and ocean technology, which traditionally had been carried out by the U.S. Navy, has declined substantially.
2. The many Government agencies dealing with control and regulation of ocean activities undertake very restricted and often narrow research and development programs in ocean engineering and technology. These programs are in many cases marginal for their intended purposes.
3. Industrial research and development in ocean technology and engineering have slowed down, because capital development plans of ocean industries are inhibited by: the uncertainties of Federal regulations (particularly those on environmental protection), the costs due to long delays in the regulatory process, and a decline in the Nation's economic posture.

One can argue that this disturbing state of affairs in the Nation's ocean engineering efforts is a natural result of the declining Government interest in technology since the late 1960s or more indirectly an effect of the Mansfield Amendment addressing agency mission relevance of research programs. In particular, there has been a shift away from adequate Federal attention to engineering developmental activities. Clearly no Federal agency has adequately assumed the responsibility for our Nation's civil ocean engineering and technology development and advancement. We see a gradual, but conscious, shift of the Federal philosophy towards reducing the Government's role in such technology support.

In contrast, the role of many foreign governments in support of their nation's technology base (and the economic utilization of such technology) has dramatically increased. The growing quality and quantity of such commercial activity rests, to a major extent, on commitments by Government and industry to foster these activities as a national purpose, and their joint determination to pursue such economic and political goals. R&D investments in foreign countries (Japan in particular) have established a strong worldwide competitive environment in ship construction (merchant ships, tankers, and bulk carriers), as well as in high-seas fisheries. Most recently, several foreign countries have become highly competitive in the construction of offshore platforms and in production, as well as in deep-sea mining technology for manganese nodules.

In retrospect, there is concern that as a Nation we are at a plateau in many areas of civil ocean technology development and are not competitively or aggressively addressing new economic opportunities, or new areas of international technological competition. Market opportunities are not being pressed and, in general, the civil ocean arena is not being addressed with sufficient purposefulness or long-term national considerations in mind.

This is in part due to inhibiting factors, such as the uncertainty concerning regulatory, patent, and other Federal policies faced by the private sector. These sets of Federal rules have caused a heightening climate of uncertainty, which makes industry wary of long-term investments and wary of innovation. The need is certainly clear for the Federal Government to assess the regulatory maze and to lessen, where appropriate, the disincentives and unknowns that currently dampen the private sector's active participation in development of ocean technology and related industrial innovation. As a country that has had a strong technological heritage, the time is clearly at hand to address the growing web of disincentives and entangling regulations that are dissuading industry from carrying inventions and innovative ideas through the costly and risky stages that hopefully convert into economically fruitful activities. When industry senses the proper climate for such risk-taking, it has, as in the past, been the Nation's active innovator.

Such a great potential lies off our shores. The potential of the ocean areas under our economic resource jurisdiction is in many ways comparable in significance to our acquisition of Alaska or of the Louisiana Purchase. NACOA is convinced that the United States must learn to pursue actively and continually the many current and future opportunities to develop

the economic potential of the oceans and the polar areas by advancing our Nation's efforts in fisheries, deep-water ports, offshore oil and gas resources, offshore mining, aquaculture, and transportation.

Our Nation needs both the vision and the technology to exploit fully the resources of the 200-mile economic zone, of the continental shelf, of the ocean bottom, and of the outer continental margins which may come under our jurisdiction. Such vision accompanied by developing appropriate technology and a policy to maximize the economic potential of the 200-mile zone will:

1. Help to meet the needs of our population and industries.
2. Reduce the national dependence on critical imports.
3. Lessen the U.S. balance of payments deficit.
4. Enhance directly the U.S. competitive position in world markets for ocean technology and engineering and associated technical services.
5. Strengthen substantially our international posture.

The Federal Role

A broad spectrum of roles of the Federal Government in non-military uses of the oceans has been created and defined by law and is oriented towards protecting and promoting the public interest. In addition to defense applications, these roles include:

1. Abating and preventing pollution.
2. Protecting life and property at sea and along the coast.
3. Enhancing our capabilities to describe and predict oceanic and weather conditions.
4. Expanding our basic knowledge of the ocean and its processes.
5. Assuring conservation and safety in utilization of recreational, esthetic, and economic resources.

The U.S. Congress has on many occasions placed emphasis on increasing the utilization of the oceans for our National purposes. However, effective utilization in the majority of cases requires new industrial developments, expansion of programs, modifications of present ocean industries, and a continuing flow of advancing technological concepts and capabilities. The key role of private industry in this is clear. The exact role of the Federal sector, however, in support of these areas is less clear, but the Federal role may be critical to the ability of industry to fulfill adequately and effectively its purposes.

U.S. industry must compete in the international marketplace or harvest ocean resources in competition with heavily subsidized foreign operations. In addition, the expansion of present marine activities, as well as the establishment of new marine activities, may entail high costs, distant payoffs, the problems of preserving proprietary positions in the international ocean regime, and the need in many cases to embrace new or high-risk technology while facing an uncertain regulatory environment.

NACOA considers the present approach of dispersed, narrowly focussed ocean engineering efforts within the civilian agencies inadequate to meet such needs as we enter the 1980s. The national and international environment is such that it requires the Federal Government to provide the climate necessary for the U.S. private enterprise system to take initiatives to be able to improve existing operations and to create new ocean-related enterprises.

It would appear that any Federal approach toward strengthening civil ocean engineering should be based on the premise that ocean engineering provides the base for enhancing ocean activities and ocean industries and should concentrate on activities that are of major national significance and thus require greater Federal concern.

For the defense and space programs, the Government sets the goals and plans most of the activities; controls and funds related research and development programs and the planning of technical systems; accepts financial responsibility and the risks involved; and becomes the main or sole user of the products. For industrial and commercial developments, the Federal Government's role is quite different. The Government's involvement in private sector activities is, therefore, not as planner, purchaser, and user, but as a surrogate for the private sector; that is, it must encourage the private sector to undertake technical developments that are in the national interest by creating an environment in which industry can operate while achieving the desired national goal. A Federal program for ocean utilization must, therefore, address two elements. One is the establishment and enhancement of commercial and industrial activities, and the other is research and technology development. These two elements, i.e., growth of needed ocean industries and the development of an ocean science/technology base, are part of a more general problem. Lewis M. Branscomb, during a recent National Academy of Engineering technical session on U.S. Technology and International Trade, concluded that Federal policy and programs aimed at industrial and economic development must be responsive to the following questions:

"First, how effectively do Federal policy and Federal research and development expenditures support the national scientific and technical infrastructure upon which economic performance rests?

Second, how effectively does the Government incorporate technological insights in policy formulation?

Third, what relationship can and should be established between Government agencies and private entities, given the delicacy of this relationship in a domestic capitalistic society?"

Effective action on ocean utilization cannot come from the Government alone or from industry alone. Normally, it only can come about in our country through joint understanding and cooperation between industry and Government in the fulfillment of their proper roles.

A critical examination of the Federal role in civil ocean technology and engineering appears to be in order. NACOA plans to establish a task group to undertake this important effort. The formulation and structuring of the Federal ocean engineering program aimed at deriving full benefits for the United States from the U.S. continental shelves, the 200-mile economic zone, and the worldwide deep oceans is a key element in achieving the Nation's national and international goals. In order to identify which areas of civil ocean engineering capabilities must be developed, how the United States would benefit from such developments, and which role the Federal Government should play in encouraging and or supporting such developments, the following issues, among others, should be considered:

(1) The ocean engineering capabilities of Japan, Great Britain, Federal Republic of Germany, France, Norway, and Canada are rapidly growing as a result of cooperation between their industries and the respective governments. They have successfully entered the international market in ocean technology and services. By comparison, the U.S. Government ocean engineering programs are weak, and ocean technology developments by U.S. industries have slowed down substantially as a result of the Federal Government's delays in decisionmaking, uncertainties in Federal regulations, and the lack of adequate Federal support for technology and the technology data base. Are the national consequences of these contrasting development efforts being seriously assessed? Do we need more explicit goals and policies in this area?

(2) In order for the Federal Government to recognize new opportunities for uses of the ocean and ocean resources, it should utilize system studies to identify those foreseeable efforts and activities that are or can prove to be important to the economic, political, and international posture of the country. These analyses should specifically identify any engineering or other constraints tending to inhibit the realization of such opportunities. Who within the Federal Government has the responsibility for undertaking such studies and acting upon them? What are the areas of ocean technology that if properly developed could result in major economic, social, or other national benefits?

(3) Industry usually takes the risk for advancing industrial developments. However, high risk, high potential developments with long lead times, and developments which have long-term significant benefits for the country but no discernible profit potential at the present are in many cases beyond the economic realities and objectives of industry. For those developments which are related to nationally important ocean activities, how and under what guidelines should the Federal Government serve as cata-

lyst and sponsor during the early stages of research and exploratory development? How can we as a Nation ensure that high risk, high potential ocean-related technology development for long-term national opportunities is supported and actively pursued? Further, is there a major continuing role for the Federal Government to sponsor new efforts within industry and the universities to advance ocean technology capabilities? What should be the extent and constraints of Government involvement in civil ocean technology development? How far should the Government go in assuring a viable ocean technology and resource development program within the private sector, and what are the boundaries of the Federal role? How can the Government stimulate foreign marketing of our ocean technology and services?

(4) In response to budget pressures during the past decade, Federal departments and agencies often confine themselves to engineering fixes and current operational exigencies. Although short-term activities alone may appear productive and cost-effective in the near-term, they will prove detrimental to our national technical position in the longer run. Who in the Federal Government is analysing the impact of this policy? To what extent can joint agency planning and single-point budgetary control enhance the effectiveness of the Federal technology program?

(5) In light of the constraints noted in (4) above, it becomes increasingly important to supplement the present narrowly mission-oriented programs of agencies and departments within broader engineering programs covering (a) the expansion of foundations related to engineering in the ocean environment, and (b) pioneering exploratory developments of important new capabilities. Where should responsibility for the generation and administration of such a program be placed? What should the Federal structure be to accomplish this Federal role in ocean technology? What are its needed resources, its objectives, its scope and purpose? To what extent should the Government undertake generic ocean engineering R&D programs and exploratory development programs as parallel functions to its ocean science efforts? What programs are necessary to support its own regulatory, monitoring, and resource management responsibility? What mapping, charting, and other service and support functions should be maintained or initiated by the Federal Government in support of civil ocean engineering and technology?

(6) To assure the Nation's capabilities for future ocean development requires the fostering and the stimulating of industrial innovation and technology developments in areas of national importance. Where within the Federal Government should the responsibility lie for providing the regulatory and tax environment necessary to stimulate such industrial developments? What actions should the Federal Government undertake to lessen reasonably what appears to be excessive and overly burdensome regulations constraining industry in general and productivity and innovation in particular? Is the Government adequately weighing the relative benefits or penalties of its regulatory practices and tax incentives to ocean-related industries?

In summary, the complexity of the issues cause NACOA to defer making specific program recommendations at this time. NACOA intends, however, to direct its attention to these areas of concern and over the coming months

to specify actions and directions that it feels should be taken.

To serve as the basis for its recommendations, the Committee sees the need for an indepth preliminary effort as a prerequisite to NACOA's assessments. This work (with NACOA project monitoring) should:

1. Identify and evaluate the major areas where civil ocean engineering and technology development should be actively pursued by drawing on the available literature, including the many existing studies of technology needs.
2. Identify the derived economic, social, and political benefits to the Nation that would result from a viable and technologically advanced civil ocean engineering program.
3. Explore the roles of the Federal Government in civil ocean engineering and technology.
4. Develop Federal policy alternatives for ocean engineering and technology.

A NACOA task force on civil ocean engineering and technology will then undertake to:

1. Assess and recommend the roles of the Federal Government in civil ocean engineering and technology.
2. Assess policy alternatives and make specific recommendations for Executive or Congressional actions in these areas.

REFERENCES

1. Engineering in the Ocean, Report for the Secretary of Commerce by the National Advisory Committee on Oceans and Atmosphere, November 15, 1974.
2. Reorganizing the Federal Effort in Oceanic and Atmospheric Affairs, Vol. I, Findings and Recommendations, NACOA, February 1979, page 27.
3. "The Nation's Need for Civil Ocean Technology and Ocean Engineering," by Alfred A. H. Keil, in Volume II of NACOA's Special Report to the President and the Congress, Reorganizing the Federal Effort in Oceanic and Atmospheric Affairs, 1979.

ATTACHMENT 1

SCOPE OF CIVIL OCEAN ENGINEERING AND TECHNOLOGY: A DEFINITION

Civil ocean engineering in the United States was developed in response to national needs and policies mainly for the maintenance of safe and competitive marine transportation, including ports and intermodal transportation systems, for carrying exports and imports; the exploration, assessment, and recovery of offshore oil and gas resources from the ocean floor, including offshore platforms and pipelines; the harvesting and processing of living resources, particularly from open fisheries but including aquaculture; the exploration, assessment, and recovery of hard mineral resources (particularly manganese nodules) from the ocean floor; the protection of the shoreline from erosion; the control and cleanup of ocean pollution; the technical support of marine science; and ocean-related support services, such as diving safety at sea, rescue, and dredging.

U.S. civil ocean technology comprises, among other elements, ship technology (ship design, construction, and operation), marine technology (power plants and machinery for marine applications), port technology (port design, construction, and operations), offshore technology (particularly related to offshore exploration and extraction of natural gas and oil), fishery technology (fish finding, fishing operations, and fish processing), offshore mining technology (both for the continental shelf and the deep ocean), coastal engineering (shore protection, dredging of channels, construction of piers, etc.), and the set of ocean technologies needed for scientific exploration of the oceans, exploration of marine resources, and pollution research and monitoring.

Another perspective on civil ocean technology and ocean engineering is gained by reviewing Table 1, "Selected Activities of Concern to Ocean Engineers." It was prepared by the Marine Board, Assembly of Engineering, National Research Council in 1975.

While ocean science is dedicated toward advancing knowledge and understanding the oceans, ocean engineering is dedicated toward ultimately providing products, systems, and services for society's benefit to be derived from the oceans. In order to provide these services, ocean engineering develops and uses technologies that are derived from advancing knowledge and science as well as engineering experience. The link between ocean engineering and technology and the actual "delivering on the promises of science and technology" is the process of design. Design deals with the development of concepts for technical systems (i.e., the conceptual design to explore what might possibly be built) and the detailed design to actually build. Design always operates in the regime of several constraints: utility; technical, economic, and regulatory feasibility; time; and industrial capability.

The process of innovative ocean engineering always requires selected adaptation of related facets of technologies, extension of existing capabilities, refinements of engineering tools, coupled with a screening of trends and possibilities in other technical fields that could be tapped. This evolutionary process is occasionally transformed into a revolutionary process through the innovation of drastically different technology. An example is dynamic position keeping for floating platforms.

TABLE 1
SELECTED ACTIVITIES OF CONCERN TO OCEAN ENGINEERS

Minerals and Mining

Sand and Gravel
Exploration Systems
Minerals
Equipment
Environmental Impact Control
Product Systems

Swimming and Diving

Salvage
Life Support
Diver Equipment
Diver Physiology
Habitats
Recreation

Coastal Processes

Artificial Island and Reef
Construction
Beach Erosion
Enhancement (Groins, Sand
Replenishment, etc.)
Shore Protection
Outfall and Intake Siting
Dredging Activities
Environmental Impact Control

Natural Gas and Oil

Exploration
Operations
Pipelines
Storage
Platforms
Subsea Completions
Environmental Impact Control
Dredging
Breakwaters
Pollution Control
Environmental Impact

Platforms

Piers and Quays
Towers and Related Bottom-Sitting
Platforms
Artificial Islands
Tunnels
Buoys
Vessels
Habitats
Floating Cities or Seadromes
Satellites
Aircraft
Balloons
Submersibles

Waste Disposal

Radioactive Materials
Chemicals
Sewage Sludge
Dredge Spoil
Environmental Impact

Marine Life

Fish Gear/Equipment
Aquaculture/Mariculture
Processing
Detection
Environmental Impact Stress

Ports, Harbors, and Channels

Marinas
Navigation
Traffic Management

Sea Floor Engineering

Sediment Mechanics
Equipment Design and Performance
Environmental Impact and Interaction

Environmental Sciences

Monitoring
Instruments and Sensors
Data Collection Systems
Laws and Regulations (affecting
engineering standards)

Communication, Telemetry, and
Power Transmission

Installation
Telephone and Telegraph Systems
Power Cables
Other Utilities
Sonar Systems
Frequency Allocation
Maintenance
Position Fixing

Marine Recreation

Safety
Sport Diving
Boats and Service
Tourism
Swimming/Surfing
Sport Fishing
Cargo Handling Systems

Naval Architecture

Ship and Boat Design and Analysis
Production Methods
Materials and Fabrication
Testing and Evaluation
Marine Propulsion
Deck and Hull Equipment

Ocean Energy

Tides
Waves
Currents
Temperature Differences
Bioconversion

Surveying

Navigation
Sonar Applications
Photo and Television
Geodesy
Magnetism
Instrumentation

List Prepared by the Marine Board, Assembly of Engineering, National
Research Council in 1975.

Mr. BROWN. A couple of places in your presentation you refer to the matter of maintaining, preserving, and utilizing the records in data systems, the need to "consolidate and maintain data bases," I think you call it on page 7.

I am wondering if you could comment as to what the general status in NOAA is from your standpoint. Could you give me an evaluation of how well you think they're doing in this area?

We brought this question of data bases and information systems up to Dr. Press because in the President's message of just 3 weeks ago on innovation and productivity one of the initiatives was a combination of the Smithsonian Science Information System and the Department of Commerce system, and Dr. Press said this was part of a broader effort, aimed at, as I gathered, analyzing the needs, or better management of our whole data system. I see your remarks as fitting into this general perspective, and I'm asking you what needs to be done there. How do you evaluate the problem?

Dr. KNAUSS. It seems to me that NOAA does quite a good job in handling the kind of data of a traditional nature, such as weather records, ocean records, which can be essentially digitized and then kept on that basis.

The problem, of course, is how does one deal with the vast amount of other kinds of information which is required in these days, if the data is going to be of any use in the decisionmaking process, such as a problem in coastal zone management with respect to the question of the tradeoffs between oil and fisheries on the George's Bank, these kinds of material. I think it's fair to say that NOAA does a less good job at providing these kinds of data.

On the other hand, having attempted to try to do some of this myself on occasion, I have great sympathy for the difficulty. What's really required is some way to be able to store and process material which can't readily be reduced to numbers, and that's a very difficult problem, sir.

Mr. BROWN. What kind of data specifically are you thinking of that can't be reduced to numbers?

Dr. KNAUSS. There's a large amount of biological data and chemical data which in principle can be reduced to numbers, but it's not easy. There's a lot of geological data, for example, that is not easy to reduce to numbers. That kind of thing is what I meant.

Mr. BROWN. But it could be stored in a nondigital fashion.

Dr. KNAUSS. That's right.

Mr. BROWN. It could be stored in microfilm or in access to computers.

Dr. KNAUSS. Yes; that's right. In principle all that can be done, yes, sir.

Mr. BROWN. But it's not being done?

Dr. KNAUSS. No; that's not quite what I said. I'm saying that it's being done, but, to my understanding of the situation, those people who are involved in trying to recall that information and get it in a form that can be useful, it's much more difficult to retrieve that kind of information than it is the much more simple numerical kinds of data.

Mr. BROWN. I know this is a complex area and one we're going to be spending considerable time on in this committee, either this subcom-

mittee or the subcommittee which I serve as chairman on, and I'm interested in just getting a little better perspective as a layman in this field as to what the problems are.

I was discussing with a scientist in another field just a little bit earlier the problems of establishing a data bank in the field of processing a taxonomic record of the flora and fauna of the United States. Apparently that is a feasible project, but it needs to be done as an integrated system, and in a sense an integrated system on the broad-sided area becomes almost the amount of the universe to investigate. It needs to be planned very carefully, putting data in, taking data out, making it usable to the user communities, and I am totally ignorant as to whether we are approaching that in the field of climatological data or weather data or whether we are way far off from getting to the point where we can do that and what the obstacles are. Obviously, it's going to cost money to do that. It takes a lot of computers and skilled manpower. But if we're not even thinking in terms of the importance of it, then in my mind we're in trouble.

Dr. KNAUSS. Yes, sir.

Mr. BROWN. We're not thinking about it?

Dr. KNAUSS. I think we're all thinking about it. I think, as you point out, the problem is that it's extremely expensive to do some of these things. One of the problems you must realize is that the sensors we now have available make it possible to collect data at a much more rapid rate than we ever had before. One of the interesting statistics is that the ill fated SEASAT satellite—I forget how many days it was up—probably collected more data points during its brief period than was in the entire NODC, the National Oceanographic Data Center, up to that time.

With that amount of data, then it almost requires some level of selectivity be exercised on what you're going to store and what you're going to keep. Storing all data is probably not useful, and, as you know, sir, I think that what happened, say, with respect to climate records in the past was that it was only when we began to look at the problems of climate that we began to think, gee, it would have been nice if back 10 or 15 years ago we had realized that these were the important kinds of information to have stored in a readily accessible form.

You try your darndest to predict the future, and hope that we are making the right decisions about the data we're storing today. But modern computers allow one to store almost anything. It's just a question of what you're willing to pay for.

I don't have any simple answers. The problem you raise is a very important one.

Mr. BROWN. Obviously, the question requires a great deal more analysis than we can give it this afternoon. But I'm trying to approach it from several different angles. You've been helpful in indicating the importance of that, and I appreciate it.

Thank you, Mr. Chairman.

Mr. AMBRO. Thank you, Mr. Brown.

Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

In looking at your statement on page 7 and reading the recommendations I notice that all of them are aimed, it looks to me, almost exclusively at ocean research.

Is that a predisposition of the group? It seems to me that there is some atmospheric R. & D., too, that might be a part of your recommendations.

Dr. KNAUSS. Yes, sir, NACOA tries to, or at least has in the past anyway tried to make recommendations on a selective basis with respect to selective problems. This particular effort that was addressed here—maybe clearly in hindsight—is mislabeled. We should have referred to it as the ocean R. & D. effort of NOAA. We had been asked to look at certain aspects of this, and we did. We have looked at other aspects of the NOAA program, including the atmospheric program. We have made comments on the climate program, comments on weather modification, and so forth. This particular short study that we did looked at only a certain aspect of the NOAA R. & D. program, and not even all of that. It was primarily related to the D rather than the R, that is, more the development than the research.

Mr. WALKER. That's a helpful explanation. The reason why I referred to it is because in the first part of your statement you did get into the climate program and the weather modification program and the weather service program, and then I come back here to the recommendations and they aren't mentioned in your recommendations. I thought the recommendations went to the ocean program.

Dr. KNAUSS. We've made recommendations on the climate program. We've made recommendations on the weather services. We've made recommendations on weather modification.

The membership of NACOA includes a number of people with atmospheric expertise. I'm not one of those, but we do have three members when we're up to full strength anyway. When we were last up to strength we had 3 members of our 18-member group who are actually professional meteorologists or have had professional meteorological training.

Mr. WALKER. So your statement is not an indication that you think that the ocean program should be emphasized over the atmosphere program in terms of the R. & D. effort? That's not a conclusion that one should draw from that?

Dr. KNAUSS. That's not a conclusion that one should draw, and our mandate says both oceans and atmosphere.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. AMBRO. Thank you, Mr. Walker.

Thank you, Dr. Knauss.

I would like to, with your consent, submit written questions to NACOA for responses to round out the record.

Dr. KNAUSS. Of course, sir.

Mr. AMBRO. Thank you very much.

[The information to be provided follows:]



**NATIONAL ADVISORY COMMITTEE
ON
OCEANS AND ATMOSPHERE**
3300 Whitehaven Street, N.W.
Washington, D.C. 20235

January 18, 1980

Honorable Jerome A. Ambro, Chairman
Subcommittee on National Resources
and Environment
U.S. House of Representatives
B21 HOB Annex 1
Washington, DC 20515

Dear Mr. Ambro:

We would like to submit the following information in response to your letter of December 4 asking the National Advisory Committee on Oceans and Atmosphere (NACOA) questions about programs of the National Oceanic and Atmospheric Administration (NOAA) in the 1980's. We regret that we could not meet your January 4, 1980, deadline, and we thank you for the 2-week extension.

Reply to Question 1:

Atmospheric: We believe that during the 1980's NOAA should assign high priority to the following research topics:

1) Climate

- . Adequate theory of global climate.
- . Understanding of the effects of climate on human activities and vice versa.
- . Techniques for using climate and weather data for improving socially useful practices.
- . Techniques for predicting climate changes.
- . Effects of variable solar events (e.g., flares, sunspots) on climate and weather.

2) Weather prediction

- Short-period weather events that pose serious threats to life and property.
- Weather conditions for periods of several weeks to several months duration.

3) Atmospheric chemistry

- Global atmospheric chemical cycles with emphasis on those, such as carbon dioxide and ozone, that can influence global and regional climate.
- Atmospheric gases and particles that pose threats directly or indirectly to the biosphere, such as acid rain.

4) Weather and climate modification

- Inadvertent changes caused by such activities as building cities and clearing forests.
- Attempts to modify weather and climate.

Oceanic: In 1979, we conveyed our views to the Administrator of NOAA concerning certain research and development (R & D) objectives. We commented on the "Federal Plan for Ocean Pollution Research, Development, and Monitoring, Fiscal Years 1979-83."

In particular, NACOA emphasized the need for NOAA to develop:

- 1) An understanding of the transport and dispersal of pollutants in the coastal and continental shelf waters.
- 2) An information base on which to estimate the effects of anthropogenic pollution in the ecosystems of the coastal zone and continental shelf.
- 3) A functional relation between various degrees of pollution and degrees of impact on the ecosystem.

We believe that other critical areas where active NOAA programs are required: 1) Constraints on oceans use and conflict resolution, and 2) ocean engineering for development of economic benefits from the ocean.

There are other areas that need further review, such as fisheries and coastal zone management. NACOA has looked at specific programs and reviewed selective NOAA activities. These reviews are an ongoing NACOA function.

We have arrived at the list of high priority subjects through Committee deliberations, workshops, studies of work of appropriate committees of the National Academy of Sciences (NAS), and discussions with atmospheric and oceanic scientists within and outside of government. With respect to the question on how NOAA determines priorities, we believe that NOAA policy-makers, such as George Benton, Associate Administrator of NOAA, and Ferris Webster, Assistant Administrator for Research and Development, follow a similar procedure. They have been active in NAS affairs in the past and recognize the value of this source of advice. They also get advice from other Federal bodies and from NACOA. As you are well aware, NOAA administrators also must take into account budgetary realities when assigning research priorities.

Reply to Question 2:

NACOA has examined the Prototype Regional Observing and Forecasting Program (PROFS) and believe it is an excellent investment of research and development funds. (See the enclosed letter, dated February 13, 1979, from NACOA to Senator E. F. Hollings and Congressman J. J. Slack dated February 13.) PROFS represents part of the effort needed to deal with research priority of weather prediction of short-period weather events given in response to your first question. The PROFS program is a long-needed step in the application of mainly existing technology to meet the weather needs of the Nation.

In the past, NOAA has been criticized for inadequately transferring research findings into operations. To an important extent, this was a result of inadequate funding. If greater resources were available, NOAA could increase its effectiveness by using modern technology for data transmission and processing. New Doppler radars would appreciably increase our ability to deal with violent weather events.

We believe that the chief administrators of NOAA are aware of the need to improve the transfer of technology to operational groups within the agency and have been encouraging greater communication between the research and operational branches of NOAA.

Reply to Question 3:

NACOA has met several times with Richard Frank, NOAA's Administrator, and his representatives to discuss a variety of questions including research planning. As far as we know the activity of the Committee on

Oceans and Atmosphere (CAO) has been quite limited over the past year. We believe that this situation should and will change. Richard Frank has stated that a subcommittee on weather modification is being established in CAO to formulate a 5-year plan for a national program. The subcommittee is expected to call on government experts for guidance.

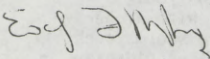
We believe that CAO should take an active role in formulating national goals in the atmospheric and oceanic sciences. It should seek the advice of appropriate committees of NAS and NACOA.

CAO should continue the reporting, coordination, and planning functions formerly performed by the Interdepartmental Committee on Atmospheric Sciences and the Interagency Committee on Marine Science and Engineering. CAO should include experts from universities and the private sector in its deliberations and decisionmaking processes. Difficult as it clearly is, CAO should seek to identify, and revise when necessary, a set of priorities for research in atmospheric and oceanic sciences.

The question posed to John Knauss during the hearing concerned the funding for an Institute for Ocean Engineering; we gave you that information when the draft of the hearing was returned to your office in early December.

Please do not hesitate to call us if you have any questions or need clarification on the answers.

Sincerely,



Evelyn F. Murphy
Chairperson

Enclosure



NATIONAL ADVISORY COMMITTEE
ON
OCEANS AND ATMOSPHERE
3300 Whitehaven Street, N.W.
Washington, D.C. 20235

February 13, 1979

Dear Mr. Chairman:

The National Advisory Committee on Oceans and Atmosphere (NACOA) strongly supports the initiative called Prototype Regional Observing and Forecasting Service (PROFS), in the Fiscal Year 1980 request submitted by the National Oceanic and Atmospheric Administration of the Department of Commerce.--

This initiative was brought to the attention of the Committee members by the Weather and Climate Panel of NACOA. The panel members are: Werner A. Baum (Chairman), Chancellor of the University of Wisconsin-Milwaukee and past President of the American Meteorological Society; Louis J. Battan, Director of the Institute of Atmospheric Physics at the University of Arizona and also a former President of The American Meteorological Society and a former chairman of the Committee on Atmospheric Sciences of the National Academy of Sciences; and Warren M. Washington, a Senior Scientist at the National Center for Atmospheric Research in Boulder, Colorado.

The objective of the PROFS plan is to provide dramatic improvements in the accuracy, timeliness, and dissemination of local weather warnings and forecasts, particularly of severe weather events. Flash floods alone cause about 200 deaths annually in the United States, with property damage of about \$1 billion a year. Other small scale severe storms such as tornadoes and lightning kill or maim even more Americans. Accidents caused by wind shear at airports have caused many deaths -- the one in New York in 1975 killed 113 people, caused \$20 million in property damage and millions more in litigation. The improved local weather services that PROFS could provide will help prevent such catastrophes in the future.

The PROFS plan calls for a transfer of available technology in observation systems, numerical modeling, communications, and dissemination of data and information to produce short-term accurate forecasts of small-scale weather events. The application of the technology that is readily available will yield a high return for the investment. The appropriation request is to expand and accelerate the preliminary work already done on PROFS--part of a multi-year program.

A study done in the preliminary work for Denver, Colorado, the 27th largest U.S. city, indicated that the cost savings for just three human activities--shopping, commuting, and recreation--could be as large as \$30 million annually if such a system existed. Economic benefits of short-period forecasts would also accrue to industries, such as aviation, surface transportation, construction, and fishing. A study made in 1975

indicated that improved forecasts for urban snow removal operations could result in savings of \$188 million per year.

Another notable feature of PROFS is that it will provide a focal point for all weather-related programs, those of the private sector as well as the various Federal agencies, such as the Federal Aviation Administration and the Department of Defense.

The United States now leads the world in almost all of the technology involved in the PROFS plan. By acting now, the United States has an opportunity to create the next-generation weather service system and capture a major share in the world market for the system. Indications are that there will be an even greater market in the future as the developing nations improve their weather services.

NACOA strongly endorses this initiative and urges your subcommittee to give it careful consideration in the appropriations hearings. Members of the Committee will be available for further consultation if it will be useful to you in your deliberations.

Sincerely yours,

Donald L. McKernan
Chairman

Distribution

Honorable Ernest F. Hollings
Chairman, Subcommittee on State, Justice,
Commerce, the Judiciary
Committee on Appropriations
United States Senate
Washington, D.C. 20510

Honorable John M. Slack
Chairman, Subcommittee on State,
Justice, Commerce and Judiciary
Committee on Appropriations
U.S. House of Representatives
Washington, D.C. 20510

Mr. AMBRO. I would like to now recall Doctors Owen, Hallgren, and Potter, with my apology for breaking in before, which is a bit unusual, but I thought the display of interest on our part might, in fact, shake loose that study that the Chairman of the Appropriations Committee and others are interested in. Just a little concession to those types.

So now we may proceed in an orderly fashion, Dr. Owen. We'll be happy to hear from you.

Dr. OWEN. Thank you, Mr. Chairman.

I would propose to submit my full statement for the record and merely leaf through it and summarize the highlights, if I may.

Mr. AMBRO. That's fine. We will include your entire statement in the record.

Dr. OWEN. Thank you, sir.

[The prepared statement of Dr. Thomas B. Owen follows:]

STATEMENT BY

Dr. T. B. Owen
Assistant Administrator for Oceanic
and Atmospheric Services

National Oceanic and Atmospheric Administration
of the
Department of Commerce
Oversight Hearings
Before the

Committee on Science and Technology
Subcommittee on Natural Resources and Environment
November 14, 1979

Mr. Chairman and Members of the Subcommittee:

I am pleased to have this opportunity to present an overview of research and development activities of selected elements of NOAA's Office of Oceanic and Atmospheric Services.

There are four major elements of OAS that are responsible for providing oceanic and atmospheric services to other components of NOAA, other Federal agencies, and the private sector. They are the National Environmental Satellite Service, the National Ocean Survey, and the two of particular interest today, the National Weather Service and the Environmental Data and Information Service. Efforts within OAS

elements are more in the general development field than in research as covered by Dr. Webster. I will first cover activities of the National Weather Service.

I. National Weather Service

The mission of the National Weather Service (NWS) is (1) to help insure the safety and welfare of the general public by issuance of public forecasts and severe storm watches and warnings, and (2) to provide specialized meteorological services important to the conduct of municipal, commercial, and other activities that are affected by the weather, such as agriculture, aviation, transportation and marine interests. To fulfill its responsibilities, NWS observes and reports status of the atmosphere, the rivers, and the oceans. It issues forecasts and warnings of weather, floods, and ocean conditions. It develops national meteorological, hydrological, and oceanic service systems. It assists in the development of community preparedness programs for weather-related natural disasters and participates in international meteorological activities in order to assure the exchange of data and forecasts.

The National Weather Service field structure is currently organized into three main tiers. At the national level are three guidance centers. The National Meteorological Center produces general forecast guidance. The National Hurricane Center, together with Hurricane Centers at San Francisco and Honolulu, specializes in tropical cyclone and hurricane forecasts. The National Severe Storms Forecasts Center is responsible for issuing watches for severe thunderstorm and tornado activity.

NWS' intermediate level is composed of 52 Weather Service Forecast Offices (WSFO's) and 13 River Forecast Centers that provide state and zone weather forecasts and river and flood forecasts and warnings to general users and special forecasts in the individual service areas.

Closest to the grass roots are 233 Weather Service Offices, responsible for a variety of functions including weather observations, pilot briefs, adaptation and dissemination of local forecasts, and preparation and issuance of severe weather warnings.

Fiscal Year 1980 resources for NWS include just over 5,000 personnel and \$206 million.

In carrying out its mission, the National Weather Service performs three broad functions. These are (1) data acquisition, (2) forecast and warning preparation, and (3) communication and dissemination. Applied research and development is carried out in each of these three major functional areas, and I will now discuss our efforts, together with recent developments, in each of these areas in turn.

A. Data Acquisition

Data acquisition involves observation, collection and some processing of atmospheric, hydrologic, and oceanic data. The observations are obtained with a variety of instruments able to measure surface weather, the state of the upper air, and conditions on and over the world oceans. Techniques and capabilities developed within NOAA's Environmental Research Laboratories, and through application of advancing technology in related fields, have recently resulted in advances with great potential. Of particular significance are recent improvements in remote sensing from surface and space based platforms, and in communications techniques. Some of these merit discussion at this point:

1. RADAP

As a result of a highly successful field development experiment, a radar processing system (RADAP) is being procured for 56 of our network and 15 of our local warning radars that will automatically determine intensities, movement, areal coverage and estimates of rainfall and will automatically convert information to digital format for transmission to our field forecast offices. These RADAP products will be available for users in near-real time.

2. Doppler Radar

As a result of the research and development program of the National Severe Storm Laboratory of NOAA's Environmental Research Laboratories in the field of Doppler radar, we have begun joint development and planning for the next-generation radar. This joint effort involves the Department of Commerce, the Department of Defense, and the Department of Transportation. A Joint System Project Office has been established and the agencies are collectively staffing and providing financial support. This next-generation radar will use Doppler technology and will replace the aging and hard-to-maintain basic network weather radar system. Doppler radar will

provide a capability to detect and track severe weather conditions that will allow significantly improved timeliness and accuracy of tornado and severe thunderstorm warnings.

3. Surface Reporting Systems

We are moving ahead with the development of our automatic surface weather reporting systems. We currently use substantial manpower in generating the surface observations required to support our forecast, warning and aviation responsibilities. New technologies are leading to automation of surface weather observations including visibility, ceiling and cloud cover, winds, temperature dewpoint and pressure. Still under development are acceptable sensors for ceiling height and for types of precipitation. Automation of our surface weather observations will provide an opportunity to redirect staff time, streamline our field structures, improve the quality and reliability of observations, and provide a truly continuous weather watch. Also the network can be expanded into areas that are normally inaccessible.

4. Upper Air Tracking Systems

The National Weather Service is moving ahead with the development of a fully automated upper air tracking system. The existing radiotheodolite equipment is nearly 30 years old and difficult to maintain. The reduction of data is mostly manual which leads to unnecessary delays and errors in acquiring upper air soundings. We will upgrade and automate the reduction of data using the latest solid state technology.

5. Satellite Data

The application of satellite data is another area where significant development strides have been taking place. NWS and the National Environmental Satellite Service (NESS) work together in the use of satellite derived data. NESS, as the satellite operator, acquires the data, and processes it into a form useful to the field offices of NWS. Emphasis is presently being placed on the acquisition of quantitative global atmospheric temperature sounding and water vapor information for use by the NWS in numerical weather prediction, sea surface temperature mapping, snow and ice coverage, snow melt data, location and collection of environmental data

from remote moving platforms, and direct broadcasts of images and data to numerous low-cost ground receiving stations.

6. PROFS

NWS is actively collaborating with ERL in the development of the Prototype Regional Observing and Forecasting Service (PROFS) concept which has the ultimate goal of providing the public with improved real-time weather information and forecasts on a local scale. In order to accomplish this goal, recent progress in observing and forecasting methods, data processing techniques, and modes of dissemination will be integrated to improve the accuracy of observations and forecasts of local weather conditions. The experimental facility in Boulder, Colorado, will provide the laboratory for a variety of techniques that can be transferred for use by the NWS forecast offices. I am sure Dr. Webster covered this major development effort in more detail.

B. Forecast and Warning Preparation

I would like to turn now to the second broad function of the National Weather Service--that of preparing forecasts and warnings. Forecast preparation includes data processing

and analysis, as well as the development of predictive materials. General research and development is conducted in the Systems Development Office, the Regional Offices, the National Hurricane Center, the National Severe Storms Forecast Center, and many WSFO's to improve the forecasts of hurricanes, severe local storms, general weather, flash floods and aviation weather conditions, using both dynamical and statistical techniques. However, our efforts in this area focus on improving the day-to-day general forecasts and severe weather and flood warnings through improvements to our mathematical models of the atmosphere.

1. Numerical Prediction Services and Computer Support

We are constantly working on numerical prediction models (which simulate atmospheric and hydrological processes) and developing better computer techniques to solve the underlying equations. The National Meteorological Center (NMC) located at Suitland, Maryland is the focus of NWS' numerical prediction services. NMC routinely provides broad-scale analysis and predictions, including long-range forecasts, for use by NWS field forecast offices in their preparation of state, regional, and local forecasts and severe weather warnings. The Center is involved in the development of the advanced numerical analysis and prediction models needed to extend the forecast period and the accuracy thereof.

Scientific improvements needed for improving the accuracy and extending the period of prediction depend heavily on high-speed computer support. For application of the models that NMC has developed, a more sophisticated computing system is needed, and we are now in the process of upgrading and replacing the three IMB 360-195's located at NMC with a high-speed processor and its associated management computer. In an effort to capitalize on new techniques that have been developed for interactive computer data access and display systems, the NWS is also proceeding with an operational demonstration in coordination with the National Environmental Satellite Service and the National Aeronautics and Space Administration will be of a centralized storm information and display system at NOAA's operational facilities in Kansas City. It will include the National Severe Storms Forecast Center and the Satellite Field Service Station of NESS. The system to be demonstrated is planned to have the capability to handle both conventional and Doppler radar inputs, visual and infra-red (IR) images from satellites, and temperature and water vapor profiles from both TIROS and VAS-type sounders. The system must perform the intercomparison and display function rapidly enough for the forecaster to meet the stringent time requirements associated with operational severe weather forecasts and the establishment of severe weather watches.

2. Hydrological Services

NWS' hydrological services are aimed at the provision of short and long-range forecasts for large-scale river flooding, furnishing information concerning potential flash floods, and assisting communities in the implementation of flash flood warning systems. Forecasts of river heights and flow rates are prepared for use in river transportation, river site construction, power generation, manufacturing/processing industries, water supply and water quality management, and water quality management, and recreation. We are also engaged in research to improve hydrologic forecasting techniques. Developments are now underway in improving the warning services by implementing a new system of river forecast models. NWS is actively involved in the development of new river forecast models that require calibration of several thousand river basins and the tailoring of these to provide detailed information for at least 2,500 specific points. Implementation of these newly developed models will provide increased warning time and improved accuracy in our flood warning service.

3. Climatological Services

In a key response to the National Climate Program Act, NWS recently has begun a long-term development effort to improve its monthly and seasonal outlooks at its Climate Analysis Center. NWS now has the capability of performing diagnostic studies to describe the behavior of the climate system, to specify the important physical factors responsible for climate fluctuations on the time scales of months to years, and to identify appropriate time and space relationships. This involves both current in-house development efforts and university contract research. Plans for the next five years include analyses of statistical predictability, development of new objective prediction techniques for low and middle latitudes, and tests of the applicability of atmospheric models to both short and long lead time seasonal outlooks.

4. Oceanic Services

A vital responsibility of NOAA is improved and expanded coastal, offshore, and oceanic prediction services in support of our coastal communities, commercial vessels, pleasure craft, offshore oil and gas development, deep ocean mining, deepwater ports and expanded fisheries. We established a prototype ocean services unit at the WSFO in Seattle in FY

1976 to improve existing marine advisory services and to develop new services for the northeast Pacific Ocean area. We are developing plans to establish ocean service units at seven additional WSFO's, three on the Atlantic coast, one additional on the Pacific coast, one in the Gulf of Mexico, and one each in Honolulu and Anchorage. These units will provide marine watches and prepare special regional and local marine warnings and forecasts similar to those being developed at Seattle. Each of the proposed WSFO ocean service units will work with the ocean activities of our satellite field service stations.

Applications of new technology are planned to enhance the capabilities of the ocean service units. Automated weather stations, adapted for the marine environment, will provide data from remote coastal areas and off-shore platforms. Data from these facilities as well as the 20 weather buoys now in our off-shore waters and Great Lakes will be automatically relayed through satellite communication to our analysis centers. Also a prototype system has been developed for automated reporting of surface observations from merchant ships using satellite communications.

C. Communications

The third broad functional area of the NWS deals with communications. The internal system involves the transmission of information between and among centers having forecast, guidance and dissemination responsibilities. These systems include land-line telephone, radio, radiotelephone, and microwave transmission. Computers are used to perform various preprocessing operations that facilitate transmission, particularly transmission of data to forecasting centers.

By external communications we mean the dissemination of weather intelligence to the users--the public, industry, and other specialized groups. The success or failure of this effort depends almost totally on the cooperation among NWS, other Government agencies, and the private sector, especially the mass news media. NWS is capable of transmitting this information in a timely manner to the media, but depends heavily on the media for the further transmission to the user. In addition, NWS is completing implementation of the NOAA Weather Radio system and the NOAA Weather Wire service. Examination of direct dissemination via public-service and cable television is also underway.

NWS views the present system for collecting, preparing, and distributing weather information as too slow and cumbersome to permit optimum response to warning situations. It has been

acceptable up to now, because the current system was limited by the state-of-the-art in communications technology. Now, the microprocessor has been adequately developed and NWS is proceeding to a new level of communication with the introduction of AFOS (Automation of Field Operations and Services), which will reduce the time between the taking of observations and the issuance of forecasts and warnings to the general public.

Through AFOS, weather offices will be provided with off-the-shelf processing display and communication technology that will allow them to automate routine forecast office duties; provide automated assistance to the professional forecasters in meeting their responsibilities; and hasten the communication of data to the forecaster and of information to the public over high-speed computer-controlled circuits. When fully implemented, AFOS will permit the elimination of many teletype communication circuits that are slow and require manpower attention.

The losses of life and property from natural disasters such as flash floods, tornadoes and hurricanes justify continued improvement in the timeliness and reliability in the dissemination of weather information and warnings to the public. This critical information must be made available in a timely manner to all segments of the population. NOAA can insure its availability through the use of developing private sector technology. Teletext, a system which automatically transmits alphanumeric

information on home TV screens, is an example. NWS plans to move ahead to develop the formats and software necessary to provide weather information for display on home TV through this system. An adaptation presently is being developed experimentally under the name "Green Thumb," for disseminating agricultural weather information.

Computer voice-generation techniques can also be adapted to NWS needs. Presently, NWS must manually prepare the worded weather messages that are given to the public. This is a very time-consuming process which can be avoided by generating a voice message automatically through the computer which would be heard immediately by people watching TV, listening to the radio, or using dial-up telephones.

II. Environmental Data and Information Service

The second major element of OAS interest today is the Environmental Data and Information Service (EDIS).

A. Functions and Organization

1. EDIS collects marine, atmospheric, solid earth, and solar-terrestrial measurements from around the world. These measurements are reviewed for quality, processed, disseminated in various forms, and archived for future use. Various analysis and assessment tasks are carried out as appropriate, and EDIS is thus able to provide information, data, and analyses required for decision making to federal, state, and local governments; the academic community; the industrial sector; and the public.

2. EDIS is organized into five major operating Centers, each with a functional identity. All together the Centers employ over 500 people and have combined budget authorities of about \$21 million.

The National Climatic Center, located in Asheville, North Carolina, is the largest of the Centers. During calendar year 1978, NCC distributed over 1.5 million climatic data publications and responded to 66 thousand user requests. The National Climatic Center receives and processes over 30 million meteorological observations annually, and makes data and summaries, including satellite

data and related products, available to a large and diverse community. The Center also administers World Data Center A for meteorology, which provides for international data exchange.

The National Oceanographic Data Center (NODC), located here in the District of Columbia, processes, analyzes, archives, and disseminates a wide variety of physical and biological data from the world's oceans to support many users including the offshore oil and gas industry.

The National Geophysical and Solar-Terrestrial Data Center (NGSDC) in Boulder, Colorado, processes, analyzes, archives, and disseminates solid earth, marine geophysical, ionospheric, solar, and other space environment data.

The Center for Environmental Assessment Services (CEAS), headquartered here in the District of Columbia, uses climatic and marine data to develop statistical analyses, models, and assessments of crop yields and of residential and commercial natural gas demand. It is also involved in examining the implications of offshore brine disposal in the Gulf of Mexico.

The Environmental Sciences Information Center (ESIC) provides library reference and referral services to user, both internal to NOAA and to other agencies, public and

private. It provides access to a variety of computerized data bases. It is responsible for editing and publishing a variety of NOAA scientific reports and documents.

Several pieces of recent legislation place special responsibilities on EDIS.

EDIS is an active participant in NOAA responses to the National Climate Program Act (P.L. 95-367) in at least three categories: climate impact assessment, climate data management, and climate information services. New NOAA initiatives are being developed in each of these categories in order to implement the several important services elements of the Act.

One high priority proposal being developed by EDIS is a plan to complete, compact, quality control, and enter into an automated data base selected sets of meteorological, oceanographic

glaciological, and paleoclimatic data. Data catalogs designed for major user groups would be published. During the first three years an intensive effort would be dedicated to processing the huge backlog of dispersed data files containing nearly 2 billion observations.

A companion high priority proposal will involve a significant increase in the existing 21 station nationwide network of reference climatological stations, sometimes called "benchmark" stations, so as to provide a baseline and a measure of broad climatic trends.

These are but two examples of plans underway in all service components of NOAA, particularly EDIS, to strengthen climate services and to support basic and applied climate research.

EDIS is carrying responsibilities mandated by several Public Laws dealing with marine areas.

Under the Marine Protection, Research and Sanctuaries Act of 1972, P.L. 92-532, Title II, Section 201 (Ocean Dumping), EDIS, through its Centers, is providing data management services which include data format development, data processing, and synthesis.

Under the Energy Policy and Conservation Act of 1975, EDIS/CEAS is serving as a manager of the marine portion of the Strategic Petroleum Reserve Brine Disposal Analysis Program.

The National Ocean Pollution Research and Development Planning Act of 1978, P.L. 95-273, contains two sections affecting EDIS. Under Section 8, EDIS is responsible for the dissemination of results and findings originating from research and monitoring efforts under the Act. In addition, EDIS will develop a Management Information System to assist in the biennial update of the Federal Plan required by Section 4 of the Act.

Under the Fishery Conservation and Management Act of 1976, P.L. 94-265, EDIS provides historical environmental data for NOAA's comprehensive program of fishery research on the impacts of pollution and of wetland and estuarine degradation upon the abundance and availability of fish.

The Environmental Protection Agency has responsibility to carry out the Federal Water Pollution Control Act of 1972, P.L. 92-500, as amended by the Clean Water Act of 1977, P.L. 95-217. EDIS will perform data management activities for EPA and other users in carrying out the terms of Section 301(h) of the Act which involves modifications to the requirement for secondary treatment and discharge into marine waters.

In addition to activities underway or planned in response to specific acts of the Congress, there are other developmental activities in which EDIS has a supporting role. One such recently approved project is AgRISTARS (Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing). Here EDIS, along with the National Environmental Satellite Service, is actively

involved with the U.S. Department of Agriculture, (USDA), NASA, Department of Interior and the Agency for International Development (AID) in a six-year program of research, evaluation, and application of aerospace remote sensing for agriculture resources beginning in FY 80.

In addition to supplying the meteorological data base for the program, EDIS will be involved in the conduct of research, development, and tests in the following areas:

- o Application of environmental satellite data to early warning/crop condition assessment and foreign commodity production forecasting.
- o Development of yield models for foreign and domestic crops.
- o Use of conventional and satellite derived meteorological data applied to renewable resources, conservation, and pollution.

To carry out its overall mission, EDIS must develop and maintain an automatic data processing capability to deliver environmental data and information products to the user community in a timely, cost-effective manner. More specifically, the EDIS computer system must provide the ability to (1) quality control and store increasingly large volumes of environmental data in continuously changing formats and modes, (2) efficiently access these data across the environment disciplines from any geographic location, and (3) deliver the processed results in time, at the least possible cost.

At the present time, the EDIS data processing operations obtain large-scale computer support from three separate, independently operated NOAA facilities. In the past, these facilities have met EDIS' requirements well. However, there is a need for quicker access to multi-disciplinary files located in various geographic locations and to deal with the increasing volumes of incoming environmental data, in frequently changing data formats and modes. The proposed plan is to have an integrated environmental data base at Asheville, North Carolina, with a network connecting other EDIS Centers and that can be accessed by the user community.

Each of the EDIS Centers has an extensive user community (total of more than 130,000 users per year) which they serve. In addition, EDIS has outreach activities through liaison officers at Anchorage, Seattle, La Jolla, Woods Hole (Mass), and Miami. Together with the Office of Coastal Zone Management and Sea Grant programs, EDIS is funding a pilot program of

three Regional Coastal Information Centers. They are located in the Northeast (Narragansett, R.I.), the Northwest (Newport, Ore), and the Great Lakes (Ann Arbor, Mich).

The Regional Coastal Information Centers are designed to collect, analyze, synthesize, and disseminate scientific, technical, legal, and economic information about a coastal region directly to industry, government, and the public.

EDIS also is supporting the development of state-funded State Climatologist activities. Currently there are State Climatologists (SC) in 42 states. The SCs are professional meteorologists, and many are associated with universities. The program is designed to expand NOAA's climatic data/information service capability to users through professionals at the local level. The NCC has obligated a portion of its base funds to support the data/information needs of these non-federal SCs. They also receive a number of free services; i.e., publications, microfiche, and weather data for stations within their state.

I trust through this testimony you have a better understanding of two of NOAA's service organizations. As indicated in my introduction, these NOAA elements are supporting applied research and development activity appropriate to their missions. We look to the Environmental Research Laboratories and to the capabilities of academia and industry for contributions to our capability over the longer term.

This concludes my formal statement. We would be pleased to answer any questions you might have concerning NOAA's Oceanic and Atmospheric Services.

**STATEMENT OF THOMAS B. OWEN, ASSISTANT ADMINISTRATOR
FOR OCEANIC AND ATMOSPHERIC SERVICES, NATIONAL OCEANIC
AND ATMOSPHERIC ADMINISTRATION; ACCOMPANIED BY RICH-
ARD E. HALLGREN, DIRECTOR, NATIONAL WEATHER SERVICE;
AND THOMAS D. POTTER, DIRECTOR, ENVIRONMENTAL DATA
AND INFORMATION SERVICE**

Dr. OWEN. Mr. Chairman, it is indeed a pleasure for me to appear with you today.

With me are Dr. Richard E. Hallgren, Director of the National Weather Service, and Dr. Thomas D. Potter, Director of the Environmental Data and Information Service.

Yesterday you heard from Administrator Frank and Assistant Administrator Webster of the research activities of the National Oceanic and Atmospheric Administration.

We in the service areas look to that research effort at the Environmental Research Laboratories, to academic institutions, and to industry for the longer range research necessary for ultimate manifestation as service capabilities. The work that we do in the service organization itself that may be called research and development is generally of an applied nature, and places greater emphasis on development.

As Assistant Administrator I am responsible for four operating elements of the foundation: the National Ocean Survey, the National Environmental Satellite Service, and the two of primary interest today, the Weather Service and the Environmental Data and Information Service.

For background, the mission of the National Weather Service is to, first, provide public forecasts and warnings of severe storms and tornadoes; second, to provide specialized services, principally in the areas of aviation, agriculture, and in marine activities: coastal, offshore, and on the high seas. In addition, we do have responsibilities for working with the Federal Emergency Management Agency in connection with community preparedness for severe storms and flood activities. We also have international responsibilities in the weather area to insure a worldwide exchange of meteorological information necessary to prepare the necessary forecasts.

In carrying out the operational functions of the Weather Service we are organized in three principal tiers. At the central and highest level there are three centers that provide guidance for the forecasting offices and the Weather Service offices. These are the National Meteorological Center, located here in Washington, D.C., more properly in Suitland, Md., that provides the long-range forecast guidance to the next tiers down. In addition, we have the National Hurricane Center in Miami, responsible for forecasting hurricanes and for forecasting the place where the hurricanes will hit. We have the National Severe Storms Forecasting Center in Kansas City, Mo., responsible nationally for establishing watches for severe thunderstorms and tornadoes.

The next level in our operational scheme comprises the 52 Weather Service Forecast Offices, who have responsibility for preparing, with the guidance received from the National Centers, area and regional forecasts, warnings with relationship to weather and to floods.

Finally, at the front line we have the 233 Weather Service offices, who are responsible for such things as pilot briefings, dissemination of local forecasts, warnings, and community preparedness.

Overall, these activities in the Weather Service consume the efforts of over 5,000 people and \$206 million.

In order to cover our research activity I thought we'd categorize the functions involved in three different ways. First of all, the matter of data acquisition, or observation; then the subsequent analysis and preparation of forecasts; and, finally, the communication and dissemination thereof. I will discuss our development activities in relationship to these three functions.

In the data acquisition area, one development underway has resulted from an experimental program that's called Radar Data Processing, and here we are developing equipment that can be linked with our existing network radars and some of our local warning radars to give us digital information that will provide better information to forecasters on how much rain is actually in a storm, what areal coverage a rainstorm might have, and some quantitative estimate of the actual precipitation.

The next development stems from work done by the Environmental Research Laboratories, and that's the development of the Doppler radar, in which Mr. Bowen indicated an extensive interest. Using Doppler techniques it is possible to analyze the detailed characteristics of a storm and to identify therein the genesis of a tornado, and with this development and its appropriate display equipment we are embarking, in conjunction with the Department of Defense and the Department of Transportation, on the engineering development and acquisition of what we call "NEXRAD" or the Doppler radar. This equipment, when finally installed, will provide much more timely indication of severe storms and tornadoes and provide opportunities for warning.

In the area of surface reporting we are trying to automate in order to save manpower. Right now, of course, we can automate the collection of temperature, dew point, winds, and such information, but we are in the process of developing equipment that will allow us to determine more precisely ceiling height and the types of precipitation, particularly in the areas surrounding airports. We feel that we can save manpower this way and capitalize on the forecaster's time by providing an opportunity for him to pay attention to forecasting the weather rather than running out and taking these observations.

Another area in which we're making advances is the automation of some of the processes associated with our upper air balloon soundings. We are providing for the acquisition of what we call automated radio-theodolites that, again, we hope will save manpower in eliminating the necessity for manual analysis of the data. It will be done automatically and provided directly to the appropriate center.

Incidentally, Mr. Chairman, may I say that Dr. David Johnson, Director of the National Environmental Satellite Service, is here in the audience and can answer questions that you may have in that area.

In the satellite area we are operating, as you are aware, sir, two polar orbiting satellites and two geostationary satellites to provide the necessary observations for worldwide forecasting as developed by the

National Meteorological Center, and we are each day able to capitalize on more and more of the information derived from satellites through the infrared data, visible data, and through what we call soundings of the atmosphere, giving us information on temperature and water vapor content.

You mentioned, Mr. Chairman, the next item, the Prototype Regional Observation and Forecasting Service.

May I assure you that the National Weather Service and the Environmental Satellite Service are jointly involved with the Environmental Research Laboratories in Boulder in developing that concept. I see that as a long-range program, experimental in nature, but it will provide a laboratory, a demonstration laboratory, from which techniques useful to the Weather Service and to its forecasting operations will ultimately derive.

Incidentally, there is a "troika" advising in connection with PROFS. Dr. Hallgren is a member, Dr. Johnson is a member, as well as Dr. Hess from whom you heard yesterday.

If I may turn to our forecasting and warning preparation activity, this is where we take all the information that we get and from it prepare the long-range guidance necessary for our forecast offices.

Each element in the Weather Service does some modest work to enhance our forecast capability. These are mentioned in the statement. The primary effort takes place at the National Meteorological Center, where we are involved in developing through advanced numerical analysis the prediction models needed to extend the forecast period and the accuracy of the forecasts that we make. In that connection we are examining our capabilities in computer support, and steps are underway to acquire a much more powerful computer capability in order to handle the tremendous increase in data that we're getting, particularly those derived from satellites.

Another development that will help the forecaster is being installed experimentally in Kansas City at the National Severe Storms Forecasting Center. It derives from work done by the University of Wisconsin in connection with the Environmental Satellite Service, and it is called a Central Storm Information System. It's a processing and display system that enables the forecaster to display in an overlay situation material derived from a computer that will enhance his ability to make a forecast in a much shorter period of time.

Chairman Fuqua, accompanied by Congressman Winn, visited the installation at Kansas City and the installation at Wisconsin and observed the capabilities of the system that we are going to put there.

Turning your attention to our river forecast responsibilities, we have 13 River Forecast Centers. They are responsible for monitoring the major river basins of the country, and, in their research efforts, they are developing new models of the extensive number of river basins in order to enhance their capability to provide good information as to flow and forecast at 2,500 specific points.

Turning to the area of climatology, the Weather Service has established just this year a Climate Analysis Center, located at the National Meteorological Center, and it is examining climate behavior and developing what we hope to be better analyses of climate and a better ability to predict climate in the middle and lower latitudes,

and also over both short and long range periods. I mean by that, hopefully, 3 months would be a short range period and 3 to 9 months would be a long range period. That's a very ambitious undertaking, Mr. Chairman. How successful we'll be remains to be seen.

One other area of responsibility is in the area of oceanic services. We have a prototype ocean services unit in Seattle, Wash. We are considering the establishment of additional centers, three on the east coast, one on the gulf, one more on the west coast, one in Honolulu and one in Anchorage, at which we will enhance our service to the areas of marine interests: recreation, fishing, marine transport, and offshore development, and to do so we will need enhanced observing systems, both onshore and offshore, on the coastlines as well as on the Great Lakes.

The third functional area for which we have to account is that of communications and dissemination. There are two communications responsibilities, one internal and one external.

The external responsibilities mean that we have to get our forecasts and information to the public, to the users. This is done primarily at this time by NOAA weather radio and NOAA weather wire. We are in the process of completing the establishment of NOAA weather radio countrywide. Over 300 of a potential 350 transmitters have been installed. With NOAA weather wire, we have almost complete coverage of the country, but we have to depend on the public media, radio, TV, newspapers, and the weather telephone, to get the data across. We are examining how we must develop our capabilities to fit in with the new television display techniques such as experimentally being done at Station KSL in Salt Lake City and to try to capitalize on other new display techniques developed abroad in Great Britain, and there are other developments in this country.

Internally our major development is associated with a system we call the Automation of Field Operations and Services. This, through the development and application of modern processing and display technology, will permit the much more rapid transmission of guidance to our various forecasting offices and, in turn, to our service offices, to permit a much more rapid picture of the weather situation, and much more time and opportunity to get the forecasts and warnings out.

Associated with that system, we hope to use what we call computer-generated voice to save time in getting messages that could be put on NOAA weather radio and ultimately on radio broadcasting systems.

I believe I've covered very generally, sir, the developmental type of activity in the Weather Service.

Congressman Brown evidenced great interest in the next topic; namely, what we are doing in Environmental Data and Information Service.

One can get an overall picture of EDIS responsibility by saying that it is to collect, to check for quality, to process, archive, and disseminate, as appropriate, environmental information; namely, oceanographic, atmospheric, and geophysical information of a variety of types.

There is not much research per se done in EDIS, but it is a major service to academic and to Federal investigators. In order to perform its job, it has five major centers for operations. They are, very quickly,

the National Climate Center in Asheville, N.C., that—in response to Congressman Brown's question—archives climate information and makes it available in substantial volume to users throughout the country. Parenthetically, I visited the Climate Center about 3 weeks ago, and I said I would like to know what the weather was in Seattle, Wash. on my birthday, and in 2 minutes they went to a microfiche file and provided me with that information immediately.

Mr. AMBRO. Had your birthday passed?

Dr. OWEN. Yes, sir. [Laughter.]

I think they could have done it if it were yet to come, sir.

Mr. AMBRO. I would like to believe that.

Dr. OWEN. The National Oceanographic Data Center is located here in Washington, and it stores physical and biological oceanographic information. Again, referring to Congressman Brown's interest with Dr. Knauss, I believe that we do have the information that Mr. Brown was interested in.

We have the installation at Boulder, the Geophysical and Solar-Terrestrial Data Center, that, as its name implies, collects, archives, and disseminates that type of information. It has been particularly helpful to the oil industry for offshore exploration.

We have the Center for Environmental Assessment Services, located here in Washington, that takes climatic information and makes various assessments, particularly in the area of crop yields, crop forecasts and for heating demands for the gas industry.

Finally, we have the Environmental Sciences Information Center, which is a library and referral service, and, again responding to Mr. Brown's question, would provide a place where persons who want environmental information can go and be referred to both digital information as well as documentary information.

I point out in my testimony, Mr. Chairman, several pieces of legislation for which EDIS has certain responsibilities. I don't know that I need to go through them. But they include the Pollution Act, the Ocean Dumping Act, the Climate Act, the Clean Water Act, and a variety of others. But in each case the Environmental Data and Information Service has a role to play.

One area of support to research is in our efforts in conjunction with the Department of Agriculture, the Department of the Interior and NASA in the program we call AGRISTARS, Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing. In this effort we are assisting in applying environmental satellite data and other climatic and weather information in order to assist in developing what we call crop warning conditions and to develop yield and production models for crops both here and abroad.

In order to carry out its responsibilities, one can understand, as Dr. Knauss said, substantial computer capabilities are required, and we are in the process of looking at the computer capability needed to tie our centers together and to be able to respond more directly from any entry point to the environmental requests made by users. EDIS maintains liaison persons in five geographical areas of the country, Anchorage, Seattle, La Jolla, Calif.; Woods Hole, Mass.; and Miami, to assist people needing access to environmental information.

In addition, we're sponsoring, on an experimental basis, what we call Regional Coastal Information Centers, one at the University of Rhode Island, one at the University of Michigan, and one at Oregon State University. These, too, are access or entry points for information on a regional basis.

Another area of interest in climate is that we are providing services to 42 State climatologists, and have arranged that they can get modest support without charge from our National Climate Center.

Very quickly, Mr. Chairman, to kind of summarize the activities of the two of the four units for which I am responsible, I do point out that our efforts are not in basic research. We look to ERL and to industry and to academia for that work. But we do do applied research and development on our part.

We would be happy to respond to questions, sir.

Mr. AMBRO. Thank you very much for a fine and comprehensive statement, so much so that I think we've added AGRISTARS to our list of acronyms, which was missing before.

I wonder if you, Dr. Hallgren, would like to add anything before our round of questions. Do you want to say something?

Dr. HALLGREN. No, sir. We are prepared to respond to any questions you put to Dr. Owen.

Mr. AMBRO. Thank you.

Dr. Potter?

Dr. POTTER. No, sir.

Mr. AMBRO. This subcommittee, Dr. Owen, has been somewhat agitated over the progress of the so-called National Climate Program. You say in a key response to the National Climate Program Act you've done a number of things. You talk about the National Weather Service's Climate Analysis Center, which produces monthly and seasonal outlooks.

I wonder if you could tell us about the Climate Analysis Center; how do its outlooks compare with those produced by the EDIS Center for Environmental Assessment Services?

Dr. OWEN. Insofar as the Center for Environmental Assessment, they don't make long range projections themselves in the sense that the Climate Analysis Center does. The Climate Analysis Center statistically examines past climate situations and current situations and, through regression analysis and statistics attempts to indicate what it believes will be the situation for 30 days and for other periods of time. The Center for Environmental Assessment Services takes climatic information and relates that, in the case of agriculture, to crop growth at certain temperatures, certain conditions of soil, moisture, and so forth, and, based on that, begins to make, on a progressive basis, an estimate of yields and of the crop condition. I think the efforts are really complementary.

I would ask Dr. Hallgren to comment first, and perhaps Dr. Potter can add to that, sir.

Dr. HALLGREN. Yes, sir.

The Climate Analysis Center is the primary home within NOAA for making the actual longer range weather predictions, and the assessments are made in the Environmental Data and Information Services to what impact they may have on particular areas.

The Climate Analysis Center is trying to provide services to major activities, such as agriculture, as a whole on a long-term look. They'll be trying to develop in the next year or two initial types of services toward water resources as well, and they will also be trying to develop services in the energy area.

Mr. AMBRO. I suffer from the strange feeling that while we may have bits and pieces in the National Climate Program, we don't have an overall plan.

Do you think I'm right, or do you think I'm wrong?

Dr. OWEN. No, sir. I think you are well aware, I know, sir, of the plan that has been prepared by the National Climate Program Office, and within the NOAA itself we are engaged in almost \$20 million worth of what we would call climate research or climate activity in fiscal year 1980, and I think that, within the resources we have, we have planned the emphasis that we intend to place this year and in the future, and I believe we've taken guidance from the committee in that we are focusing, insofar as possible, on applications and use, on coming around with a better balance, I should say, between research and then applications and use.

Mr. AMBRO. Would you say, then, that the Climate Analysis Center's efforts are well coordinated with the National Climate Program and even the NOAA climate program?

Dr. OWEN. Yes, sir. I am the focal point for coordination within NOAA of the efforts of fisheries, the research and development activity, and those of my own units. I have an office, and we work very closely with Dr. Epstein, who is heading the National Climate Program Office.

Mr. AMBRO. Which is why you've focused on these questions.

Dr. OWEN. Yes, sir.

Mr. AMBRO. I want to switch for a minute to the Doppler and ask you some questions about that.

Is that new technology, in your view, or has that technology been around for a while?

Dr. OWEN. Dr. Hallgren can answer the details.

The application that is called for here is, I would call it, comparatively new. It's in the analysis of the Doppler return and in how best to present that information so that it can be used by a forecaster; I think is the real development.

Mr. AMBRO. What does relatively new mean? Two years? Five years?

Dr. OWEN. I would say within 5 years. I would defer to Dr. Hallgren.

Mr. AMBRO. All right.

Dr. HALLGREN. We had our first insight into the value of Doppler radar in terms of severe weather between 5 and 10 years ago. But the intensity of the research really developed in the mid-seventies, and it's been over the last few years that we have fully recognized some of the very important applications of the Doppler radar to weather phenomena, particularly in the tornado area and understanding mesoscale circulations, which includes thunderstorms.

So we have had, I would say, over the last 3 years a good awareness of the capability of such a system. In the last few years we have been

developing the display type technology that is needed. It's a far cry whenever you say that you have something that's proven in research to the point where you can say it is now ready for operation in the field by a very large number of people, who are not highly sophisticated scientists in interpretation. The translation has been taking place in the last few years.

Mr. AMBRO. What translation? Are you suggesting that you made the judgment that it was ready for operational use a couple of years ago?

Dr. HALLGREN. I made the judgment—a number of us made the judgment—that the value of it was such that we should move toward the operational stage. But at that time——

Mr. AMBRO. When?

Dr. HALLGREN. About 2 or 3 years ago. But at that time we did not have the display type of capability that is required really to put it into operation, and we still have some more development to do on that display type technology.

It was about 3 years ago that we established a joint project between the Air Force, the FAA, and NOAA to move forward in the display area and get ready for the final developments to go into operation.

Mr. AMBRO. Let me understand this.

We are not, then, at the point where the figure of 100 installations or \$1.5 million is either accurate or feasible if you had the money immediately. Is that what you're suggesting here, that there's still more work in the display area to be done in order to make these systems operational throughout the Nation? Is that what you're saying?

Dr. OWEN. Mr. Chairman, we have established a Joint System Project Office, staffed jointly by the Department of Defense, DOT/FAA, and NOAA, to prepare the specifications and procurement plans for what we call the next generation radar, and we hope that we will be able to actually commence procurement of the prototype in 1982, with delivery of the prototype in 1984.

So there is activity leading to what will be, to a degree, a performance specification, and there is some still remaining development to do to get us to an operational hardware capability.

Mr. AMBRO. How many units would your performance specification call for? One, two, five? Do you have any idea?

Dr. OWEN. Number of radars?

Mr. AMBRO. Yes.

Dr. OWEN. Insofar as NOAA is concerned, ultimately, by the end of the decade, we would hope to have replaced our portion of the national radar network, namely, at least 56 on our part. But the numbers that you hear tentatively represent the needs of the FAA and the Department of Defense as well.

Mr. AMBRO. The hundred?

Dr. OWEN. Yes, sir.

Mr. AMBRO. If we're talking about 1982 and on-line 1984 for prototypes, how realistic is the \$1.5 million figure?

Dr. OWEN. That's per unit.

Mr. AMBRO. Yes.

Dr. OWEN. That is an estimate arrived at jointly by a team representing the three agencies of which I spoke with their best estimate of what the hardware costs would be of operating equipment.

Mr. AMBRO. So that could change radically, depending upon the particular variety.

Dr. OWEN. Yes, sir.

Mr. AMBRO. Are tornadoes, in your view, a national or a regional phenomenon?

Dr. OWEN. Generally they're regional; occurring in the Midwest, in the South, Texas, Oklahoma, Mississippi, Alabama; further north in the Midwest up into Iowa and Ohio on occasion. But they are generally a regional phenomenon because they are formed by weather patterns that meet in those areas, deriving from the west coast in one case, and off the Gulf of Mexico in the other case. That's where generally those weather systems meet and generate a tornado potentiality.

Mr. AMBRO. What was your figure you used, exclusive of Defense and other agencies, for the installation of these Dopplers? Fifty-six, is that what you said?

Dr. OWEN. Yes, sir. We would plan to replace ultimately our 56 national network radars, and I have to ask Dr. Hallgren about our local warning members.

Dr. HALLGREN. Could I just rephrase it slightly?

What we are trying to do, the three agencies together, is to put a plan together that would give national coverage, and the exact number of radars required will depend on exactly what area, based on their development, that each one will cover. In general, the best estimate at this time is it's going to take in the vicinity of just slightly less than 100 radars to give full coverage east of the Rockies and limited coverage in the Rocky Mountain area.

Mr. AMBRO. So 44, if we use the figure of 100, would be used for more than one purpose?

Dr. HALLGREN. Yes, sir.

Mr. AMBRO. You see no inconsistency there, when you think about comprehensive coverage? What's the entire system going to cover?

Dr. HALLGREN. The number of systems?

Dr. OWEN. No. Total coverage. If you had the 100 would that give you entire coverage of the area you indicated?

Dr. HALLGREN. Yes, sir. That's the best estimate at this time, sir.

Mr. AMBRO. There is no priority use assigned to the other 44 that would inhibit the anticipation of tornadoes and other occurrences if the total system included the 100?

Do you follow me?

Dr. HALLGREN. Not totally.

Dr. OWEN. I think what the chairman would like to know is—and there are two parts to the question—in what priority would you install them? Would you install them in hazardous areas, and then, once you had the coverage, would you have a reasonable expectation of total warning capability?

Mr. AMBRO. Yes.

Dr. HALLGREN. Yes: with roughly the 100. I'm not trying to tie to the 56 because I'm saying that we will locate these radars based on the expected effective coverage for the Doppler-type capability, and the best estimate is about 100 radars are required to give adequate coverage for those areas that do experience significant severe weather, including much of the Middle Atlantic States and southward and westward out to the Rockies.

I believe that's what you're asking.

Mr. AMBRO. My last line of questioning:

How does the Weather Service determine what basic research would be useful to its mission?

Dr. OWEN. May I respond first, Mr. Chairman?

Mr. AMBRO. Yes.

Dr. OWEN. I've had the opportunity to observe both the Weather Service and the Environmental Research Laboratories, and have seen the interaction that does take place. In my visits to Boulder I've seen a variety of initiatives underway to meet the need for new observing systems, very sophisticated ones, that would enhance substantially the capability of the Weather Service.

The Geophysical Fluid Dynamics Laboratory at Princeton is involved in atmospheric modeling that will enhance our capabilities at the National Meteorological Center. These other centers that I've mentioned, the Severe Storms Research Laboratory at Norman and the Hurricane Experiment Laboratory in Miami, all of them have focused on Weather Service problems, and in return the Weather Service people have made their needs and problems known to the ERL, as well as to the elements of universities.

Mr. AMBRO. How do they, in fact, convey their needs? How do they make them known?

Dr. OWEN. Principally by visits and discussions.

I would ask Dr. Hallgren to respond specifically, sir.

Mr. AMBRO. Is there a formal structured arrangement for doing that, or is it just sitting down and chatting?

Dr. HALLGREN. No; we do not have what I would consider a very formal structure that says at certain times that you will transmit exactly what you need. We work in the individual areas, as Dr. Owen was just referring to, and there are specific developments that we need. For example, we need better soundings of the atmosphere. We work very directly with the Wave Propagation Laboratory to tell them what our needs are, and, in turn, work in a very collaborative way as to how they might go about meeting those needs in the future with more advanced remote sensing systems.

We work in a similar way with the National Severe Storms Laboratory on what are our basic forecast problems, and then, in turn, work with them on individual projects that are aimed at understanding convection in the atmosphere from which tornadoes and thunderstorms are spawned, and participate in their projects. For example, for the SESAME project that Tom just referred to, we were very deeply involved in working out the plan for that project and in the execution. While the mainstream of research is done by ERL, some of our people are doing research, but it's much more applied, trying to translate early research in operations.

We've worked with all the individual labs. The National Hurricane Center, is colocated with the Research Laboratory, working on hurricanes, and they work on specific requirements, what the problems are in the hurricane forecasting end of the business, and, in turn, they are doing development work in support of our needs.

Mr. AMBRO. But the arrangement is rather informal and non-structured.

Do you think that's a workable, and feasible, and beneficial kind of arrangement?

Dr. OWEN. Mr. Chairman, we are examining that situation within NOAA. We do not have a structured situation such as exists in the Department of Defense. The assistant administrators have discussed a more formal procedure to follow in connection with research requirements and response thereto, and we have not arrived collectively at a formalized system. But it is a matter of interest that we are pursuing.

Mr. AMBRO. I'm not suggesting that in this kind of atmosphere in dealing with research laboratories of this nature that there should be a more structured arrangement. I'm just asking whether or not it's being examined, and whether there would be some benefit in setting up a more formal arrangement. But I think your response is fine.

I would like to turn to my colleague from California, Mr. Brown.

Mr. BROWN. Mr. Ambro, I'm sorry that I was out of the room when Dr. Owen made his statement.

I would just like to observe, which I'm sure everybody knows, that I'm very deeply interested in all of the subject matters that he testified on, and am continually fascinated by the progress that you're making.

The general thrust of my observations in the past, and probably in the future, generally has to do with whether you're moving ahead with the improvement of your various systems, both the ocean and the atmosphere, at a reasonable pace or as reasonable as the technology allows, and if you're being adequately integrated. I'm thinking here particularly of the complex data systems which you necessarily have and the increased consideration that is being given to improving the utility of these systems to the user community of all kinds, making the data more broadly available.

I don't know quite how to narrow this down to specific questions. You have probably commented in a general way in your statement, but maybe you could repeat for me your own capsule analysis as to whether or not you are being unduly restricted in the acquisition and deployment of new systems, such as the Dopplers, the computers, the ocean buoys, the satellites, and so on, that you operate because of a lack of resources, or do you think that you're moving ahead in accordance with a reasonably adequate plan to continue to upgrade your systems?

I know that's a very broad question.

Dr. OWEN. Sir, I'll attempt to answer it.

In your absence, sir, I did try to respond to the points that you made about data and information systems. But, going to the more general question, I have to be frank to say that we all have to pay attention to the resources, and when we develop capabilities useful in surveillance, for example, such as a radar, we have to recognize that a radar is limited in area and you have to have a lot of them in order to do the whole job, and then it becomes a case of real resources, and that's true of any pieces of equipment that generally the Weather Service will use.

We'll never be able to replace ground equipment entirely with satellite observations. We're moving to capitalize on satellites as fast as we can.

I think, in general, that the Weather Service is conscious of what its equipment needs are, is moving toward the acquisition of the equipment that is needed, and the big question is a systems examination, in order to carry out its job, of how these should be geographically located, and how many accordingly are needed in order to do the job to maximize service at minimum expense, and in some cases, as in the potential radar acquisition, big money will be involved over a period of years.

Mr. BROWN. Is the radar system going to be the most expensive type of new technology that you're faced with budgeting for over the next few years?

Dr. OWEN. I believe that to be the case except, of course, for satellites. Satellites are expensive. However, they are very productive, and I think that we are going to continue to have satellite costs that are substantial in magnitude.

I would ask Dr. Hallgren to comment insofar as his view point on that.

Dr. HALLGREN. I would guess that the Doppler radar is the most expensive system, beyond the satellites, as Tom just said. There are other systems that Dr. Owen mentioned for automating surface observations across the country that require significant resources. There are systems to make better use of the satellite data in the field, in conjunction with the radar data and the conventional data, costing significantly less than the Doppler radar system, but it will involve significant resources whenever we move forward with a plan to implement. Those are a couple other examples of systems less costly, but still requiring significant resources.

Mr. BROWN. One area that seems to be on a curve of declining unit cost seems to be computer systems. That is, the storage capacity, the processing time, and so on, are getting cheaper.

Is this making your job a little easier?

Dr. OWEN. Yes, sir.

I can comment to two areas.

I indicated in my testimony that the National Meteorological Center needs extended computer capability to be able to accommodate to all the observations that are coming from surface, but principally from satellites, and they really pump it out. When we launched the second polar orbiter the data stream really increased. So we are looking to acquisition of a greater capacity there.

In the Environmental Data and Information Service we are doing the same thing to meet the kind of objectives that I believe you had in mind when you posed questions to Dr. Knauss.

Mr. BROWN. Thank you, Mr. Chairman.

Mr. AMBRO. Thank you, Mr. Brown.

I would like, before I turn to Mr. Walker, to welcome and recognize some of our counterparts from down under, our close allies in Australia, with us today, after having met with the chairman of the full committee, Sir Geoffrey Badger, who is the chairman of the Australian Science and Technology Council; Dr. Roy Green, who is the secretary of the Australian Science and Technology Council; and Dr. Jim Whitten, who is the counselor for scientific affairs at the Embassy in Australia. Gentlemen, welcome. We are delighted to have you with us.

Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

A little while ago, I think when Dr. Hallgren was responding to Congressman Bowen, you got into the National Weather Service, and maybe I misunderstood. I thought you were pursuing a line of questioning there with regard to the agricultural tie-in to that.

Do I understand, from past testimony, that at some point you do want to give more extensive coverage to the agricultural kind of needs as part of NOAA weather radio at some point in the future?

Dr. HALLGREN. On NOAA weather radio, depending on which area you're in, we do put some agricultural forecast information. We know that NOAA weather radio cannot serve all users simultaneously, or they'll all be unhappy because they'll have to listen too long to get what they want. We have to concentrate it primarily on the public. But in agricultural areas, where many of these listeners are farmers, we do put agricultural information on it.

We will try to do a better job on a selective basis in that way, but also intend to use improved systems in the future, like Dr. Owen was referring to, in which you can get on demand what you need as a farmer.

The information which I was referring to earlier was the Now Cast, in which NOAA weather radio has a certain level of capability to provide detailed information on the short period. That would be useful to all users, including agriculture.

Mr. WALKER. So there is not a problem at this point with regard to funding or research data coming in in terms of getting additional information out to farmers through the Weather Radio Service?

Dr. OWEN. Mr. Walker, I recently examined what I believe was a General Accounting Office report. It was a survey on how farmers obtain weather information, and it surprised me at the number who did not evidence much of an interest, but, on the other hand, there were a number who did.

I believe in the planning for the structure of the Weather Service in the years ahead this question of how best to provide service to the farmer is a major consideration.

There are a variety of ways that it is done now. I have to be frank to say that our principal agricultural coverage is in the Midwest, the South and, with the consideration of the fruit problems, in California and in Florida principally. We're never satisfied with the amount of service that we can extend to agriculture, but there has to be a balance, and the Weather Service is really considering that situation at the moment in how it views its structure.

Mr. WALKER. I guess I'm trying to encourage you to move in that direction as well because it's been at least my experience that my farmers, who have been frustrated for some time about calling the Harrisburg Weather Station and not being able to get updated information because they found busy phone lines, and so on, since Weather Radio has gone into our area I have not had that kind of communication from the farmers saying that that's a problem for them any longer because that service is available.

Insofar as you can get more detailed information out there, if you need additional research, and so on, to get more detailed information out there I think you'll serve that community even better and you will

have an even more productive benefit from it insofar as the farmers, at least in my area, are concerned.

Dr. OWEN. I understand, sir.

Mr. WALKER. The other thing that I wanted to just follow through on to make certain we get it on the record is with regard to the Doppler radar.

Would you supply us for the record specifics as to when the Doppler radar units are to be procured, when and where they are going to be installed, and what projected costs we are going to have for those units? Can we get that information for the record?

Dr. OWEN. Yes, sir. Insofar as our plans are, we can do that. This is all in the process of development by our Joint System Project Office under a project leader that reports to Dr. Hallgren.

Mr. WALKER. Mr. Winn, from Kansas, as well as I, has been particularly interested in this I know, and I think that having that on the record would be a good thing to do.

Dr. OWEN. I understand, sir.

[The information to be provided follows:]

DOPPLER WEATHER RADAR

Weather radar is the principal tool for detecting and warning of tornadoes, severe thunderstorms, and flash floods. NOAA, the U.S. Air Force and the Federal Aviation Administration have operated a joint project since 1977 to explore the potential application of the Doppler principle to weather radar. The joint program has clearly demonstrated the concept of Doppler weather radars and established that such radars will make dramatic improvements in warning timeliness and accuracy. Results obtained with laboratory Doppler radar equipment show that warning lead times of 20 minutes or more are possible for large tornadoes compared to average lead times of a minute or so with present conventional weather radars. Similarly, false alarms from unnecessary warnings are reduced by two-thirds from more than 50 percent to less than 20 percent.

As a result of the successful joint R&D program, NOAA, DOD and FAA have proposed a national system of Doppler radars that will make this new technology available to meet public, aviation and military needs at the lowest possible cost. A joint systems project has been established to plan such a national system, manage the final development work, and procure and install the radars. Current planning calls for operational system definition to be completed in 1981, competitive development by industry in 1982 and 1983, limited production to begin in 1984 and full-scale production late in 1985 or early 1986. The entire national system would be completed by 1989.

With the joint R&D program having already demonstrated the concept, a recent multiagency review concluded that even though considerable development work remained to transfer this new technology to an operational system suitable for use by civil and military operating units, there was very little technological risk involved. The hardware technology is well established and most components are available "off the shelf." Computer programs that will reduce the radar data to signature identifications are the major development step remaining.

The new Doppler radar sites will be determined as part of the system planning and definition phase in 1980 and 1981. The new radars would supplant aging civil and military conventional weather radars in a carefully designed system that would meet most civil and military requirements in a cost-effective way. Considerations such as severe thunderstorm threat and locations of metropolitan areas, communities, and civil and military airfields will go into the analyses of siting tradeoffs.

The proposed national system of Doppler weather radars is under review by the Office of Management and Budget as a new program start in the FY 1981 Budget with funds requested for initiation of final development. As proposed by DOC, DOD and FAA, there would be subsequent decision points in FY1982 when added funding would be required to initiate competitive development by industry, in FY 1984 when funding would be required for full-scale development and

limited production, and in FY 1986 when full funding for production and installation would be requested.

Preliminary estimates of the agencies involved in the joint program are that production radars may cost as much as \$1.5 million each installed with spares and training for operators and technicians. The national system would require between 100 and 128 radars in the 48 contiguous states and DOD needs 32 more for its overseas bases.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. AMBRO. Thank you, Mr. Walker.

Gentlemen, I would just like to engage in one more line of questioning and that has to do with, I think, your testimony on page 22, where you said, Dr. Owen, that: "The EDIS computer system must provide the ability to (1) quality control and store increasingly large volumes of environmental data * * *"

Maybe I don't understand it fully, but it seems to me that once out of the hands of the researcher and into the computer all data looks alike, and I think we need a human equation at the end of the process to discriminate the data which gushes forth from these computers.

Do we agree that quality control is an undertaking that is best left to human endeavor?

Dr. OWEN. Quality control, insofar as the input, I believe the answer to that is yes, sir.

Mr. AMBRO. How about insofar as the output? How do we propose, for example, to incorporate quality control in the computer, both with respect to input, which is a human undertaking, and output? What do we do with all of the data that's pouring out? How do we discriminate it to provide meaningful kinds of information to end users?

Dr. OWEN. All right, sir. Let's take climate, for example. What we hope to do there is to provide, as a result of withdrawal of data, stored data, analyses or assessments of particular interest to certain sectors, either in the Federal or public, that would be meaningful, and some of this can be done internally; some will have to be done by external people drawing on that information, with our assistance.

I would ask Dr. Potter to comment more fully on how in his organization he is doing and how he plans to enhance his capability insofar as useful information output and quality information and data.

Mr. AMBRO. That's fine. I'd like to hear from Dr. Potter because then we can chat a bit about whether or not you have qualitative standards with respect to input and how you determine which will be stored and which will be discarded, and things of that nature. If you would comment I would appreciate it.

Dr. POTTER. Yes, sir.

We have sponsored over a period of years, a series of user workshops where we involve the representatives of the user community in terms of stating to us what their requirements are. So we have a continuing interaction with users in the series of workshops that we've had over the past several years in the use of climate data, climate and health data, the satellite data in cooperation with the Environmental Satellite Service, and so forth. So we have a good indication from the users themselves exactly what kind of information they need.

With respect to the quality control on the input, we've worked with the National Weather Service and the other providers of the information and, in addition, do some of the quality control in our own proc-

essing centers, where it is both a combination of manual effort to look at those data as they're entered and, insofar as we can automate it in order to save manpower, do it by machine.

On the output end, we are most concerned with the process of interpreting that kind of data so that it can be given to the users in a form that's useful to them in a timely fashion and at a reasonable cost. That, in my opinion, is the most difficult—it's the most important, but it's the most difficult—aspect of our entire activity, being able to take the output and provide it to users on the outside in formats which they can find useful.

We are taking steps to improve our internal capability from the standpoint of improved automation and also to improve the capability to interpret that information so that we provide it to the users in forms they can use.

Dr. Owen previously gave two examples where we are doing that, in the area of taking climate and temperature information, along with crop yield information, to provide to the USDA some estimate, both in this country and in other countries, of what the crop yields will be.

Mr. AMBRO. Consider this: During the first 3 years if intensive effort would be dedicated to processing, with the huge backlog of dispersed data filed, containing nearly 2 billion observations, I guess you would have to automate that.

Dr. POTTER. Yes, sir.

Mr. AMBRO. But how do you automate quality control? Two billion around here, as applied to dollars, is very easy to deal with. We do it all the time. But when you're dealing with 2 billion observations how do you discriminate it, if that's the right phrase? How do you handle that? It's mind boggling.

Dr. POTTER. Yes, sir, it is for us as well. We discriminate on the input side by determining from the users and from our own information what the output requirements are going to be and hence what data we will process through our system. In other words, we don't handle all the data that comes out of all the observing systems that are possible. It's simply not possible for us to do that. But in order to get a handle on what the trends have been in climate over the last tens, in those cases where we have long-term observational records, we need to process the previous historical data that have been gathered over the years.

Mr. AMBRO. Let's say that's a set of criteria or a category. Do you have qualitative standards that are developed to be used in determining which data should be stored and which should be discarded?

Dr. POTTER. Yes, sir.

Mr. AMBRO. Do you have a little man who sits there and makes decisions as to the value of a given set of data among the 2 billion that come in? How do you do that?

Dr. POTTER. The 2 billion is a number that represents the historical gathering of data over long periods of time. Not all of those have been automated, as Dr. Hallgren explained. With the introduction of the AFOS system we will then have immediate digital data that we can process through our system through the computers.

Mr. AMBRO. I just used that to be dramatic.

Dr. POTTER. Those that are necessary to be put in digital form will have to be keypunched or otherwise read by automatic reading equipment, which translates various forms of observations into digital form and they're processed through the system.

But first before that's done, a determination is made, from our knowledge of what the users want and what we see down stream, as to which data are put through that rather expensive process, to be put into a form that can be handled digitally.

The other forms of the data are put into microfiche form and are then readily available in augmented forms to the users.

Mr. AMBRO. And you're satisfied that the computer, then, has the capability to be interdisciplinary in terms of output?

Dr. POTTER. Not by itself, sir. We only use the computer as a tool to be able to handle the massive amounts of data that are already existing in the historical record and that are pouring forth from various sensors.

Mr. AMBRO. How long does a process like this take?

Dr. POTTER. To be able to handle the 2 billion?

Mr. AMBRO. Yes.

Dr. POTTER. We think we can handle the essential elements——

Mr. AMBRO. One hundred years?

Dr. POTTER. To do the job? No, sir. I'm thinking in terms of a catch-up period of 3 to 5 years.

Mr. AMBRO. What kind of personnel, in terms of numbers, would you need?

Dr. POTTER. We believe that we can do it with the existing personnel that we have at the National Climatic Center.

Mr. AMBRO. Is that right?

Dr. POTTER. Assisted by other elements within the federal system. We are cooperating with the Department of Defense and with NASA and with other organizations that also have large volumes of data.

Mr. AMBRO. And you do think you can do it with the projected level of funding, with no increase over the next 3 or 4 years?

Dr. POTTER. I'll defer to Dr. Owen.

Dr. OWEN. My comment there, sir, is that we are in the process of preparing this proposal—you'll note in my testimony I call it a proposal—and we will be indicating to this committee and to the Appropriations Committee in future years what the cost will be. In order to get "on the step," and to pick up and to put into computer or microfiche storage this tremendous amount of data that has accumulated over the years it will cost some money, and the amount we will be proposing.

Mr. AMBRO. We have learned something. It obviously will be minimal because you'll be using existing personnel.

Dr. OWEN. Insofar as possible.

Mr. AMBRO. This is most fascinating. I could get into a lot more, but it's 4 o'clock.

I would like as well to have your consent to provide you with written questions, and receive your timely responses, so that we can round out the record.

Dr. OWEN. We would be happy to do so, Mr. Chairman.

[The information to be provided follows:]



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md. 20852
OA2:SP

JAN

DATE JAN 24 1980 DOC# _____
AIDE: _____ REC# _____
CATS: _____
PARA: _____

Honorable Jerome A. Ambro
House of Representatives
Washington, D.C. 20515

Dear Mr. Ambro:

In response to your letter of December 4, 1979, I am pleased to send additional information regarding activities of the National Weather Service and the Environmental Data and Information Service. As agreed during my testimony on November 14, I am enclosing information on NOAA performance in reacting to Mississippi floods (Enclosure 1). Information on the schedule for procurement and installation and the projected costs of Doppler radar units by National Weather Service was submitted earlier and inserted in the hearing transcript following page 69.

Answers to your additional questions for the record are in Enclosure 2.

Sincerely yours,

T. B. Owen
Assistant Administrator
Oceanic and Atmospheric Services

Enclosures

NOAA PERFORMANCE IN REACTING TO
MISSISSIPPI FLOODS

Record flooding occurred in the Pearl River Basin following extreme rainfall of as much as 20 inches total on April 11 and 12, 1979. The greatest damage occurred in the Jackson area.

Flood forecasts for the Pearl tributaries upstream of Jackson and the Pearl below Jackson were good to excellent -- within one to three feet. But at Jackson we did not give the public an accurate early forecast of the magnitude and timing of the flood crest, although we did give early warning of a record breaking flood.

There were three primary sources of uncertainty during this flood. First, the actual areal extent and timing of the rainfall was not well defined from the available rainfall reports. Second, we did not know early in the flood how water would be released from the reservoir. Third, we did not have the latest information on the hydraulics of the river channel at Jackson.

We have completed an in-house disaster survey to examine in detail our performance, our relationships with the public, and our coordination with other government agencies. Our report should be published in a few weeks. It presents detailed findings with recommendations to improve our service.

We have already taken the following steps:

- o In cooperation with the Corps of Engineers, the U.S. Geological Survey (USGS) and local interests, the data networks are being improved by automating gages and adding more rainfall and streamflow gages;
- o A data interrogation and read-out system is being provided at WSFO Jackson;
- o Responsibility for flood forecasts at Jackson has been reassigned from the local weather station to our Lower Mississippi River Forecast Center at Slidell, Miss., where improved and more detailed forecast procedures are being developed and can be operated;
- o Improved lines of communications have been established between NWS, USGS, Corps of Engineers, and local interests. We have improved procedures to give inflow forecasts to the operator of the reservoir above Jackson, and we plan to coordinate these with the USGS. We have established improved relationships with the reservoir operator so we can know what the future releases will be. Finally, we will advise the Corps of Engineers of future flood forecasts and will seek their advice to assure the public of a single, coordinated forecast.

ADDITIONAL QUESTIONS FOR THE RECORD

National Weather Service (NWS)

Question 1a. What role does the Weather Service have in assessing when a particular project is ready to move from the research to operational stage?

Response: The National Weather Service plays an important continuing role in the total assessment process that a research project undergoes as it progresses from the research stage to the operational stage. In making the decision on whether or not an R&D project is ready for operational implementation, the National Weather Service requires that the following be demonstrated:

- (1) Operational requirements are met
- (2) Service capability is enhanced
- (3) Stable operation in an operational mode
- (4) Cost effective in funds or personnel

If the project involves implementation or deployment that requires additional resources, a budget initiative is prepared and started through the regular budgetary process.

Question 1b. Does NWS have any input to the way an ERL research program is proceeding -- specifically with respect to how useful the program will be for NWS purposes?

Response: NWS input to on-going ERL R&D projects is generally informal, and although occurring at all levels, is most common at the working level where interaction is frequent. Major projects such as Prototype Regional Observing and Forecasting System (PROFS) and Next Generation Radar (NEXRAD) have a more formal management structure designed for agency-wide and multi-agency management and review, respectively.

Question 1c. What role do you think would be appropriate?

Response: The present system for assessing operational readiness of a research project has been effective, and continuation of the present modes of cooperation is appropriate.

Question 1d. How does the Weather Service determine what basic research -- whether conducted by NWS or by the ERL'S -- would be useful to its mission?

Response: Research directed at improving all phases of the forecast and warning programs is considered essential to the National Weather Service in meeting existing and changing user requirements. Specifically, research that will improve the National Weather Service's forecast and warning programs through better prediction capability, better forecast and warning dissemination methods, and more effective data acquisition, processing, and analysis is useful in accomplishing its mission. Further, research efforts must lead to improved quality of performance as well as greater efficiency through lower costs and better use of personnel resources.

Enclosure 2

Question 1e. How are these needs conveyed to the researchers?

Response: The functions of the Weather Service are widely known within ERL as well as NWS, and most of the needs are apparent to researchers. Specific needs for applied research are identified and articulated by in-house NWS elements who are closely identified with the operations, and these groups in turn seek advice and assistance from persons with appropriate expertise in ERL.

Question 1f. Do you believe the ERL programs to be responsive to both the short and long term needs of the Weather Service?

Response: ERL's programs are more basic and long-range oriented than NWS' internal programs, but they do support both short- and long-term needs. Much of the contribution to short-term needs results from anticipating the need for new results as part of a long-range effort rather than pursuing a program dedicated to the particular short-term problem. Sometimes the success of the research effort, e.g., the development of a new technique or system, quickly establishes the need for itself by its very utility.

Question 1g. Can you give us some specific examples of needs defined by the Weather Service that have been addressed by the research labs in such a way that you can point to a tangible end product relevant to the expressed need?

Response: An excellent example of a need already defined by the Weather Service with response from ERL is the development of subjective techniques for forecasting heavy precipitation in association with mesoscale events. This need, expressed by the Director of NWS, after the "Big Thompson" flash flood of 1976 led to an immediate response by ERL. The tangible product of this response was the development of a procedural checklist for forecasters to use in identification of potential flash-flood situations associated with summertime mesoscale convection. The checklist has been disseminated to Weather Service Forecast Offices where it is regularly used. Both the basics and techniques are being taught to forecasters attending the flash-flood training course at the National Weather Service Training Center in Kansas City.

Another important example of ERL response to a requirement of the NWS is in the development of techniques to automate the observation of "current weather," one of the elements of a standard surface weather observation package. During an annual exchange visit between NWS' Systems Development Office and ERL's Wave Propagation Laboratory (WPL), WPL was requested to develop a test laser to identify various hydrometeors. This test laser would be used for gathering data to develop algorithms for detecting snow, fog, rain, etc. Approximately \$150,000 of NWS funds was transferred to WPL and an NWS engineer was assigned to Boulder for about 6 months. After the test instrument was completed in 1977, it was installed at the NWS Test Facility, Sterling, Virginia. The instrument has been the basis of the project for a laser indicator of present weather, and has been proposed to be incorporated into the Automated Surface Observation Program.

Question 2a. You claim that the Automation of Field Operations and Services (AFOS) project, a major undertaking of the Systems Development Office, "will reduce the time between the taking of observations and the issuance of forecasts and warnings to the general public." In light of the fact that criticism of the Weather Service is generally focused more on the accuracy of forecasts than on the timing factor, do you think that automating systems for the sake of time (as opposed to improving the accuracy of the forecasts) is an appropriate use of research dollars?

Response: The three goals of the Automation of Field Operations and Services (AFOS) project are to: (a) improve response time, (b) improve productivity, and (c) effect economy in operations. The requirement for improvement in response time refers more to weather warnings than to routine day-to-day forecasts. It is in this part of our service that minutes can be extremely valuable in the protection of lives and property.

Criticism of our efforts has been related both to the accuracy of forecasts and to the timely dissemination of forecasts and warnings -- especially in severe weather events. We believe that research and development in both areas is essential to better service.

Question 2b. Don't you also have a problem with "overwarning" related to severe weather conditions?

Response: We do have a problem with overwarning. This problem will be reduced only through better observing systems, such as Doppler radar and more precise short-term forecasts. Most of our research and our expression of research needs to Environmental Research Laboratories deal with improvements to weather forecasts and to the development of better observing systems required for better forecasts.

Question 2c. How do NWS research programs reflect these two important problems, both of which are questions of forecast accuracy and not dissemination?

Response: While AFOS has not been directed to the development of better forecasting techniques, it does bear on that problem in two ways (other than the response time cited). Both relate to our productivity goal. The system is designed to relieve the forecaster of a number of subprofessional duties and thus free more time for professional duties such as formulation of the forecasts. Further, the formulation of public forecasts is now aided solely by manual techniques. For the first time, AFOS will place local processing capability at the forecaster's disposal to help both in the application of currently available techniques and to provide a higher technology base for introducing more sophisticated results of research and development into our normal field operations. In the latter instances, it provides a means to the forecaster for handling the data and techniques required to offset the first two factors that contribute to overwarning.

This year we are applying about 75 percent of our direct research funds on weather and hydrologic forecasting work. The remaining 25 percent is being applied to equipment development. However, the bulk of the equipment

development work is at least indirectly related to the improvement in forecast accuracy.

Question 3a. It appears that some of the NWS components conducting research have counterparts in the ERL organization. For example, how is research in the NWS National Severe Storms Forecast Laboratory related to that of the ERL Severe Storms Lab?

Response: The Techniques Development Unit (TDU) at the NWS Severe Storms Forecast Center (NSSFC) is responsible for the development, testing, and evaluation of new or improved operationally-oriented techniques used to predict the onset and movement of tornadoes and severe thunderstorms. In contrast, ERL's National Severe Storms Laboratory (NSSL) seeks to understand the basic processes that create and sustain thunderstorms and their manifestations -- hail, heavy rain, lightning, and tornadoes -- and to develop improved techniques for storm observation and prediction. Coordination between TDU and NSSL is maintained by individual researchers through representation on committees working on joint projects such as the Severe Storms and Mesoscale Experiment (SESAME).

Question 3b: Programs of the NWS National Hurricane Center and the ERL National Hurricane and Experimental Meteorology Lab?

Response: The National Hurricane Center's R&D Unit is engaged in applied research (mostly short-term payoff) to develop more accurate methods of forecasting the behavior of hurricanes and tropical storms. Their research is geared specifically to the needs of hurricane forecasters. This function was once provided by ERL's National Hurricane and Experimental Meteorology Lab (NHEML) but was transferred to NHC upon the formation of the NHC R&D Unit in 1971. In general, NWS conducts only applied research and development in direct support of its ongoing programs. ERL's work is more basic R&D; their main concern is to increase understanding of the atmosphere and its processes.

Question 3c. What form does cooperation between these two groups take -- are we talking about Assistant Administrators, program managers, or individual researchers effecting this coordination?

Response: The NHC R&D Unit and ERL's NHEML are collocated and maintain an excellent working rapport. They participate at the working level in joint weekly seminars. NHC provides operational forecasts to NHEML's Hurricane Strike Program. NHEML has offered financial resources to NHC to help them obtain technical assistance they do not have. Coordination takes place primarily at the level of individual researchers and program managers.

Environmental Data and Information Service

Question 1a. You state, "We look to the Environmental Research Laboratories and to the capabilities of academia and industry for contributions to our capability over the longer term." Can you give us some specific examples of ERL research that has contributed to EDIS capability?

Response: (1) National Climatic Center (NCC): ERL research in air pollution modeling has allowed the NCC to be responsive to government and industry needs. Examples of programs in this area are stability (STAR program), mixing height inversion, plume rise, and visibility studies.

(2) Center for Environmental Assessment Services (CEAS): ERL developed specifications and calibration standards for solar radiation measuring equipment, and a site specific clear sky model for solar radiation. These standards and the clear sky model are used by CEAS to process and validate the data.

(3) National Geophysical and Solar-Terrestrial Data Center (NGSDC):

(a) ERL supports the Cooperative Institute for Research in Environmental Science (CIRES) with the University of Colorado to conduct a wide range of research activity including solid earth geophysics and solar-terrestrial physics. The staff of CIRES is available to advise NSGDC on scientific matters and to review their activities to keep them current and useful. CIRES scientists working with the data files at NSGDC regularly advise them of errors in the files and better ways to structure them for users.

(b) ERL has also:

- o developed a scheme for systematic digitization of tsunami mareograms;
- o developed computer compatible data submission formats for marine geologic grain-size data, beach profile data, and sediment geotechnical properties data;
- o developed digital ionosondes and other observational techniques including state-of-art data handling techniques;
- o provided experience for handling digital geomagnetic data, and Solar Terrestrial Physics satellite monitoring data;
- o research on new solar activity measures and indices to modernize their data products;
- o helped in their development of data management plans for the Middle Atmosphere Program;

o provided experts on climate as a resource for developing our proxy and paleo-climate data inventories, bases and products.

Question 1b. Of academic research?

Response: (1) NCC: The techniques and software developed at the University of Wisconsin for the Man-Computer Interactive Data Acquisition System (MCIDAS) will be useful to NCC in data editing and validation.

(2) CEAS:

(a) Massachusetts Institute of Technology developed a transient plume model used by CEAS to estimate patterns of brine disposal in the Gulf of Mexico for the salt dome leaching process to support the Strategic Petroleum Reserve Program.

(b) CEAS worked closely with the University of Missouri in developing crop-yield models. The models were used extensively to support the Joint NASA-USDA LACIE Project (Large Area Crop Inventory Experiment). A similar cooperative effort is underway for the AgRISTARS Program (Agriculture and Resources Inventory Surveys through Aerospace Remote Sensing).

(3) National Oceanographic Data Center (NODC): The University of Rhode Island has developed methods for checking marine bird data before they are sent to NODC. This relieves NODC of this responsibility and permits them to use their resources for processing other types of data.

(4) Environmental Science Information Center (ESIC): The Ohio College Library Center, the Research Libraries Network (university consortium), Stanford University and others, have developed library networks under the National Science Foundation and Council of Library Resources sponsorship.

(5) (NGSDC):

(a) Scripps Institute of Oceanography and the Lamont-Doherty Geological Observatory were key institutions in producing formats for the "Index to Marine Geological Samples" and the MDG77 underway geo-physical marine data. These standard formats greatly facilitate the job of acquiring the data.

(b) The University of Colorado operates World Data Center-A for Glaciology and does studies for EDIS on contract.

Question 1c. Of industrial research?

Response: (1) EDIS; The major contribution to all EDIS from industry is in the development of new technology (hardware and software) for data processing, storage, and retrieval.

(2) NCC: The American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) has worked with NCC in developing

recommendations for the Test Reference Year and their requirements for heating and air conditioning related to energy conservation.

(3) CEAS: EDIS has contracted with Environmental Simulations, Inc., to develop an ecological model to estimate the impact of the initial brine discharge in the vicinity of the diffuser in the Gulf of Mexico, in support of the Strategic Petroleum Reserve Program.

(4) ESIC: ESIC has contracted with industry to assist in the development of a detailed collection development policy to spell out priorities for acquisition and retention of published material in ESIC's library system.

(5) NGSDC: Industrial research has provided new and improved instrumentation and data recording systems which not only provide better data, but also new information.

Question 1d. Is there any formal mechanism to incorporate input from any or all of these in determination of EDIS programs and priorities?

Response: Although there is no formal mechanism for incorporating inputs from such varied sources, each program manager is responsible for increasing program capabilities by incorporating such inputs.

Question 2a. Does EDIS have a set of qualitative standards that are used in determining what data should be stored and what should be discarded?

Response: Yes, but in many instances the standards necessarily involve subjective judgments by EDIS personnel.

Question 2b. If so, how are these standards developed?

Response: The qualitative standards used to determine what data should be stored and what should be discarded are developed by considering:

(1) User needs - location, length of record, time resolution (hourly, daily, etc.), area resolution, data quality and other factors (see question 4 for further details);

(2) Quality of data - for weather data must meet NWS or World Meteorological Organization standards for current observations (these rather bulky standards are available upon request);

(3) Uniqueness of data - do these data fill in a gap in our current files?

(4) Documentation - all data sets must have full documentation on instrumentation, site location and observing procedures;

(5) Availability of resources to do the job;

(6) Effective use of government resources.

We do not and should not attempt to store all available environmental data and information. We do attempt to maintain inventories of where the most important data sets are located and what shape they are in. We cooperate with other Federal agencies (e.g., DOD, USDA, EPA, NASA, NSF and others), with state and local governments, with universities, and with industry in maintaining essential data and information to meet national needs within available resources.

Question 2c. If not, who makes the decision as to the value of a given set of data, and on what basis?

Response: Not applicable.

Question 2d. To illustrate this process, on page 20 of your written testimony, where you're talking about climate data, you say, "During the first three years an intensive effort would be dedicated to processing the huge backlog of dispersed data files containing nearly 2 billion observations." As you go through this particular 2 billion bits of information, what kinds of criteria might be used in the quality control process?

Response: The criteria that will be used in processing the backlog of data at NCC will include:

- (1) User needs
- (2) Quality of instrumentation and observation
- (3) Spacial and temporal resolution requirements
- (4) Data uniqueness
- (5) Estimates of the resource requirements (processing and storage requirements for both the initial addition of data and future updates)
- (6) Availability of resources
- (7) Is this an effective use of government resources?

Question 3a. EDIS has two functions -- (1) information collection, storage and retrieval, and (2) data analysis and assessment. It is our understanding that some 90% of what you do could be characterized as the former kind of data handling and only 10% as analysis and assessment. Are these figures accurate?

Response: Overall, yes, although the percentage devoted to analysis and assessment ranges up to 15% in some years. Also, the rates will vary from Center to Center.

Question 3b. If so, are you satisfied with this division?

Response: No, we believe that more effort should be put into analysis and

assessment because those activities provide more complete and more direct answers to user questions. Also, use of our own data in analysis and assessment will eliminate errors and provide better data bases for use by others. However, until the data bases are processed into easily retrievable sets within a system of adequate hardware and software, the analysis and assessment efforts must remain at about their current level, with the available resources. We estimate that the system for efficiently retrieving and processing environmental data and information will be completed in EDIS in about five years.

Question 3c. Given sufficient authority, would EDIS be capable of doing more data analysis and assessment?

Response: We already have the mission authority to do more analysis and assessment. However, the data management activities (collection, quality control, processing into efficient formats, storage and retrieval) must produce efficient data sets before any significant increases can be made in analysis and assessment.

Question 3d. How would such a shift in emphasis be reflected in EDIS programs?

Response: A shift in emphasis would of course result in more effort being put to EDIS analysis and assessment activities in all Centers. The output would result in more useful products for the user, providing direct, concise answers to questions rather than large volumes of data or large bibliographies.

Question 4a. You note that EDIS has an extensive user community -- how are the needs of users first of all determined?

Response: EDIS has sponsored or co-sponsored several user workshops to determine their requirements (Attachment 1). User needs also are developed by analyzing patterns of specific requests as to the type of information asked for by whom, for what purpose, and so forth. Field offices and State climatologists provide first-hand knowledge of user needs through personal and telephone contacts.

Question 4b. How are the needs of users incorporated in planning EDIS programs?

Response: Program managers ultimately are responsible for incorporating user needs into EDIS planning. Guidance is provided by EDIS and Center Directors.

Question 4c. When data is provided by EDIS in response to a user request, is it accompanied by any kind of qualitative evaluation?

Response: Ordinarily, qualitative evaluations do not accompany the responses because most users are aware of the quality of the data. When assumptions are made in analyses or interpretations of the data, they are clearly identified as assumptions.

Question 4d. Does EDIS have any standard procedure for soliciting input from users on the usefulness of information provided to them?

Response: Currently, EDIS does not have a standard procedure, although user evaluations are obtained. Two Centers, NODC and ESIC, routinely send requests for user evaluations with their information transmittals. The other Centers rely on feedback from users at conferences, workshops, and/or personal contact for user evaluation. A uniform procedure is now under development as part of the new EDIS program evaluation system.

Question 4e. If not, why not?

Response: Not applicable.

Question 4f. If so, what are some typical responses?

Response: An overwhelming percentage of the responses are positive. Typical examples of positive and negative comments are:

(1) (Positive)

(a) "It was accomplished exactly as requested and in an extremely timely manner."

(b) "I want to thank you for going to the extra lengths of passing degree day information to me over the phone last week...You helped out in a project for the U.S. Department of Housing and Urban Development that was under some time pressure, so your timely assistance was appreciated."

(c) "The speed and efficiency with which our requests were processed were so exceptional I felt that a comment on our part was necessary. It's good to know that a government agency can be so responsive."

(d) "Again, we thank you for your very courteous and professional assistance."

(e) "As you can see, we are optimistic that this slide series is going to be a "winner" and enthusiastically accepted in all disciplines. Without your slides this show would not have been a reality. Please accept a copy of the set and commentary as our way of thanking you."

(f) "I appreciate the account and the many other cooperations and I congratulate you on the unparalleled services and courtesies provided by NCC."

(g) "My thanks to you and your staff for all your assistance."

(2) Negative

"You sent 43 copies instead of 44."

User Workshops

Climatological Data Users Workshop	April 1976
National Solar Energy Workshop	May 1976
Climate and Health Workshop	June 1976
Climate Diagnostics Workshop	November 1976
NESS/EDIS Satellite Data Users' Workshop	March 1977
Climate Diagnostics Workshop	October 1977
Climate and Fisheries Workshop	March 1978
Natural Hazards Data Workshop	April 1978
Conference on Climate and Energy: Climatological Aspects and Industrial Applications	May 1978
Solar Terrestrial Influence Workshop	July 1978
Annual Meeting of American Association for State Climatologists	October 1978
Climate Diagnostics Workshop	November 1978
Paleoclimate Data Management Workshop	November 1978
Climate and Architecture Conference	February 1979
Climate Data Management Workshop	May 1979
Annual Meeting of American Association for State Climatologists	October 1979
Oil Spill Modeling Workshop	November 1979

Attachment 1
(to Question 4)

Question 5a. Regarding an operational Landsat program -- assuming NOAA were given lead responsibility for such a satellite remote sensing system, what changes would be required of EDIS?

Response: On November 16, 1979, the President assigned to NOAA the management responsibility for civil operational land remote sensing satellite activities. NOAA is preparing a plan to assume this responsibility in addition to our ongoing atmospheric and oceanic remote sensing satellite activities. This implementation and transition plan, coordinated with other appropriate agencies, is to be submitted to the Executive Office of the President on June 1, 1980. The plan will cover:

- (1) A Program Board to be established and chaired by the Department of Commerce for continuing Federal coordination and regulation with representatives from the involved Federal organizations.
- (2) Organization for management and regulation
- (3) System financing including pricing policies for the users sharing of costs
- (4) Technical programs
- (5) Establishment of private and international participation
- (6) Identification of facilities (including the Earth Resources Observation Systems data center), hardware, and personnel that should be transferred
- (7) Identification of actions such as executive orders and legislation required.

Until this plan is completed and approved, we cannot state what changes would be required of EDIS when NOAA initiates its operational role for land remote sensing from space. If NOAA undertakes, itself, to archive and disseminate land remote sensing data, EDIS undoubtedly will play a major role in this function. If other agencies share in this function, EDIS may be called upon to manage and coordinate the activity on behalf of NOAA to assure that program objectives are met. If some or all of these functions are assumed by the private sector, EDIS would be a candidate to contribute to NOAA's planning in this important area, and to provide oversight and regulation of the archival activities.

Question 5b. Are any new authorities or large capital expenditures required?

Response: The need for any new authorities or large capital expenditures will be established when the above-referenced plan is completed.

Question 5c. Ceiling limits?

Response: The need for any new ceiling limits will be established when the above-referenced plan is completed.

Question 5d. How would such data be incorporated into a National Climate Program?

Response: Land remote sensing data is being combined with other environmental data and climate/crop-yield models to develop improved and more timely estimates of global grain production under the inter-agency AgRISTARS project recently approved by the Congress. The National Climate Program Office is expecting AgRISTARS to contribute significantly to its "principal thrust" on Climate and World Food Production. Other National Climate Program Office concerns include the Northern Hemisphere polar regions where LANDSAT data already have been used, with other satellite data, to monitor the extent and changes of polar ice and to track changes in snow cover over the continents in winter. An operational data system will increase the value of this new data source in monitoring climate change and in climate impact assessments.

Mr. AMBRO. I would like to turn my time over to Mr. Brown.

Mr. BROWN. I have no questions.

Mr. AMBRO. I want to thank you very much for coming, for being so forthcoming in providing us with your time and your testimony. The committee appreciates it immensely, and I think it adds to our volume of knowledge immeasurably. Thank you very much.

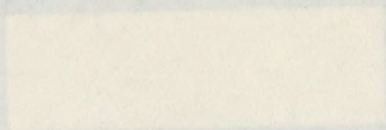
Dr. OWEN. Thank you, Mr. Chairman.

Mr. AMBRO. The subcommittee is adjourned.

[Whereupon, at 4:02 p.m., the subcommittee adjourned.]



My dear Mr. [Name], I have just received your letter of the 15th inst. and am glad to hear from you. I am well and hope this finds you the same. I have been thinking much of late about the future of our country and the state of our Union. I feel that we are in a critical position and that it is our duty to stand by our principles and our Constitution. I am sure that you share these views and I am confident that we can overcome all our difficulties and build a better future for our people. I am, Sir, very respectfully,
Your obedient servant,
[Signature]





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