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THE NEED FOR A REGIONAL APPROACH FOR DETECTING, UNDERSTANDING, AND PREDICTING CHANGES IN THE COASTAL OCEAN

"Region, n. A part of the earth's surface of considerable and usually indefinite extent." –Random House Unabridged Dictionary of the English Language

"A region is the next larger scale system that must be observed to understand the local scale of interest." Scott Nixon

Admiral and members of the Commission, thank you for the opportunity to speak with you today in my capacity a the Co-Chair of the U.S. GOOS Steering Committee and of the IOC Coastal Ocean Observations Panel. As requested, my statement today is based in part on a recent NRC report entitled "Bridging Boundaries Through Regional Marine Research."

Coastal Change

The combined effects of climate and human alterations of the environment are especially pronounced in the coastal zone where ecosystem goods and services and people are most concentrated. Managing and mitigating these effects to safeguard public health and safety, protect and restore healthy ecosystems, and sustain living resources depend on our ability to rapidly detect and provide timely predictions of changes in coastal marine and estuarine systems. We do not have this capability today. Effective management and sustainable utilization also depend on efficient and timely coupling of the processes by which new scientific knowledge is gained and the fruits of this knowledge are used for the public good. Today, there is an unacceptable disconnect between these processes.

Closing the gaps between scientific understanding, the formulation and implementation of effective environmental policies, and public understanding requires significant progress on at least three fronts:

(1) Rapid detection and timely predictions – The rates at which environmental data are acquired and processed are not well tuned to the time scales on which decisions need to be made on issues concerning the public well being and the sustainability healthy marine ecosystems and the resources they support. We must improve and streamline current mechanisms by which data are acquired and processed in support of public health and safety, coastal zone management, coastal engineering, environmental protection and resource management.

(2) Local expressions of large-scale changes – Although most of the changes occurring in the coastal ocean are local in scale, they often reflect changes that are occurring on larger scales in the ocean basins, coastal drainage basins, and airsheds. Significant improvements in our ability to rapidly detect the propagation of variability across scales in both time and space are needed to develop the capacity to provide timely predictions with known certainty.

(3) Creating an environmentally literate public – The gap between the development of new scientific knowledge and public understanding of environmental issues is wide and growing wider. We must create windows to the sea that enable U.S. citizens to see and relate to changes in marine ecosystems.

Current scientific understanding and technological capabilities are more than sufficient to begin addressing these challenges. However, we must make more effective and efficient use of our collective assets. This can be done by investing in a system of operational oceanography that enables government agencies to achieve their missions more effectively and benefits private enterprise, science and education, and the public at large. A regionally based national system of observations and analysis is needed that transcends existing jurisdictional and political boundaries, is better tuned to the scales of change in marine systems, and provides a tractable scale for the development of a user-driven system based on regional priorities.

The Beginnings of a Revolution

We are on the cusp a revolution in how we detect, understand, and predict changes in the marine environment. Key ingredients of the revolution, remote and *in situ* sensing, numerical models, and methods for linking observations to models, are improving rapidly. Together, these advances provide the means for

- more timely detection of changes in 4-dimensions;
- understanding and predicting local changes that are related to larger scale forcings from land, sea and air; and
- for resolving anthropogenic drivers of change from natural sources of variability.

The revolution is occurring on several related fronts.

(1) Technological advances and new knowledge has made it possible for oceanographers to invest in long-term, high resolution time series observations that capture the broad spectrum of variability of marine systems from micro-turbulence and waves to trophic interactions, coastal eutrophication and climate change. This trend is and will continue to have a profound impact on the conduct and significance of marine research. On one hand, hypothesis-driven research will benefit enormously from long-term time-series observations. On the other hand, the technical staff required to maintain sustained observations is inadequate and a high priority must be placed on training a new generation of technicians. (“If a Ph.D. is needed to operate the system, it is not operational and we are not making the most effective use of our brain power.”)

(2) It is increasingly recognized that changes in the physical environment, public health risks, living marine resources, the character and extent of habitats, water quality and biodiversity are related; that a small set of core variables is relevant to all of these changes; and that these changes can be modeled in an ecosystem context. With this knowledge has come the realization that the effects of human activities and natural sources of variability can be most effectively detected, predicted and managed in an ecosystem context. For example, overfishing of primary consumers can exacerbate the effects of anthropogenic nutrient inputs on coastal eutrophication and habitat loss just as the loss or modification of essential fish habitat can reduce the carrying capacity of ecosystems for fish populations and increase the susceptibility of coastal populations to natural hazards. Thus, it is becoming increasingly clear that data acquisition and processing for natural hazard mitigation, marine operations, national security, public health and safety, and healthy ecosystems and living resources need not and should not be done in isolation.

(3) Just as weather forecasts are not possible without sustained observations and models, ecosystem-based approaches are not possible without operational models and timely access to sustained (in perpetuity) data streams and information on changes in the physical-chemical environment, biologically structured habitats, and the organisms that inhabit them, i.e., a system that provides relevant information to government agencies on the time scales of the decision making processes that drive the development and implementation of environmental policies and procedures – polices and procedures that encompass and integrate the management of land-use practices and utilization of marine environments and resources.

Timely, cost-effective realization of the combined benefits of these developments can only be achieved through the implementation and evolution of an integrated and sustained ocean observing system (the IOOS) that provides the data and information required to understand and predict changes on the local scales of variability and change that are most relevant. The system must be integrated to provide multi-disciplinary (physical, chemical, biological) data and information to many user groups and to establish an "end-to-end" system that effectively and efficiently links observations; data acquisition, management and dissemination; and data assimilation, modeling and analysis. It must be sustained (in perpetuity) to detect and predict changes in the marine environment that are most relevant to U.S. citizens.

As Dr. Colwell has noted, designing and implementing the IOOS will require unprecedented cooperation, coordination and collaboration among state and federal agencies. However, the federal, state, and private mechanisms established to fund and implement marine research and monitoring programs were not designed to facilitate or support such an operational observing system. Mechanisms are needed that will enable government agencies to collaborate more effectively, to migrate new capabilities from research to operational observing systems for the public good as needed, and to develop a more effective synergy between the research enterprise and operational oceanography.

Designing and Implementation an Integrated, Sustained Ocean Observing System (IOOS)

The character of the coastal zone and environmental priorities of state governments vary regionally from the Gulfs of Mexico and Alaska to the NE seaboard and the Hawaiian Islands. Changes in the marine ecosystems that define the coastal zone in these regions, from changes in sea state and coastal erosion to increases in human health risks, habitat loss and declines in fisheries, reflect a complex interaction between the inherent dynamics of ecosystems and the external forcings that impinge on them. Resolving the effects of human activities from natural variability requires the development of regional "climatologies" for key physical, chemical and biological variables. Rapid detection of deviations from such climatologies and timely prediction of changes in marine ecosystems require regional approaches that take into account regional priorities and the impacts of larger scale changes, i.e., approaches that simultaneously quantify variability on local, regional and global scales.

The U.S. IOOS is envisioned as a hierarchy of local, regional and global scale networks that systematically acquires and disseminates data and data products to serve the needs of government, industries, scientists, educators, non-governmental organizations and the public for information on changes in the marine environment from coastal ecosystems to the open ocean. The IOOS is being planned as two related components: (1) a global ocean component concerned primarily with the ocean-climate system and marine services and (2) a coastal component concerned with the effects of large scale changes in the ocean-climate system and in coastal drainage basins on marine services, public safety and health, the health of coastal marine and estuarine ecosystems, and the sustainability of living marine resources. To date, progress in the development of the coastal component has been relatively slow. This is a consequence of many factors, not the least of which are the challenges of

(1) formulating comprehensive strategic design and implementation plans for a complex environment that has the unified support of state and federal agencies;
(2) establishing an integrated system of data communications and management that efficiently links data applications to diverse data from disparate sources;
(3) the development of biological and chemical sensors, data assimilation techniques for biological and chemical data, and operational ecosystem models; and
(4) capacity building to provide the opportunity for all states to benefit from and contribute to the observing system.

As discussed by Drs. Colwell, Grassle, Bogden and Keeley, important advances are being made on each of these fronts.

The Coastal Component

Given the nature of the coastal environment and differences in environmental priorities among regions, the coastal component is conceived as a national federation in which regional observing systems are nested in a national backbone of observations, data management and analysis. The national backbone measures and processes a core set of variables that are required by most regions to detect or predict most of the phenomena of interest, but are not necessarily sufficient to do so in the absence of additional observations.

Regional observing systems will benefit from and contribute to the backbone an, in so doing, realize the value-added nature of the IOOS. Depending on regional priorities, regional observing systems will increase the resolution at which core variables are measured, supplement the core variables with additional variables, and provide data and information that are tailored to the requirements of stakeholders in each region.

The national backbone will (1) establish a relatively sparse network of reference and sentinel stations**;** (2) provide economies of scale that will improve the cost-effectiveness of regional observing systems by investing in a global system that minimizes redundancy and optimizes data and information exchange; (3) formulate and institute national standards and protocols for measurements, data dissemination and management; (4) link the coastal federation of observing systems to the global ocean component; (5) provide the means for comparative ecosystem analysis required to understand and predict variability on the local scale of interest; and (6) facilitate capacity building.

<u>The Northeast Region</u>

The elements of a national federation of coastal observing systems are developing nationwide. In the NE, these are in the form of coastal observatories, such as LEO-15 and the Martha's Vineyard Coastal Observatory (MVCO), and nascent observing systems, such as GoMOOS and the Chesapeake Bay Observing System (CBOS). Although the initial focus of GoMOOS is on improving the safety and efficiency of marine operations (ship routing, search and rescue, fishing), the system is expected to develop capabilities to provide data and information important to the management of nutrient inputs and fisheries. As we have just heard, GoMOOS provides a model for the development of regional observing systems in that it is operated by a consortium of regional stakeholders (state agencies, private sector, NGOs, academia) who are involved in the system's design, implementation and performance evaluation. CBOS is proving valuable to shipping, recreation and nutrient management in the Chesapeake Bay region. It too is expected to evolve into a more comprehensive system that integrates data from remote and *in situ* sensing to aid in the management of fisheries, nutrient pollution, and land-use practices. LEO-15 and MVCO are prototype coastal observatories that functions as both test beds for the development of new technologies, knowledge and models and as catalysts for the development of a fully integrated observing system for the Middle Atlantic Bight. These efforts are the first steps in the development of a regional observing system for the NE that provides the hierarchy of observations and analyses required to resolve the effects of human activities and natural variability and to predict their socio-economic and ecological consequences from the region's estuaries to the EEZ.

Such a development not only requires close linkages with important research efforts in the region and beyond (e.g., CoML-OBIS, GLOBEC, CoOP, GODAE, and related modeling activities), it requires the establishment of a governance mechanism(s) that will enable (1) cooperation on three fronts (within and among federal agencies, among federal agencies and regional consortia, and among regional consortia); (2) sustained federal funding that does not compromise basic research (but enhances it); (3) the timely migration of new knowledge and technologies into an operational mode as needed; and (4) training of the technical workforce that will be required to develop and operate operational observing systems.

Conclusions

Although the challenges are significant, we are witnessing a convergence of societal needs and technical capabilities that provide the motivation and means to begin the implementation of an integrated and sustained ocean observing system. The time is right to develop an observing system that (1) is based on sound science; (2) is responsive to the information needs of many user groups; (3) makes more effective use of existing resources, knowledge and expertise for the public good; (4) provides a direct window to the ocean environment for research and public education; and (5) provides a framework that will enable government agencies to achieve their missions and goals more effectively. No single government agency has the resources (funding, infrastructure, and expertise) to design and implement such a system by itself. Successful implementation will require a strong commitment by NOPP agencies to develop mechanisms that ensure coordinated development of the national backbone and a federation of regional observing systems.