

**TESTIMONY OF
DR. RITA COLWELL
DIRECTOR, NATIONAL SCIENCE FOUNDATION
AND
CHAIR, NATIONAL OCEAN RESEARCH LEADERSHIP COUNCIL
TO THE
U.S. COMMISSION ON OCEAN POLICY
Boston, Massachusetts
July 23, 2002**

Admiral Watkins and members of the commission: thank you for the opportunity to speak to you today as chair of NORLC. I'd like to preface my remarks with an announcement: I am now an "Official Navigator." Last week I was one of four awardees who received the Navigator Award from the Potomac Institute for Policy Studies. Armed with this new authority, I feel all the more qualified to call us together as navigators to address the challenges in coordinating Federal efforts in ocean science.

We all know that the admiral is in charge of the ship, but the navigators have an important role in charting the right course and getting us all to the destination. We have both a huge challenge ahead and a tremendous opportunity. It makes me think of the Chinese saying, "May you live in interesting times." The Chinese character for this maxim consists of two parts: one denotes danger and the other represents opportunity. Certainly that duality describes the task before us.

The challenge is that we know less about the oceans than we know about much of the rest of the planet, and out of this ignorance we have abused the marine environment. Marine pollution and plummeting fisheries resources are two obvious examples. To address this, a first task is to educate ourselves about the oceans, and science will be our path. We're beginning to glimpse the other side of our task: coupled with the daunting challenge is the rich potential provided by the convergence of scientific disciplines and the fantastic new tools at every level of observation. Now we are poised to focus on such areas as marine genomics, pharmaceutical resources, and the role of the oceans in global climate--to name only a few.

Both the challenges and the opportunities frame a critical task before us. That is to present both the dilemma and the excitement of the oceans to the broader public, so that the bounty of the oceans will be sustained for future generations. This Commission has a mandate to recommend a coordinated ocean policy for now and for the future. With this in mind, I will cite three specific roles I envision for NOPP.

First, NOPP provides a valuable forum for addressing shared needs of importance to the ocean science community, including oceanographic facilities and ocean education. Dr. Leinen spoke to the Commission about oceanographic facilities at your recent meeting in Los Angeles, including renewal of the academic fleet, so I won't cover the same ground here. I do wish to highlight another critical requirement -- ocean science education and ocean literacy. Scientific literacy so often begins with a spark of excitement, whether kindled in childhood or later in life.

The geosciences and the ocean sciences in particular offer an ideal platform for advancing scientific understanding. The multidisciplinary nature of these sciences and the natural interest people have in the world around them offer an opportunity to convey the principles of biology, physics, chemistry, geology and mathematics simply yet elegantly, with students simultaneously becoming ocean literate. The pending revision of the National Science Education Standards offers

a good opportunity for NOPP to make sure that ocean science will be properly represented in those standards and, ultimately, in the text books.

Incorporating ocean sciences into national science education standards and linking research more directly with educational opportunities will make a difference in our nation as will having a future well-trained cadre of ocean scientists and technologists. In building a future workforce, we need to make a commitment to diversity; the talent pool of the underrepresented minorities, including women, must be full participants in the ocean sciences. The Ocean Research Advisory Panel, NORLC's advisory body, is preparing recommendations for a NOPP education strategy, which we look forward to receiving at our next meeting.

The second role I see for NOPP is in facilitating and coordinating the transfer of research results into applications that meet societal needs. The Integrated Ocean Observing System is the first major test for this new approach, and we must ensure its success. NOPP's *Ocean.US* office recently convened a workshop that resulted in a summary plan providing recommendations for phased implementation of a national ocean observing system. I am pleased to provide you with copies of that report. Dr. Marburger, the President's science advisor, will convene an Interagency Working Group to examine the recommendations of the report in order to prepare a plan for delivery to Congress. The interagency group will focus on appropriate governance for the Observing System and the commitment of each agency to a plan.

Implementation and maintenance of the Observing System will require unprecedented cooperation and collaboration with other countries. We are working very actively with counterpart agencies to strengthen bilateral partnerships and with multinational organizations, including the Intergovernmental Oceanographic Commission and the World Meteorological Organization.

Implementing the Observing System will test the grit of the NORLC. Determining how best to budget for, and manage, an effort of this magnitude on an interagency basis is new territory that will require a new way of thinking. We are presently looking at a number of interagency and international models as we evaluate options for budgeting and management. I believe NOAA's David Evans, who chairs the Executive Committee for *Ocean.US*, will be speaking about this tomorrow.

The final role I see for NOPP is to provide a mechanism for identifying and developing oceanographic research directions that cut across agency missions. Astronomers are adept in developing a consensus for a few over-arching questions, such as "How are stars and planets - including the Sun and our Solar System - formed, and how do they evolve?" This provides scientific direction for the entire field of Astronomy. Ocean science needs a mechanism to focus on comparable questions that set a long-term direction for oceanographic research. We need not look far to see the benefits that result from investments in oceanographic research.

Admiral Watkins, many of us have heard you remark that U.S. R&D won the Cold War, and basic research in marine acoustics and other fields of oceanography made key contributions. NOAA's current capability to forecast and monitor El Nino started with basic research that revealed the important dynamics controlling the El Nino and La Nina cycle in the equatorial Pacific, and its dramatic effects on the weather, ocean biology, and the Earth's climate system. We know that more exciting breakthroughs lie ahead. Current knowledge is rarely the final word on a subject or a security blanket for the future. It will help us in the present. Tomorrow, new more complete knowledge will always replace today's - a process of constant renewal that is speeding up.

NORLC is nicely positioned to lead in this endeavor. I am not suggesting that the NORLC determine the entire ocean research agenda. I refer only to broad research directions and in particular, to those that require interagency cooperation.

Let me give an example of what I have in mind. A major intellectual challenge in biological oceanography is to elucidate the properties of marine organisms that comprise the ecology and biogeochemistry of oceanic ecosystems. These range from plankton-based ecosystems in the water column to those on the surface of the sea floor, from the amazing vent communities to the biosphere buried deep below the sea floor.

These are fascinating areas of research and the information gained will facilitate rational solutions for societal problems such as global change, fisheries management, toxic blooms, emerging diseases, and marine pollution. Furthermore, since marine organisms are uniquely adapted to the extreme conditions found in the ocean environment, their molecular adaptive strategies may include novel chemicals.

During the past decade we used pre-genomic advances to significantly increase our assessment of life processes in the oceans. With the new tools of marine genomics, we can efficiently find the next generation of biomedical research and forensic technology. Genomics unlocks the information of life and can provide a new understanding of the capacities of the world oceans. As is typical of science, it will reveal more questions (and answers) about ocean life and its benefits for humankind.

The next frontier, proteomics, will be an even greater challenge with payoffs hard to imagine. While genomics leads to the discovery of new organisms and the identification of functional genes in natural microbial populations, proteomics follows the path of life's biochemistry from the genes to their expression in the building blocks and machinery of life - proteins. This gives us much greater capacity to identify useful products that can be developed for their commercial value, useful processes to harness, as well as useful predictions on how life can respond to environmental changes.

Advances in genomics bring powerful tools to bear upon public health and ecological challenges alike. A Federal interagency group, including NSF, supports "The Microbe Project," a coordinated effort in microbial genomics. The NORLC could, as an example of a long-term goal for oceanographic research, establish a similar program for ocean ecosystems.

Genomics, for the first time, offers the possibility to identify "what's out there" -- such as what lives in the rich communities around deep-sea hydrothermal vents, where life may well have originated. Although microorganisms constitute more than two-thirds of the biosphere, they represent a great unexplored frontier. Of bacterial species in the ocean, less than one percent have been cultured. Just a milliliter of seawater holds about one million of these unnamed cells.

Last November, scientists partly funded by NSF sequenced DNA at sea for the first time. They sequenced creatures from vent communities from about two miles deep in the Pacific Ocean. Tubeworms, crabs, and other vent-dwellers thrive there, along with bacteria and archaea in water near or above the boiling point. NSF and the National Institute of Environmental Health Sciences are discussing how to connect this fundamental research to our health.

For example, we know little about what happens to pathogens in the marine environment. Indeed, sea floor sediments may provide a long-term reservoir for pathogens. Some ideas ripe for

research include vector and water-borne diseases, marine pharmaceuticals, and harmful algal blooms. Harmful algal blooms are a serious marine hazard for humans and other life forms. More than 60,000 human infections occur each year in the U.S. alone, caused by toxins that exist at the limit of detection. These organisms share interesting traits with pathogens that cause infectious disease: both induce disease by the toxins they produce. As the environment changes, these algal blooms may be on the increase.

Bringing the benefits of convergent technologies to ocean science is a second example of how the NORLC could set a long-term direction for oceanographic research and ocean technology. Convergent technologies refers to the merging of four distinct technologies: nanoscience and nanotechnology, biotechnology, information technology, and cognitive science, each of which is progressing at a rapid rate. NSF and the Department of Commerce sponsored a workshop in December 2001 to assess progress in this rapidly emerging field. The workshop report, to be published this month, provides 20 examples for applications of this new technology that will merge in the next 10-20 years. One can easily envision potential oceanographic applications as well.

For example, the report notes that cheap, smart sensors will be extremely useful in agriculture--increasing yields and reducing spoilage through real-time monitoring. The same benefits could apply to the fishing and aquaculture industries. Sensors and computers worn on the human body could enhance every person's awareness of his or her health condition and environment. Similar sensors could be deployed as part of the Observing System, perhaps on marine organisms themselves.

Transportation will be safer and faster due to real-time information systems and the use of synthetic materials and machine fabrications from the nanoscale. The same technology could be employed in ocean sampling platforms such as autonomous underwater vehicles, gliders, and drifters.

Marine genomics and convergent technologies are just two possible new directions for long-term oceanographic research. I am sure our research community can provide many other candidates. Identifying the kinds of overarching questions I referred to earlier will guide our efforts. We will then need to work together in seeking answers to the "cosmic questions" selected for attention.

The increasingly complex nature of ocean science and technology requires fresh and unconventional partnerships among all members of the ocean science community engaged in this important work. As federal agencies, we must be agile, resilient, and interconnected, just like the science and technology we encourage. And we must get the most value for taxpayers' dollars.

NOPP is becoming that partnership, with the NORLC providing leadership to this effort. It's important to recognize that each of the federal agencies involved with ocean research and operations has a unique mission and must maintain responsibility for implementing its own mission-related programs. The NORLC can identify those areas in which agencies can leverage efforts of common interest, through coordination and collaboration. NOPP can then serve as a mechanism for making strategic investments for programs of high national priority that serve to advance those areas of shared interest.

The roles I've outlined today are all essential elements of a National Science and Technology Strategy for the Oceans, and this is the direction in which the NORLC should encourage NOPP to go. Carrying out these roles requires identifying the needs, developing strategies, and engaging in cooperative budget planning to implement them.

Building an S&T strategy for the oceans is a task clearly worthy of the NORLC. A long-range strategy will provide a broad view of investments -- from research to operations to education -- and how knowledge coupled with technological innovation can address societal challenges and needs.

Thank you for the opportunity to speak. I shall be pleased to respond to questions.