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OCEAN EXPLORATION AND COASTAL
AND OCEAN OBSERVING SYSTEMS

JOINT OVERSIGHT HEARING

BEFORE THE

SUBCOMMITTEE ON ENVIRONMENT, TECHNOLOGY, AND STANDARDS
SUBCOMMITTEE ON RESEARCH
COMMITTEE ON SCIENCE

AND THE

SUBCOMMITTEE ON FISHERIES CONSERVATION, WILDLIFE AND OCEANS
COMMITTEE ON RESOURCES
HOUSE OF REPRESENTATIVES

ONE HUNDRED SEVENTH CONGRESS

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FRANK PALLONE, JR., New Jersey

C O N T E N T S

Submitted Statement of Dr. William J. Merrell, President, H. John Heinz III Center for Science, Economics and the Environment

International Commitments for Argo Floats, NOAA

NOAA Research handout on Ocean Exploration

"Ocean Observatories," *Oceanus*, Vol. 42, No. 1, Woods Hole Oceanographic Institution, 2000

OCEAN EXPLORATION AND COASTAL AND OCEAN OBSERVING SYSTEMS

JULY 12, 2001

House of Representatives,
Subcommittee on Environment, Technology,
and Standards,
Subcommittee on Research, Committee on Science,
Joint with Subcommittee on Fisheries
Conservation, Wildlife and Oceans,
Committee on Resources,
Washington, DC.

The Subcommittees met, pursuant to call, at 1 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Vernon J. Ehlers [Chairman of the Environment, Technology, and Standards Subcommittee] presiding.

SUBCOMMITTEE ON ENVIRONMENT, TECHNOLOGY, AND STANDARDS

SUBCOMMITTEE ON RESEARCH

SUBCOMMITTEE ON FISHERIES CONSERVATION, WILDLIFE AND OCEANS

Joint Oversight Hearing on:
Ocean Exploration and Coastal and Ocean Observing Systems

THURSDAY, JULY 12, 2001

Witness List

Panel I:

Mr. Scott B. Gudes
Acting Undersecretary for Oceans and Atmosphere, Department of Commerce

Dr. Rita R. Colwell
Director, The National Science Foundation

Admiral Jay M. Cohen
Chief, Office of Naval Research, U.S. Navy

Admiral Conrad Lautenbacher, Jr.
President, Consortium for Oceanographic Research & Education

Panel II:

Dr. Marcia K. McNutt
President and Chief Executive Officer, Monterey Bay Aquarium Research Institute

Dr. Robert D. Ballard
President, Institute for Exploration

Panel III:

Dr. Robert A. Weller
Director, Cooperative Institute for Climate and Ocean Research
Woods Hole Oceanographic Institution

Dr. J. Frederick Grassle

Director, Institute of Marine and Coastal Sciences, Rutgers University

Dr. Alfred M. Beeton
Senior Science Advisor, National Oceanic and Atmospheric Administration

Dr. Alexander Malahoff
Director, Hawaii Undersea Research Laboratory, University of Hawaii

HEARING CHARTER

Ocean Exploration and Coastal and Ocean Observing Systems

On Thursday, July 12, 2001, at 1:00 p.m. in 2318 Rayburn House Office Building the Resources Subcommittee on Fisheries Conservation, Wildlife and Oceans, and the Science Subcommittees on Research, and Environment, Technology and Standards will hold a hearing on ocean exploration, and the development and implementation of coastal and ocean observing systems. The following witnesses are scheduled to testify:

Panel I

Mr. Scott B. Gudes, Acting Undersecretary for Oceans and Atmosphere, Department of Commerce

Dr. Rita R. Colwell, Director, The National Science Foundation

Rear Admiral Jay M. Cohen Chief, Office of Naval Research, U.S. Navy

Vice Admiral Conrad Lautenbacher, Jr., President, Consortium for Oceanographic Research & Education

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Dr. Marcia K. McNutt, President and Chief Executive Officer, Monterey Bay Aquarium Research Institute

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Dr. Alfred M. Beeton, Senior Science Advisor, National Oceanic and Atmospheric Administration

Dr. Alexander Malahoff, Director, Hawaii Undersea Research Laboratory, University of Hawaii

II. BACKGROUND

This hearing follows up on hearings in the 104th, 105th, and 106th Congresses on Federal interagency cooperation on ocean research and particularly on the progress of, and plans for, the implementation of an integrated and sustained-ocean observing system. The hearing will also examine the need to coordinate the rapidly proliferating coastal observing systems. Finally, it will review the Report of the President's Panel on Ocean Exploration and the implementation of that report's recommendations.

Until the last decade, technological limitations confined oceanographic research to discrete observations that were not available in real time, continuously or over long time periods. These limitations in data acquisition, dissemination and analysis in turn limited our understanding of the structure and processes of the marine environment. Over the last decade, advances in the technology of in situ and remote sensors (data acquisition), and data transmission, distribution and analysis has greatly expanded our ability to monitor ocean and coastal processes in real time, continuously and over long time periods.

These new capabilities have already lead to enormous advances in. our understanding of the coastal and marine environment. However, these sensors have only been deployed on relatively small scales, and the systems that are deployed are have not been coordinated into an integrated system that will optimize our understanding of the oceans. Coordinating and, of course, funding an integrated and sustained coastal and ocean observation system will have many benefits. Such a system will assist in:

detecting and forecasting oceanic components of climate variability;

facilitating safe and efficient marine operations;

ensuring national security;

managing living resources for sustainable use;

preserving healthy and restoring degraded marine ecosystems;

mitigating natural hazards; and

ensuring public health.

Recognizing the technological revolution that was underway in oceanographic research, and concerned that the fractured structure of Federal ocean oversight and research programs may be preventing the Federal

government from capitalizing on those technological advances, the House Resources, Science and Armed Services Committees held a hearing in 1995 on leveraging Federal oceanographic resources. As a result of the hearing, Congress enacted the National Ocean Partnership Act (NOPA) in 1996.

NOPA established the National Ocean Partnership Program (NOPP), an interagency coordinating and grant making program lead by the Navy, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). NOPP is operated under contract with the Consortium for Ocean Research and Education (CORE), a private group that represents U.S. coastal and ocean research institutions. The interagency coordinating functions are carried out by the National Ocean Research Leadership Council (NORLC) which is made up of 12 Federal agencies with significant ocean-related responsibilities. NORLC uses the 10 member Ocean Research Advisory Panel (ORAP) to assist in outreach to non-Federal governmental and research entities.

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In 1998, as a follow on to the enactment of NOPA, the Subcommittee on Fisheries Conservation, Wildlife and Oceans held a hearing on a National Research Council paper, entitled "Opportunities in Ocean Sciences: Challenges-on the Horizon". That hearing examined recent advances in understanding the ocean through the application of up-to-date technologies, and future oceanographic research needs. The report concluded that technological advances have greatly expanded the ability of scientists to observe the depths of the ocean, and to establish real time, or near real time, long-teen monitoring of ocean phenomena. The most well publicized example of this is the El Niño/Southern Oscillation mooring array that allowed scientists to track the large 1998 El Niño and the subsequent La Niña in the equatorial Pacific Ocean. If these enhanced technological abilities are harnessed properly, they can generate the data needed to understand the many other annual and decadal trends that occur in the world's oceans and atmosphere. Decoding these large-scale, long-lived events can lead to improved weather and climate forecasts, and improved natural resources management. According to the National Research Council report:

"Ocean observations have always been the driver of new knowledge and predictive capabilities in the ocean and its basins. Ocean drilling has produced sediment cores that provide our best long-term records of natural climate fluctuations. Submersible observations (both piloted and robotic) opened our eyes to hydrothermal vents and the unique life forms that surround them. Our present ability to forecast and assess El Niño variability depends critically on the coupling of extensive oceanic and atmospheric observations with increasingly accurate computer models. Despite these and many other accomplishments, the oceans remain vastly undersampled in time and space."

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"With new technologies, new kinds and levels of ocean, ocean/atmosphere, and ocean/solid earth observations can be made.. . . In the future, data from ocean sensors, undersea vehicles, and satellites can be combined with highly capable communications systems and computer models to assess the evolving daily state of ocean currents, temperature, nutrients, biota, ice, and air-sea fluxes. The overall system can then display for anyone, on the world wide web, accurate estimates of the present state of the ocean. The information can be put to practical use for such diverse purposes as improved weather prediction, safer

offshore operations, better short-term climate forecasts (e.g., El Niño), and more successful management of living resources. The resulting system will be capable of providing as good an ongoing assessment of the ocean as is currently taken for granted for the atmosphere and land surfaces."

As a result of that hearing, the then Chairs of the Resources Subcommittee on Fisheries Conservation, Wildlife and Oceans and Armed Services Subcommittee on Military Research and Development wrote to the National Ocean Research Leadership Council (NORLC) requesting that the Council prepare a "plan to achieve a truly integrated ocean observing system". In response to that request, a NORLC-appointed Ocean Observation Task Team under the direction of ORAP drafted the plan. After an interagency review, that report, *Toward an Integrated Ocean Observing System,* was provided to Congress in April 1999. It was then used to prepare a December 1999 NORLC report entitled *An Integrated Ocean Observing System: A Strategy for Implementing the First Steps of a U.S. Plan.* The two subcommittees held a hearing on those report in May, 2000.

The implementation plan prepared by NORLC describes the process that needs to take place in order to develop that system of accurate, up-to-date ocean measurements in a way that integrates the needs of all of the ocean agencies. The reports did not specify the details of agency programs and budgets. It did suggest that an initial infusion of $30 million was necessary to begin system implementation, and that the cost could rise to $100 million per year over 3–5 years. No budget requests of that magnitude have been made. The December report concluded that there are no technical nor legislative impediments to implementing a National Ocean Observing System and, with proper and realistic investment, a comprehensive national ocean observing system can be built within ten years. It did, however, identify that there are two main components currently missing: a framework and the necessary funding.

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The report concluded that the framework necessary to build an integrated ocean observing system need not be fully determined at the outset, rather it should be dynamic and respond to the needs of the system as it matures. In the beginning, however, the framework should build upon the existing NOPP statutory and management structure. In addition, NOPP should be used to allocate and coordinate funding decisions. NOPP provides a mechanism to augment ongoing activities and immediately start key near-term initiatives in a phased approach to implementation.

Recently NORLC has established Ocean.US, the National Office for Integrated and Sustained Ocean Observing and Prediction. This office will coordinate the framework for the integrated system. It is assumed that most of the elements of the system will be developed and operated by the Federal agencies whose mission those elements serve, or in the case of the coastal components of the system by local or regional research institutions. The connections, including data comparability standards will be organized by NORLC through Ocean.US. Currently NOPP funding is inadequate to address gaps in the system, establish data standards, or coordinate data storage.

Many potential components of an integrated system exist or are being planned. The El Niño/Southern Oscillation mooring array has already been discussed, but other ocean observing efforts are also underway. Examples include:

The VENTS program was established in 1984 in order to better understand the spreading of the seafloor in the Pacific Ocean. Not only is the geology being reviewed at these hot spots under the sea but also the unique and only recently discovered ecology surrounding these vents. In 1996, the VENTS program deployed high-quality acoustic hydrophones which augmented the Navy's SOSUS hydrophone arrays, allowing underwater volcanic activity to be more closely monitored and studied. This understanding will shed light on the emissions stemming from these underwater eruptions as well as provide an understanding of the events that surround the spreading of the ocean floor. Additionally, the organisms found at these hydrothermal vents may have significant industrial biotech applications. The VENTS website is *http://www.pmel.noaa.gov/vents/home.html*

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NEPTUNE is establishing a fiber optic transmission system to bring data from sensors that surround the entire Juan de Fuca Plate on Washington, Oregon and British Columbia. NOPP is providing primary funding for this project. The NEPTUNE website is *http://www.neptune.washington.edu/*

In the Mid-Atlantic, the Long-Term Ecosystem Observatory in 15 meters of water (LEO–15) has been under development for several years with most of the funding coming from NSF. LEO–15, operated from a field station in Tuckerton, New Jersey, and incorporates biology, geology, chemistry and oceanography through the monitoring of the marine environment at a depth of 15 meters. With the application of in-situ technology and satellite imagery, a better understanding of current systems and the associated sediment transport can be acquired, which may provide invaluable insights into areas suffering from recurrent hypoxia. Several projects in the Southeastern United States are now being planned. The LEO–15 website is *http://marine.rutgers.edu/cool/*

Woods Hole Oceanographic Institution is currently developing the Martha's Vineyard Coastal Observatory for Meteorological & Oceanographic Studies. The Observatory's website is *http://www.whoi.edu/science/AOPE/airsea/observatory.html*

NOAA and other agencies are funding the ARGO buoy program. These drifting profiling buoys provide data about temperature, salinity and current over large geographic areas, and relatively inexpensive to deploy and operate. The ARGO website is *http://www.argo.ucsd.edu/*

The Gulf of Maine Ocean Observing System (GOMOOS) provides data for the New England coast. The Navy provides most of the funding for this project. The GOMOOS website is *http://www.gomoos.org/*

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NOAA operates tsunami warning buoys as part of the Tsunami Hazard Mitigation Program, a partnership between NOAA and several state governments. The Program's website is *http://www.pmel.noaa.gov/tsunami-hazard/index.html*

NOAA operates Physical Real Time Oceanographic Systems (PORTS) that provide real time tide and

current data at several major U.S. ports. The PORTS website is *http://www.co-ops.nos.noaa.gov/co-ops.html*

It is clear from this sampling of sites that coordination of coverage, and data comparability and storage are important issues that must be addressed.

OCEAN EXPLORATION

On June 12, 2000, President Clinton directed the Secretary of Commerce to convene a panel of experts to formulate a national strategy for ocean exploration. The Secretary did so, and on October 10, 2000, presented to the President the Report of the President's Panel on Ocean Exploration. This Report presents specific recommendations to increase the amount of time and funding that is available to carry out ocean research, actions to create a strategic plan, and highlights the need for a multidisciplinary exploration program for the U.S.

The Panel found that much of the ocean has not been subjected to scientific review, and that no specific program existed to fund and coordinate ocean exploration in the United States. The Panel recommended: 1) the mapping of the physical, geological, biological, chemical and archaeological aspects of the ocean; 2) exploring ocean dynamics and interactions at new scales to better understand the complex interactions of the ocean; 3) developing new sensors and systems for ocean exploration to regain a U.S. lead in marine technology, and; 4) reaching out to stakeholders and better educate all ages about the oceans through new methods of information dispersal. The Panel recommended a 10 year/$75 million per year program of dedicated exploration voyages to accomplish these goals.

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After the report was delivered, NOAA established an Office of Ocean Exploration within the Office of Oceanic and Atmospheric Research. In fiscal year 2001, $4 million was appropriated to NOAA for ocean exploration. NOAA used this money to leverage existing ocean research initiatives including east coast research on the ALVIN, and work in the Gulf of Mexico, the Astoria Canyon off the mouth of the Columbia River, and at the MONITOR excavation site.

For fiscal year 2002, NOAA has requested $14 million for ocean exploration. This money would be invested in undersea exploration, research and technology in the deep ocean and areas of special concern. NOAA specifies that the money requested would support goals fully consistent with the recommendations of the President's Panel on Ocean Exploration. The new exploration effort would focus on five areas: new ocean resources, exploring ocean acoustics, American's maritime heritage, exploring ocean frontiers, and the census of marine life.

All the projects proposed in Fiscal Year 2001 and 2002 are conducted in partnership with other NOAA and Federal programs as well as academic institutions, and nongovernmental organizations. Recommendations for partnerships must also include a broader organizational strategy to ensure the needs of all the partners are met. The Panel suggested the President instruct the White House Science Advisor and appropriate Cabinet officials to design a management structure so that it is a recognized uniform process as ocean exploration expands and more interests become involved.

To encourage development of potential opportunities and new resources, the Panel recommended U.S. laws be reexamined to provide proper incentives for potential commercial users of ocean discoveries. Possible actions include: increasing funds to federal agencies to support early-phase research on discoveries with commercial potential; providing incentives to private industry to encourage the funding of research and development of discoveries with commercial potential, and; designing mechanisms whereby those who directly profit from the exploitation of marine resources support research on their environmentally sustainable use.

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Finally, the Panel advocated a new national Ocean Exploration Program to permit exploratory expeditions because the initial phase of oceanographic discovery ended before the oceans were fully explored and new tools now exist that allow exploration in dimensions that were unachievable 50 years ago when oceanographic research expeditions were still broad based, and multidisciplinary. An exploration program differs from research that is currently being done in that an exploration expedition has no specific idea or theory it is gathering data to prove or disprove. An expedition would gather as much interdisciplinary data as possible about a site rather than just explore a single aspect of the site.

ISSUES

1) What funding did each of the Navy, NOAA and NSF request in Fiscal Year 2002 for ocean and coastal observing systems?

2) What are other countries contributing to the integrated ocean observing system? Is there an international structure in place to coordinate the contributions of various nations?

3) Will the ocean observing system help sort out natural versus human induced contributions to climate variability? How can additional ocean and coastal observation data and technologies best be integrated with existing meta data and observation technologies used to monitor global climate change?

4) How will data be retrieved from the various platforms to be deployed in the integrated ocean observing system?

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5) What ocean and coastal observations can be made by satellites?

6) How will agencies coordinate information exchange so that the same research is not undertaken multiple times, including military research in areas that might have national security interests but also biological, chemical, geological or other area importance also?

7) To what extent can Department of Defense assets and data be utilized for greater civilian use in exploration and monitoring?

8) What new technologies should be developed to enable a more expansive and comprehensive ocean exploration capability?

Ocean Exploration and Coastal and Ocean Observing Systems

Chairman **EHLERS.** I am pleased to call this meeting to order. We just did a little re-juggling. The problem is we have a vote on the floor. We had planned to go and vote immediately and come back, but now, we discovered that there is going to be a second vote because there is an attempt by one of the parties, which shall remain unnamed, to delay things today. And so we decided to go with the opening statements and then we will—whenever we have to leave for the first vote, we will leave, try to get both votes and come back as quickly as we can.

I am Vernon Ehlers. I will also be sharing the Chairmanship with Mr. Gilchrest of Resources Committee and with Mr. Smith of the Research Committee—the Science Committee. And so I will begin with a fairly brief opening statement.

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I want to thank my friends and colleagues, Chairman Gilchrest and Chairman Smith for working with me to put together this Hearing. I will keep my remarks brief, as we have many distinguished witnesses to hear from today. However, I must mention while it took me seven years before I was able to chair a Hearing in this room, it has taken Mr. Gilchrest only one month as the newest member of the Science Committee. That is what we call rapid advancement. We recognize talent when we see it.

But this is a Hearing that I have wanted to put together for some time. And I talked to Mr. Gilchrest about it months ago and said, oceanography and ocean sciences is too badly split. We have to put it together and this is our first attempt to do that.

Ocean science is clearly a topic that transcends jurisdictional lines. But that appears to be one of the biggest obstacles to advancing ocean science, whether in exploration or the creation and integration of ocean observing systems. While our subcommittees have made a commitment to work more closely together, we also need further cooperation and coordination among the various Federal agencies and the research community, in general, on ocean science issues. The problem is not just Congressional Committees, but also the Federal structure and the research community's interest.

With limited financial resources dedicated to ocean research, we must agree on specific priorities to achieve goals. I am particularly interested in how an integrated National and International ocean observing system will promote our understanding of climate change. Oceans are clearly a poorly understood but critical piece of our efforts to model climate change. Obviously, we must agree on what data needs to be collected, by whom and how in order to improve our climate modeling efforts.

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After reviewing the written testimony, I am concerned about the seemingly disparate efforts toward this

aim. I also want to make sure that that data and the information collected, analyzed and stored for all parties to use effectively. This is no simple task.

I hope that our witnesses will help provide some guidance on where our subcommittees can work together to help the ocean science community achieve a consensus on where to allocate resources and how to move these issues forward.

We will simply proceed down the line. I will next recognize Chairman Gilchrest for his comments—opening statement.

[The prepared statement of Vernon J. Ehlers follows:]

PREPARED STATEMENT OF THE HONORABLE VERNON J. EHLERS

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Mr. **GILCHREST.** I thank Mr. Ehlers—Dr. Ehlers, Chairman. I ask unanimous consent that my full statement be submitted to the record.

Chairman **EHLERS.** Without objection, so ordered.

Mr. **GILCHREST.** And basically, welcome all the witnesses here this afternoon. We look forward to your testimony. We do live on this infinitesimal blue-and-white speck in the midst of an infinite hostile environment upon which we have no place to go. So it is important to us, very simply, to take upon ourselves a difficult, complex task of taking care of our home.

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I think we have the ability to do it. Richard Leakey said in his book, *Origins,* some 25 years ago, that we have the genetic predisposition for cooperation. So that we can include that understanding in the various Federal, State, local, private sectors initiative to understand the cooperative effort that will reveal a great deal about the heart and blood of the planet. And the co-evolution of species, along with the wonders and the mysteriousness of our blue oceans. We will get the job done. And succeeding generations will be very pleased with that effort. Whether it is sustaining the fishing industry by sustaining the fisheries in an ecological way, to understanding the nature of man's activities in the atmosphere and the climate. All these things can be done and now is the time to do it.

I thank Mr. Ehlers. I was here, though, in 1991, Vern. So it has taken me quite a long time, even though I left the Committee for a while. But I appreciate the rapid advancement.

[The prepared statement of Chairman Gilchrest follows:]

PREPARED STATEMENT OF THE HONORABLE WAYNE GILCHREST

Today's hearing follows up on efforts over the last three Congresses to improve interagency cooperation in oceanographic research, and on implementing an integrated, sustained ocean observing system. As a result of those hearings,

Congress created the National Ocean Partnership Program, and,

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the ocean partnership agencies have

developed a plan for implementing an ocean observing system; and

created an office called Ocean.US [Ocean-dot-US] to coordinate the Federal ocean observing efforts.

I look forward to hearing today what progress we can look forward to in the near future on making the planned ocean observation system a reality. In other words: where's the money.

This hearing will also look at how to coordinate the work of current and proposed coastal observing systems. Data from these systems can greatly improve our ability to monitor and predict significant short and long changes in the coastal environment. Such knowledge can improve natural resources management, and lessen the damage from storms and other natural phenomena.

However, the data from these systems needs to be consistent and readily available in order to be useful. Clearly, the Federal government should assume this data comparability and access responsibility. I look forward to hearing how the ocean partnership agencies intend to fill this role.

Finally, this hearing will examine implementation of the Report of the President's Panel on Ocean Exploration. It is estimated that we have explored less than 5% of the ocean. However, since World War II broad-based interdisciplinary oceanographic research voyages that looked at all aspects of the ocean environment have been replaced by increasingly narrow single purpose research enterprises. This level of specificity has lead to great leaps forward in the understanding of ocean processes. However, these narrow efforts have failed to capture the public's imagination.

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This failure may help to explain the extraordinary disparity in funding between ocean research and space and health research. Unfortunately, with the exception of a limited, though spirited, response from NOAA, the ocean partnership agencies have chosen to hide behind their narrowly focused mission needs rather than look at how to coordinate those needs and create interdisciplinary missions that may spark public interest and support. I hope we will hear today how such missions can be created without diverting or wasting limited agency resources.

We have a long afternoon ahead of us, but, given our distinguished witnesses breadth of experience in and knowledge about ocean exploration and research, it should be a very interesting day.

Chairman **EHLERS.** Yes. Thank you.

Mr. **GILCHREST.** I yield back the balance of my time. Thank you.

Chairman **EHLERS.** Thank you. We—the normal process is to recognize the Ranking Members, but the Ranking Members for the other Subcommittees have not come. But let me just, in the interest of fairness, turn next to the Congresswoman from Texas, Ms. Eddie Bernice Johnson, for her opening statement.

Ms. **JOHNSON.** Thank you, Mr. Chairman. I would like to ask for unanimous consent just to submit my full statement and simply say——

Chairman **EHLERS.** Without objection, so ordered.

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Ms. **JOHNSON.** Thank you.

The oceans encompass seventy percent of our planet's surface and are the last frontier on earth to be explored, but we spend most of our time on 30 percent, which is ground level. And every now and then, we are reminded of the importance of the oceans when our weather patterns shift to El Niño, when commercial

fish catchers decline, when our beaches are closed due to red tides and when pollution-related problems threaten the quality of coastal waters. We don't always give it the kind of attention needed. So I am very pleased that these Subcommittees are going to bring our efforts together to do that. I do think it is an important area. Thank you very much.

[The prepared statement of Eddie Bernice Johnson follows:]

PREPARED STATEMENT OF THE HONORABLE EDDIE BERNICE JOHNSON

I want to join my colleagues in welcoming our witnesses to this hearing on ocean exploration and ocean observing systems.

The oceans encompass 70% of our planet's surface and are the last frontier on earth to be explored. Since most of us spend our time on the other 30% of the earth's surface, we tend to focus more of our attention and research efforts on it.

Every now and then, we are reminded of the importance of the oceans when weather patterns shift due to El Niño, when commercial fish catches decline, when our beaches are closed due to red tides, or when pollution-related problems threaten the quality of coastal waters.

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I am pleased that our three subcommittees are focusing their attention on this important area today. We will review the research opportunities that are now available. In doing so, we need to consider whether effective coordination and collaboration exists among the relevant federal research agencies, and whether the required resources are available to exploit those research opportunities.

I look forward to hearing from our witnesses, and I thank all of you for being with us this afternoon.

Chairman **EHLERS.** I thank the gentlewoman for her comments. We will recognize Chairman Smith for his opening statement.

Mr. **SMITH.** Thanks to all the Ranking Members of these committees and, certainly, the Chairmens of these committees. We held a—just about exactly 12 months ago, we did hold a Hearing on this subject. We have much still to learn. And, Mr. Chairman, also without objection, I would ask that my full statement be entered into the record.

Chairman **EHLERS.** Without objection, so ordered.

Mr. **SMITH.** As we explore more of the processes that drive the ocean and are driven by the ocean, it becomes apparent how much more we have to learn. And so I welcome this opportunity to examine all of these ways and I look forward to the testimony.

National Science, Dr. Colwell, of course, National Science Foundation is one of the keys in the funding of this area. In fact, of the four major Federal agencies that play a role in ocean sciences, the NSF, the U.S. Navy, NOAA, the National Aeronautics and Space Administration, NSF contributes the largest share. About

$255 million. It is an important aspect and if there is any area that we need to pursue aggressively in terms of our knowledge and understanding, it is certainly this area of our earth and planet. And I yield back, Mr. Chairman.

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[The prepared statement of Nick Smith follows:]

PREPARED STATEMENT OF THE HONORABLE NICK SMITH

Thank you, Mr. Chairman. Twelve months ago, at a joint hearing of the Subcommittees on Basic Research and Energy and Environment covering some of the issues we will examine today, I said, "If our oceans are a window on the life on our planet—and elsewhere—we have only just parted the curtains." Judging from the written testimony our witnesses have submitted, the statement is correct and we have much to learn. As we explore more of the processes that drive the ocean and are driven by the ocean, it becomes apparent how much more we have to learn. And so I welcome this opportunity to examine the way in which we manage the federal role in that exploration effort.

A key part of that effort is enabled by funding from the National Science Foundation. In fact, of the four major federal agencies that play a role in the ocean sciences—NSF, the U.S. Navy, NOAA, and the National Aeronautics and Space Administration (NASA)—NSF contributes the largest share, about $255 million. And, in light of the recent developments with the VA–HUD appropriation legislation, it appears that amount is likely to increase. So I am interested in how NSF views that investment and its role in the overall ocean exploration effort.

I am also very interested in examining how effectively the agencies represented here today—and all the agencies involved in ocean science—coordinate their research efforts. We must make the best use of the resources available at each agency. How would future research efforts like the Ocean Observing System or the Oceans Exploration program be implemented at each agency?

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We have much to learn about how our oceans work including how they drive and shape our climate. In fact, it is clear that predictions about future climates are not reliable. So I am pleased that we will review our knowledge about oceans today, and talk about ways to increase it. I want to thank all of our witnesses, and I look forward to the testimony.

Chairman **EHLERS.** Thank the gentleman for yielding back. And I next recognize Mr. Underwood, who has probably come from the area most surrounded by water of any member.

Mr. **UNDERWOOD.** Well, thank you, Mr. Chairman. And, of course, oceans are very important to Guam. And I know it is frequently—the comment is made that I don't know, I guess some—a majority of our population lives within 50 miles of the ocean. 100 percent of my population lives within 4 miles of the ocean, so it is very important. But I have a statement that I will submit for the record.

I would just make one observation. NASA scientists said yesterday that they have found signs of water around a distant star, suggesting that there may be planets outside of our own capable of supporting life. How spectacular that is that we may have found water in space with life-sustaining capabilities, yet we don't really know all the life which exists in our own oceans.

While this doesn't prove that we have confused priorities, it certainly suggests that we need an ocean exploration strategy for planet Earth. Thank you.

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[The prepared statement of Robert Underwood follows:]

PREPARED STATEMENT OF THE HONORABLE ROBERT UNDERWOOD

Thank you, Mr. Chairman. Some of the finest minds in ocean exploration, observation and research are with us today, which says a lot about the growing importance for Congress to develop a comprehensive ocean exploration and observation policy.

If there is one thing we can all agree on, it is that not enough is known about the oceans that cover 70% of the Earth's surface. This includes the more familiar waters immediately adjacent to the continental United States, and the lesser known portions of the EEZ further off-shore in the Western Pacific.

In recent years, a number of thoughtful reports, such as the President's Panel Report "Earth's Final Frontier: A U.S. Strategy for Ocean Exploration" and "A National Initiative to Observe the Oceans," prepared by the Consortium for Ocean Research and Education, have been circulated. These reports demonstrate that there is a legitimate need for a more robust national ocean exploration and observation program. There should be greater incentives to encourage cooperation across sectors in order to bring together the strengths of the Federal and non-Federal sectors. Most importantly, there is a need to establish a long-term Federal commitment to ocean exploration and to build and deploy a cohesive ocean observing system.

From the Resources Committee perspective, we ought to ask how a focused ocean exploration program or an integrated observation system would benefit the management of ocean resources, in particular biological resources such as fisheries. Where or what is the appropriate link from ocean exploration and observation to resources management?

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The plans for ocean observation and exploration that have been brought to my attention focus on the general, large-scale picture. But it remains uncertain how the actual implementation of these programs would incorporate the expertise of local island communities, particularly researchers and resource managers in the Western Pacific. Local knowledge and capabilities should be tapped or we are missing something important in the equation for getting the most out of this investment in technology.

Finally, while we are developing this new program, we must ensure that the benefits of this investment in new technology for ocean exploration and observation is understood by the common citizen, not just scientists and researchers. For without broad public support, it will be impossible to sustain any long-term strategy. Thank you again, Chairmen, for holding this joint hearing and I look forward to the suggestions that our witnesses have worked so hard to produce.

NASA scientists said yesterday that they have found signs of water around a distant star, suggesting that there may be planets outside of our own capable of supporting life. How spectacular is that—we may have found water in space with life-sustaining capabilities, yet we don't even know what life exists in our oceans! While this doesn't prove the U.S. has confused priorities, it certainly suggests that we need an ocean exploration strategy for the planet Earth.

Chairman **EHLERS.** Thank you for the statement. We have two minutes and 33 seconds left to make it to the vote. So we stand in recess.

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[Recess.]

Chairman **EHLERS.** The Hearing will come to order. I had intended to wait for all the other Chairmen to return, but let us begin. We have with us—joining us, Mr. Weldon, who is an active member of this Committee. And I believe, also, another—are you in Resources, as well? Natural. Okay. And who—he was a leader several years ago and, in fact, when my early years in the Congress. What I am trying to put together is a bill covering ocean research and oceanography, an immense, Herculean effort and Mr. Weldon is very active, very hard-working and I appreciate his effort on that. I would give him an opportunity to give an opening statement.

Mr. **WELDON.** Thank you, Mr. Chairman. And I applaud you and the other Subcommittee chairs for this Hearing. In fact, it was six years ago that we, in fact, had three full Committees join together, the Armed Services Committee, of which I have been a member for 17 years, the Science Committee, which I have been a member and the Natural Resources Committee. We held three Hearings around the country. One up in Rhode Island, one out in California and one here in Washington, on the whole issue of oceanographic research. And what we found during those Hearings was the fact that we had a disjointed effort that was not coordinated among our Federal agencies. In fact, at that time, we had nine separate Federal agencies. Each of which had at least a partial function involving ocean research. And not that I want to distort my good friend, Nick Smith, but I believe the largest funder of ocean research is actually the U.S. Navy, if I am not mistaken. And Admiral Cohen, you can correct me if I am wrong.

So as a result of those Hearings, what we did was we introduced that National Oceans Partnership Act, which Patrick Kenney and I co-sponsored. That did become law as a part of our Defense Bill. And actually was the vehicle to bring together, through dollar allocations, the nine Federal agencies involved in ocean research. Since the formation of NOPP, we have actually increased that, I believe, by two additional agencies. Our panelists can discuss that today. And we have begun to raise the awareness and the coordination of the need for more ocean cooperation.

As another direct result of that action, we formed the Oceans Caucus. The Caucus now has four co-chairs, two from each party. I am one of the co-chairs and we now have about 60 Members of Congress who have agreed to work on an oceans agenda.

We also work very closely with Admiral Watkins, who could not be here today. He was Admiral Cohen's predecessor. Well, actually, the CNO, I should say. Admiral Gaffney was his predecessor. And working with Admiral Watkins, he, in fact, led the formation of the consortium for oceanographic research and education. Which for the first time, brought together all the Nation's oceanographic research institutions. From Woods Hole to Scripps, to all of those major universities that have a stake in ocean research.

So I would say, Mr. Chairman, that since the initial effort in 1995, there has been, in fact, significant progress. The focus on ocean research and the needs of our oceans has significantly improved. We have held several International Hearings and conferences in this country, one involving 200 delegates from 35 nations where Speaker Gingrich and Vice-President Gore, on the same day, spoke about the need for more proactive effort on the oceans.

The problem has been two-fold. First of all, we have a Federal agency system that requires us to try to bring together 11 separate and disparate agencies. The NOPP Program has begun to provide that coordination. And it is a beginning, but it is not enough. The New Oceans Commission, which I hope you all speak to today, in fact, should take that one step forward. I would be remiss if I didn't say I am somewhat concerned that the administration of which I am a strong supporter, has not moved, in my opinion, quickly enough to one, appoint the Ocean Commissioners and to name a Chairperson. In fact, during the questioning today, I will propose some ideas that I have about that function and that position. And hopefully, convince Admiral Watkins that he should step to the plate, if he would so desire and lead that effort.

The second problem is the Congress. We have a number of Subcommittees and full Committees that have various parts of jurisdiction on ocean issues. I chaired the Research Committee for National Security, which had a major chunk of that for six years. I now Chair the Readiness Committee. I have a separate chunk of those operational dollars. We need to find a way in the Congress to convince the leadership to allow us to bring together, as you are doing here, an ongoing legislative agenda focused around an oceans agenda.

Because the problems of the oceans are real. They are severe. There are many opportunities for us. You are going to be exploring one of those today. There are many other opportunities that we should be using. It is also a way for us to build coalitions with some of our potential adversaries. In particular, Russia and China. Where we can, in fact, work together on a common oceans agenda.

So I would applaud these Subcommittee chairs for this Hearing. I would say as a senior member of the Armed Services Committee and a senior member of this Committee, I will continue to be an outspoken voice for further cooperation, so that we, in fact, have a coordinated oceans agenda hopefully led by the new Oceans Commission with the kind of coordinated support that you are seeing from these panels. And trying

to make sure that legislatively, we are putting more resources into the oceans.

Sylvia Earl, who is probably one of the most renown people on the oceans in this country, when she was the Chief Scientist for NOAA, she used to say that we spend more on the development of the waste removal system for our space launch capability than we do on studying the oceans. We spend more on studying the oceans of Mars than we do on studying the oceans of the U.S. That is an absolutely unacceptable reality. And we have got to change that.

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So hopefully, this Hearing will help continue what I think has been a very positive movement over the last several years to bring forth the more coordinated and positive and cohesive agenda on the oceans and how the U.S. can affect, in a positive way, that agenda. Thank you, Mr. Chairman.

Chairman **EHLERS.** I thank the gentleman for his comments and for all his hard work in this issue over the years. And I hope that, indeed, this is the first step toward creating the agenda that you are referring to.

It is the policy of the Science Committee that the Chairman and Ranking Members make opening statements, that all other statements be entered into the record. I exceeded that only for Mr. Weldon because of his long-standing role in this. And if a member of the minority wants to make an opening statement to counteract that, I will be happy to recognize Mr. Faleo for—sorry. John Wayne Vega.

Mr. **FALEOMAVAEGA** John Wayne is just fine, Mr. Chairman.

Chairman **EHLERS.** You actually look like him.

Mr. **FALEOMAVAEGA.** He's more handsome.

Chairman **EHLERS.** You may proceed.

Mr. **FALEOMAVAEGA.** Mr. Chairman, thank you for the opportunity. And I, too, would like to echo your sentiments and express my sense of appreciation to the gentleman from Pennsylvania for his leadership and tremendous efforts in raising a higher sense of consciousness, not only among the members, but certainly in our National policy about the importance of the ocean.

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And probably no two members can appreciate more what the ocean is about than myself and the gentleman from Guam. Where every time we have to travel to our home districts, we have nothing but the ocean. Not only is the Pacific Ocean g of the Earth's surface, but culturally and historically, our people have always been part of it and in a very historical and in a very personal way. A couple of years ago, maybe 10 years ago, I was privileged to sail on a Polynesian voyaging canoe from Tahiti to Hawaii. Non-instrument navigation without sextants and all of that, Mr. Chairman. We used the stars, as it was done by my ancestors thousands of years ago. And we do have a very, very close affinity and association with the ocean.

Unfortunately, it has been my observation, and I think our National policy toward the ocean has always been military and strategic. I think we need to get away from that, even though it is important, as it is. But the fact of the matter is, and I am sure that this has already been stated. We are able to land a man on the moon, but we don't even know what is underneath—in the ocean. Now, let alone the Marianas Trench and the Tohman Trench, some of these resources have diminished potential on some of the things that we need to look into, very, very valuable and important.

And I think from this perspective, Mr. Chairman, two—a classic example, in my opinion, in the years that I have followed the issues of the oceans, policies of our Nation, we have a National Program known as a Sea Grant Program with an annual appropriation of only $60 million a year that is supposed to give some sense of understanding and appreciation of our communities about the ocean and the viability and the importance of it not only as a resource, but so many other programs that we can do in association with the needs of our country. Compare that to the Land Grant Program that gets well over $1 billion in funding. And I am not putting down the Land Grant Program, Mr. Chairman, and its importance.

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The fact of the matter is that this is an area that—and I am talking about the oceans and the resources—we—our Nation is far behind what other Nations in the world are going into, not only in developing technology, not only in learning from the resources of the marine environment, the fisheries and so many other things that we know we must understand a little more in appreciation of this valuable resource. We are not ahead, in my humble opinion, as far as if we compare ourselves comparatively to other countries.

I say this, also, with the real sense of concern about the seabed minerals. The law of the Sea Conference has real, serious implications, especially in the area Mr. Underwood and I represent. I can cite you an example, Mr. Chairman; the Cooke Islands government. I know many people who probably never heard of the Cooke Islands. It is a little island with about 30,000 people, but three million square miles of jurisdictional ocean and as equivalent, a value over $200 billion estimates of the seabed nodules that contain magnese, cobalt, nickel. These are the kinds of things that I think that nothing has been done about, as far as our National policy is concerned, Mr. Chairman. And I hope in your efforts as Chairman of the Science Subcommittee that relates to this, let us push oceans a lot better and with greater intensity as we have done in the past. Thank you, Mr. Chairman.

Chairman **EHLERS.** Thank you for your comments. And we—I am pleased that the Pacific Islands and the Pacific Oceans are so well-represented here. Without objection, all other statement—opening statements will be entered into the record. And we will proceed with our panel.

Panel I: Scott B. Gudes, Dr. Rita R. Colwell, Admiral Jay M. Cohen and Admiral Conrad Lautenbacher, Jr.

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Chairman **EHLERS.** We are pleased to have an outstanding panel here. Mr. Scott Gudes, Acting

Undersecretary for Oceans and Atmosphere at the Department of Commerce. Dr. Rita Colwell, Director of the National Science Foundation. Admiral Cohen, Chief, the Office of Naval Research at the U.S. Navy. And Admiral Lautenbacher, who is the President of the Consortium for Oceanographic Research and Education. Sometimes called CORE. When I was a student at Berkeley in the sixties, there was another CORE that I became better acquainted with.

It is a pleasure to have you all here and I thank you for taking the time and we will just simply go down the line. Mr. Gudes?

STATEMENT OF SCOTT B. GUDES, ACTING UNDERSECRETARY FOR OCEANS AND ATMOSPHERE, DEPARTMENT OF COMMERCE

Mr. **GUDES.** Good afternoon, Chairman Ehlers, Chairman Gilchrest, Members of the Subcommittee and Staff. On behalf of Secretary Don Evans and the men and women who make up NOAA, it is my pleasure to represent all of them here today to talk about a few issues that are at the core of NOAA's mission. We are talking about a different core: ocean exploration, ocean observations and coastal observations. And I should note, as I was listening to the opening statements, there are a number of other issues in the oceans that are of great interest to us, from Sea Grant, the marine sanctuaries that we talked about. But I was asked to talk about these three areas. And that is what my testimony will revolve around.

The President's budget includes some $170 million for these programs in fiscal year 2002 to conduct NOAA activities in these areas. And I want to thank the Resources and Science Committees for your strong support for them. But, Mr. Chairman, I want to note at the outset that my own view is that these are interrelated subjects. That they are really all about understanding the oceans. So let me turn first to ocean exploration and our role at NOAA.

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Ocean exploration is an area that NOAA takes very seriously and I believe it is an area, frankly, where we really haven't stepped up to the plate of what the original mandate was for NOAA when we were created in 1970 by the Stratton Commission recommendations. It is an area of personal interest to me. In fact, this Monday, a few days ago, I was over at the Monitor Marine Sanctuary in North Carolina, watching the joint Navy/NOAA effort to recover elements of that wreck. Most people know the ironclad from 1862. It was the first National Marine Sanctuary in our system. And it is really a great example of joint agency efforts on the oceans. Literally, after this hearing, I am going to be flying off to Oregon to be in Newport tomorrow morning to welcome back an effort by Oregon State University and other researchers in NOAA. It is an exploration mission of the Astoria Canyon, which really continues the legacy of Lewis and Clark, if you will.

Last year, at Secretary Mineta's request, a blue ribbon panel of marine scientists and explorers was convened by the previous administration to review this Nation's efforts in ocean exploration. The panel was chaired by Dr. Marsha McNutt and included a number of prominent experts in the oceans, Dr. Bob Ballard. Both of those people are testifying on a later panel. It recommended the United States undertake a National program of ocean exploration and discovery, of which discovery and spirit are the real cornerstones. And we have set up an office of ocean exploration headed by Captain Craig McLean, who is here and Dr. Steve Hammond, our Chief Scientist, is here, as well, today.

On the slide before you are a few of those examples. That is Astoria Canyon and the Monitor. But also, is a picture—an image of a squid that was discovered in a joint NOAA, Texas A&M, University of North Carolina-Wilmington mission with Woods Hole's ALVIN Submersible in the Gulf of Mexico last year. Which makes the point of just how many species we really haven't discovered that we know are out there. This is just from a year ago.

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Next slide, please. I have made the point to both of your Committees before, that for NOAA, the O in NOAA is not only the oceans—the saltwater around the United States—but it also includes the Great Lakes. That goes back to the very origins of our Agency. And NOAA and Dr. Bob Ballard jointly conducted an acoustic mapping and survey of shipwrecks and geological phenomena in our Thunder Bay National Marine Sanctuary in Lake Huron, Michigan. That is our newest marine sanctuary. My slide shows an image of the Montana, which sank in 1914. And, finally, about ocean exploration, I will just point out that we have set out the program so that 10 percent of any dollars that are appropriated by the Congress for this Program will go to education and outreach. Because that is a big part of what our NOAA Ocean Exploration Program is about.

Next slide, please. Turning to ocean observations. I want to make the point that we really don't have the same amount of measurements in systems in the oceans that we do on land. And I asked our satellite service yesterday to give me a recent image. I think that is from two days ago. I don't know if all the members can see that, but red are the land-based observations of the atmosphere. And in blue are the observations in the oceans just a few days ago. And it—it is not perfect as an image, but it does sort of represent this point that we have a lot more measurements on a daily basis on land than we do in the oceans. And that is part of what ocean observations and, frankly, coastal observations are about. It also points out another point that for NOAA, we are the Civil Operational Remote Sensing Agency.

We operate two types of satellite systems. And, in fact, ocean remote sensing is part of what we are about. And, in fact, it is also atmospheric measurements. Over the Southern oceans, it is our polar satellites, actually, that are the main source of data that we get for weather and climate around the world. Our polar satellites provide sea surface temperatures—there is an image for you there—on a daily basis. And the National Polar Orbiting Environmental Satellite System, which I have talked about before with both of the Committees, which is a partnership between the Department of Defense, NOAA and NASA, will really, also be an ocean satellite. And that will provide sea surface temperatures, ocean colors, scatterometry, if you will, surface winds and altimetry.

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The next slide shows two observation programs that are important to NOAA. First, the TOGA TAO or atlas buoys that we maintain across the equatorial Pacific. This is how we are able to monitor and predict El Niño, La Niña and other ocean temperature changes. And on the upper right are the ARGO floats, which dive down to 2,000 meters, drift and surface while taking salinity, temperature and current measurements

and then broadcast these data to satellites. The ARGO float then dives back down and drifts again for 10 days. I should note, again, this is an example of partnership. The ARGO floats' research and development was done at Scripps in California, with funding by the National Science Foundation. ARGO, if you will, is a radiosonde system or weather balloon system for the world's oceans. Our budget proposes about $8 million, which will get us up to 275 floats per year to get to this 3,000 worldwide system. And NOAA puts this funding out through the National Ocean Partnership Program or NOPP, along with the Navy, NSF and other agencies.

And to go back to the comments, I think, that were made by Congressman Weldon and others, NOPP is an excellent mechanism to bring all the agencies together. And I think that CORE does a super job in supporting this.

Let me just go to the last slide. I see that I am on the red light. I think this always happens when I get a chance to testify about the oceans, which I care about. It is about port systems—Chesapeake Bay. Let me just get to the final system on tsunamis. Just one thing we don't think about that much; our tsunami warning devices. These are if—I am not sure if they are coastal or ocean, frankly. They are out in the deep ocean, but they are about doing coastal hazards for communities. These were developed by the Pacific Marine Environment Lab. And they actually measure very minute changes in ocean pressure that enable us to tell whether or not earthquake generated waves or tsunamis are coming across so we can get warnings out.

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About two weeks ago, I took part in the first Tsunami readiness program in Ocean Shores, Washington. I know there are members here from the Pacific. This is a big issue we don't talk a lot about on the East Coast. But it is a very big issue about coastal hazards and about using these observational systems to really protect life and safety.

There are a number of other issues I would like to talk about. But let me just thank you again, Mr. Chairman, Chairman of the—and all the members of the Subcommittee for giving us this opportunity today. Thank you.

[The prepared statement of Scott B. Gudes follows:]

PREPARED STATEMENT OF SCOTT B. GUDES

Good afternoon, Chairman Gilchrest, Chairman Ehlers, and Chairman Smith, members of the subcommittees and staff. My name is Scott Gudes, and I am the Acting Administrator and Deputy Under Secretary of the National Oceanic and Atmospheric Administration (NOAA). It is my great pleasure to be here this afternoon to testify on three important topics that are at the core of NOAA's mission-ocean exploration, coastal observations and ocean observations. NOAA believes that these three topics are components of one mission—to understand the complex dynamics—physical, biological and geochemical—that shape the world's oceans and Great Lakes. History shows us that voyages of discovery-like Charles Darwin's expedition on the HMS BEAGLE, are often followed by longer term observation and monitoring efforts. I expect that our initial exploration efforts will also be followed by the implementation of ocean and coastal observing systems which will routinely collect, record and transmit data on the state of our fragile

ocean and coastal regions. Conversely, I expect that our coastal and ocean observing systems will uncover secrets or anomalies that are beyond our ability to decipher and must be investigated further by targeted voyages of exploration.

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Ocean Exploration

Thirty-one years ago, the Stratton Commission proposed the creation of an agency that we know today as the National Oceanic and Atmospheric Administration. In their final set of recommendations, the Stratton Commission included an entire chapter that indicated that this new ocean agency should develop U.S. leadership in ocean exploration. Over the last three decades, NOAH has successfully pursued a course of ocean management, ocean resource protection, and of primarily management-focused ocean research and monitoring. Much of our resources are consistently directed toward specific resource crises, and narrow scientific investigations. As a result, we know a lot about a few things, such as specific fish stocks and coastal water quality, but we actually know very little of our total oceans. Ocean science experts tell us that we have seen only five percent of the world's ocean, and that the U.S. lags behind Japan, France, and Russia in our technical ability to explore and study it in at least one dimension, sending scientists into the sea. The challenge of fulfilling the original Stratton Commission vision, of a NASA-like exploration of the sea component, remains to be filled. The President has requested $14 million for NOAA's ocean exploration activities in FY 2002 and these funds would provide NOAA with a solid start on fulfilling the Stratton Commission's original vision of exploring the seas.

In FY 2000, the President convened a panel that included some of the Nation's best ocean scientists, explorers, and educators. The panel, convened as a subset of the NOAH Science Advisory Board, was ably led by Dr. Marcia McNutt of the Monterey Bay Research Aquarium Institute and included Dr. Robert D. Ballard. The Panel's report, "Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration," recommended a new era of exploration which could become as remarkable and ambitious a chapter in the history of human exploration of our planet as were the achievements of Balboa, Columbus, or Lewis and Clark. While stressing the importance of partnerships, the panel recommended that a single lead agency be responsible for the program and its budget. NOAH, with over thirty years of experience in ocean science, management, and stewardship, has already stepped into a leadership role by requesting and receiving funding specifically to establish a program of ocean exploration and has established the NOAH Office of Ocean Exploration. I believe that NOAH has a significant leadership role to play in ocean exploration and in implementing the President's Panel Report recommendations.

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The American public seems to agree that we need to focus more effort on exploring the oceans. In 1996, the Mellman Group conducted a nationwide survey to better understand the public's view of ocean policy issues. The results of that survey indicated that more than 80 percent of Americans believe our oceans are threatened by human activity, and 85 percent agree with the statement that the "federal government needs to do more to help protect the oceans." Seventy-five percent believe ocean exploration is more important than

space exploration. With a $4 million appropriation in FY 2001, Congress endorsed the need for such a program; NOAA created a dedicated program, the Office of Ocean Exploration. The Administration has reaffirmed the requirement and requested $14 million in the FY 2002 President's budget. I am hopeful that as this budget makes its way through the Congress that the full amount is enacted. Clearly, most of us agree on the need to explore and understand this most important component of our planet and on the enormous impact it may have on all aspects of our daily lives.

The U.S. Panel on Ocean Exploration

First, and foremost, NOAH is the Nation's ocean and atmospheric agency and was created for that specific purpose. We have been given the responsibility for the focused study of the oceans and atmosphere and for the application of these findings to fulfill our stewardship role. As such, we are responsible in a clear and direct chain of command to the Cabinet level of the Executive Branch, the Secretary of Commerce, and enjoy the benefit of constructive guidance from multiple Congressional oversight committees. Our agency focus is to generate sound scientific knowledge and apply it to ocean and atmospheric issues. In this regard, we fill the appropriate role defined by the Panel as a focused lead ocean agency and accountable for results.

We are not alone in the ocean community, and we certainly do not work alone. Other agencies, such as the Navy and the National Science Foundation, are responsible for much larger subject matter areas and, perhaps, more challenging missions. The Navy goes to sea to understand that component of ocean science that will benefit our national security and keep our Nation safe. The National Science Foundation conducts scientific investigations in all environments, including the ocean, to promote the progress of science, generating valuable knowledge wherever it is found. Partnership institutions, such as the National Oceanographic Partnership Program (NOPP), serve valuable coordinating and implementation roles for such multilateral projects as the Argo Project, in further technology development, and in the coordinated handling and processing of oceanographic data. We look forward to addressing the data management and availability issues raised by the Panel through the National Oceanographic Partnership Program. We are also working through the National Oceanographic Partnership Program to achieve an ocean observation system. The role NOAA can fill in a national ocean exploration strategy is one of leadership. We responded to the challenge of the President's Panel by instituting a national program, embracing multiple partners of many disciplines, and creating the NOAH Office of Ocean Exploration.

NOAA's Response to the Report of the President's Panel on Ocean Exploration

The NOAA Ocean Exploration program identifies unknown areas of the ocean and seeks to reduce this information deficit. Specifically, the program targets the oceans in areas or subject matter that is missed or bypassed by our current management-focused science and subject matter driven research programs. The science activity in NOAA today, and largely throughout our thirty-year history, has been targeted to answer specific and necessary questions to support climate prediction, fisheries management, resource recovery, safe navigation, and environmental monitoring. NOAA's Ocean Exploration program takes a broader approach to scientific inquiry and subject matter, as the President's Panel suggested. We conduct multidisciplinary scientific expeditions to characterize ocean areas with modern technologies, employ sound scientific methodologies, and convey these results in an exciting and informative manner to the science

community and the general public. The knowledge gained through exploration will extend our ability to conduct more focused research on a wider array of subjects and better perform our overall mission of ocean stewardship.

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This year, FY 2001, we are engaged in a number of multidisciplinary expeditions in the manner suggested by the Panel Report. We are examining benthic communities along the east coast with the submersible *Alvin.* We are teaming up with the National Geographic Society to document the marine sanctuaries from Belize, through the Gulf of Mexico, to Cape Hatteras. At Cape Hatteras, with the U.S. Navy, we are rescuing the steam engine and turret of the famed Civil War ironclad, the *USS Monitor,* now a National Marine Sanctuary. And we are engaging some of the best technology in what I would describe as a definitional exploration cruise, in the Astoria Canyon. This is the basin into which the Columbia River flows, and where Lewis and Clark ended their amazing journey of discovery. We begin ours there. Using a commercial survey ship with multibeam and high frequency side-scan sonar, we have mapped the bottom at a new scale of resolution. The cruise will be completed tomorrow with the arrival in port of the NOAA Ship *Ronald H. Brown,* which has carried NOAH and university scientists with expertise in biology, geology, and geophysics, and the Canadian Remotely Operated Vehicle, *ROPOS,* which will have visually explored the canyon areas identified in the sonar surveys. The combination of these tools and combined disciplines will enable a more complete understanding of this dynamic part of the ocean that, although close to shore, is scarcely explored. We have several other projects underway, but I would prefer to return and report on their completion at an appropriate time and turn now to our implementation of the President's Panel Report.

Principal Objectives of the President's Panel on Ocean Exploration

The President's Panel on Ocean Exploration provided four principal objectives for a national strategy to achieve an invigorated ocean exploration program. These were: to map the physical, geological, biological, chemical, and archaeological aspects of the oceans; to explore ocean dynamics and interactions; to develop new sensors and systems for ocean exploration and regain U.S. leadership in marine technology; and to reach out in new ways to stakeholders.

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Mapping: The Panel's recommendation to map the oceans is squarely within NOAA's domain, at least so far as the Nation's Exclusive Economic Zone (EEZ) is concerned. NOAA's precursor agency, the Coast Survey, was responsible for charting the Nation's marine waters, and NOAA continues this mission today. The United States has the largest EEZ of any nation in the world, over three million square nautical miles, but only five percent of the U.S. EEZ is mapped. As such, we agree with the Panel report's suggestion that NOAA increase its efforts to chart and map the Nation's EEZ.

Exploring ocean dynamics: The Panel identified the need to explore ocean dynamics and interactions at new scales. Our sampling methodologies, regularly applied throughout our decades-long data streams, do not fully sample the biota of the ocean. We use techniques that have only slightly advanced in the previous

hundred years. While incremental progress in acoustic surveys continues, an invigorated ocean exploration initiative would allow the United States to become a leader in the use of this promising technology. NOAA is working with multiple institutions and agencies to explore the dynamics of submarine regions, such as deep sea hydrothermal vents, through partnerships with universities and the National Science Foundation. The President has requested funding that would allow NOAA to work collaboratively with the larger scientific community.

New technologies: The Panel identified the need to develop new sensors, technologies, and platforms. The merit of this recommendation is apparent. We clearly need new and improved technologies, devices, and craft to take our exploration of the oceans to a point not only beyond where we are today, but to a position of regained international leadership, a position we have lost. NOAA is working to advance undersea technologies through Ocean Exploration, the National Sea Grant Program, and the National Undersea Research Program (NURP). We look forward to working with academia, industry and the National Oceanographic Partnership Program to develop the new ocean sensors and technologies that the Panel recommended.

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Education and outreach: The Panel recommended that ocean exploration reach out in new ways to stakeholders. Our own website, *oceanexplorer.noaa.gov*, has already proven a great success with thousands of students of all ages around the world tuning in, even though most schools have not even been in session since it launched on June 1 of this year. NOAA is allocating ten percent of our Ocean Exploration budget to education and outreach. I consider the education and outreach component of the ocean exploration program to be essential to the success of this initiative.

New Approaches and the Future of Ocean Exploration

The President's Panel also stressed the importance of partnerships for pooling limited resources and multiplying the accomplishments achieved from ocean exploration activities. We have engaged the university community, private industry, and other government agencies and services. In fact, less than half of NOAA's $4 million appropriation in FY 2001 for ocean exploration activities remained "in-house"; the remainder passed through the agency to the private sector, academia, or other agencies. We have chartered or engaged nine vessels belonging to the private sector or other agencies for our Ocean Exploration missions this summer. Those vessels ranged from University-National Oceanographic Laboratory System (UNOLS) sources, such as the Harbor Branch Oceanographic Institution, the Woods Hole Oceanographic Institution, Scripps Institution of Oceanography, and Monterey Bay Aquarium Research Institute, to commercial fishing vessels, private survey ships, and a commercial diving barge. We also gained support and participation from an EPA ship and two Navy salvage ships. This demonstrates NOAA's desire to work cross-agency, collegially, and through meaningful partnerships.

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The President's Panel recommended several opportunities and implementation strategies, and I have detailed how NOAA is responding to these challenges. But NOAA is also embarking on exploration

activities that will be based on the needs defined, in part, by the larger scientific community. Beginning in the fall of 2001, we will conduct a series of at least 6 regional planning workshops in the northeast, southeast, Gulf coast, west coast, Alaska, and Hawaii. Through this geographic distribution, we will learn from an integrated body of participants from academia, industry, and other government agencies about local and regional informational needs. We will identify those needs and knowledge deficits, prioritize them, and thereby generate a strategic plan and implementation agenda of exploring our oceans and the oceans of the world. The value of these workshops will be to represent the collective wisdom and experience of the combined scientific and technical communities and not those singularly in NOAA. I am confident that the product will be a well supported agenda of exploration.

In FY 2002, we will continue to take projects to sea and, hopefully, at a level supported by the funds requested in the President's budget. Much of this effort will be proposal driven and result from the peer review of proposals submitted by scientists and explorers from government, industry, and academia. The emphasis of this research and discovery-based science will be in five thematic areas: (1) New Ocean Resources—in which we seek to discover living and nonliving resources that may have a significant beneficial potential, such as gas hydrates or bioprospecting; (2) Exploring Ocean Acoustics—to expand the network of hydrophones monitoring marine sound of natural and human origin, thereby determining the effects of noise on marine animals, developing new methods of counting and identifying whales, and accomplishing the early detection of underwater seismic activity; (3) America's Maritime Heritage—in which we will survey, locate, and inventory shipwrecks and archaeological sites of historic interest, plus compile a National Shipwreck Inventory from which we can make informed management decisions; (4) Exploring Ocean Frontiers—for which we will employ modern technology to survey, characterize, and define diverse marine environments and the processes therein, particularly in areas not well known or understood; and (5) Census of Marine Life—in which we will join global academic and government institutions in collecting data on the distribution and abundance of marine organisms and improve our assessment capabilities.

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NOAH led the effort to support and staff the President's Panel on Ocean Exploration. NOAA is the dedicated ocean agency of the Nation and is currently the only Federal agency administering and requesting specific funds for an ocean exploration program. We understand mapping. We have been doing it since 1807. We understand partnership. More than half of our appropriation for ocean exploration is being spent outside of NOAH, and our projects sail on ships other than NOAA vessels. We understand and support ocean education and outreach through such partners as the Jason Foundation, the National Geographic Society, and such esteemed ocean leaders as Dr. Robert Ballard, Dr. Sylvia Earle, and Jean Michel Cousteau. NOAH has a role in implementing the President's Panel Report on Ocean Exploration. That role is one of leadership, as the ocean agency, and as the ocean exploration program. It is one we will not do alone. It is one we cannot do alone. For us to regain the leadership position in the world community of ocean science, we must continue to work with the other Federal agencies, academic institutions, and private-sector industries. Working together, our national ocean exploration efforts will yield even greater results.

President Bush recently announced his intention to appoint 16 distinguished individuals to serve on the Commission on Ocean Policy. The Oceans Act of 2000 tasks this Commission to develop a report over the

next 18 months to address a very broad range of oceans policy issues. These include existing and planned activities of State and Federal entities, facilities associated with private and public activities, and ocean and coastal resources. We look forward to following the efforts of the Commission and to working with other agencies to develop the National Ocean Policy required by the Act once the Commission completes its report.

Coastal Observations

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I would now like to address the Subcommittee's request for information on developing and implementing a system of compatible coastal observatories. Throughout history people have had many reasons to settle by our coasts, and they have long recognized that the oceans critically affect human endeavors. Cargo, fishing, and military ships have always been affected by winds, waves, ice, ocean currents, as well as hurricanes and typhoons. Primitive observing systems were initiated centuries ago to measure and try to predict these phenomena.

As uses of the ocean and coastal waters increase, evidence of widespread impacts of these activities on land, the oceans, and the atmosphere is steadily mounting. These interrelated earth systems have been strongly affected by the direct and indirect consequences of human population growth, industrialization, and demand for natural resources. It is increasingly evident that changes in the environment need to be monitored, that effective action must be taken to mitigate damage based on these measurements, and that future changes to the environment must be anticipated.

A sustained coastal ocean observation program to detect, track, and predict changes in physical and biological systems and their effects is needed to measure not only the impacts of humans on the ocean, but also the impact of the ocean on human endeavors. The oceans are currently monitored far less effectively and completely than terrestrial systems; yet humans depend strongly on the sea as a source of food and for transportation and trade, among many other uses. Such a program would build upon integrated existing monitoring efforts by both government and academia.

NOAA's mission is to describe and predict changes in the Earth's environment and conserve and wisely manage the Nation's coastal and marine resources. An integrated coastal observing system is needed to monitor the "state" of the coastal ocean in order to understand and ultimately predict how the coastal ocean responds to weather, climate, and human activities. Just as continuous measurements of weather and climatic conditions are maintained on land, similar sustained measurements of the coastal ocean are required to monitor change and to assist in understanding and predicting its impacts.

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It must be noted that there are already many U.S. coastal observing systems and monitoring programs in place that serve the needs of many users. It is equally important to state that these observing elements are not yet integrated and do not constitute a complete system. The systems provide data that help mitigate

losses to life and property, enhance profits to industry, ensure national security, and provide information to mitigate anthropogenic changes to the environment. They are not, however, as cost effective or as useful as they could be, even at present levels of funding. These elements do not serve the complete needs of users. The Congress recognized these gaps and, in 1992, passed the National Coastal Monitoring Act calling for "a comprehensive national program for monitoring of the Nation's coastal ecosystems." However, lack of funding has limited progress. Today, growing needs add urgency, and advancing technologies make major improvements possible. An integrated coastal ocean observing system would serve better a much wider array of users.

There are many indications that coastal environments are experiencing rapid changes as a consequence of human activities. These include habitat loss and modification (e.g., wetlands, coral reefs, oyster reefs), coastal erosion, excessive accumulations of algal biomass, oxygen depletion, harmful algal events, fish kills, shellfish bed closures, declines in fish stocks, the growth of exotic species, chemical contamination, and the loss of biodiversity. These changes are making the coastal zone more susceptible to natural hazards, more costly to live and recreate in, and of less value to the national economy.

In the absence of scientific understanding of coastal ecosystems and how they change in response to human activities and natural variability, the formulation and implementation of environmental policies has become, and likely will be increasingly, controversial. Substantial advances in the predictive understanding of environmental changes in coastal ecosystems and their effects on people cannot be achieved in the absence of long-term and large-scale observations.

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Nowhere do the missions of so many Federal and state agencies overlap as in the coastal zone, and this region is the subject of more monitoring and research activity than any other place on Earth. Yet we still do not have a predictive understanding how people are changing the environment and how these changes are affecting people (e.g., wetland loss and coastal flooding, hog manure and *Pfiesteria).*

Clearly, we must make more effective use of the combined resources/assets of Federal and state agencies (environmental monitoring for the purposes of research and management, fisheries stock assessment, habitat surveys, etc.), the private sector, and academia to get a clearer picture of the dimensions of change and make more timely and meaningful forecasts of changes and their impact.

The first step is to coordinate and integrate existing efforts to collect, manage and analyze data to minimize redundancy, maximize access to diverse data, and produce timely analyses that are useful to a broader spectrum of users. The second step is to enhance and supplement the observing to achieve a more comprehensive and useful view of changes and their impact.

Benefits of an Integrated Coastal Ocean Observing System

An effective, efficient, and useful coastal ocean observing system would:

facilitate safe and efficient marine operations, ensure national security, support managing living resources, preserve healthy marine ecosystems, mitigate natural hazards, and protect public health;

build upon existing coastal and ocean monitoring and be responsive to the needs of those who depend on the Nation's coastal waters for work, security, research, and recreation;

provide sustained, continuous, long-term, reliable, and, as appropriate, real-time observations and analysis of ocean events and phenomena;

provide a common set of parameters deemed to be in the national interest, using uniform methods and protocols, with augmentation as desired by regional and local concerns;

provide a consistent national framework for regional efforts yet allow for flexible design at all levels; and

engage and support a wide range of participants from Federal, state, and local governments; academia; and the private sector.

Future Plans and Needs of an Integrated Coastal Ocean Observing System

The first step in establishing a comprehensive coastal ocean observing system is to integrate existing data and networks and provide access to this data. Working through NOPP and the OCEAN.US Office, NOAA could coordinate with components offered by other Federal Agencies to provide the backbone of an integrated coastal ocean observing system. This effort could be initiated with coastal elements of existing national networks and could support additional National needs and/or needs identified through the regional efforts.

NOAA currently operates several relevant monitoring and observing systems that would contribute to this backbone for coastal ocean observing system. These include:

National Water Level Observation Network (NWLON), which includes approximately 175 continuously operating water level measurement systems, providing basic water level data for all coastal and Great Lakes states.

Physical Oceanographic Real-Time Systems (PORTS) operating at five extremely busy harbor entrances, provide measurements from water levels, currents, meteorological data, and water temperature in real time.

National Data Buoy Network provides real-time data on the sea state and meteorological conditions at buoys in the Great Lakes and coastal ocean, and the 60 shore-based *Coastal-Marine Automated Network* (C–MAN) stations provide similar information to NOAH, state, and private weather forecasters.

National Status and Trends Program measures the status and changes in levels and effects of toxic contaminants at about 280 locations in the U.S. Coastal and Great Lakes ecosystems. In addition, temporal trends are being monitored through the *Mussel Watch* project that analyzes mussels and oysters collected

annually at about 200 of those sites.

National Estuarine Research Reserve System (NERRS) System-Wide Monitoring Program (SWMP) monitors physical, chemical, and biological parameters at each of the 27 Reserves, covering over one million acres of estuarine waters and lands. The President's Request for a $1.7 million increase for NERRS operational grants will help expand the SWMP by increasing spatial coverage of water quality stations, and by monitoring additional biological indicators.

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Harmful Algal Boom monitoring program works in conjunction with states and other Federal agencies to monitor levels of toxic algae, including *Pfiesteria*, and related water quality properties to determine the threat posed to human health and the ecosystem by this organism.

Tsunami Warning System (TWS) in the Pacific, comprised of 26 participating international Member States, monitors seismological and tidal stations throughout the Pacific Basin, providing real-time information needed for the early detection of tsunamis and for assessing and forecasting the threat to coastal communities.

Land-cover and Habitat mapping. The Coastal Change Analysis Program (C–CAP), Effects of Fishing on Essential Fish Habitat (EFH), and Seafloor EFH Characterizations programs provide routine observations on the habitats of managed species.

Long-term ecosystem data collection programs, including the *California Cooperative Fisheries Investigation* (CalCoFI), the *Marine Monitoring and Assessment Program* (MARMAP) in the Northwest Atlantic, *SEAMAP* in the Southeast U.S., and the *Fisheries Oceanography and GLOBEC* programs in the Pacific Northwest, Gulf of Alaska, Bering Sea, and Gulf of Maine provide essential information on abundance and distribution of marine fish and invertebrates, and environmental changes which affect them.

Coast Watch provides near real-time access to high-resolution satellite remote sensing data from NOAH and other platforms, including sea surface temperature and ocean color.

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The second step of a strong integrated National coastal ocean observation program would be support for a federation of regional observing systems that could provide additional full national coverage at higher-resolution, tuned to regional issues. These regional systems would collect and exchange data on a free and open basis and according to national standards and protocols. These regional enterprises composed of consortia of state, academic, private, and Federal partners would be most effective in understanding and responding to the needs of the regional users. Working with NOAA's national data centers, these regional efforts would also ensure that their observations are made available for long-term stewardship.

The third, equally important step is a strong Data Management and Data Sharing effort. This would include working with all of the relevant data stakeholders to develop standards and protocols for storing,

sharing, and accessing coastal data. This should include protocols for the transfer of data among regional and national backbone systems, the user community, and a national repository; as well as the documentation of data type and quality via approved metadata standards. A key component of the data management program should be a coastal data portal through which users from all sectors should find, view, access, integrate, and share data from national, regional, state, and academic sources regardless of original formats. NOAA's National Environmental Satellites, Data, and Information Service and National Ocean Service stand ready to provide its extensive expertise and experience in data management, sharing, and archiving to all of its partners in this effort.

These enhanced coastal observation systems would serve as the basis for two programs. The first is a concept we are working with our partners to develop an ecological forecasting capability to parallel our weather and climate forecasting service. Ecological forecasts predict the effects of biological, chemical, physical, and human-induced changes on ecosystems and the components. Being able to forecast, for example, harmful algal bloom outbreaks, the impacts of decisions on coastal hypoxia (dead zones), the impacts of water use on oysters and other estuarine species, the impacts of changes in the distribution of precipitation and temperature on coastal habitats all depend on a robust and sustained observation system. Data from this system are required to both drive the forecasting process and test the forecasts against the real world.

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The second is an initiative called Coastal Storms, for which we are asking $3 million in the President's FY 2002 Budget to do a pilot project in Florida. Coastal Storms proposes to build on and enhance existing coastal observation systems such as our National Water Level Observation Network and Physical Oceanographic Real Time System, to help dramatically reduce the loss of property and life in regions vulnerable to natural disasters. Recent estimates for disaster losses are between $10 and $50 billion per year, with an average cost of $50 million an event. Over 70% of disaster losses occur in coastal states or territories and much of this damage occurs in inland areas adjacent to the coast resulting in costly impacts throughout coastal watersheds. Coastal Storms will enable NOAH to provide an integrated suite of capabilities that capitalize on our coastal observations to predict and reduce the watershed impacts of coastal storms.

Partnerships

NOAA is committed to working with other agencies, academia, and the private sector in arrangements such as the National Oceanographic Partnership Program (NOPP) to make this coastal observing system a reality. NOAH worked hard with other agencies to facilitate the implementation of the NOPP Observation Office, OCEAN.US, for the coordination of these efforts. A strong partnership would allow each organization to execute its own research and/or operational-driven mission while deriving maximum benefit from interagency coordination.

Ocean Observations

Now I'd like to turn to a different category of ocean activities, in particular the essential observations necessary for understanding and predicting the ocean's role in climate. Last month, the President announced

a new Climate Change Initiative, dedicated to reducing uncertainties in climate change knowledge and identifying priority areas where research can make a difference. Clearly, our observations of the ocean will be a major factor in clarifying the future course of climate change.

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An important difference between ocean observations for climate and those for exploration is the sustained nature of the data collection. A useful analog is the system we use to observe the weather. We could not expect to predict the weather based on an occasional weather balloon or an intermittent Doppler radar image. It is necessary to keep the system going to see change on the horizon. Similarly, an ocean observing system must be sustained to see a developing El Niño or longer-term changes in ocean circulation that will influence the evolution of climate.

We have known for some time that we must observe the ocean to predict the course of climate, and NOAA has a strong track record in this endeavor. In 1997–98, the strong E1 Niño and its effects on the U.S. and the world were anticipated well in advance. By contrast, an El Niño of similar strength in 1982–83 was largely a surprise to the world. The difference in predictive skill was largely the result of an ocean observing system deployed in the tropical Pacific, together with the understanding and computer model development that was the result of decades of research. This provides the basis for our ocean observing system of today.

The Present System

Presently NOAA's major ocean observation system, centered on the tropics and designed to enhance climate prediction on seasonal to interannual time-scales, is the El Niño-Southern Oscillation (ENSO) Observing System. The ENSO Observing System has four elements. It consists of approximately 70 fixed buoys in the tropical Pacific that provide surface atmospheric and ocean mixed-layer observations, several hundred drifting buoys in all of the major ocean basins, a Volunteer Observing Ship (VOS) program of about 40 commercial ships, and a network of tide gauges. NOAH recently expanded the fixed buoy system to the tropical Atlantic sector, and has maintained a monitoring system for the Florida Current for many years. The resulting data are used to initialize climate models, verify model results, and monitor the changes in the upper ocean. Complementing this system are NOAA's environmental satellite systems, which provide regional and basin-wide observations of sea surface temperature and estimates of rainfall.

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There is also an emerging observational system—called the Argo Array—that, in combination with satellite remote sensing, will provide the backbone of sustained global ocean observations needed to improve climate forecast skill. Argo will consist of three thousand autonomous instruments that can change their buoyancy to rise or sink in the ocean. Argo builds on the observations, extending their spatial and temporal coverage, depth range and accuracy, and enhancing them through addition of other measurements. For the first time, the physical state of the upper ocean will be systematically measured in near real-time and used in models.

Here's how Argo works. The instruments cycle to depths up to 2000 meters every ten days, travel submerged for a specified period, then surface and relay data to satellites about the ocean temperature, salinity, and currents. Each instrument has a four to five-year lifetime. With a design based on experience from the present observing system and on estimated requirements for climate and high-resolution ocean models, Argo will provide 100,000 temperature and salinity profiles and reference velocity measurements per year from the 3000 floats distributed over the global oceans. All Argo data will be publicly available in near real-time and in scientifically quality-controlled form within a few months. Essentially, the Argo array will be the ocean analog of the radiosonde—or weather balloon—system; it will initiate the oceanic equivalent of today's operational observing system for the global atmosphere.

Objectives of Argo fall into several categories. Argo will provide a quantitative description of the evolving state of the upper ocean and the patterns of ocean climate variability, including heat and freshwater storage and transport. The data will enhance the value of NASA's Jason altimeter through measurement of subsurface vertical structure and reference velocity, with sufficient coverage and resolution for interpretation of altimetric sea-surface height variability. Argo data will be used for initialization of ocean and coupled forecast models, data assimilation, and dynamical model testing. A primary focus of Argo is seasonal-to-decadal climate variability and predictability, but a wide range of applications for high-quality global ocean analyses is anticipated. The Argo program will be coordinated through the National Ocean Partnership Program described earlier.

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The current proposal before Congress includes a requested funding increase of $3,190,000 for the Argo system as part of the Climate Observations and Service budget. These new funds will allow NOAH to reach an annual deployment rate of about 275 floats. With an annual expected loss rate of 10 percent, this level of funding will bring the U.S. to the 1000 float target that is the U.S. contribution to the international goal of 3000 floats by FY 2005. Other nations will contribute the majority of the system.

In addition to Argo, the other components of the sustained ocean observing system being requested in NOAA's $7.3 million initiative include the following:

Ocean Reference Stations: NOAH plans to implement a global network of ocean reference station moorings, expanding from the present three pilot stations to a permanent network of 16. These fixed buoys provide the long-term record of ocean climate, often at sites with long historical records.

Volunteer Observing Ships: Ships of opportunity provide global atmospheric and oceanic data that is the foundation for understanding long-term changes in marine climate. The data are also essential input for climate and weather forecast models. VOS need improved monitoring capabilities, better observer training, and improved data quality in order to reduce both systematic and random errors. NOAH wants to expand operations from 17 to 22 shipping lines over the next five years.

Ocean Carbon: Cross-ocean sections measuring dissolved ocean carbon were taken during the World Ocean Circulation Experiment of the last decade. It is critical for our understanding of the global carbon cycle to ensure that the long-line measurements of ocean carbon are maintained so that we can see any changes in carbon dioxide uptake by the oceans.

Arctic Ocean Fluxes: Over the past 20 or more years, significant changes have been noted in the Arctic, such as thawing of permafrost, earlier break-up of ice on rivers, and thinning of the ice cover on the Arctic Ocean. Recent studies conclude that changes seen in the extent of the Arctic ice are unlikely to have been caused by natural variability. In partnership with other Federal agencies, NOAA proposes to begin a long-term effort to quantify the flux of "fresh" water from the Arctic to the North Atlantic. An international team has identified five key mooring sites suitable for a program of long-term observations.

Data Management: A robust system for managing data is essential to the vision of a sustained ocean observing system. The value of the observations does not end with their initial use in detecting and forecasting present conditions. The data must be retained and made available for retrospective analyses to understand climate change, and for managing observing system operations and improvements.

Data Assimilation: To make use of these observations, an enhanced program of assimilating the data into ocean models is required as well. This is similar to the process used in weather prediction models, where observations are used to give the best possible description of the atmosphere before running the prediction.

Future Plans and Needs: An Integrated, Sustained Ocean Observing System

The ocean system as envisioned internationally and by NOAH will include platforms and sensors (both remote and in-situ), data management, and assimilation and analyses. This end-to-end ocean system will provide the critical data and products needed for forecasts, research, and assessments. The ocean system will be effective only through continuing interaction with other national and international communities. To fulfill its responsibilities for providing climate services, NOAH will lead the U.S. effort to enhance its present components, establish new components, and maintain the global operational ocean observing system necessary to deliver needed forecasting and assessment services to the Nation and the world.

The present international observing-effort is about 25% of what will be needed over the long term. An international plan for a comprehensive global ocean observing system was drafted by over 300 scientists from 26 nations in October, 1999. When completed, the composite ocean system, including the satellites, will deliver continuous, long term, climate quality, global data sets and a suite of routine ocean products:

For the global ocean, four-times-daily distributions of sea surface pressure, sea surface wind, and marine weather and sea state conditions.

For the global tropics, daily distributions of precipitation, sea surface temperature, and air-sea fluxes.

For the global ocean, weekly distributions of upper ocean temperature and salinity, sea surface temperature, and sea level.

For the global ocean, an ocean carbon inventory once every ten years and seasonal (four-times-yearly) analyses of the variability of ocean-atmosphere carbon exchange.

At fixed climate reference stations, documented long tern trends in sea level change and ocean/atmosphere variability.

These observing system deliverables comprise the essential raw data from the ocean that will be needed by the climate forecasters and researchers to help deliver assessments and predictions of climate, on time scales of seasonal to decadal and longer. In addition to completion of the Argo array, a system to deliver these products would require completion of the global drifting buoy network, establishment of an enhanced array of tide gauges for documenting sea level change, completion of ocean reference station moorings described above, and occupation of new volunteer observing ship lines. Completion of the U.S. array of coastal moorings, described in the previous section, will also be a critical part of the ocean observing system for climate. From the satellite perspective, continuous altimeter and scatterometer measurements will be needed for determination of global sea level and surface winds, respectively. Finally, the system-wide infrastructure requirements, including research vessels, data systems, and modeling capabilities, will need to be in place to support this system.

All Three Efforts Are Important

On a summer day, our eyes and ears can sense an approaching thunderstorm. Our senses are extended by radar and satellites to detect advancing storm systems. Our senses are being extended yet again to anticipate changing states affecting coasts and oceans, our environment, and our climate. To truly understand the consequences of our actions on the environment and the environment's impact on us, data obtained through ocean exploration, coastal observations, and ocean observations will be critical.

"Coastal observations" include observations in the Nation's ports, bays, estuaries, Great Lakes, the waters of the EEZ, and adjacent land cover. Some of the properties measured in coastal zones, such as temperature and currents, are the same as those measured in the larger, basin-scale ocean observation systems. However, the users and applications of those data can be quite different. For those properties that are similar, there should be a consistent plan for deployment in the coastal and open ocean systems so that coastal observations represent a nested hierarchy of observations collected at higher resolution than those from the open ocean.

As I mentioned earlier, NOAA is prepared to begin coordinating existing coastal observing data and networks working through NOPP and the OCEAN.US Office to provide the backbone of an integrated coastal ocean observing system.

Ocean exploration includes the examination of the temporal components of the sea, and that includes the long-term monitoring of ocean characteristics, and an integrated ocean observation system. NOAH is engaged in multiple ocean observation programs already, and recognizes that an integrated ocean observation system is worthy of its own identity and will hold merit to future aspects of scientific inquiry.

Mr. Chairman, on behalf of Secretary Don Evans and the 12,500 men and women who make up NOAA, thank you for this opportunity to address how NOAH can contribute to expanding the frontiers of human knowledge. As I've stated, ocean exploration, ocean observations and coastal observations are at the core of NOAA's mission and we look forward to working with the Subcommittees on charting the future course of these important endeavors.

Chairman **EHLERS.** Thank you for the testimony. Dr. Colwell?

STATEMENT OF RITA R. COLWELL, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. **COLWELL.** Mr. Chairman and members of the Committee, I appreciate the opportunity to testify today on ocean exploration and ocean observations because these are areas of really great interest to the National Science Foundation, as well as our fellow agencies, as you will hear today, and to the academic community and the private sector, also. And it is a pleasure to be here with Admiral Cohen and with Admiral Lautenbacher and Mr. Gudes.

NSF has a very proud history of supporting basic research and education in the ocean sciences. This includes the tools that are necessary to access the oceans from the surface to below the sea floor. Even though NSF accounts for less than about four percent of the total Federal R&D budget, the Foundation does provide about 70 percent of Federal funding to academic institutions for oceans research. The Foundation has a broad, encompassing role that advances the frontiers of discovery and seeks to engage the public. And to illustrate this, I would like to take us on a very brief journey to the depths of the sea floor.

The footage that we would like to show you was taken from the submersible ALVIN two miles below sea level. NSF has supported ALVIN since the 1970's, along with NOAA and ONR. And we also helped to support this filming. The deep sea vent called nine Degrees North is located in the Pacific Ocean South of Mexico. These scenes will be released next year in the film, Volcanoes of the Abyss. And this IMAX feature will bring the astonishing life of this environment to millions of people throughout the world. These unique features are called black smokers. They are mineralized chimneys that tower above the communities of life at the hydrothermal vents. The mouths of the vents spew forth boiling water full of chemicals. And these conditions are toxic to most life forms, yet, the list of known species inhabiting the vents now is greater than 300.

Understanding these remarkable ecosystems can help us explain the origins of life and open up new avenues of research in biotechnology. Now, that amazing footage embodies both the NSF's research and education activities. And these efforts are right in line with the recent recommendations from the Panel on Ocean Exploration. The panel opens their report by stating that over 95 percent of the oceans remain unknown and unexplored. NSF is dedicated to reaching into this untapped realm. And one way we are doing this is through the support of ocean observations.

Last January, one of these projects, the Hawaii Ocean Times Series, made headlines with the discovery of a new group of microorganisms in the Northern Pacific Oceans. Now, these microorganisms, we call them Archaea, we microbiologists, were previously thought to exist only in extreme conditions, such as volcanic vents or in the hot springs like at Yellowstone. Now, they appear to comprise a very large percentage of the biomass, the living things in the open ocean. And marine scientists have yet to determine how these Archaea absorb nutrients. How do they multiply? What role do they play in the ocean ecosystem? There are so many of them, they must play some role.

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NSF is working with the academic community and with the Federal agencies, my fellow agencies, to provide a new infrastructure to gain access to the oceans—on the coast and in the open sea. And this network of ocean observatories will facilitate the collection of time series data, and the time series data will help us to understand the basic biology, the basic chemistry, geology and physics of our oceans.

Now, this network will also help us fill in these gaps, that you have eloquently spoken about, in our knowledge of the Earth's climate system.

So, in closing, let me say again that this is a time of unparalleled opportunity to advance research and exploration in oceanography. As the new observation systems are put in place, we are going to learn a lot more about the changes that are occurring across our planet. And if we make the right investments, the coming decades in ocean research, exploration and education will be truly extraordinary. NSF looks forward to working toward this goal with our many partners across the government, in academia, and in other nations. Mr. Chairman, thank you very much for the opportunity to share the exciting work being supported by and the work we plan to do at the National Science Foundation. And I will be very pleased to respond to any questions that you and the Committee may raise.

[The prepared statement of Rita R. Colwell follows:]

PREPARED STATEMENT OF DR. RITA R. COLWELL

Mr. Chairman, members of the Committee, I appreciate the opportunity to testify today on ocean exploration and ocean observations, activities in which the National Science Foundation plays an important role. These are areas in which many agencies, as well as the academic community and private sector, have a substantial interest and it is a pleasure to be here with Admiral Lautenbacher, Admiral Cohen, and Mr. Gudes.

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For generations, the search for knowledge and understanding of the oceans has captivated the human imagination. It will continue to do so for generations to come. But it is quite clear that our generation has a tremendous opportunity, and a keen responsibility, to fuel discovery in this realm. Technological and computational advances, as well as fundamental breakthroughs in understanding, are transforming the ocean

sciences. At the same time, we are becoming increasingly aware of the economic, public health, and environmental significance of our oceans. Ocean exploration and the potential implementation of an integrated ocean observing system are two areas that can advance discovery.

EXPLORATION

NSF funds basic research and education in ocean sciences, and the facilities and instruments necessary to gain access to the oceans, from the surface to deep in the seafloor and from pole to pole. Exploration is a fundamental component of basic research. It is where science begins—with general ideas or broad hypotheses that seek to characterize new areas and processes in the ocean. The resulting knowledge provides a framework for further inquiry through subsequent, more specific investigations.

Last fall, the President's Panel on Ocean Exploration, convened by the previous administration and chaired by Dr. Marcia McNutt, produced a report highlighting the fact that oceans remain largely unexplored and calling for establishment of an ocean exploration program. The report identifies many areas offering high potential for scientific advances. NSF is currently active in and seeks to expand activities associated with relatively unexplored areas and aspects of the oceans, incorporating both educational and data management and dissemination components, as well as technology development.

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Let me highlight a few of the areas in which we see NSF playing an important role.

Relatively Unexplored Regions

The deep biosphere (including the subsurface biosphere) found along seafloor volcanic ridges still remains a mystery. We are continuing to discover new hydrothermal vent locations, with their associated and remarkable ecosystems that may help to explain the origins of life on earth and open new avenues of research in biotechnology. These seafloor volcanic ridges and vents also help us develop an understanding of plate tectonics and how the earth itself was formed.

A particularly compelling example of the kind of exploration activity the Panel has described is a recently completed expedition to the Indian Ocean. NSF funded an interdisciplinary team of 34 scientists, technicians and engineers to explore a newly discovered vent field by collecting biological samples and samples of vent and smoker fluid and plumes, rocks and sediment samples from the seafloor, and by precisely mapping the area. The research project is fully integrated with an educational component entitled "Dive and Discover", co-funded with Woods Hole Oceanographic Institution and Ohio's Center of Science and Industry, with live webcasts (through NASA), interactive opportunities between students and scientists, and companion materials that assist teachers in explaining the science and technology behind the cruise and in providing classroom activities. The "Dive and Discover" web site has been nominated for the "Webby Award" for its educational and scientific content.

The ALVIN research submarine, in which I've had the privilege of diving, has been an extraordinary tool for reaching the deep ocean over the past thirty years. A design study for an ALVIN replacement with even greater capabilities will start this summer.

As noted by the Panel, both the Arctic and many areas of the Southern Ocean offer tremendous opportunities for exploration.

The Arctic is data-poor. It is difficult to reach much of the region, especially in the winter. NSF is presently developing robotic aerosondes, small pilotless planes, to sample the marine atmosphere and monitor sea ice. These planes can fly in hazardous conditions and over an extremely wide range—assets for obtaining measurements where manned missions would be costly and dangerous.

We have also established an environmental observatory at the North Pole. This year we carried out a hydrographic survey from the North Pole toward Alaska. Automated instruments at the station transmit data by satellite from the ice surface and from instruments anchored to the sea floor.

In cooperation with the Office of Naval Research and the Navy, we used Naval submarines to explore the Arctic Ocean from below and to chart the seafloor as part of our Scientific Ice Expeditions (SCICEX). We are now moving to a new way of exploring under the sea ice using Autonomous Underwater Vehicles (AUVs). They are designed to make long duration (11 day) forays under ice-covered oceans, and can transmit their position and data while underway using mini-torpedoes that heat their way through the ice and report by satellite.

The Southern Ocean—the southernmost reaches of the global oceans—is uniquely placed to contribute to understanding of many global environmental issues. In recent years it has been the site for regional global research programs, and more efforts are planned to understand the dynamics of Antarctic ocean circulation processes, the global dispersion of Antarctic water masses, and the region's contribution to the carbon cycle.

The cold temperatures, long periods of darkness, and episodes of high UV radiation place extreme stresses on biological systems in the Arctic and Southern Oceans. Scientists are discovering species of fish that have evolved specific genetic adaptations that enable them to live in freezing waters.

Exploring in Time

The Panel emphasized the need to explore ocean dynamics and interactions, often referred to as "exploring in time." Many of the most revealing discoveries today are coming from measurements made at the same location but over sustained time periods. NSF is vitally active in this area.

The availability of long time-series data that extend over several decades is recognized as a key element to understanding the role of the oceans in modulating the behavior of the earth system. For several years, we have supported time-series projects near Hawaii and Bermuda to enable understanding of processes that cannot be captured by snapshot visits. The data collected cuts across disciplines and sets the stage for further scientific inquiry.

We have also invested in technology development and emplacement of prototype seafloor observatories off of the New Jersey coast and Hawaii. Consistent with numerous recent reports, including one by the National Academy of Sciences highlighting both interdisciplinary research and educational benefits, NSF is planning for an enhanced investment in seafloor observatories. I will discuss this further in the context of the proposed Integrated Ocean Observing System (IOOS).

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Ocean Drilling Program

I would be remiss to discuss ocean exploration without mention of the Ocean Drilling Program, a longstanding program dedicated to ocean exploration and basic research which advances many areas highlighted by the Panel. The program is an international partnership involving over 20 nations with NSF providing about $50 million annually to support U.S. academic community involvement. It explores aspects of Earth's history, structure and processes by taking core samples of the Earth's crust from all of the world's oceans.

NSF has been working with its international partners to develop the Integrated Ocean Drilling Program (IODP), the future phase of scientific drilling. The Integrated Ocean Drilling Program envisions an expansion of exploration beneath the oceans, made possible by increasing drilling capability, from the single-ship operation currently in use, to a multiple-drilling platform operation of the future. The new drilling, sampling and observing capabilities would allow scientists to conduct experiments and collect samples in environments and at depths never before attempted. The IODP would recover cores from the subseafloor ocean and from as yet poorly sampled environments, such as the Arctic Ocean basin. The results assist efforts to "explore in time" by studying sediments which record historical changes in the Earth's environment.

Technology Development

Research in technology development and subsequent capital investments in such technologies is critical to exploration as well as other areas of basic research. I have already mentioned many of these technologies, such as aerosondes, AUVs, through ice communications, submersibles, and seafloor observatories, in the context of the science they support. Development of these important tools must proceed hand-in-hand with the development of scientific questions requiring their use.

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One such technology development effort resulted in the Autonomous Benthic Explorer or "ABE." The concept of a roving robot that could remain on station in the deep sea for up to a year was developed in discussions between engineers and scientists studying hydrothermal systems. ABE is capable of performing detailed survey work with video cameras, sonar, and other sensors at pre-programmed areas and time periods. Between surveys, ABE remains parked on the seafloor awaiting the next pre-programmed survey,

or a direct command to start a new survey. By being able to remain on the seafloor in an unattended mode over long time periods, ABE allows us to study seafloor processes on space and time scales that we are unable to by using surface ships and manned submersibles alone.

While the kinds of technology I've just described are fundamental to exploration activities, their importance is by no means exclusive to them. In the remainder of my testimony I will discuss the proposed Integrated Ocean Observing System, including coastal observatories, which would profoundly influence the conduct of basic research, exploration, and, for our sister agencies, operational activities.

COASTAL OBSERVATORIES AND

INTEGRATED OCEAN OBSERVING SYSTEM

In establishing the National Oceanographic Partnership Program (NOPP) in 1997, the Congress found that "understanding of the oceans through basic and applied research is essential for using the oceans wisely and protecting their limited resources. Therefore the United States should maintain its world leadership in oceanography as one key to its competitive future."

A major focus of NOPP has been the development and implementation of a comprehensive, integrated national ocean observing system. NSF-supported researchers would contribute to, and would benefit from, an ocean observing system in fundamental ways.

Design and Development

Effective and efficient oceanographic observation systems cannot be designed without some knowledge of the active processes that they are intended to study. Only with an understanding of the underlying processes can we make good decisions about what measurements will best characterize changes in the ocean, and, most importantly, how many measurements are required, and where they should be located. NSF-supported researchers contribute to an understanding of these processes and the intimate links that exist between the chemical, physical and biological variables.

Observational Activities in the Coastal and Open Ocean

In addition to the valuable operational uses of data that would be made available through a national Integrated Oceans Observing System (IOOS), access to long time-series data is imperative for basic research. The need is outlined in a variety of reports, the most recent of which is "Ocean Sciences at the New Millennium" published in April 2001. The report, developed by a committee of distinguished scientists with extensive community input, states that *"the lack of extensive, more-or-less continuous time-series measurements in the oceans is probably one of the most serious impediments to understanding of long-term trends and cyclic changes in the oceans and in global climate, as well as episodic events such as major earthquakes, volcanic eruptions or submarine landslides. We recommend strong support for the development, deployment and maintenance of long-term observing systems."*

As part of its ongoing activities in both the coastal and open oceans, NSF's Division of Ocean Sciences has been working with the academic community to develop an Ocean Observatories Initiative. The effort would provide basic infrastructure for a new way of gaining access to the oceans, by starting to build a network of ocean observatories that would facilitate the collection of long time-series data streams needed to understand the dynamics of biological, chemical, geological and physical processes. Just as NSF supports the academic research vessel fleet for the spatial exploration of our oceans, the system of observatories provided for by the Ocean Observatories Initiative would facilitate the 'temporal' exploration of our oceans. The effort envisions implementation of a set of seafloor junction boxes connected to a series of cables running along the seafloor to individual instruments or instrument clusters. The junction box, with undersea connectors, provides a source of power to the instruments, and a means of transmitting two-way communications to and from the instruments. A data/operations center would be established that would function within the framework of the proposed Integrated Ocean Observing System and would be responsible for insuring unified data handling and dissemination procedures using the most advanced information and communications technologies.

The location and types of observatories to be established would be determined through a competitive peer review process. This new ability to continuously receive and record ocean data and to communicate with scientific instruments on the seafloor would greatly advance our knowledge and predictive capabilities in ocean science.

Data Collection, Management, Access, and Analysis

Advances in instant communication, vast databases, computational power, and extensive analytical capability contribute to making IOOS possible. One of the key aspects of IOOS would be a network for the system that links together various components (e.g., observatories, data archives, modeling groups) to form a distributed "hub-node" system that is centrally coordinated.

NSF is providing support, along with its NOPP partners, for a consortium of private, academic, state, federal and international partners to plan and implement a network based system for the integration of regional, national and international oceanographic data.

In addition, NSF and the Office of Naval Research have tasked an Ocean Information Technology Infrastructure Steering Committee to develop a flexible and comprehensive implementation plan for a distributed information technology infrastructure that can be readily integrated with the "hub/node" enterprise.

Support for Management Structure

With its agency partners, NSF is currently supporting the recently established OCEAN.US office to coordinate implementation of the proposed IOOS.

CONCLUDING REMARKS

We are in a time of rich opportunity for research and exploration in oceanography. The advances that have been made are impressive. As new observation systems are implemented we will learn more about the changes that are occurring on our planet on time scales of days, years, decades and centuries. With the right investments the coming decades in ocean research and exploration will be truly extraordinary. NSF looks forward to working with other agencies, institutions, and nations to see that this happens.

Thank you again, Mr. Chairman, for the opportunity to share with you and the members of your committee the exciting work being supported and planned by NSF. I would be pleased to respond to any questions that you might have.

Chairman **EHLERS.** Thank you very much for your thoughtful comments on a very deep subject. Admiral Cohen?

STATEMENT OF REAR ADMIRAL JAY M. COHEN, CHIEF OF NAVAL RESEARCH

Admiral **COHEN.** Chairman Gilchrest, Chairman Ehlers, Chairman Smith and members of the Subcommittees and Staff, on behalf of the Secretary of the Navy, Mr. Gordon England, Chief of Naval Operations, Admiral Vern Clark, and the Commandant of the Marine Corps, General Jim Jones, we want to thank you for giving the Department of the Navy an opportunity to discuss the national importance of ocean exploration and our efforts to develop and implement an integrated and sustained national ocean observing system. I am, like my fellow panelists here, honored to share this desk with them and to be amongst true friends.

I have submitted written comments, Mr. Chairman. I thought I might just share with you a few verbal thoughts. Several of us, at noon, were at the Naval Observatory on Massachusetts Avenue where we recognized the contributions of Admiral Watkins as the Oceanographer of the Navy dedicated a conference room at the Naval Observatory to Admiral Watkins. Admiral Watkins, of course, with his great respect and deference to the Congress, looked at the three of us and said that our time would be better spent preparing our testimony. And I hope we were able to do both well.

But I thought I would share with you from the pamphlet, on the back, a little summary, which I think is apropos. It says, "Why are we so concerned with the nature and condition of the ocean everywhere, everyday?" Because the ocean covers over 70 percent of the Earth's surface. It is changing all the time. And it happens to be the Navy's operating environment. To keep the U.S. Fleet safe, to get it where it needs to be for any given global crisis, to get our weapons on the right targets and all our systems and sensors operating to their best tactical advantage, the Navy must continually collect data from all the world's oceans.

I don't know who wrote it, but I think they said it very well. I can tell you, being the Chief of Naval Research, it is a fulfillment of a lifelong dream for me to support meaningful ocean research in support of our sailors and Marines who sail the seven seas everyday, often in harm's way in support of our great Nation.

So why did this New York City boy join the Navy at age 17? Well, simply said, I joined the Navy to see the world. The advertising really does work. And I have seen the world. I have spent my life, both under and at sea. And why at age 23 would I return to the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution to study oceanography and become an oceanographer? Well, because in 1970, in my opinion, the oceans, as has been addressed here, were the last great frontier. Thirty years later, they remain the last great frontier. And that is really what we are here to discuss today.

Now, given the Navy's budget, I don't have the graphics. And I know I am not making Dr. Ballard proud with this humble attempt. But it occurred to me that it is difficult to get members and staff and the public to Naval research. And so I feel an obligation to bring Naval research to them. And what I have right here is a little poster board. And we can pass it around. But at the top, it is what Admiral Clark refers to as my flagship. It is a surplus shark patrol craft from the Naval Academy. Because we have downsized a little. We have painted on the side, "powered by Naval research." And you see that Fleet Week in New York last month where we had English and Spanish placards. We had three dozen technology and science kiosks. And the middle picture shows the faces of the young people who visited that ship during Fleet Week. And you can see the awe that they hold that research in. It was really heartwarming.

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And based on that, we have brought that YP here on the Potomac. Many of the staff members have had a chance to ride it. We invite you too. We are going to bring it to Baltimore. We are going to take it down to Norfolk so that the good taxpayers understand the kind of research that we are doing in the Navy and Marine Corps in the oceans. And we have not forgotten the Pacific or the West Coast. This lower left-hand version, it is my Nascar version of a Swath Ship, which is an interesting hull form. High speed, very stable. It was built in Pacific Marine in Hawaii. And we have painted it up and we are going on a West Coast tour, starting in Alaska, working down to San Diego for each of the Fleet Weeks. And to inspire the young people, we are going to have adjacent kiosks, which Dr. Ballard is providing to inspire them as to what the Navy is doing and what ocean research is all about.

So I thank you very much for this opportunity. I look forward to your questions.

[The prepared statement of Rear Admiral Jay M. Cohen follows:]

PREPARED STATEMENT OF REAR ADMIRAL JAY M. COHEN

Ocean Exploration and Observation—A Navy Perspective

Chairman Gilchrest, Chairman Ehlers, Chairman Smith, members of the subcommittees, and staff, on behalf of Secretary England, the Chief of Naval Operations, Admiral Vern Clark, and the Commandant of the Marine Corps, General Jim Jones, thank you for giving the Department of the Navy this opportunity to discuss the national importance of ocean exploration and our efforts to develop and implement an integrated and sustained national ocean observing system.

Since its inception, the U.S. Navy has been in the business of exploring the world's oceans. One naval pioneer was Lieutenant Charles Wilkes, first head of the Depot of Charts and Instruments—the precursor to the Naval Observatory—who charted almost 300 islands in the Pacific, explored Antarctica and circumnavigated the globe in the 1800's. Another innovator was Lieutenant Matthew Fontaine Maury, the "Father of Oceanography," who compiled charts of ocean currents, winds, weather patterns, and bathymetry (depth measurements of large bodies of water), creating links between ocean science and national and commercial interests.

Today, we are building on this same foundation of ocean knowledge with ocean surveying conducted by the Oceanographer of the Navy and ocean research supported by the Office of Naval Research, which I oversee. This information base is vital to naval forces because our domain of ocean interest spans the globe, and we cannot afford to be surprised by ocean phenomena that impact our operations. Because the Navy and Marine Corps are on a continual quest to discover new phenomena and illuminate the ocean's mysteries, I am pursuing the recommendation from the President's Panel for Ocean Exploration to extend our definition of ocean exploration into the time domain. That is the ability to continuously monitor and measure the coastal and deep oceans, permitting the investigation of the ocean in a comprehensive fashion that cannot be achieved by isolated observations, cruises, or visits. We are making progress towards establishing a national capability for sustained and integrated ocean observations and predictions.

A year ago, my predecessor, Vice Admiral Paul Gaffney II, came before you to stress the need for an integrated ocean observing system. The National Oceanographic Partnership Program (NOPP) through its Ocean Research Advisory Panel, proposed a strategy for giving users such as operators, managers, teachers, industry engineers, researchers, and the general public, broad and easy access to ocean data, tools, knowledge and products.

Last year you were told such an integrated and sustained ocean observing and prediction system could be assembled through a relatively simple web-based federation managed by an interagency joint program office. Today, we have the Ocean.US program office in place, which has been established, funded, and staffed by a number of NOPP agencies.

Chartered by an interagency Memorandum of Agreement on October 25, 2000 to establish a national sustained ocean observing system over the next decade, Ocean.US is dedicated to:

Detecting and forecasting oceanic components of climate variability;

Facilitating safe and efficient marine operations;

Ensuring our national security;

Managing marine resources for sustainable use;

Preserving and restoring healthy marine ecosystems;

Mitigating natural hazards; and

Ensuring the public health.

Ocean.US is designed to improve access to already existing agency ocean observing and predicting activities while filling in gaps so that the end sum will be greater than a simple compilation of the parts, creating a fully integrated system. As this integrated system develops, a number of powerful synergies need to happen.

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Fully integrated ocean observing systems bring together communities using space-borne, remotely-sensed data with those making direct ocean measurements and also foster collaboration between operational observational efforts and long-term research programs such as ocean observatories. Ocean observing partnerships need to be further developed amongst the federal, state, and local governments as well as with the private and academic organizations and Non-Governmental Organizations (NGOs). We must continue to build bridges between oceanographers and meteorologists while also facilitating meaningful cooperation between ocean physicists, biologists, chemists, geologists, and others who will be able through this integrated ocean observing system, to collaborate in addressing pressing problems. Indeed, the test of our success will be whether we can deliver these tools to the people who use them—those who actually do the work we all depend upon to address these problems.

Ocean.US will be in the unique position of being able to get information currently held by individual federal agencies, state and local governments, private industry, academia, NGOs and other nations into the heads of the people who can put the information to work. This centralized effort will reduce unnecessary duplication of data-gathering efforts while also fostering cooperative research projects. Our goal in accomplishing this task remains, as we stated last year, to have the initial framework in place in the next year and a half, with the system fully functioning by 2010.

The interagency collaboration and cooperation facilitated by NOPP allowed us to move forward quickly and decisively in establishing Ocean.US. In just the last four years with an investment of $57 million, NOPP has supported 54 separate ocean science research and education projects. The NOPP investment portfolio is based on the seven societal needs identified by Dr. Worth Nowlin of Texas A&M University and Dr. Tom Malone of the University of Maryland in the report "Towards a U.S. Plan for an Integrated, Sustained Ocean Observing System." These are the same societal needs I mentioned earlier that Ocean.US is addressing.

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In 2000, NOPP invested $15 million towards an Integrated Ocean Observing and Prediction System; the Ocean Biogeographical Information System; Regional and Special Ocean Observing Initiatives; and the

renewal of Education and Outreach projects funded since NOPP's inception. This year, the Alfred P. Sloan Foundation teamed with NOPP to fund eight projects under the Ocean Biogeographical Information System endeavor, marking the first-time collaboration for the Partnership Program with a private entity. NOPP's research solicitation is again this year mirroring the Partnership Program's focus towards an integrated and sustained ocean observing and prediction system. There are proposals addressing satellite-derived ocean surface winds, improvements to the sensing suite of profiling ocean floats, the exploration of robust telemetry technologies for ocean sensors, and the planning and implementation of data assimilation and modeling nodes in a "commons" for the oceanographic community.

I am gratified to note the interagency cooperation in this joint effort to establish an integrated ocean observing system. Organizations signing the Memorandum of Agreement establishing Ocean.US are the Navy, the National Science Foundation, the National Oceanic and Atmospheric Administration, the Minerals Management Service, the National Aeronautics and Space Administration, the U.S. Geological Survey, the Department of Energy, and the Coast Guard. We need the synergy of this interagency collaboration and cooperation, which is the true strength of NOPP and is indicative of the powerful role the oceans play in our national life.

Within the Navy and Marine Corps., both the research and operational sides of our Department are fully committed towards this endeavor. The Office of Naval Research is now funding and will continue to fund the scientific and developmental aspects of this system and will remain an active participant in the NOPP process and Ocean.US. On the operational oceanography side, the Oceanographer of the Navy, Rear Admiral Dick West, is equally supportive of NOPP and Ocean.US and has provided resources to the office and a senior naval officer to serve as the first director of Ocean.US. Additionally, the Oceanographer has firmly articulated the need for an integrated ocean observing system in a formal document, "The Importance of Ocean Observations to Naval Operations" that he promulgated in 1999.

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We continue to take steps to further ease the accessibility of the Navy's oceanographic data holdings, some of the most robust in the world, as well as make available our real-time ocean observations to the national community. For example, the Navy provides real-time, satellite-derived, sea surface temperature and satellite altimetry sea surface height information to the nation from the Naval Oceanographic Office. Further, much of that office's oceanographic data is available to the public through its "White Front Door" effort designed to speed the delivery of appropriate Navy oceanographic data to general users.

The Global Ocean Data Assimilation Experiment (GODAE) is a similar effort sponsored by both the Oceanographer of the Navy and the Office of Naval Research at the Fleet Numerical Meteorology and Oceanography Center in Monterey, Ca. GODAE is designed to assimilate vast amounts of ocean information into powerful numerical models to serve many national needs. The Navy expends effort in such experiments because it needs to accurately characterize the oceanic environment in which we operate and relies on observations in the open ocean and coastal zones for all Naval and joint warfare missions.

High quality ocean observations, taken more often and in more locations around the world, will yield improvements in mission planning as well as safety and effectiveness of operations, enabling Naval forces

to make more informed and higher confidence decisions. Knowledge of the ocean is power, and our Navy and Marine Corps must possess that knowledge if we are to remain dominant in our control of the seas.

The Navy fully and absolutely endorses and supports the development and maintenance of an integrated, sustained ocean observing and predicting system for the country. We are providing resources, information, and personnel. We are convinced that the interagency NOPP model shows how an effective, multi-agency partnership effort can contribute to the creation of an integrated and sustained ocean observing system.

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In closing, I would again like to thank the Members for their support, and for inviting me here today to talk about these very important topics.

Chairman **EHLERS.** Thank you very much. And I just want to tell you that you still have better graphics than we have in the Congress. We only have black and white Xerox machines. Admiral Lautenbacher.

STATEMENT OF VICE ADMIRAL CONRAD C. LAUTENBACHER, JR., PRESIDENT, CONSORTIUM FOR OCEANOGRAPHIC RESEARCH AND EDUCATION

Admiral **LAUTENBACHER.** Thank you, sir. Chairman Ehlers, Chairman Gilchrest, Chairman Smith, Mr. Weldon, Mr. Underwood, other distinguished members of our Committees today and the staff members, thank you very much for the opportunity to appear before you.

We, in the CORE organization appreciate the hard work that went into bringing this Hearing together and to bring all of the folks together to provide a good background on the need for ocean science and ocean exploration and ocean observing. The—I have no graphics at all, so we—you don't have to worry about that.

I just want to make three points so that there is time to hear from the distinguished scientists that we have right here. I have, of course, the honor and the pleasure of representing CORE, which is a consortium of 64 premier oceanographic institutions of our great Nation. It represents a wealth of scientific knowledge and a storehouse of just about everything that is good for our country. And I also want to note that the agencies that I am with today have a number of great scientists, too. And when you go out there and look at what is happening, you will see these folks working together. It is a community that is interested in doing the right thing for the country and building the best science that you can build the best public policy and they work together well. And I am proud of that.

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The three points I want to make, first of all, the Hearing today is about ocean exploration and about ocean observing. And there have been a number of comments about which is the best approach. Which deserves the best support. How should we get this together. We, from—in the CORE organization view them as two ways to get at the same answer. So we believe they are both important and we need to emphasize the values that we get from each of these attacks to the problem.

The second issue is that the timing is right. We have the technology available and we have the need to do this. And the third point that—and I will embellish in a few minutes on this. Is that we have the mechanism and it is time to take the leadership and go and do these things. And this is just some additions to what Congressman Weldon has also so eloquently stated about the Oceanographic Partnership Act.

But let me go back to the needs or go back to the exploration and observation piece of this. Really, there are two ways to get at the same thing. I like to look at this as the two bookends that you would put up on a shelf. And that shelf right now is mostly empty. We need to write the volumes in the middle. And that is going to come from both ends. We are going to do it by exploration and we are going to do it by observing. We are still, today, as you will hear from our good scientific folks that are waiting for the next panel, of the many discoveries that are being made out there on the exploration front. You will also hear from folks who understand the need for observations, who realize that we have gotten to the stage where we have to get sustained time series data from around the globe and from around our coastal areas in order to answer the difficult questions in such things as management and the environment. Now, so both of these things are needed and we need to write those volumes in the middle. We need everyone's support.

Now, the timing is right. The technology is such today that we are doing some incredible things. Certainly, the tape that Dr. Colwell showed is an indicator, as well as some of the projects that Scott Gudes mentioned. We have technology today in the information world, in computing processing, in moving data and information management that has been unheard of. And it is growing everyday. We have AUVs, Underwater Autonomous Vehicles that can do things people never dreamed of before. So the technology is being developed that can do some of the things that were only dreamed about several years ago.

We also have the need at this point. So the timing is right. If you look at the issues on the climate, you look at determining what the economic health of this country will be in the future if we do not do the things today to uncover and find the right—the science that is out there waiting to be discovered and built upon and the knowledge that is needed to produce good public policy. The need is there. And the need is there for the United States to take the leadership.

That brings me to the third point. The mechanism of the Oceanographic Partnership Act that was so thoughtfully worked out here in this building, signed by Members of Congress, signed by the President, enacted, has been put in place, is now in the fourth year of operation. And as—things work slowly in the government. So after three years, this may be a glacial pace, but in government, this is a rapid time frame. If you look at the way that is operating today, it has become inculturated into our system. It is a way in which all of our agencies work together, along with our private foundations and academic institutions.

So I encourage that whatever we do, we look at this superagency mechanism to support and to finance the proper level of exploration and observations. Thank you, Mr. Chairman.

[The prepared statement of Vice Admiral Conrad C. Lautenbacher, Jr. follows:]

PREPARED STATEMENT OF VICE ADMIRAL CONRAD C. LAUTENBACHER, JR.

Good afternoon, Chairman Ehlers, Chairman Gilchrest, Chairman Smith, Committee members and staff. Thank you very much for the opportunity to testify on ocean exploration and on development and implementation of a coastal and ocean observing system. I am Vice Admiral Conrad C. Lautenbacher, Jr., new President of the Consortium for Oceanographic Research and Education (CORE). Many of you knew my predecessor, now CORE President Emeritus, Admiral James D. Watkins. CORE is the Washington, DC-based association of U.S. oceanographic research institutions, universities, laboratories and aquaria. Our 64 members represent the nucleus of this Nation's ocean research and education.

This hearing is extremely timely because today we are truly at a crossroads in the ocean sciences. Exciting new technologies for exploration and observations provide an intersection with real world challenges such as climate prediction, fishery management, maritime safety, and energy needs. CORE's position is that we must use available new technologies to answer key questions and make progress down a path towards constructively addressing these challenges. Our member institutions believe that ocean exploration and ocean observations are complementary activities that together move us forward. Thus both need to be supported.

Today I would ask you to consider three key questions. The first is—what are the physical, chemical, biological, and geological components and processes that make up the oceans? This may sound simplistic, yet today we know more about other planets than we do about the ocean depths. Only about 5% of the world's oceans have been mapped and our knowledge of their living inhabitants is similarly rudimentary. Nor do we understand many of the complex interactions among the biota and the physical environment. We have a severe knowledge gap that needs to be closed for a number of reasons.

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We know that there are marine animals and plants with the potential to enhance human health and provide new products, but until such useful organisms are identified, we derive no benefit. As examples, the pharmaceutical industry has developed several drugs from ocean sponges, doctors use horseshoe crabs for surgical sutures and dressing wounds, and researchers study sharks for clues to a cure for cancer. These preliminary findings demonstrate the opportunities awaiting those willing to look into the oceans. I recognize that ocean exploration may be more costly than terrestrial exploration, but can assure you it is not as expensive as exploring space and we may derive more immediate benefits.

We also know the ocean contains abundant deposits of methane hydrate that have substantial energy potential. However, we need to better understand the chemical and physical properties of hydrate deposits in order to discern their possible role in meeting our Nation's energy needs. I thank all of you for your support and passage of the Methane Hydrate Research and Development Act of 2000 in the 106th Congress (P.L. 106–193). This was a good first step that should prove very beneficial now and in the years to come for evaluating investments in our ocean and energy future.

One impetus for the current interest in ocean exploration was the 1998 Oceans Conference held in

Monterey, California. As a result of that meeting, the National Oceanic and Atmospheric Administration (NOAA) was tasked to conduct an assessment and develop an action plan on ocean exploration. NOAA, with the aid of academic and agency partners, produced "Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration." The plan calls for a $75 million investment over 10 years with funding to be divided equally among NOAA, the National Science Foundation (NSF) and the U.S. Navy. Equally important, the report places a new emphasis on educational partnerships, recognizes the need to involve students of all ages, and sets as a goal "to improve the scientific literacy of America's schoolchildren and to realize the full potential of a citizenry aware of and informed about ocean issues."

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In fiscal year (FY) 2002, the Bush Administration requested $14 million in the NOAA budget for its role in implementing that plan. It is our understanding that the House Appropriations Subcommittee on Commerce, Justice and State proposes to include $6 million for this initiative for FY 2002. CORE believes these are positive developments that should be supported by the full Congress.

Other Federal agencies also have recognized and are supporting programs of ocean discovery and scientific exploration. NSF has already taken major steps to develop ocean science programs that balance regional, national and global information needs. Among the most successful are the Global Ocean Ecosystems Dynamics (GLOBEC) program, the U.S. contribution to the Program on Climate Variability and Predictability (CLIVAR), the Ocean Drilling Program, and the Joint Global Ocean Flux Study (JGOFS). Working with the Navy and the University-National Oceanographic Laboratory System (UNOLS), NSF has long recognized and supported the need to invest in a research infrastructure for exploring the oceans, including the academic research fleet. CORE members support these ongoing activities and have enthusiastically endorsed the agency's proposal to fund ocean and seafloor observatories as a major research equipment project.

Bridging the technological gap between ocean exploration goals and capabilities is the Office of Naval Research (ONR). The Navy and ONR have pioneered efforts to develop deep submergence vessels like Alvin and autonomous underwater vehicles like REMUS and the University of Washington's ocean gliders. Another long-term supporter of the academic fleet, the Navy has spent more than $25 million over the past five years to support ocean surveys by the UNOLS vessels. In addition, they are working on an innovative design for the newest UNOLS member, a twin-hulled SWATH vessel that will be operated by the University of Hawaii. The oceanographic community has come to rely on the Navy for leadership in diverse areas ranging from acoustic research and sensor development to exploration of such inhospitable environments as the Arctic Ocean. As the Ocean Exploration panel report suggests, NOAA, NSF and ONR together offer unique capabilities for exploring the Earth's marine frontier.

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The second key question focuses on one of the most serious scientific issues confronting us today—what is the role of the oceans in climate? If we think of ocean exploration as providing 'snapshots' of the ocean at its frontiers, understanding the oceans' role in climate requires full-length "videos" across 70% of the Earth's

surface. In order to achieve the long time series and observational coverage that is needed, scientists agree that an integrated and sustained ocean and coastal observing system is essential. In addition to providing vital climate information, the system also would supply ocean information for such diverse users as weathermen, fishermen, coastal managers, shipping companies, boaters, the Navy and Coast Guard, and the offshore oil industry.

One of the great ironies of climate research is that for years we dealt with the ocean and atmosphere as two distinct systems. New insights and advanced computer capabilities now allow us to examine the ocean and atmosphere as a single, coupled system. No climate issue has made the need for this approach more apparent than efforts to understand and predict El Niño events. Today, farmers, water managers in the Great Lakes, Pacific salmon fishermen, and home heating suppliers in the northeast all rely on accurate predictions of an El Niño or La Niña. The economic ramifications of a correct forecast are staggering.

If the oceans have a profound effect on seasonal climate events, we know that they must also play an important role in the longer climate outlook and significantly influence atmospheric warming. However, our current understanding is limited, in large part because we simply do not have the same observational capabilities in the oceans that we have on land.

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The World Meteorological Organization (WMO) currently runs the World Weather Watch. The WMO collects data from member-operated observation systems and provides this as a service to participants in the program. The WMO program includes information from four polar-orbiting and five geostationary satellites, about 10,000 land observations, 7,000 ship stations and 300 moored and drifting buoys carrying automatic weather sensors. The fact that we have twice as many land-based as marine observations highlights the data problem. Now you may say, "Wait a minute, there are 7,000 ship stations—that's a lot of ocean data points" but the problem is that the ship observations come from well worn ship tracks rather than an evenly distributed spatial net across the ocean. The simple fact is that even at the sea surface *large areas of the ocean are never sampled.*

One of the first steps to remedy this data gap and implement an ocean observing system is the Argo Program. Argo, of course, is a global array of profiling floats that measure the ocean's upper layer in real time. Argo buoys are about 3 feet long and descend into the ocean depths taking key measurements down to 2,000 meters where they loiter for 10 days and then pop back up to the surface and relay their data to a satellite. When the program is fully implemented, the United States and its international partners will maintain a network of nearly 3,000 Argo buoys and greatly enhance basic knowledge of our oceans.

The Argo system was developed under the National Oceanographic Partnership Program through the collaboration of NOAA, Navy and NSF, and currently is being funded through NOAA. For FY 2002, the NOAA budget request included funding of almost $8 million for the program and I understand that the House Appropriations Subcommittee mark three weeks ago provided full funding. I know that Chairmen Ehlers and Gilchrest wrote letters supporting funds for this program and I want to take this opportunity to thank you personally for your efforts.

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Last month, the Bush Administration announced that U.S. policy on climate change would be shaped by the best science and pledged to work aggressively to improve our scientific understanding. The Secretary of Commerce, working with other agencies, was asked to conduct a review to set priorities for additional investments in climate change research. Responding to these Administration objectives, CORE proposes that highest priority be given to funding for an integrated ocean and coastal observing system.

While there are many contentious aspects of the climate issue, one area where there is little disagreement is on the central role of the oceans in storing carbon dioxide (CO) and heat. We know the oceans contain 50 times more CO than the atmosphere and the upper few hundred feet of the ocean stores 1,000 times more of the sun's heat than the atmosphere. This relates to climate change in a very direct way because if we want to slow or reverse greenhouse warming, the oceans may respond very slowly to our efforts. The scientific problem is we currently don't know how sluggish the ocean response is, and we will need better data in order to improve our estimates.

We also need to better define how the oceans sequester CO, and how the oceans store energy to understand the ocean's role in the total climate picture. We know CO is stored in the ocean but we do not understand the processes in detail and it will be critical for us to get the science right on this very important issue. These examples illustrate why it is essential that we secure the initial funding this year to begin implementation of an integrated ocean and coastal observing system for the United States.

You may recall that in the late 1980's this country embarked upon a $4.5 billion modernization effort for the National Weather Service. A key component of that modernization was better observational systems integrated by a common software platform. Over the next decade, the Weather Service improved its predictive capability because it improved its observational capability. This national investment in improved observing systems paid off both economically and in enhanced public safety. Similarly, an integrated ocean observing system could give us more accurate predictions of seasonal and interannual climate events. It also would greatly advance and enhance our understanding of longer-range climate issues. Fundamental knowledge of our climate system processes so vital for the development of sound policy options would be available on demand to members of Congress.

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There is wide consensus in the oceanographic community on the need to fill our climate knowledge gaps and that those gaps can only be bridged with an ocean and coastal observation system. That leads me to my final question.

The third key question is—what is the most cost-effective method for implementing an ocean and coastal observing system, as well as an ocean exploration program? Many of the elements of an ocean and coastal observing system currently exist, funded by numerous entities and for a variety of purposes. The need for ocean and coastal observations is similar to the need for weather information—they promote public well-being. Unlike the weather system, however, ocean and coastal observations are funded, managed, and used by different agencies, organizations, and institutions and for a variety of purposes. Thus, a major challenge is to integrate diverse observational systems and data sets to maximize their usefulness and minimize costs.

The goal must be to develop a national system that responds to local and regional needs.

In 1997, Congress approved, and the President signed P.L. 104–201 establishing the National Oceanographic Partnership Program (NOPP). NOPP grew from the need to better understand the ocean and coasts and their role in national security, economic growth and quality of life. It provides an effective approach for addressing national needs, such as an ocean observing system, that do not fall under the purview of a single agency. A key provision of the NOPP legislation was the establishment of the National Ocean Research Leadership Council (NORLC) that brings together the heads of the Federal ocean agencies to form partnerships and work cooperatively toward common goals. Together the members of the NORLC can identify strengths and weaknesses in Federal ocean research programs and plan where future investments in the ocean sciences should be made.

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Members of the NORLC recognize that collaboration is necessary to advance our understanding of the world's oceans and meet Federal mission requirements. Their representatives meet monthly to discuss NOPP funding priorities and levels, and work collectively to address critical ocean science needs. In this way, the NORLC can focus and direct Federal oceanographic research dollars.

At present, only a small fraction of the national ocean sciences budget or less than $16 million annually is allocated using the NOPP process. Of that annual total, the U.S. Navy provides $10 million, NSF provides slightly under $5 million, and NOAA provides a little less than $1 million. Furthermore, the partnership process has used federal funding to leverage investments by private, state, and local government agencies so that the total funding for the program is increased by a factor of two. While federal government investments to date have been relatively modest, the NOPP process is developing a record of achievement demonstrating that it is cost-effective and does work.

To date, several of these NOPP achievements foster and support implementation of an integrated ocean and coastal observing system. Dr. Fred Grassle will discuss one notable example, the Rutgers University Long-term Ecosystem Observatory (LEO–15), in his testimony later this morning. While the list of other related NOPP projects is extensive, I would like to mention a few examples, including:

The design of the NEPTUNE project to establish a linked array of undersea observatories on the Juan de Fuca plate in the northeastern Pacific Ocean.

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The development of a Virtual Ocean Data Hub (VODHub) that builds on rapidly growing distributed oceanographic data systems to implement a network-based system and provide seamless access to ocean information.

The modeling of the coastal upwelling ecosystem within the Monterey Bay National Marine Sanctuary to guide management and direct future observational efforts within the sanctuary.

The South Atlantic Bight Synoptic Offshore Observational Network (SABSOON) that uses Navy "Top Gun" training facilities as a platform for an ocean observing system.

The BRIDGE: Ocean Sciences Education Teacher Resource Center that offers teachers an on-line, easy-to-navigate collection of resources for ocean science education.

As the projects listed above indicate, the NOPP process has been used to develop successful approaches to both ocean exploration and ocean observing systems. In addition, the Ocean.US office has been tasked under a NOPP memorandum of agreement to being the process of designing and implementing a national system. Thus, I would propose that NOPP is the right mechanism to coordinate a coastal and ocean observation system as well as an ocean exploration program. I hope that you can join CORE in supporting these ocean endeavors and in using the NOPP process for their implementation.

An old adage claims that what you don't know can't hurt you, but I would argue quite the contrary in this situation. Exploration and observation are hallmarks of scientific endeavor, and both by discovery and by observing nature over time we are better able to understand and to model critical ocean and atmospheric processes. At present, our knowledge of the oceans is insufficient and hinders efforts to monitor the coupled climate system. However, we stand at a unique moment in history where we can now probe the depths of the oceans with new technologies and get the information we need to better understand our ocean planet. Moreover, the National Oceanographic Partnership Program offers us a mechanism for using Federal resources to achieve that goal.

Thank you for the opportunity to testify today. I look forward to working with you on these issues and would be happy to answer any questions.

Panel I Discussion

Chairman **EHLERS.** Thank you for your testimony. While I was sitting here listening to the testimony, I scribbled a short note to Mr. Weldon suggesting a mechanism by which we could coordinate our Congressional Committees to work better. He sent an even shorter note back saying, good idea, we will pursue it. So let us hope we can develop something that will work. We have now reached the time to ask questions of the panel. And I would first of all, like to recognize Mr. Gilchrest for the opportunity to question.

Mr. **GILCHREST.** Thank you, Mr. Chairman. I wasn't quite ready, but I will go with what I have. Admiral Lautenbacher, you made a comment about bookends that need to be filled in and have some sense that the bookends—that the framework that we are looking for for this whole integrated process and that if so, what are—what, in fact, are the bookworms—bookends, if that is the framework for the integrated process. Then how were you going to fill that in? And what do you estimate the cost of that to be and how long will that occur?

Admiral **LAUTENBACHER.** Chairman Gilchrest, let me clarify. I was talking about the bookends being the approaches to fill in the knowledge. The subject of today's Hearing has been the need for ocean

exploration and the need for ocean observing. So we could get caught up in semantics as to whether the right way to go about discovering and developing science in the ocean should be done from the exploration path or from an observation path. What I was saying is that we need both of these. Our organizations contribute to both of these, as well as the Science. . .

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Mr. **GILCHREST.** The bookends are exploration and observation.

Admiral **LAUTENBACHER.** Absolutely. You have got to have both of these. We are still at a point in the ocean, we know more about the dark side of the moon than we do about the bottom of the ocean. There are discoveries being made everyday. So that the exploration theme, the way of going about exploring—obviously, it needs to be done with some thought and done at a level where it is efficient——

Mr. **GILCHREST.** I think we should agree that exploration is on one end, observation is on the other end. I guess my question was, how do we—is there some sense right now as to integrating the various agencies, departments, military, private sector scientists on how to prioritize the exploration and the observations and then how to integrate that information with the various agencies and the technologies? And when I say prioritize, I guess I am—leave this open to the other panel—if—and I think it is important for us to view the oceans in such a way that we don't take away the various diversity of the talent among the different agencies or private universities, but in some way, we enhance their ingenuity, I think, by the exchange of information. When you do that, you are going to hopefully have some sense of prioritizing the nature of the exploration and prioritizing the nature of the observation. What is going to be observed? What are we out there looking for? And, certainly, there will be crossovers in between. But is there a sense, Admiral, about how, once we have framed exploration and observation, to fill that integration of information?

Admiral **LAUTENBACHER.** I think there is. And I would offer the National Ocean Research Leadership Council, which was created by the National Oceanographic Partnership Act. That is what I call a superagency-level body. It is essentially the National Security Council of oceans. It includes, you know, Cabinet-level departments and agency heads working together. This Act created this superagency mechanism three years ago or four years ago. It is in the fourth year of work. There is a working group set up where each of the agencies talk together. It created partnerships not only with the—among the agencies, it created them with our institutions with local and regional authorities and industry, as well. Now, we haven't explored as much of the industry and regional as we ought to. And that, you know, is kind of the next step. But that mechanism is there. Now, in terms of filling out the priorities, what I would suggest is that this council has created something called ocean.us, which is essentially an integrated program office. If I were in the Pentagon, I would tell you this is the equivalent of a joint program office.

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Mr. **GILCHREST.** What is the status of—because my time is limited.

Admiral **LAUTENBACHER.** Yeah.

Mr. **GILCHREST.** I have a question to Dr. Colwell. But I would like to maybe in the next go around, I would like to find out what the status of ocean.us, whatever that is, is.

Admiral **LAUTENBACHER.** This man can answer the question.

Mr. **GILCHREST.** Are there people employed there now?

Admiral **LAUTENBACHER.** Yes.

Mr. **GILCHREST.** Are they working?

Admiral **COHEN.** I am pleased to tell you I was there yesterday.

Mr. **GILCHREST.** Okay.

Admiral **COHEN.** You are looking at the employee right behind—we are hiring. We have the spaces. We are moving the furniture in. I would tell you in a matter of months——

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Mr. **GILCHREST.** I see.

Admiral **COHEN** [continuing]. It will be full up in operation. This is going to be a success story.

Mr. **GILCHREST.** I am going to try to get one question in before the red light. Dr. Colwell, when microbiology, I guess, do you see that there has been a lot of discussion about the change of—and the potential damage to ecosystems if there is global warming over the next 50 or 100 years? Will that same impact in climate change happen in the same timeframe or over a longer period of time in the oceans?

Dr. **COLWELL.** We are already observing that in places like Antarctica, the increased ultraviolet light is causing a change in the community structure; that is, the kinds of species of bacteria that you see there and other microorganisms that are chlorophyll-bearing that are involved in the whole photosynthetic cycle. So the answer is yes, there will be changes. And there will be geographic changes that we can already measure. And interestingly, there probably will be public health effects that we didn't expect. For example, in my own research, we have been able to show that just an elevation in sea surface temperature of a fraction of a degree or so in a place like the Bay of Bengal can affect the organisms that cause the disease cholera. So that the epidemics are directly related to the sea surface temperature. Now, that is a serendipitous finding, but it is a very exciting one because it suggests very strongly—does more than suggest—it demonstrates that we are fragile beings and that we are all interconnected as living beings on this planet. And we can't eradicate or eliminate or shift without changes in our own hill. I could go on, but the answer to your question is that, yes, there are profound changes that we are only just beginning to determine because we now have the tools of molecular biology that allow us to actually measure, at the DNA level, changes that are occurring.

Mr. **GILCHREST.** Well, I would ask for unanimous consent that you go on for about another hour. I might hear an objection. Thank you, Mr. Chairman.

Chairman **EHLERS.** The gentleman's time is expired. Next, we turn to Mr. Faleomavaega. Sorry. For ——

Mr. **FALEOMAVAEGA.** It is all right, Mr. Chairman.

Chairman **EHLERS.** For your five minutes.

Mr. **FALEOMAVAEGA.** Just to follow-up on Chairman Gilchrest's statement, Dr. Colwell. You know, we have some members, a dear friend who serves not only as a leader of the Science Committee, but we served together in the International Relations Committee. And he considers global warming as global baloney. And I wanted to ask you, based on our scientific—from our scientists, are we really serious about this issue? Because there seems to be a strong difference of opinion on the—among the scientists about—there—is there really a serious problem of global warming? Because we are getting different feedbacks. And I wanted to say that I happen to disagree with my good friend, who makes these descriptions. A member of the Congress considers global warming as global baloney. Can you respond to this?

Dr. **COLWELL.** I would say that the evidence for an increase in temperature is quite genuine. It has been reproducibly demonstrated in the increase in CO. The question is, over a very long period of time, is this a natural series of events or is this, in fact, an induced event? I think the data are beginning to be fairly dramatic. And I do agree with the President's position that we do have gaps in our knowledge and fundamental research is badly needed. And I think with my colleagues here, we understand that there is a lot of work we need to do, especially in the study of ocean atmosphere interactions. Very important. But we need to include the biological component. That has not been present in many of the studies that have been done, especially the earlier studies 10, 20 years ago. It is now time to incorporate the biological component.

Mr. **FALEOMAVAEGA.** I won't get into the Kyoto Protocols and the differences of opinion we have on that issue. But just—I just wanted to get a sense from our own American scientific community if there is support from our scientists of our country that there should be some serious concern about global warming. That is my concern here.

Dr. **COLWELL.** There really needs to be——

Mr. **FALEOMAVAEGA.** There is consensus.

Dr. **COLWELL.** There is need for research.

Mr. **FALEOMAVAEGA.** Okay.

Dr. **COLWELL.** No question. I think the consensus on that is pretty strong.

Mr. **FALEOMAVAEGA.** Okay. As I heard earlier from my good friend Curt Weldon about the need for consolidation of so many different Federal agencies involved in research and all of this dealing with the oceans, if I were to shuffle these four basic categories together for the members of the panel, strategic, economic, environmental, scientific, how would we place a sense of priority in terms of what our current National policy in that order of those four basic areas? Could any member of the panel respond to this? Because in—let me tell you my sense of opinion. I think our number one policy is military strategic. It is not any of the others. But I may be wrong. Could you correct me on this?

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Dr. **COLWELL.** I won't correct you, but I certainly would like to offer a beginning discussion and ask my colleagues to join in. And I would say that what we are finding is that it continues to be military, but in a very different way. It is an economic competition and it is a—an environmental security that is necessary. For example, if there is devastation to wheat crops or let us say to our fisheries, which is a very important source of protein for the public——

Mr. **FALEOMAVAEGA.** But collate—I know, but I just wanted to ask in terms of—I know where you are coming from.

Dr. **COLWELL.** Yes.

Mr. **FALEOMAVAEGA.** Because I could just simply say, why do we have to import $9 billion worth of fish? Why can't we not domestically produce the fish for our own consumption? Why do we have to import from the—why do we have to buy fish from foreign countries? Because that indicates that we are not up to par in providing fish for domestic consumption in terms of our own National needs. So I just want to get a sense of number from the members of the panel, what do you consider to be the number one priority among those four categories?

Mr. **GUDES.** Am I the fish person?

Mr. **FALEOMAVAEGA.** Whatever you want to call it. Whatever—I am sorry. My time is. . .

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Mr. **GUDES.** Do—I mean, let me just. . .

Mr. **FALEOMAVAEGA.** Our current national policy, in your best opinion, how do you place these four basic areas that I think are basic as far as where our resources are going into, how we are going about and doing these things? Because it does relate to exploration and observation. Doesn't it?

Mr. **GUDES.** Sure. I think it is legs of a stool, as you have in other areas. That—I mean, obviously, there

is a National security issue, which we have talked about before here, where the oceans relate to that. Obviously, there is an environmental issue.

Mr. **FALEOMAVAEGA.** Oh, I know. I know. I know.

Mr. **GUDES.** Are you saying—I—I can't—I'm sorry. Go ahead.

Mr. **FALEOMAVAEGA.** I am saying that we cannot all put the four of them equally on the same stool. That is my—I just wanted to get a sense, where are we really making the most emphasis in terms of our resources or——

Mr. **GUDES.** Well, I suppose that is it maybe—this is one of the areas where maybe it is a little different and the different agencies that are a part of all these issues. In the case of the Navy, I would assume it is first on the strategic. In the case of NOAA, I would assume that it is first and foremost on environmental. And fisheries, which you mentioned, is definitely one of the areas that we have a mission that we deal with.

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Mr. **FALEOMAVAEGA.** I am sorry, Mister—yeah.

Mr. **GUDES.** I think it all—I don't think it is that easy to distinguish between them.

Mr. **FALEOMAVAEGA.** I am sorry, Mr. Chairman. My time is up. I will wait for the second round.

Chairman **EHLERS.** I thank the gentleman from Samoa. Next yield to myself 5 minutes. I—following up on the question of the previous questioner about the climate change issue. Mr. Gudes, first of all, I know you are putting some more solar polar satellites in orbit soon. And I know much of that is to try to measure properties of the ocean. Will you be able to get data accurately enough to really assist you in climate change models or are we really going to have to go out there and disburse these clever little devices all over the ocean, which will bob up periodically and give reports on temperature and other conditions?

Mr. **GUDES.** I think that it is an integrated system. My only point before was that it includes space-based systems. And some of the other panels I sat on with this Committee—Mr. Goldin was here and talked about several systems. But definitely, they play a role in it. But I think that most of the climate experts would say, no, you have to have in situ measurements. You have to have these long-term measurements. And it is about understanding the oceans. I think it is one of the key areas. The oceans are the driver of the world climate system. And definitely to get the kind of measurements one needs to really understand what is happening in the world climate system, you need those sort of ocean measurements. ARGO is one way to do that, in a broader sense. The TOGA TAO atlas buoys I talked about are another one. The only other point I was going to make as I rushed through my presentation earlier, Mr. Chairman, is that this is sort of a dual use issue, if you will. Clearly, ARGO floats are probably first and foremost about climate. But they are also about understanding the oceans and about understanding the currents and really unlocking some of the secrets of the oceans at the same time. I know that some of these answers come across similarly that these things are interrelated, but it is an interrelated system. And I—but I definitely do think the answer to your question is you definitely do need ground-based systems.

Chairman **EHLERS.** Now, the satellites are going to be about 6b billion. How much will the ARGO system cost?

Mr. **GUDES.** The ARGO system, I don't have the total out. It is $7.9 million in our budget this year to get up—per year to get up to a U.S. contribution toward a 3,000 float system. I think about a thousand, basically, are United States floats. Most of which would be contributed by NOAA, but not solely NOAA. And I have some papers here, which I can provide for the record on other countries.(see footnote 1) But the idea is to get to a 3,000 system. And that would probably get us about where we need to be. So about $8 million a year. And these floats last, I believe, for about five years. So there is a replacement to them. It is not as though you put them out one time. It is not as though you put them out one time, just like you don't put out any system one time. But there will be a replacement and 275—I think that is about where we need to be.

Chairman **EHLERS.** Okay. Thank you. On the ocean exploration program, I—Dr. Colwell and Admiral Cohen, are you both intending to put in appropriate amounts of money into that program for the next year?

Dr. **COLWELL.** We plan to do so. It is a very, very important program. Having continuous measurements as opposed to sort of snap shot measurements gives us a much better understanding. I defer to Admiral Cohen for further comment.

Admiral **COHEN.** Mr. Chairman, the answer is yes. The oceans are where we operate. As I think many of you are aware, the Office of Naval Research invests about $400 million a year in category 6.1 basic discovery and invention. Of that amount, approximately $100 million goes into ocean studies. Of that amount, about half goes into acoustics. Now, acoustics is unique to the Navy because it is not only a censorious part of our weapons systems, it is integrated, et cetera. And it may not have other commercial or scientific spin-offs, except when you retrieve that data and are looking for things that you may not have looked at in the past. So we feel we are strongly committed in the tens of millions of dollars to this area.

Chairman **EHLERS.** Thank you. And I am sure NOAA is also fully involved in that. I yield back the remainder of my time. I will next recognize the gentleman from California.

Mr. **MILLER.** Thank you, Mr. Chairman. I believe that some science is necessary in making any decision. I mean MTBE in California is a great example. It sounded good. But we found once it mixed with water, you couldn't remove it from the water. And now, we have polluted water in California we are trying to figure out how to clean up. And all of you had testified about the inadequacy of observation in the oceans as it relates to climate. In fact, just as complicated powers of problems involving models, it seems that we have learned today from all of your testimony that ocean observation is a problem, as well. And, first—and this is for all of the panelists. Do you believe that the models used in the Intergovernmental Panel of Climate Change, IPCC, assessments adequately incorporate the role of oceans in climate? Why or why not in your

answer.

Mr. **GUDES.** The models do integrate the ocean. They—definitely we could do—we could get more measurements and integrate and develop better models. One of the efforts that we are always involved in, Congressman, is actually improving these models. A big issue is actually the supercomputing power to run these models. And NOAA, through our Geophysical Fluid Dynamics Lab, is one of the key areas. In fact, had one of the key models that is used by the climate community. Dr. Colwell and I were just at a Hearing in Alaska, actually, where we looked—before the Senate Appropriations Committee—where we looked at several models that the IPCC uses, as well as the general climate community.

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Mr. **MILLER.** But all of you have testified about the inadequacy of observation of the oceans. If you have not adequately addressed the issue of oceans and how that does impact it, how could you feel that it is adequate in coming up with a reasonable answer?

Mr. **GUDES.** I think that it is an issue of continually getting better measurements. Just as it is, actually, in the atmospheric sciences. But the National Academy of Sciences Report, which just was done recently, actually supported the IPCC modeling that was done.

Mr. **MILLER.** And you think there is an adequate understanding of oceans as it applies to climate?

Mr. **GUDES.** I think there is a good understanding. And as I said before, we need to do better. I think that a great example is actually the TAO Array across the Pacific. This, back in the early '70s or so, this was a forecast by our scientists that the equatorial Pacific temperatures affected weather in your State. Now, in the latest El Niño that we experienced, we came up with a forecast ahead of time that was largely made possible through those buoys and through those measurements. It is definitely just like with weather forecasting, Congressman. It is definitely an issue where you can get better and better. Better, in terms of models. Better, in terms of the observations. And better, in terms of the integrating, getting that data into the models, simulating into the model in the way that the model improves.

Mr. **MILLER.** Well, I don't disagree with that. But you could apply that to water quality in the same question. You could say, how pure is pure? Are the water quality standards today, are they adequate to provide safe drinking water? And my question would be, is our understanding of the oceans adequate in order to use that portion in the equation of climate?

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Mr. **GUDES.** Right. It is not—it is obviously not just about understanding the oceans. It is about a lot of other measurements that we have taken. Our understanding of the oceans is good in terms of the interaction and coupling with the climate model, but it could definitely be better. And it is definitely, as I said, an issue of where—getting better information, getting better measurements, getting better measurements within the whole water column on a regular basis. Sometimes, it is—as I pointed a lot of times, these climate measurements are not dynamic. They are these long-term data sets by getting them everyday, it is—again, it

is not just the oceans, Congressman. If you will, cooperative observers and improving—one of the things that we do in NOAA is about improving the quantum measurements on land. I know I showed you an image earlier of a lot of red dots across the land surface. But definitely, those measurements can be improved, as well. It is one of the things that we are working on all the time. Getting those same measurements, temperature—exact temperature measurements and getting them on a regular basis and then getting those into the models is all about putting together this puzzle and about understanding the whole earth dynamic that is driving our climate system.

Mr. **MILLER.** And recently President Bush made a decision not to support the Kyoto Protocol. And he did that—he made the decision based on what he perceived to be inadequate understandings of the global warming issues and the environment and such. I saw some other heads when you were answering—kind of yessing a question, kind of going no. So Admiral Cohen, I believe you had a comment. You might have a different opinion.

Admiral **COHEN.** I think you have to frame this—and I do like your analogy, how pure is pure? From the warfighter's point of view, we have to worry about how good a prediction capability do we have for an area and for what length of time in advance of the needed information. And so for small areas and for near term, we are doing okay. If we would like to be able to predict the length of time it takes to get across an ocean using current and ship speeds for an amphibious landing that would occur upon arrival, we are not doing well. I like the competition that we have with NOAA models and the Navy Meteorology Command models, which are complementary, tend to leap frog each other. And, in fact, NOAA came to Navy during Hurricane George, which did so much damage to our East Coast because of the flooding issues, because for that environment, the Navy Meteorology model was better suited than the NOAA model at that point of time. And I understand subsequently, they have integrated that. So it is a continuum that moves on. It is not a black or white kind of issue. And I know you are sensitive to that, based on the question.

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Mr. **MILLER.** Well, thank you for your patience, Mr. Chairman. Thank you for your answers.

Chairman **EHLERS.** The gentleman's time has expired. We would like to move on to the next panel, but Chairman Gilchrest has asked for two quick questions of this panel before we move on.

Mr. **GILCHREST.** Given the sensitivity of the time, Mr. Chairman, I had a couple more questions, but I think I can contact the witnesses myself outside the Hearing. I do want to say, Mr. Gudes and I were planting marsh grass a few weeks ago on the Chesapeake Bay improving that estuary for habitat for the entire ecosystem of the oceans of the world. And I want to thank him for that. Mr. Gudes.

Chairman **EHLERS.** My question is how do you mow it after you——

Mr. **GILCHREST.** With Canada Geese and Tundra Swans.

Chairman **EHLERS.** I want to thank the panel very much for their appearance and their testimony and their comments. This will be extremely helpful to us.

Dr. **COLWELL.** Mr. Chairman, if you would indulge me just very briefly. I wanted to acknowledge Congressman Smith and Congressman Eddie Bernice Johnson for two superb articles in today's *Capitol Hill*. Thank you very much.

Chairman **EHLERS.** All right. Fine. Thank you. We are pleased to call up the next panel.

Panel II: Dr. Marcia McNutt and Dr. Robert Ballard

Chairman **EHLERS.** Panel II, Dr. Marcia McNutt and Dr. Robert Ballard. And I ask Chairman Gilchrest to take the Chair at this point.

Chairman **GILCHREST.** Our next panel is Dr. Marcia McNutt, President and Chief Executive Officer of Monterey Bay Aquarium Research Institute. Welcome. And Dr. Robert Ballard, President, Institute for Exploration. Dr. Ballard, thank you for coming today. We look forward to your testimony. Dr. McNutt, you may begin.

STATEMENT OF MARCIA K. MCNUTT, PRESIDENT AND CEO, MONTEREY AQUARIUM RESEARCH INSTITUTE

Dr. **MCNUTT.** I'm glad to be here to speak today about a topic that I care about most passionately. That is ocean exploration.

I am speaking to you today not only as the President and CEO of the Monterey Bay Aquarium Research Institute, but also as the President of the American Geophysical Union and as the Chair of the Ocean Research Advisory Panel for the National Ocean Partnership Program.

Since time is limited, I just want to cut right to the important issues regarding ocean exploration. First of all, why does the U.S. need a program in ocean exploration? I am very heartened by the comments that have been made so far today by the distinguished Members of Congress. Clearly, you get it. The ocean is essential to life on earth. The ocean is the earth's largest living space. It contains most of it's biomass. 80 percent of all phyla are represented only in the ocean. And most photosynthesis occurs there. The ocean moderates our climate, it keeps earth habitable and it processes our waste. It provides an inexpensive source of protein to feed our population. Yet 95 percent of the ocean is unknown and unexplored.

To be sure, much has been learned about the oceans through research programs funded by our Federal agencies. But research is distinct from exploration. Exploration leads to the questions. Research leads to the answers. Everyday, Congress and other legislative bodies are asked to make policy decisions concerning the ocean based on the best scientific answers to those posed questions. But what if we don't know enough to ask the right questions?

For example, right now, we are considering direct sequestration of carbon dioxide into the ocean below

three kilometers depth to mitigate global warming. But how can we assess the biological impact of ocean sequestration when we know practically nothing about what lives at those depths? Everyday when the submersibles of my institution go out to those depths, we find new creatures that have never been seen before. As another example, observatories that were installed by my institution at Monterey Bay saw that during the decade of the '90s, for a mere one degree increase—one degree Fahrenheit increase in temperature, the productivity of the ocean plunged 25 percent. That extreme effect was not predicted by any of the sophisticated computer models and it was because they did not have the resolution and had not explored—we had not explored the ocean sufficiently in the time domain to ask the right questions of those models. In order to know those questions to ask, the U.S. needs a program in ocean exploration.

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So what is ocean exploration? It is the systematic observation of all facets of the ocean in the three dimensions of space and in the fourth dimension of time. Ocean exploration leads to great but largely unpredictable rewards. Cures for diseases, untapped mineral energy and biological resources, insight as to how the ocean system functions, geological and biological vistas of unsurpassed beauty. Appreciation for our maritime past. Ocean exploration captures the attention of the public and provides engaging content for improving math and science literacy.

When should we begin a program in ocean exploration? Well, probably 20 years ago. But better late than never. Right now, even Ireland is better off than the U.S. in terms of its ocean exploration program. Japan, France and Russia all have ocean exploration tools that are decades newer than what is currently available for the U.S. research community. I personally can't understand why a country that has won World Wars, walked on the moon, and increased the standard of living for its citizens through superior technology could allow itself to sink to second-tier status when it comes to something as important as the oceans. To own the technology is to own the oceans.

So who should be involved in ocean exploration? Well, it should involve all stakeholders: Federal laboratories, businesses, universities, educators, conservation, students, all of the relevant Federal agencies. Each brings an important element to the table. The efforts of all of these groups will need to be well-coordinated through some effective management structure, including coordination of Federal funding. The Ocean Exploration Panel felt that NOPP was a perfect mechanism for doing this. But what the agencies need to hear from the White House and what they need to hear from Congress is that they will cooperate through NOPP and that they will route their funding for ocean exploration and ocean observation through this mechanism.

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The fruits of exploration should be equally available to all stakeholders so that policy decisions can be well-informed from all viewpoints.

So, how should we explore the oceans? The program will be most effective and systematic with built-in mechanisms for educational outreach and information dissemination. The Ocean Exploration Panel felt that

we should center the program around a signature mission, a poleward circumnavigation of the entire planet, concentrating in areas under U.S. jurisdiction. In each region, the exploration would begin with reconnaissance mapping of the sea floor and water column. Next space would involve detailed exploration by the state of the art flagship equipped with new generation submersible technology and high bandwidth satellite communication to bring the real-time discoveries to aquaria, schools, homes and offices.

My institution does that right now, everyday in the Monterey Bay Aquarium. There is no reason why we can't do that nationwide. The flagship would also be set up to archive samples and distribute validated data to data repositories and over the Internet. In the wake of the flagship's observations, ocean observatories would be installed in key locations to continue that exploration into the time domain.

In summary, I hope that Congress will support ocean exploration because the ocean is a mysterious living universe critically important to the functioning of the planet. But even if you support ocean exploration only because of its potential to increase National wealth, encourage ocean conservation, improve public health, regain U.S. technological superiority and promote science literacy for the public, aren't those reasons good enough? Thank you.

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[The prepared statement of Marcia K. McNutt follows:]

PREPARED STATEMENT OF MARCIA K. MCNUTT

Thank you, Chairmen Gilchrest, Ehlers, and Smith, for this opportunity to speak to you about a topic that I care about most passionately, Ocean Exploration.

Since time is limited, I will cut right to the important issues regarding ocean exploration: Why, What, Where, When, Who, How, and How Much.

Why does the U.S. need a program in ocean exploration?

It is very simple. The ocean is essential to life on Earth. The ocean is Earth's largest living space and contains most of its biomass. Eighty percent of all known phyla are found only in the ocean, and most photosynthesis occurs there. The ocean moderates our climate to keep Earth habitable, and it processes our wastes. The ocean provides an inexpensive source of protein to feed the global population. Yet 95% of the ocean is unknown and unexplored. How could that have happened? During the great era of exploration from the 15th through the 18th centuries, the target was unknown lands: the New World, the Dark Continent, Terra Incognita. Many of the explorers of that era were indeed superb mariners—Columbus, Magellan, Drake, Cook—but the ocean itself was not the target of their journeys. It was merely a barrier that needed to be crossed in order to claim new lands and discover new riches. The technology did not even exist at that time to explore the ocean itself. By the time we developed the platforms and instruments that could explore the ocean and its depths, exploration had gone out of favor as most of the land surface had already been catalogued, and the vast resources of the oceans were unappreciated. To be sure, much has been learned about the oceans through research programs supported by Federal agencies, primarily NSF, the Navy, and NOAA. But research is distinct from exploration. Exploration leads to questions. Research finds answers. Every day Congress and other legislative bodies are asked to make policy decisions concerning the oceans,

based on the best scientific answers to those posed questions. But what if we don't know enough to ask the right questions? For example, some are now proposing direct sequestration of carbon dioxide in the ocean, below 3 km depth, as a way to circumvent the atmospheric release that leads to global warming. But how can we assess the biological impact of ocean sequestration when we don't know all of the creatures that live in those regions, much less the role they play in the overall health of the ocean ecosystem? As another example, my institution's ocean observatories documented a 25% drop in ocean productivity in Monterey Bay in the decade of the 1990's caused by a 1 degree Fahrenheit rise in ocean surface temperature. This extreme effect was not predicted by the sophisticated computer models because we have not explored the ocean sufficiently in the time domain to ask the right questions of the models. In order to know the right questions to even ask, the U.S. needs a program in ocean exploration.

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What is Ocean Exploration?

Ocean exploration is the systematic observation of all facets of the ocean (biological, physical, chemical, geological, archaeological, etc.) in all three dimensions of space and the fourth dimension of time. Ocean exploration leaves a legacy of carefully documented information for posterity, to address questions we do not know enough to even pose at the time that the data are collected. Ocean exploration pushes the envelope for technology as we attempt to gain access to Earth's most challenging environments. Ocean exploration leads to great, but largely unpredictable, rewards: cures for diseases from novel biological compounds, untapped mineral, energy, and biological resources, insight as to how the ocean system functions, geological and biological vistas of unsurpassed beauty, appreciation for mankind's maritime past. Ocean exploration captures the attention of the public and provides engaging content for improving math and science literacy.

Where should we explore?

The highest priority for U.S. ocean exploration should be the underwater territories under our jurisdiction. As stewards of these areas, we have a moral obligation to concentrate our efforts there. It is also in these areas that we are most likely to protect and profit from new discovers. The second priority is the Arctic Ocean, largely unexplored and yet the sentinel for global climate change. Other priorities are the vast Southern Ocean and inland seas, where a significant portion of our cultural heritage awaits discovery.

When should exploration begin?

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Probably twenty years ago. But better late than never. A number of other nations have already begun programs to explore their territorial waters. Even Ireland has an ambitious program to map its entire (and large) Exclusive Economic Zone, and is already reaping rewards in terms of new discoveries from its efforts. A number of other nations (Japan, France, Russia) have invested in technology for ocean exploration that is decades newer than what is currently available to the U.S. research community. I don't understand that why a country that has won world wars, walked on the Moon, and increased the standard of living of its

citizens through superior technology could allow itself to sink to second tier status when it comes to something as important as the oceans. To own the technology is to own the oceans.

Who should be involved?

Expeditions should be led by explorers, with broad interdisciplinary backgrounds, who understand the importance of observing everything, regardless of whether it relates to a specific area of their own interest. Ocean exploration should involve all stakeholders: public, private and non-profit. Business interests, universities, federal laboratories, educators, conservationists, students. NOAA, NSF, Navy, NASA, USGS, MMS, EPA, DOE. Each brings an important element to the table. The efforts of all of these groups will need to be well coordinated through some effective management structure, that includes the coordination of Federal funding. The fruits of exploration should be equally available to all stakeholders so that policy decisions can be well informed from all viewpoints. International collaborations will be essential in territorial waters of other nations and desirable in international waters as well.

How should we explore the oceans?

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The program will be most effective if it is systematic, with built-in programs for educational outreach and information dissemination. A plan that appealed greatly to the Ocean Exploration Panel was to center the program around a signature mission: a poleward circumnavigation of the globe. The mission would begin in Maine, continue down the U.S. eastern seaboard, into the Gulf of Mexico, to the Equatorial and South Atlantic, around Antarctica, back up through the Indian Ocean to the western Pacific, across to Hawaii and California, northward along the Pacific Coast to Alaska, and culminating with a mission under the Arctic ice cap. In each region, the exploration would begin with reconnaissance mapping of the seafloor and water column. The next phase would involve detailed exploration by a state-of-the-art flagship equipped with new-generation submersible technology and high-bandwidth, satellite communication to bring the real-time discoveries to aquaria, schools, homes, and offices. The flagship would also be set up to archive samples and distribute validated data to data repositories and from there, over the Internet. In the wake of the flagship's detailed observations, ocean observatories would be installed in key locations to continue the exploration into the time domain.

How much should the U.S. invest in ocean exploration?

The Ocean Exploration Panel recommended $75M/per year for an initial period of ten years, exclusive of capital costs. This is clearly a small investment compared with the value of the ocean to the U.S. economy. We decided on this number based on several arguments. Given that the discoveries from ocean exploration will lead to questions and specific hypotheses that will need to be followed up by research programs, an Ocean Exploration Program that is approximately 10% of the size of the total federal ocean research portfolio is reasonable. Alternatively, a bottom-up calculation for the necessary components of the program: (signature mission, auxiliary explorations, technology development, the education and public outreach, the technology transfer) leads to a similar dollar estimate. Our assumption was that contributions towards ocean exploration from state and private sources and in-kind support from existing government-funded efforts would make the total investment in ocean exploration several times the nominal $75M recommended.

Summary

I hope that Congress will support ocean exploration because the ocean is a mysterious living universe critically important to the functioning of the planet. But even if you support ocean exploration only because of its potential to increase national wealth, encourage ocean conservation, improve public health, regain U. S. technological superiority, and promote science literacy for the public, aren't these reasons good enough?

The full text of the panel report is available at:

http://oceanpanel.nos.noaa.gov/

Chairman **GILCHREST.** Thank you, Dr. McNutt. Dr. Ballard.

STATEMENT OF ROBERT D. BALLARD, PRESIDENT, INSTITUTE FOR EXPLORATION

Dr. **BALLARD.** I want to thank the Chairman and the Ranking Members of the Resources and Science Committees for convening this Hearing today and most importantly, for convening that jointly.

Many people perceive Resources and Science as separate categories, yet in my field, at least, in ocean exploration, they are closely related. It is appropriate to hold this joint Hearing as we begin to define our policy for ocean exploration so that we can move forward into the new millennium with a blueprint for the future.

For years now, we have referred to space as the last frontier. The words of Star Trek. We must go where no one has gone before. I strongly believe that America must maintain its lead in space exploration, but it is by no means the last frontier. Ironically, we have better maps of Mars on the side we can never see, than we have of Earth, itself. Most people don't realize that when Neil Armstrong took that giant leap for mankind on the surface of the moon, it occurred before earthbound explorers using deep diving submersibles entered the largest mountain ranges on our home planet.

Today, we have only explored a fraction of the world's oceans that cover more than 71 percent of the earth. This is particularly true in the Southern hemisphere where the oceans occupy 81 percent of the surface area of the planet.

Going back in time, I find it—as I have somewhat become a historian over recent years, to look at exploration in the 18th and 19th century. In the 18th and 19th century, England commonly had more survey ships in the Southern hemisphere of Earth than America now has exploring there in the 20th century.

There is virtually really no major ocean exploration program within our country. You might ask why

explore? Because exploration has always preceded exploitation of the natural resources of our planet. Before we discovered the vast oil and gas and coal deposits of the West, before we had Yellowstone National Park, before there was an Anaconda Copper Mine, there was a Lewis and Clark expedition. The vast majority of our planet has never had a Lewis and Clark expedition pass through its unchartered wilderness.

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I am also convinced that there is more history to be found in the deep sea than all the museums of the world combined. Yet we are only now beginning to look for that history.

I can't think of a better Nation to lead the world in a new wave of ocean exploration than our Nation. A Nation founded and explored by pioneers. I also would like to make an aside. When I was watching Dr. Colwell's videotape of the hydrothermal vents, I had to smile. Because I was co-chief scientist of the expedition that made that discovery in 1977. And we were not looking for what we found. We were looking for something else. And fundamental exploration is commonly when you are looking for something and you find something else. And, certainly, that discovery points that out.

But future explorers of Earth need to develop the technology necessary to explore the vast and remote regions that lie beneath the sea. We need a new generation of exploratory vehicles that we call AUVs, autonomous vehicles capable of accelerating our rate of exploration.

But I would also like to take the discussion a little bit further afield than what Marcia said so far and what I have said so far. Because while our exploration is underway, it—we really need to begin looking at how we can better farm the sea.

The use of the sea is still primitive, just as the farmers and ranchers came to America to plant their crops and tend their herds, significantly increasing the productivity of the Great Plains and eventually feeding the world, we need to stop being the hunter—gatherers of the sea and start to become their shepherds. To do that, we need to develop technology that—in the future for future farmers and future ranchers of the sea that will follow exploration.

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Besides exploring, exploiting, farming and hurting the sea, we also need to protect it's natural beauty and cultural heritage for the enjoyment of countless generations to come. Just as we have set aside wildernesses and national parks and preserves on land, we need to do the same in the sea.

The National Marine Sanctuary is a beginning of that concept. But it is just a beginning. These newly created sanctuaries need to be expanded. And the creatures and human history within their boundaries better protected. But before the marine sanctuaries can gain the necessary public support to ensure their long-term protection, the public needs to be able to visit them, just as we visit Yellowstone Park and the Grand Canyon today. Working with NOAA, our team is—at the Institute has just made a systematic survey of the latest marine sanctuary in Thunder Bay, Michigan. There, in addition to shipwrecks, which we were mapping and discovering, we also found evidence of geological features that suggest possible Indian habitation before

that area went under water.

Later this year, again, working with NOAA, we will be working in Monterey Bay at the Marine Sanctuary using the latest in telepresence technology. People visiting our facility in Connecticut will be able to do live tours in the Monterey Bay Marine Sanctuary, home of the beautiful sea otters and sea lions, all the way across the United States, building a constituency and support for the public.

I know my time is short and I wanted to submit the rest of my testimony, which has been submitted to you for the record. So I will see the red light is on and I will stop. Thank you very much.

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[The prepared statement of Robert D. Ballard follows:]

PREPARED STATEMENT OF ROBERT D. BALLARD

I want to thank the Chairmen and ranking members of the Resources and Science Committees for convening this hearing today and I'd like to commend you for doing this as a joint effort.

Many people perceive Resources and Science as separate categories, yet in my field, at least—ocean exploration—they are very closely related. It is appropriate to hold this as a joint hearing, as we begin to refine our policy for ocean exploration so we move forward into the new millennium with a blueprint for the future.

For years now, we have referred to space as the last frontier and in the words of Star Trek, felt we must "go where no one has gone before". I strongly believe America must maintain its lead in space exploration but it is by no means the "last frontier".

Ironically, we now have better maps of the far side of the moon that has never faced Earth than we do of Earth itself. We have better maps of Mars and Venus than of Earth.

Most people do not know that Neil Armstrong TOOK that "giant leap for mankind" on the surface of the moon BEFORE earthbound explorers using tiny deep diving submersibles entered the largest mountain range on our own home planet. We had to wait until 1973 for that, four year after Armstrong's "giant leap".

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Today we have explored only a fraction of the world's oceans, which cover more than 71% of the Earth. This is particularly true in the Southern Hemisphere, where the oceans occupy 81% of the planet's surface area.

Going back in time, you will find that, during the 18th and 19th centuries, England commonly had more survey ships in the Southern Hemisphere of Earth than America had in the 20th century.

Why explore? Because exploration has always preceded exploitation of the natural resources of our planet. Before we discovered the vast oil, gas, and coal deposits of the west, before there was Yellowstone National Park, before there was an Anaconda Copper Mine, there was a Lewis and Clark Expedition. The vast majority of our planet has never had a Lewis and Clark Expedition pass through its uncharted wilderness.

What better Nation to lead the world in a new wave of exploration than our nation, a nation founded and explored by pioneers?

But future explorers of Earth need to develop the technology necessary to explore the vast and remote regions that lie beneath the sea. We need a new class of exploratory vehicles known as AUVs: autonomous undersea vehicles that can accelerate our rate of exploration.

And while this exploration is underway, we need to begin developing how we can better farm the sea. Our use of the sea is still primitive. Just as the farmers and ranchers came to America to plant their crops and tend their herds, significantly increasing the productivity of the Great Plains and eventually feeding the world, we need to stop being hunters and gatherers of the sea and become their shepherds. To do that, we need to develop the technology future farmers and ranchers of the sea will need.

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Besides exploring, exploiting, farming, and herding the sea, we also need to protect its natural beauty and cultural history for the enjoyment of countless generations to come. Just as we have set aside wildernesses and national parks and preserves on land, we need to do the same in the sea.

The National Marine Sanctuaries are a new concept that begins that task. These newly created Sanctuaries need to be expanded and the creatures and human history within their boundaries better protected. But before these Marine Sanctuaries can gain the necessary public support to insure their long-term protection, the public needs to be able to visit them just as they visit Yosemite or the Grand Canyon. Working with NOAA, my team from the Institute for Exploration just recently made the first systematic exploration of our newest Marine Sanctuary in Thunder Bay, Michigan. There, in addition to the shipwrecks that have already been identified, we found more highly preserved ones in pristine condition.

Later this year, again working with NOAA, we will conduct the first guided tours of the Monterey Bay Marine Sanctuary using the latest in telepresence technology. People visiting our facility in Mystic, CT will be able to participate in "live" guided tours of the wonderful kelp forests of Monterey Bay, home to sea otters and California sea lions.

The technology to do all this is brand new, cutting edge and very exciting. Developed in cooperation with NOAA, it was field-tested in the Black Sea last summer and is slated to go to Antarctica in the coming spring. In addition to the exploratory technology, we have to develop the technology that will be needed to live in the sea. I am not talking about living underwater in habitats but living on the surface of the sea. At this very moment NASA's International Space station is orbiting Earth and inside that space station scientists are attempting to grow plants in the simulated soil of Mars. Isn't it ironic that we are preparing for the eventual colonization of Mars, the Moon, and outer space but are not exploring how we might someday

colonize the sea?

Years ago, the Office of Naval Research sponsored the development of the FLIP. A large human occupied buoy that is towed to sea and flipped vertically into position, FLIP makes it possible for a team of scientists to live for long periods of time at sea, able to survive the roughest of seas in relative comfort. The oil industry has utilized this concept to build large offshore oil and gas platforms. Now we need to do the same with an eye toward families living at sea like the pioneering families that settled the west. We need to conduct research that would enable these families to grow their own food as well as develop their own aquaculture.

To conclude, I truly believe that the next generation of explorers who are presently in elementary school will explore more of earth than all previous generations combined. But it is our job to insure this prediction comes true. First and foremost, we need to motivate and inspire the coming generation to be explorers. That is why I created the JASON Foundation for Education more than 12 years ago. When this effort first began, the dominant child in this program was a white boy.

But I am proud to say that during the short history of the JASON Project that demographic make-up has changed dramatically. Today, we have more than 1 million children in America participating in the JASON Project and their demographics reflect America's population diversity and in fact, the majority of participants are young women.

I want to thank you again for holding this joint meeting and asking me to give this short presentation. This concludes my formal statement.

Panel II Discussion

Chairman **GILCHREST.** Thank you very much, Dr. Ballard. Dr. Ehlers?

Mr. **EHLERS.** Thank you, Mr. Chairman. A few quick questions. Dr. Ballard, first of all, I am curious, where does your money come from? And I mean the Institute's, not yours, personally.

Dr. **BALLARD.** Well, fortunately, we are fortunate as Monterey Bay, in fact, Dr. McNutt and I have just written a joint paper together in the Journal of Marine Technology about how our institutions are rather unique to traditional oceanographic—in many cases, the vast majority of my funds come from the public visiting our facilities. We have received Federal funding. We have received support from the Office of Naval Research, from Admiral Cohen and his group behind me for the development of technology. We received support from NOAA for the use of that technology and exploration, but my salary and all of my staff's, quite honestly, come from people visiting our facility.

Mr. **EHLERS.** And Dr. McNutt, same question for you.

Dr. **MCNUTT.** Yes. I find it—and, of course, you have picked up immediately on this quite important distinction that the two institutions that are probably doing ocean exploration in its pure form right now are both privately funded. We receive small amounts of Federal grants. But basically, the mission, the technology we have developed has all been done under the auspices of the David and Lucille Packard Foundation.

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Dr. **BALLARD.** And I would like to add just that exploration is only recently begun to join—enter the vocabulary of oceanographers. Through most of my career, you did science, you did research. You did not do exploration. And it has only been fairly recently that one can actually find a place to submit a proposal to as an explorer.

Mr. **EHLERS.** Thank you. I have used the—an immense amount of Hewlett-Packard equipment during my lifetime. I am pleased that some of that went to support your Institute. What new technologies should we develop or work on as a nation to enable more expansive and comprehensive ocean——

Dr. **MCNUTT.** Actually, it is an important issue. My own sense is that in the physical sciences area, the technology is far more mature and available off-the-shelf for measuring things like the temperature of the ocean, measuring currents, measuring its interaction with the atmosphere.

I believe that in the chemical and in the biological realms that is where the sensor technology is very much less advanced. But with the marvelous new tech—new tools—the new tools that are coming down the line thanks to the biotechnology revolution and also through MEMS technology, micro electrical mechanical devices, there are now possibilities to explore the ocean in the biological and the chemical realm that were never available before.

And as Dr. Ballard already mentioned, the importance of cost effective platforms for delivering those tools to the ocean is extremely important. We have relied on tools such as ALVIN for nearly 50 years now as a primary tool for exploring the ocean. But it is simply too expensive to use in some mass quantity. And we need autonomous underwater vehicles and remotely operated vehicles to provide more affordable access to the oceans.

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Dr. **BALLARD.** In Dr. McNutt's testimony she talked about having an exploratory research vessel. I mean, the problem is I think what is the recipe for chicken soup. First you get the chicken, and we do not even have the chicken. We do not have a ship that is dedicated to ocean exploration. And certainly not in the Southern Hemisphere. I mean, you just have to realize how much of the Southern Hemisphere is unexplored, the vast majority of it. And we really need a ship platform. And then from that platform vehicle systems that will greatly accelerate our rate of exploration, which is very slow right now.

Mr. **EHLERS.** I will resist the temptation to ask you where chicken of the sea comes in.

Dr. **BALLARD.** It's a tuna.

Mr. **EHLERS.** I know, I know. I am struck by some of the things that you have said. And it reminds me when I as a youth religiously read National Geographic about their tremendous underwater explorations with very primitive vessels. And I found that really intriguing.

I wonder if what we do not need is another Jacques Cousteau to stimulate public interest.

Dr. **BALLARD.** It was not bad.

Mr. **EHLERS.** Pardon?

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Dr. **BALLARD.** It was not bad. He did a pretty good job.

Dr. **MCNUTT.** He is the reason I am an oceanographer.

Mr. **EHLERS.** Yeah. And just—we have to stimulate more public interest in this issue. And the whole idea of exploring the ocean, which is what we did for a number of years. And now we have just gotten into the measurement and research phase.

Dr. **BALLARD.** We do have a JASON Project which has 1.3 million children in it right now.

Mr. **EHLERS.** I am well aware of that.

Dr. **BALLARD.** And it has been stimulating a lot of them.

Mr. **EHLERS.** And presumably, some of them will be Members of Congress at some point.

Dr. **BALLARD.** Or President.

Mr. **EHLERS.** Yes. I see my time has expired. I yield back.

Chairman **GILCHREST.** Mr. Underwood.

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Mr. **UNDERWOOD.** Thank you, Mr. Chairman. And thank you for your testimonies. I was struck too by some of the comments, especially made by Dr. McNutt. If you would care to elaborate on some of your comparisons to what our country does in terms of oceanographic research versus some internationally. You seem to indicate that perhaps we are not giving it as much effort and attention as some other countries in a proportionate way.

Dr. **MCNUTT.** Yes. Compared to our GNP there are a number of countries, New Zealand, Ireland,

France, Japan, that invest more in the ocean than we do. And given the very large amount of territorial waters under our jurisdiction it simply does not make sense.

My sense is that one reason why the U.S. oceanographic community has managed to maintain a premiere position is not because per capita our funding is the best, or because our tools are the latest generation, but simply we have a very, very well educated, very creative work force that is drawn globally from all over the planet that is conducting ocean research here. And we have a good system for identifying the best people and getting them funded.

It is not because we pay them the most. It is certainly not because we give them the best tools. We have a good system. And if we could build upon what are those strengths, by giving them the A-Team in terms of facilities and in terms of funding, the bottom of the ocean is the limit. The sky is the limit——

Mr. **UNDERWOOD.** The—what is the—what is the nexus then between the research institute and the universities, and what do you think is an appropriate relationship, I suppose, between the research institutes, the universities and government support of that? And do you—do you see that there are models in other fields of endeavor which would be conducive to the kind of enterprise we want——

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Dr. **BALLARD.** Clearly, space exploration I think does——

Mr. **UNDERWOOD.** So is it——

Dr. **BALLARD.** Well, fine. But I think they do encourage exploration more.

Dr. **MCNUTT.** Yes.

Dr. **BALLARD.** I think there is——

Mr. **UNDERWOOD.** Well, how did that come to be, in your estimation? And——

Dr. **BALLARD.** Perhaps just the shear vastness of the problem. I think too that the unknown.

Dr. **MCNUTT.** Well, I think too we cannot downplay the fact that solving this problem was much easier in space because we had one government agency with the mandate for space that was created. NASA. It is easy—NASA has a very large external program that supports both technology and science and exploration in the university community, as well as, its NASA centers. They work well together. In the oceans the jurisdiction is much more diffuse. And it has been much harder to build a system like that.

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I think from the standpoint, speaking as someone outside of the government, I think there is a great amount of good will out in the academic community and the research center community to all work together

to these great aims. But when we look at where in the Federal Government do we plug in, we find that it is a much more diffuse system. And there is not sort of sole leadership there, we know where to go in order to all work together and to make this gel the way it has for the space community.

Mr. **UNDERWOOD.** Well, and you were a member of the President's panel, are you not?

Dr. **MCNUTT.** Right.

Mr. **UNDERWOOD.** And what—how was that issue addressed?

Dr. **MCNUTT.** The President's panel recommended that NOPP was probably the best mechanism we had right now for trying to get that to come together. In other words, the National Ocean Partnership Program which has representatives on the Leadership Committee from Navy, NOAA, NSF, NASA, USGS, that that is one place where they come together and try to coordinate. It still does not have quite the central management, if it were simply one agency. But it is certainly the closest we have yet come in my 30 years of being an oceanographer to something that works to coordinate ocean research.

Mr. **UNDERWOOD.** Okay. Dr. Ballard, I know you want to address that as well. But could you also address then in the context in your answer about how perhaps better we could utilize the Navy or Department of Defense assets?

Dr. **BALLARD.** Well, we have. I mean, the Navy has—certainly the Office of Naval Research in particular has always been a pioneer in the development of ocean exploration technology. It was the Navy that first developed manned vehicle systems, first encouraged the use of the Bathyscaph 3S. Later the Bat—developed the ALVIN vehicle system. ONR has been a pioneer in ocean exploration technology development. It is the use of that technology in exploratory manners.

You have to understand that exploration is a risky business. And scientists are—tend to be very cautious about taking great risks. You cannot come up short too many times and maintain your career. And I think scientists tend to be very cautious. And I think the agencies tend to—to somewhat encourage that cautiousness, which is part of the scientific process.

It is not the process exploration. Exploration is very risky. And that is there is no place for explorers, like myself, to go. I mean, I have to go to the National Geographic Society to do what I would do really risky exploration. Or do things and then beg forgiveness from the Navy later on. I have done that a number of times. Do not ask permission, beg forgiveness. And I have done that numerous times. Of course, the Office of Naval Research has a wonderful philosophy about that kind of thing.

Dr. **MCNUTT.** Forgiveness——

Dr. **BALLARD.** Yes. And he is sitting right behind me.

Chairman **GILCHREST.** Thank you. Mr. Faleomavaega.

Mr. **FALEOMAVAEGA.** Thank you, Mr. Chairman. And I certainly want to compliment Dr. McNutt and Dr. Ballard for their fine testimonies. I was struck by your statement, Dr. McNutt about the fact that several other nations of the world are far more advanced than us. And that is the very point that I was trying to get to in my earlier line of questions. As the saying goes, if you want to know what our national priorities are look at the budget. And I—that is where I raise the curiosity about those four areas that I was trying to seek or solicit the best opinions of our previous panel in terms of where are we really putting emphasis in terms of our national priorities. And the bottom line is how does it compare to those areas.

I—and to compliment, also Dr. Ballard mentioned, in my recent discussions with the Prime Minister of the Cook Islands, he has had to contract a Norwegian commercial oceanographic exploratory company to do the research for the Cook Islands to find out how many seabed minerals are out there in the three million square miles of ocean that is part of the jurisdiction of this little island nation. Small in numbers, but three million square miles. And to my surprise there was no American company. And that really shocked me. And I thought, man, I thought we had the best scientific situation as far as going into this kind of a situation.

Seabed minerals is a risky business, I am sure. Dr. Ballard is very familiar with the issue involved here. But when I hear the Prime Minister telling me that estimates at least, at least, well over $200 billion worth that could be harvested from the ocean of this little island nation, can you imagine what it is like in the rest of the other regions of the Pacific Ocean. And as well as the Atlantic, I suppose.

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So that is where my concern comes in. I honestly believe, and in my opinion, and I have known Mr. Chairman, Mr. Gilchrest, we are not advanced in our agriculture development. We are a nation of importers of fish, which really baffles my mind. Why we—why looking at other nations where they really are far more advanced even in their fisheries programs.

You mentioned earlier about the situation that we find ourselves in the Pacific. I do not know, is there any difference between research and exploration?

Dr. **BALLARD.** You bet.

Mr. **FALEOMAVAEGA.** Okay. So the research of the pencil pushers, right. There are other ones out there looking at the dangers of——

Dr. **BALLARD.** No, not at all. I think that exploration is fundamental exploration. I would not think that you would characterize the Lewis and Clark Expedition as a scientific expedition. It was funded out of the pocket of the White House.

Dr. **MCNUTT.** Yeah, if I could add. Typically, what happens in order to conduct research, someone has a hypothesis. And they go out and they gather data that is pertinent to that hypothesis. They do not gather data that is not pertinent to the hypothesis, even though it might have been more important to gather. And that data is then used by that researcher to address that narrow aim. The data is not necessarily widely sent out to

anyone to answer questions that were not—that did not occur to the researcher at the time that the study was conducted.

Mr. **FALEOMAVAEGA.** I think both of you had also made comment earlier about not only do we need to explore the ocean, but we also need to maintain it. No other region of the world where the people living in this region of the Pacific, and I can say that our own country detonated 66 nuclear explosions, hydrogen bombs and atomic bombs. The Bravo test that took place in 1954 was 1,000 times more powerful. The nuclear detonation in 1954 was 1,000 times more powerful than the nuclear bomb that we put on Nagasaki and Hiroshima.

The French Government, many Americans do not know this, exploded over 218 nuclear bombs——

Dr. **MCNUTT.** Mihara.

Mr. **FALEOMAVAEGA** [continuing]. In the South Pacific. And right now this little island of Mihara is called a Swiss cheese because they have had to go down 2,000 feet in exploding supposedly that is supposed to contain it. And now they find out that there are fissures, there are cracks. And I would like to see some day that maybe we will find a nuclear fissure and send it to President Chirac and see what kind of a job he has done in caring for the ocean and the problems that we face. And I say this with tremendous sensitivity. Because we live there. And I would like to think that there is a sensitivity that we do care for the environment, especially in this area of the ocean.

I just want—I am not going to get into anymore hypotheticals and my good friend, Admiral Cohen, there. I am absolutely certain that the U.S. Navy Department has got more information on exploration and observation that they would care to share with us that I just wish that maybe they could declassify it so in that way the scientific community can benefit, we can make more sense economically to compete with other nations when it comes to fisheries and the amount of things that we need to do in this area. And perhaps, Mr. Chairman, we can hold an oversight area where the Navy Department alone and maybe help us in that.

Because I honestly believe that it is true that these four basic areas are interaction and you cannot separate one from the other. But I believe that the—I should not say monster, but the good person out there with all the money and the scientific resources to do this is our—none other than the friendly U.S. Navy. And maybe they could help us a little more with the rest of our scientific community to come up to par with all the information so that we could be more economically viable in getting into the resources of the ocean.

One quick comment, Mr. Chairman, there are 14,000 varieties of algae. We have only been able to discover there is only about 1,000. And one algae product right now that is now being used by one company is for a tremendous cure for a lot of the—certain diseases. This is something that we have not even touched on.

I am sorry, Mr. Chairman, my time is up.

Chairman **GILCHREST.** All right, Mr. Faleomavaega, we appreciate your question. I think these people that are coming to testify before us today are encouraging us to do a lot more than we are doing of the things you are suggesting. So it is really our responsibility to appropriate the sufficient funds.

We also have a hearing scheduled with the Navy to deal with some of the things that you suggested about their research. Specifically, with sonar and marine mammals. But we certainly can add to that some of the hot-spots globally that they may be aware of. And we might find it pretty interesting.

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They have rung for a vote. I think I may be the last person to ask questions before the vote. What we will do when I am done with my questions, unless there are any follow-up questions, we will recess. I believe there is just one vote. And we will back for the third panel.

Dr. McNutt, you talked about a signature mission with a flagship. Is there a ship presently in the U.S., without building one, that you could recommend do that?

Dr. **MCNUTT.** I am sure there is. I do not believe that it would be necessary to create a new ship. I think that it would be necessary, however, to refit substantially any existing ship. I think some of the larger class ships in the Naval Fleet could be adequate. I am sure that Navy or NOAA probably have adequate ships.

The important thing would be it must be a ship that is equipped for public outreach. And it has to be equipped, I believe, with the latest in submersible technology. Because what the public is going to want to see is not a chart recorder. They are going to want to actually be part of the exploration. They are going to want to see the high definition television cameras on the sea floor, see experiments going on, see marine creatures being observed in their environment. They are going to want to feel that they are part of that, not just see instruments writing down numbers.

It will also be important that that ship be ice-strengthened to go to polar seas. And it is going to be important that the ship be equipped with the latest in navigation and telecommunications equipment. So I believe that we could find in the current fleet——

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Chairman **GILCHREST.** Have you discussed this at all, this particular concept signature mission with let us say, National Science Foundation or NOAA or the Navy or Dr. Ballard?

Dr. **MCNUTT.** Yeah. It has certainly been discussed with——

Dr. **BALLARD.** I was on the same commission.

Dr. **MCNUTT.** Yes, yes.

Chairman **GILCHREST.** I see.

Dr. **BALLARD.** I was part of that recommendation. And I would add that remember when we found hydrothermal vents we had no—we did not have the right scientists aboard. We had no biologists. And we had to wait 2 years before we could get the experts who knew something about this discovery back to that spot.

That is why we need not only public outreach for telecommunications so that the young explorers of tomorrow can participate in these expeditions, also the necessary telecommunications technology, the network scientists when you are out exploring and you are making discoveries, you are more than likely do not have all the experts aboard. And you need to be able to network them in. So the use of telecommunication technology is critical. It would certainly be nice if we could get oceanographic ships that could go faster than 15 miles an hour.

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Chairman **GILCHREST.** Is this a concept that can be—you mentioned NOPP a number of times, National Ocean Partnership Program. Is this a concept that can work through NOPP?

Dr. **MCNUTT.** I believe it is. But you have to understand that this would be a great expansion of NOPP. Because NOPP is an actually pretty small pot of money that they are dealing with now. I think to do this right——

Chairman **GILCHREST.** When I say NOPP though, I mean, the—we could do our best to come up with the funding. And I certainly think this concept is one of those things that we can pursue to sort of enhance exploration research. But to push the public momentum toward this kind of thing.

Dr. **MCNUTT.** I think NOPP can do it. With my experience in being involved with NOPP, I have been impressed at the way that they have been able to do things that are larger than an individual agency's purview.

Chairman **GILCHREST.** As a first step though, you know the Administration recommended a budget of I think it was $14 million for ocean exploration. And I think the House to this point has put up $6. I think as a beginning it would be nice to...

Dr. **BALLARD.** Keep to $14.

Chairman **GILCHREST.** Absolutely.

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Dr. **BALLARD.** I think the Senate may be with you on that.

Chairman **GILCHREST.** Well, maybe we can work that out in conference.

Last question, Dr. Ballard, you mentioned an idea of shepherds of the sea where we used to—we went into the frontier of various areas of the planet and began to harness the energy there and then began to produce food. We know a lot more now about soil in its complexity than we did just 20 years ago. And the nature of good bacteria, bad bacteria, nutrients, nitrogen, phosphorus——

Dr. **BALLARD.** Right.

Chairman **GILCHREST** [continuing]. And those kinds of things. And their impact on the local ecosystem and the watershed. If we pursue, and I am sure it will be pursued, this idea of shepherds of the sea I would assume then we would have to know a great deal more about the complexities of that marine ecosystem.

Dr. **BALLARD.** Absolutely.

Chairman **GILCHREST.** Set aside refuges on the land, marine protected areas in the sea. So do you see ——

Dr. **BALLARD.** Yeah. I have been frustrated over the years. I have been in the field for 4 decades. And without taking a global approach to managing the oceans. I mean, certainly there are resources in the ocean. But there are certainly beautiful places that need to be preserved. I see it no different than I look at the United States. I have national parks. I have areas where farmers farm. I have places where the military operate. You know, there are so many ways that one can look at it in a much more sophisticated way. We are still very primitive.

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Dr. **MCNUTT.** We are still open range.

Dr. **BALLARD.** We are no different than hunter gatherers of thousands of years ago of going out and hunting buffalo. We are out there hunting buffalo right now. We are blowing the buffalo all the way. And we are basically replicating what we did to the—in the early history of our country. We should not do that. We should really be taking a sophisticated look at management. When I say shepherds, I mean that. I mean shepherding the ocean for both—everything that we are talking about. Exportation, exploration, living.

Is it not amazing that right now you have a space station going over our head. And in that space station they have soil simulating Mars. And they are trying to grow plants. Because NASA has the mission to talk about colonization of Mars, the Moon and outer space. And nowhere in this country are we talking about the colonization of the oceans. I just find that mind-blowing.

Chairman **GILCHREST.** I am going to have to go for a vote. And I do appreciate, as we all do, your time, your chosen careers, and your testimony here this afternoon. Dr. Ballard, Dr. McNutt, thank you very much.

Dr. **BALLARD.** Thank you.

Chairman **GILCHREST.** We will recess for about 15 minutes.

[Recess]

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Next Hearing Segment(2)

(Footnote 1 return)
See document entitled "International Commitments for Argo Floats" in Appendix 4.

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INSERTS SPEAKERS CONTENTS

NO INSERTS IN THIS HEARING