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Ocean and Atmosphere—The Future

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As the newest member of the group of former NOAA Administrators, and as someone who is very proud of the achievements of NOAA's dedicated, world-class scientists and support personnel, I remain, and anticipate always remaining, very much interested in the future of NOAA's mission and its people. So what does that future hold?

What are the global trends affecting the ocean and atmosphere?

In the atmosphere, human-produced contaminants threaten the health and welfare of all air-breathing species. In the ocean, marine debris generated by one country washes up on the shores of another. The absorption of increased atmospheric carbon has made the ocean more acidic (or less basic, to be accurate), thus jeopardizing the existence of organisms that depend on calcification and are essential to the entire food chain. Biodiversity is declining at an alarming rate, and overfishing worldwide has brought about a rapid decrease in populations of large fishes. Trends in the ocean and atmosphere are clearly affecting the sustainability of the human race.

Population trends are alarming. With almost seven billion people, the earth is strained as never before to support the human species. People are moving to the coasts and large cities, thus magnifying the need to study, understand, and apply large-scale ecosystem approaches to the management of human activities.

Climate change and global warming are clearly affecting the ocean and atmosphere; or, better said, observed changes in the ocean and atmosphere indicate that the earth is warming and the climate is changing.

What are the relevant national investment priorities for the future?

Given this cursory look at trends, I find it helpful to think of future needs in terms of four interconnected categories, all of which must be resourced to gain overall benefits. First, we must build the infrastructure and capability to collect and analyze data on Earth's family of systems. Second, we need a much improved understanding of the water and air that are essential to life. Third, we must develop the skill to understand, and the will to use, ecosystem approaches to the management of human activities. Fourth, we must build new and effective mechanisms for national and global cooperation in earth science research and applications.

To begin, there is an urgent need to invest in a comprehensive, integrated, and sustainable global observing system. Every major challenge to building a sustainable world—which should be our common goal—requires that we gain significantly more knowledge of earth's ecosystems. Monitoring and forecasting climate change and global warming is just one important and current example.

Earth observation systems require robust and sustained satellite constellations. Unfortunately, relatively few citizens recognize how dependent we have become on Earth-observing satellites, or that the current system is fragile today and inadequate for the future. Earth scientists at NOAA and around the world have become increasingly more dependent on satellite data to serve the public with life-saving information and environmental forecasts essential to the economic growth.

Hurricane forecasting is one simple example. Satellites not only provide physical information but are becoming integral to biological pursuits as well. For example, satellite information is used to determine the migration patterns of endangered sea turtles and the level of oceanic primary productivity.

In terms of global warming, the single most important investment needed today is a GCOS (Global Climate Observing System), including a carbon monitoring system. Both climate-monitoring satellites and ground-based monitoring instruments are necessary to achieve this goal. Such a system is critical to a successful agreement on any type of worldwide carbon-limiting scheme and, more importantly, to determining whether we are actually having the desired effect on the earth's climate.

Regarding water and air, again investment in large-scale monitoring systems is needed. For example, there is no large-scale system to monitor the chemical composition of the atmosphere. It will take more than the satellites and ground stations of today; unmanned air systems will be needed to fill the gaps.

Although some progress has been made, much more work remains to complete the required comprehensive ocean-observing systems. A positive example of what has been accomplished is the development of a worldwide tsunami monitoring system. Such a system is now a reality in the entire Pacific and in half of the Atlantic, and is in embryonic stages in the Indian Ocean, thanks to worldwide investment and cooperation both in developing and placing sensors, and in sharing the information obtained.

Satellites are certainly useful for ocean monitoring, good examples being the

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development of ocean topographical and ocean color satellites. However, satellite instruments are currently useful only for monitoring surface and atmospheric conditions over the ocean. There is no substitute for drifting floats and for diving and moored buoys equipped with appropriate physical, chemical, and biological sensors. Much remains to be completed, including investment in coastal systems to monitor and react to coastal pollution, erosion, and harmful biological changes. Reliable biological sensors are a particularly pressing need, yet their development lags behind that of physical and chemical sensors.

On the continents, both groundwater- and surface water–monitoring systems must be installed and sustained, again with appropriate physical, chemical, and biological sensors. Air quality monitoring networks need to be built and sustained using consistent technical standards, and results should be shared appropriately to meet agreed-upon needs for the public good.

Ecosystem approaches to management of human interactions with our environment require even more work. Again, observing systems are needed to provide hard scientific data detailing the interactions that occur throughout the entire chain of life. An example of the usefulness of a global observing system to ecosystem approaches to management is the development of the OBIS (Ocean Biogeographic Information System), a global database and information source for life in the ocean.

Needless to say, investment in conservation, including preservation and restoration of natural resources such as our estuaries, wetlands, and National Marine Sanctuaries, is needed on a much larger scale. More resources must be invested to understand the complex food webs in the ocean and to manage fisheries in the world's largest EEZ (Exclusive Economic Zone).

All of the investment priorities I have outlined will require handling vastly increased amounts of data and developing improved computer modeling techniques. These requirements dictate a massive increase in the size and speed of today's high-performance computers, which in turn leads to the imperative to share these expensive resources. By necessity, these resources will need to be concentrated in efficient large-scale computing centers.

Finally, we must also build new and more effective cooperative and collaborative mechanisms for scientific discovery and for the development of national and global policies in harmony with a sustainable world. Observing systems are clearly a priority, and with the advent of the GEO (Group of Earth Observations), a ministerial-level commitment by more than 75 nations and 50 participating United Nations and intergovernmental agencies to a 10-year plan to build the GEOSS (Global Earth Observation System of Systems), we have a way forward. The United States has matched that effort with the White House–led interagency USGEO (US Group on Earth Observation), which is developing the US contribution to this worldwide effort.

More cohesion within national and international scientific organizations is needed as well. A serious commitment to collaborative research on issues that are regional and global in scale is a must. These large challenges require large-scale infrastructure and management across a wide variety of not only earth science disciplines but also engineering and the social sciences. We must also move research results to policy as quickly as possible. For example, chartering a National Climate Service within NOAA would be enormously helpful to depoliticizing the global warming issue.

This article has been a rather condensed look into the future because of time and space constraints, so if you did not see your favorite priority mentioned, remember that NOAA operates on a budget that is less than half of what it would take to meet the requirements dictated by the relevant laws. Thus, let me close with a forceful reminder of the need for education and public outreach to ensure that citizens around the world understand the importance of investment in earth sciences, and of the imperative to live within the guidelines that come with greater understanding of how our planet lives and breathes.

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