Beginning with this issue, *Oceanography* will publish a regular column on international policy issues of interest to the oceanographic community. Both science and environmental policy issues will be addressed.

The first article in the series concerns the international scientific assessment process. The article provides a concise overview of ongoing assessment activities related to biodiversity, stratospheric ozone depletion, and climate change, describes the assessment process, and explains the crucial role of such assessments in international and domestic policy formulation. The column also encourages top-notch oceanographers to contribute to these assessment activities, which—although extremely demanding in terms of time and effort—are essential in order to build consensus on and find solutions to global environmental problems.

Topics under consideration for future columns include the key conclusions of the Biodiversity Assessment regarding ocean ecosystems, issues surrounding ocean-related geoengineering (iron fertilization, ocean dumping, carbon dioxide disposal, etc.), the relative costs and benefits of coordinated versus individual research projects, the status of women in oceanography, and the concept of sustainable development as applied to the world's oceans. Should you have an interest in any of these topics or suggestions for other appropriate issues, please contact me at the e-mail address listed below. In order to foster broader international participation in The Oceanography Society, submissions from non-U.S. experts are particularly welcome.

Responses to items published in this column in the form of letters to the editor are welcome.

PROVIDING ADVICE TO POLICYMAKERS: INTERNATIONAL SCIENTIFIC AND TECHNICAL ASSESSMENTS OF GLOBAL ENVIRONMENTAL ISSUES AND CHALLENGES FOR THE SCIENTIFIC COMMUNITY

By Robert Watson, Richard Moss and Anne Arquit Niederberger

THE DRAMATIC INCREASE in world population and industrial activities during the last century has given rise to concern that human activities are adversely affecting the environment at all geographic scales. Until the last decade or so, the key environmental issues were local, regional, or continental in scale and were primarily linked to air and water pollution. More recently, our concerns have increasingly focused on global-scale issues. In particular, there are three interrelated global-scale environmental issues that affect both human well-being and the quality of life and that also threaten the very foundation of sustainable development: stratospheric ozone depletion, loss of biological diversity, and climate change. The scientific community is coming under increasing pressure to improve humanity's understanding of key processes, to estimate the potential impacts of global environmental change, and to evaluate technologies and strategies for dealing with such issues. This is providing new opportunities for research as well as increasing the responsibilities for participation in scientific assessments designed to provide timely information for decision-making.

Our current understanding of each of these issues can be summarized as follows.

- Stratospheric ozone depletion has been observed throughout the year at all latitudes except the tropics and has been definitively linked to the anthropogenic emissions of chlorine- and bromine-containing chemicals into the atmosphere. Ozone depletion leads to an in-

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crease in biologically damaging ultraviolet radiation reaching the Earth's surface, with adverse consequences for human health (skin cancer, eye cataracts, and suppression of the immune system) and terrestrial and aquatic ecosystems (loss of productivity and diversity). In addition, because stratospheric ozone is a greenhouse gas, changes in its abundance and distribution affect the Earth's climate.

- Loss of biological diversity is occurring at an unprecedented rate because of the loss, fragmentation, degradation, and conversion of natural habitats; over-exploitation of wild resources; the introduction of nonnative species; and pollution of soil, water, and atmosphere. Anthropogenic climate change is an additional newly emerging threat to biodiversity. Loss of biological diversity (genetic, species, and ecosystem diversity) results in a reduction in sources of food, fiber, and medicines and a loss of regional and global environmental services such as water purification, soil maintenance, and nutrient cycling.
- The Earth's climate is becoming warmer, and the influence of human activities is now discernible in the observational record. Human-induced climate change—which is predicted to occur as a result of increasing atmospheric concentrations of radiatively active trace gases such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and tropospheric ozone—leads to changes in temperature, precipitation, and severe weather (e.g., floods, droughts, high-temperature episodes). These changes in climate are expected to have adverse effects on human health (increases in heat stress mortality and the incidence of vector-borne and non–vector-borne diseases), socioeconomic systems (agricultural production, fisheries, forestry, human settlements) and terrestrial and aquatic ecosystems.

Ocean ecosystems will be affected by all three issues; moreover, the critical role of the oceans in regulating climate and biodiversity could be altered also. Increased UV-B penetration resulting from depletion of stratospheric ozone is expected to affect phytoplankton and ocean productivity. The oceans also play a key but not adequately understood role in the carbon cycle and in controlling the rate and regional patterns of climate change. Another key issue is how fisheries, coral reefs, and coastal wetlands will be affected by climate change. With respect to the loss of biological diversity, there are significant concerns associated with coastal and open ocean ecosystems.

In response to the scientific information and assessments provided by the scientific and environmental communities, the importance of these three environmental issues has now been recognized by governments and the private sector. This recognition has resulted in three global conventions, each signed and ratified by hundreds of countries: (1) the Vienna Convention for the Protection of the Ozone Layer signed in 1985, its Montreal Protocol on Substances that Deplete the Ozone Layer signed in 1987, and the London (1991), Copenhagen (1993), and Vienna (1995) amendments and adjustments; (2) the Convention on Biological Diversity, which was signed in 1992 at the Earth Summit in Rio de Janeiro, Brazil; and (3) the Framework Convention on Climate Change, also signed in 1992 at the Earth Summit.

Each of these conventions acknowledges the importance of continued research, monitoring, and scientific and technical assessments, and the need for scientific and technical information to develop prudent, cost-effective national and international policies. And now that the conventions are in place, governments, in consultation with the private sector and environmental organizations, are deliberating what further actions must be taken to reduce stratospheric ozone depletion, to conserve, sustainably use and equitably share the benefits of biodiversity, and to limit and adapt to climate change. Policymakers are now relying on the scientific community to provide answers to complex scientific and technical issues as they arise in the convention processes. They are expecting that scientific uncertainties be reduced and that technical or policy solutions to these problems be identified and their efficacy and cost-effectiveness assessed.

As a result, some developed countries are putting an increasing percentage of research funds aside for environmental research, recognizing that it can assist in achieving a number of societal goals: improved health and increased life expectancy for their citizens, economic growth and job creation, improved environmental quality, and enhanced national security. However, in many developing countries the scientific and technical infrastructure is inadequate to address critical societal challenges associated with sustainable development.

Thus the recognition of the risks associated with these global environmental issues and the need to find sustainable solutions to them is placing additional demands on the scientific community:

- The increasing pressures for decreasing research funds are forcing researchers to spend ever more time on developing research proposals;
- because of the large geographic scales involved, improved understanding and monitoring of global environmental issues such as ozone depletion and climate change require research programs to become increasingly coordinated at the national and international level, requiring a significant investment in time for planning by researchers;
- the environmental issues are both inter- and multi-disciplinary, thus requiring unprecedented collaboration between natural scientists, social scientists, and technologists;
- scientific and technical assessments are needed to provide to policymakers the information needed for prudent policy formulation; and
- the policy relevance of the research demands that the scientific and technical communities interact with decision makers at all levels and across sectors: local, state, national, and international government policymakers and the private sector.

Many of these demands actually represent significant opportunities for the research community. In particular, the need to conduct assessments of scientific and technical information provides an opportunity to communicate the state of knowledge to policymakers in a form that they can understand and apply. To be credible as a common basis for decision making in the national and international context, such assessments must be transparent, objective, and comprehensive. They must be prepared and reviewed by experts (not advocates or lobbyists!) from both developing and industrialized countries, and they must result in a concise and unambiguous statement of the consensus view of what is known, unknown, and uncertain about the issue in question. Finally, the assessments must be free of policy recommendations, because decision making depends on more than scientific and technical information alone.

Faced with these demands, it is not surprising that there has been some criticism of assessment efforts from the scientific community. The amount of effort that individual scientists must invest in drafting, revising, and presenting the assessments is often far greater than originally anticipated, and authors are not always funded to contribute to the assessment process. Thus there is a natural trade-off between the costs and benefits of contributing to an assessment versus publishing a paper in a recognized scientific journal. Procedural issues have also led to some frustration among individual scientists, e.g., the short time allowed for revisions, the role of governments in reviewing highly technical scientific material or the fact that building a consensus view requires judgement on which issues are truly "known" with a high degree of confidence.

This having been said, sound science and risk assessments form a crucial basis for policy making to address these and other environmental issues. Ozone assessments were issued in 1981, 1985, 1989, 1991 and 1994; a biodiversity assessment was completed in 1995; and major climate change assessments were completed in 1990 and 1995, with special reports in 1992 and 1994. Because the international assessments conducted to date represent the views of the large majority of the scientific community—including scientists from academia, government laboratories, environmental organizations, and industry—they have provided a commonly accepted basis from which to discuss and negotiate legally binding international environmental agreements and to develop effective policies and measures at the national level. Because of the participation of government representatives in both scoping and reviewing the assessments—which has been frustrating to some participating scientists—policymakers develop interest in the results of scientific research, and thus are more likely to face up to the policy implications of new scientific information. Ultimately the international assessments have provided the justification for action, the tools for analysis, and the information needed to develop cost-effective strategies to address these environmental threats.

The need for scientific assessments will continue in the future, and we hope that the world's best oceanographers will continue to support and contribute to such efforts. This may mean some sacrifice and a great deal of effort on the part of individual scientists, but the benefits to society—and to the research community—can be profound. ❑