Charting a course for ocean science

"Progress, therefore, is not an accident, but a necessity...It is a part of nature."
—Herbert Spencer, 1851

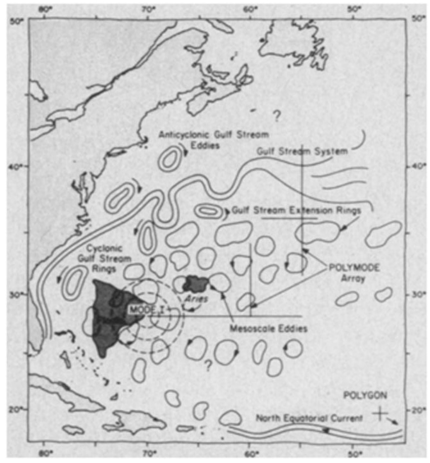
By 1970, social, political and technological events had converged with the tides of scientific endeavor, leading to a widely recognized need for an international program for oceanographic research. People were increasingly aware of the ocean's importance: Human activities threatened to affect climate through introduction of gases, such as carbon dioxide, but relatively little was known of the interaction between ocean and atmosphere. Burgeoning understanding of plate tectonics, the growing possibility of seabed mining and concern about the fate and effects of pollutants all accentuated the paucity of data about deep ocean processes. Ultimately, the necessity for a broad-based research effort was realized during the 1970s—the International Decade of Ocean Exploration.

The experimental effort is chronicled in "The Report of the Decade: The International Decade of Ocean Exploration," released recently by the National Science Foundation. Despite some hitches caused by bureaucratic overlap and failure to meet some early goals, such as an international ocean monitoring system, "most scientific goals were met and far exceeded" through the IDOE projects, the report notes. The decade produced results that altered widely accepted perceptions of the ocean. It also transformed ocean science from a discipline focused on limited areas in biology, chemistry, geology and physical oceanography into a more interrelated, multi-disciplinary field.

"The 10 years of work really changed the way we do oceanography," says M. Grant Gross, director of NSF's Division of Ocean Sciences. He cites the North Pacific Experiment (NORPAX) as an example of an IDOE program that significantly increased understanding of physical oceanography, specifically how heat is received, stored, transported and transmitted by the North Pacific. "What you see is the first indication that it may be possible to predict climate a season or a year ahead of time, based on ocean features," he says.

A related IDOE experiment focused on El Niños, periodic upwellings of warm waters off the coast of Peru that can have devastating effects on fisheries. Now, prediction may be possible: Changes in winds along the equator are believed to occur as much as a year before the onset of an El Niño, which results when water from the western tropical Pacific piles up and washes toward the South American coast.

Similarly, the GEOSECS program has enabled oceanographers to map the ocean by charting the movement of chemicals



MODE and POLYMODE projects studied major oceanic features such as currents and eddies.

through the water column. A follow-up program, one of 13 started since the end of the IDOE, will continue the use of transient tracers, notably radioactive material injected into the oceans during the 1960s.

"One of the most important contributions of the IDOE program is that it has given us a concept of a very dynamic ocean," says Derek Spencer of Woods Hole Oceanographic Institution and the University National Oceanographic Laboratory System. "It is only in the last few years that we've realized that the ocean floor is an environment that responds very rapidly, in a period of a few weeks to a few months, to changes that take place at the ocean surface. This is quite a revelation. There are processes taking place down there that we didn't even imagine could be possible." He suggests that discoveries made through the Ocean Drilling Program may exert as great an influence as the IDOE on future oceanographic research.

With the end of the IDOE, ocean scientists are looking ahead with both anticipation and uncertainty. Immediate research directions are fairly clear, building as they do on recent discoveries and on technology either already available or in planning stages. The task of predicting future research needs is more difficult. A preliminary report circulated at the Joint Oceanographic Assembly in Halifax, Nova Scotia, by the Scientific Committee on Oceanic Research, tries to pinpoint major areas in ocean research through the year 2000 by extrapolating existing trends. With the caveat that "the vitality and creativity of our science will be demonstrated in the years ahead by the degree to which we have erred," the report highlights advances in instrumentation and remote sensing, and identifies a number of "particularly critical" areas. These include the relation of large-scale thermal anomalies to ocean circulation and atmospheric processes, transport and storage of heat and salt in the ocean, storage of carbon dioxide, studies of oceanic eddies and vertical mixing.

—*C. Simon*

The social spiders of Mexico

As a Mexican spider, *Metepeira spinipes*, rests alone in its dense, heat-reflecting retreat, a sudden vibration in the signal thread wakes it — a fly has been snared by the spider's orb web. The fly struggles in the sticky thread and breaks free—only to be trapped again in a neighboring spider's connecting orb web.

Biologists George W. Uetz, Thomas C. Kane and Gail E. Stratton of the University of Cincinnati suggest in the Aug. 6 SCIENCE that *Metepeira spinipes*, because they exhibit both solitary and communal behavior, might represent a link in the evolutionary progression of the social behavior in spiders. Kane says, "What we have here [*Metepeira spinipes*] is the bridge between being solitary and being social."

To explain their theory, Kane says that because spiders are aggressive and will attack any prey of appropriate size, most spiders tend to live alone. There are, however, a few species of spiders that are gregarious. These spiders build communal webs, share captured prey and even exhibit maternal behavior. *Metepeira spinipes* are intermediates in that they live communally but exhibit solitary behavior.

They live alone in retreats, but they connect their prey-catching orb webs to neighboring spider webs; the result is a massive web structure that can contain as many as 6,000 or 7,000 spiders. *Metepeira spinipes* weave their webs alone, catch their prey alone and defend their retreats alone, but because they build their webs near one another they can capture prey more effectively than spiders living alone.

Uetz explains that an insect caught in the communal web might ricochet off as many as three or four individual spider webs before it is eventually captured by one spider who will either eat the snared insect or wrap it in webbing for later use. This method of prey capture means that individual spiders have a greater chance of catching insects. Uetz adds that the overall webbing of the communal spider home is massive and that larger insects that would escape a solitary spider are more easily trapped.

But Uetz also says that *Metepeira spinipes* can only take advantage of communal living in environments where the food source is plentiful enough to support the whole colony. In these environments the advantages reaped by communal living, such as increased prey capture, outweigh the disadvantages of having aggressive spiders living close together.

In harsh areas like the desert where prey are scarce, Uetz says, spiders become less willing to tolerate their combative neighbors. In such environments spider colonies are smaller, sometimes containing as few as three or four spiders.

—*K.A. Fackelmann*