Roundtable

Immiscible investigators: oceanographers, meteorologists, and fishery scientists

by Warren S. Wooster

Important scientific problems often lie in the zones where disciplines overlap, and thus require interdisciplinary collaboration. But in ocean studies, interdisciplinary research is uncommon (NRC 1979). Although there are urgent problems that require the joint efforts of oceanographers, meteorologists, and fishery scientists, such collaboration has proved difficult to arrange. These difficulties can be traced to cultural differences among these fields in the United States.

One urgent problem that demands an interdisciplinary solution is the influence of human activity in climatic changes. For example, does increasing the carbon dioxide in the air by burning fossil fuels and removing of forests increase the frequency and severity of droughts, floods, or extreme heat or cold? The oceans are important to understanding climate change and predicting its direction. They provide 71% of the earth's surface exposed to the atmosphere, and they store and transport enormous quantities of heat. Progress in climate studies requires close cooperation between oceanographers and meteorologists.

Forecasting the influence of environmental conditions on fish abundance is another problem requiring interdisciplinary collaboration. Oceanic changes of seasonal and interannual frequencies not only drive and are driven by comparable atmospheric phenomena, but also affect the abundance and availability of marine organisms, particularly in the surface layer, the upper 100 meters or so of the water column. For example, year-to-year differences in success of fish recruitment can be attributed to environmental conditions (Cushing 1982). As the stocks are subjected to ever more intense fishing pressure, the need for collaboration of oceanographers, fishery scientists, and meteorologists will become more urgent.

In attempting to promote such studies of the effects of climate and ocean variability on fish abundance (which might be called recruitment fishery oceanography), I have encountered considerable difficulties. Problems arise because of differences among scientists of these fields in their education, research styles, funding, and institutions. Consideration of these differences may reveal some ways to improve the chances of joint action in the future.

Education

The separate and divergent evolution of disciplines has its roots in the universities. The departments, or other disciplinary units, appoint and promote faculty. The junior faculty members generally believe that their future depends on performance within a discipline, including publication in its elite journals.

In the United States, most meteorologists are educated in departments of meteorology (or atmospheric science), usually located with other scientific fields in colleges of arts and science. Departments (or schools) of oceanography are found both in colleges of arts and sciences or in units separate from other sciences. Fishery students are usually in distinct schools, sometimes associated with wildlife management. Thus interaction among students in these fields is limited from the beginning.

To some extent, these locations reflect whether a field is considered basic or applied. While researchers in fisheries are generally regarded as applied scientists, oceanographers and meteorologists are more likely to be seen, at least in universities, as "pure" scientists, although these fields appear "applied" compared with physics or chemistry. There are status differences associated with these perceptions.

In both meteorology and fishery science, undergraduate programs are common. Only graduate degrees are usually available in oceanography. (This difference appears to be related to employment opportunities.) An important consequence is that these undergraduate programs are a major source of graduate students in meteorology and fishery science, whereas nearly all graduate students in oceanography enter with degrees in physics, chemistry, geology, or biology.

In graduate school, meteorologists and physical oceanographers may have a few courses in common, for example, geophysical fluid dynamics. It is uncommon for students in other branches of oceanography to take courses in meteorology or vice versa. Meteorology is largely a physical science, including some chemistry and scarcely any biology.

Oceanography contains major elements of physics, chemistry, biology, and geology, and an effort is made to expose students in each of these specialties to problems and approaches in the other. Fishery science is primarily a biological specialty. Few graduate students in fisheries go beyond the introductory level courses in oceanography, and it is even more unusual for students of oceanography to take courses in fishery science.

Thus by the end of graduate school, those whose collaboration is required to unravel problems of climate and fishery oceanography have come from different backgrounds, have had few courses in common, and have seldom met in seminars and discussions.

Research

There are marked differences in the conduct of research in these subject

areas. Each area has its own laboratory and theoretical aspects, but it is in the nature of their field research where the differences become most apparent.

Field research in meteorology takes advantage of extensive atmospheric monitoring by the technical staffs of national weather services. In large-scale international meteorological experiments, most observations are made by technicians or by remote sensing. In contrast, research on fish stocks, which are often monitored by commercial fisheries, commonly consists of experimental and survey fishing by technicians. Routine oceanographic monitoring is limited. The field work of oceanographers involves both specialized research vessels and the full participation of the scientists themselves. Thus in large-scale field experiments, the involvement of the principal investigators is greatest for oceanographers and least for meteorologists.

These differences in research approach are reflected in employment patterns in the three fields. Academic institutions are the most important employers of oceanographers, while government laboratories employ most meteorologists and fishery scientists. Generally, there is a significant market for bachelor- and masters-level meteorologists and fishery scientists in the government and private sector, while the major oceanographic work—research—demands more extensive training.

Funding

Differences in research funding depend on the extent to which the results are considered applicable to identified societal problems. Most fishery research and much meteorological research (especially related to short-term forecasting) is performed by scientists in government laboratories (e.g., those of the National Marine Fisheries Service [NMFS], other parts of the National Oceanic and Atmospheric Administration [NOAA], and the Navy). In contrast, oceanographic research is much less likely to be performed in government laboratories.

If a large-scale experiment were conceived involving the three fields (e.g., to examine the effect of interannual differences in the frequency and intensity of late winter storms on the success of recruitment in fish), scientists of each field would seek financial support differently, and different institutions would be involved. The oceanographers would commonly turn to the Ocean Sciences Division of the National Science Foundation (NSF); some support might be available from the Office of Naval Research. The principal institution participants would be academic laboratories, which gained experience in pooling resources during the 1970s NSF program, the International Decade of Ocean Exploration (NRC 1979). NOAA ships might also be expected to participate.

In meteorology, academic investigators and NSF funding would also be involved. A major additional element would be the large NSF-funded national laboratory—the National Center for Atmospheric Research in Boulder, Colorado. NOAA participation would be expected to be significantly greater than in the case of a purely oceanographic experiment.

Large-scale fishery research in the United States tends to be done by NMFS laboratories, and there are few examples of interdisciplinary interagency field experiments. More common is cooperation in survey or monitoring operations, for example the California Cooperative Oceanic Fishery Investigations. But generally, NMFS priorities (e.g., for stock assessment) seem to preclude assigning scientists and vessels to conducting experiments. Fishery scientists in academic laboratories tend to work on smaller, individual projects. Funding for them is usually not available from NSF if commercial species are studied and not available from NMFS because payoffs from the experiment are too distant.

Institutions

The differences in education, research style, and employment are also reflected in the professional organizations. Both fisheries and meteorology are served by professional societies, the American Fisheries Society and the American Meteorological Society, while the needs of oceanography are met only by subsections of broader scientific societies (e.g., the American Geophysical Union and the American Society of Limnology and Oceanography, and trade groups such as the Marine Technology Society and the American Oceanic Society). The societies publish specialized scientific journals for their members. There are also a few publications where interdisciplinary papers may be found.

The three fields come together in the federal government, in NOAA, although there appears to be only limited collaboration in research between fisheries on the one hand, and oceanography and meteorology on the other. In the NRC, there are committees and boards dealing with aspects of oceanography and meteorology (the Ocean Studies Board and the Board on Atmospheric Sciences and Climate), but no designated body related to fisheries.

Internationally, the divergence continues to be evident. Within the United Nations, for example, oceanography has the Intergovernmental Oceanographic Commission, meteorology has the World Meteorological Organization, and fisheries has only the Food and Agriculture Organization (FAO), whose major interest is in agriculture. These organizations differ widely in their effectiveness in promoting research, and jurisdictional jealousies are fierce.

In one regional intergovernmental organization, the International Council for the Exploration of the Sea (ICES), there is reasonably effective cooperation between oceanographers and fishery scientists who meet regularly to plan joint scientific endeavors. The focus of ICES is on fishery resources and protection of the marine environment; unrelated oceanography is not given much consideration.

On the nongovernmental side, all aspects of oceanography are accommodated within the Scientific Committee on Oceanic Research (SCOR), a scientific committee of the International Council of Scientific Unions (ICSU). SCOR also has close links with the more specialized societies of the various ICSU unions. There is no comparable nongovernmental body for fisheries, although FAO has a scientific advisory group, the Advisory Committee on Marine Resources Research (ACMRR), that has cooperated with SCOR. For example, ACMRR has recently joined with SCOR in sponsoring a working group on oceanography, marine ecology, and living resources.

The future

In view of these cultural differences, what could be done to improve effective cooperation among scientists of these fields? Recognition of the practical importance and scientific interest of recruitment fishery oceanography should promote such cooperation. There are three areas where progress might be made—mutual understanding, communication, and support for research.

To improve mutual understanding, the education of scientists in the three fields must broaden. While meteorology will remain an essentially abiotic endeavor, its practitioners need a thorough understanding of ocean circulation and mixing.

Most graduate programs in oceanography have a reasonable interdisciplinary breadth, but knowledge of relevant meteorology and ocean-atmosphere interaction must reach the biological, as well as the physical, oceanographers. Both fishery research and oceanography would benefit if oceanographers were more familiar with today's fishery problems and experimental methods.

Fishery scientists concerned with the variable abundance of marine fish can make little progress without a professional-level education in phenomena and processes of variability in the ocean environment—that is, graduate level instruction in physical, chemical, and biological oceanography. It is even to be hoped that the rosters of scientists in government fishery laboratories will increasingly include physical oceanographers.

Communication can be enhanced through joint scientific meetings on problems of mutual interest, such as SCOR's Joint Oceanographic Assemblies of 1970, 1976, and 1982; recent meetings on fish ecology; the 1983 workshop on interannual variability of the environment and fisheries of the Gulf of Alaska and the eastern Bering Sea; and the Ocean Sciences Meetings of the American Geophysical Union. Another approach is represented by formation of the International Recruitment Investigations in the Subarctic (IRIS), which is furthering the exchange of views and the coordination of research among university and government laboratories in Alaska, British Columbia, Washington, and Oregon.

Finally, the miscibility of these presently disparate types of investigators could most quickly be enhanced by the generous application of money to support interdisciplinary work on atmosphere-ocean-fish problems. Efforts are underway in NOAA to launch programs in fishery oceanography. These Fisheries-Oceanography Coordinated Investigations could provide that boost, although first indications are that the bulk of the funds will be spent within government rather than university laboratories, so oceanography may not benefit. The programs will, however, encourage an increase in the number of fishery investigators concerned with recruitment fishery oceanography. It is also conceivable that a well-defined interdisciplinary study of an atmosphere-ocean-fish problem might be funded by NSF, although preparation of a successful proposal is likely only after efforts to improve mutual understanding and communication have already succeeded.

Progress in these areas will eventually eliminate the need for further consideration of the immiscibility of oceanographers, meteorologists, and fishery scientists. However, improved mixing should not be expected quickly, since university curricula are slow to change, as are the present priorities of fishery research institutions.

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