NOAA's Coastal Ocean Program: science for solutions.Lauren Wenzel and Donald Scavia. ***Oceanus*** 36.n1 (Spring 1993): pp85(8). (3187 words)

Abstract:

The Coastal Ocean Program (COP) was created in 1989 by the National Oceanic and Atmospheric Administration (NOAA) to address pressing and evolving problems in the environmental aspects of the oceans. COP is designed to develop scientific information that would help in the conservation and management of marine resources, control of coastal ocean pollution and minimize coastal dangers.

Full Text:

The year 1988 was not a good one for the coasts. Hundreds of dead and dying dolphins washed ashore from unknown causes; medical wastes, including syringes, appeared on New Jersey beaches; and many areas were too contaminated to permit shellfish harvesting or swimming.

People responded to this visible evidence that the coast was in trouble. Congressional committees held hearings to find out what was causing the problems, and what could be done about it. Time and Newsweek featured cover stories on "Our Filthy Seas," advising, "Don't Go Near the Water." Many problems that drew attention that year were symptoms of longstanding patterns of human activities near the coast. And some, such as the pollution of beaches by sewage outflows, could be addressed by available technology and management decisions. Others were, and are, more complicated. The depletion of US fisheries continued, reaching crisis proportions in some regions, due to the inexact nature of stock assessments and the social and economic consequences of imposing restrictions. For other issues, such as the contamination of estuaries and coastal waters by toxics and nutrients, the sheer complexity of the problems frustrated managers looking for solutions.

Congress responded by passing legislation to control ocean dumping and medical wastes. Looking at the broader set of coastal issues, the National Oceanic and Atmospheric Administration (NOAA) created the Coastal Ocean Program (COP) in 1989 to focus NOAA and academic coastal ocean science efforts on emerging and longstanding problems.

Today, the coastal ocean's troubles are, if anything, more formidable and complex than they seemed even four years ago. Toxic algal blooms, bringing public health concerns and severe impacts on coastal tourism, have become increasingly common, yet are still poorly understood. Hurricane Andrew, with an estimated $20 billion price tag, vividly illustrates the economic impacts of tropical storms along our coasts. And even toxics banned years ago, such as DDT and PCBs, continue to accumulate in fish and shellfish, threatening human, wildlife, and ecosystem health.

Within NOAA, COP has become a focal point for developing the scientific information needed to predict, and, where possible, prevent or mitigate negative human and natural impacts on valuable coastal resources. From its inception, COP was designed to "cross-cut" the agency to work effectively with all of NOAA's offices. To provide scientific information on a wide range of issues, the program aims to improve predictions of:

* fishery stocks for better conservation and management of living marine resources,

* coastal ocean pollution to protect and restore environmental quality, and

* coastal hazards to protect life and property.

This cross-cutting approach allows the program to adopt a broad, integrated perspective on coastal issues. COP has also acted as a catalyst for enhancing NOAA/university partnerships, bringing agency and academic scientists together to coordinate their investigations on important issues. COP represents a stable yet flexible approach to scientific research on critical coastal issues. Rather than attacking each problem piecemeal, the program supports research toward fundamental advances in our ability to predict environmental conditions and changes.

In the three years since COP began, the program has made significant contributions to our understanding of coastal processes and ecosystems in seven "theme" areas: nutrient over enrichment, toxic chemical contamination, coastal fisheries ecosystems, estuarine habitats, coastal hazards, CoastWatch, and information delivery. In addition to the research discussed below, COP supports the development of sensitive indicators of toxic contamination, models to predict flooding from storm surges, and research dissemination efforts to ensure that critical research reaches coastal managers.

CoastWatch Delivers Data Rapidly Where It's Needed

While NOAA has long had an impressive ability to gather information about the ocean's surface through satellites and aircraft, these data were often stored thousands of miles from the areas they pictured, reaching the local managers and researchers who needed them weeks or even months after they were collected. To solve this problem, and put the agency's considerable information resources into the hands of those who need them, NOAA conceived CoastWatch. A system of regional data-access sites, supported by a central data processing and distribution center, CoastWatch allows managers and researchers to obtain satellite and in situ data far more quickly and easily than in the past.

CoastWatch was first applied in 1987 when National Marine Fisheries Service scientists at Beaufort, North Carolina, found that sea-surface temperature maps derived from NOAA's polar satellites could be used to analyze oceanographic conditions associated with an offshore harmful algal bloom. The bloom, which lasted for three months, destroyed nearly half the state's scallop population, and forced the closing of all shellfish beds, although not before dozens of illnesses were reported. Fishery and tourism losses rose to $25 million. The blooming dinoflagellate (Gymnodinium breve) was a species native to the Gulf of Mexico but new to the Atlantic, carried by the warm waters of the Gulf Stream. After the bloom subsided, researchers reviewing satellite data from that period found that a breakaway stream of warm Gulf water had snaked its way off the Cape Hatteras coast, bringing the bloom with it.

While CoastWatch's pilot application was too late to prevent seafood poisonings in 1987, it now provides near real-time products to monitor and predict such disruptive events. CoastWatch data are used across the country for a wide range of research and management applications. In California, the CoastWatch node tracked coastal ocean responses to 1992 El Nino conditions (see Oceanus, Summer 1992). Fisheries managers received critical information. El Nino brought warmer waters inshore, creating conditions that are believed to benefit subtropical fish at the northern end of their range and a detriment to stocks at the southern end of their range. Anomalous fishing conditions have also been detected in the Gulf of Mexico by fisheries managers using CoastWatch data. In the Great Lakes, CoastWatch data is part of the Great Lakes Forecast System, a linkage of observations and models that will provide coastal planners with forecasts of winds, waves, water levels, and temperatures throughout the region. In the Northeast, CoastWatch data have been used to track "red tide" blooms, and to study the oceanic aftereffects of Hurricane Bob.

New remote sensing technologies present another opportunity for coastal researchers and managers. In 1993, a new satellite will be launched with an ocean color sensor, SeaWiFS

(Sea-viewing Wide Field-of-view Sensor), capable of measuring spectral radiances at the ocean's surface. SeaWiFS data can be used to estimate phytoplankton biomass and productivity on a variety of scales. COP will support the development of coastal ocean and Great Lakes applications.

A National Program Maps Watershed and Habitat-Change Analysis

Recently, the general public has come to see what scientists have been saying for years--that while wetlands, especially coastal wetlands, are among Earth's most productive ecosystems, they continue to be filled, drained, or otherwise degraded. Loss of half the nation's coastal wetlands has eliminated breeding grounds for such commercially valuable species as shrimp, reduced the habitat that waterfowl and other wildlife require, made coastal waters more vulnerable to unfiltered, polluted runoff, and left coastlines unprotected from storms.

To preserve remaining resources, detailed data on the changes in important coastal habitats are needed. COP's Change Analysis Program (C-CAP) staff addresses this need by working with scientists and resource managers to develop a national protocol for mapping watersheds and habitats and detecting change through satellite and aircraft remote sensing. Through regional workshops, more than 200 scientists debated myriad issues to arrive at a unified, consistent approach to mapping land-cover data. This protocol will be used by federal agencies, states, and academic researchers to map coastal habitats and adjacent uplands so that habitat losses around the country can be consistently documented, compared, and analyzed. Intended to evolve as new technical issues are confronted and resolved, the protocol will provide a practical tool for resource managers.

The standardized approach has already made a difference. With federal technical assistance, several states are beginning to explore their coastal habitats through satellite data and aerial photography. In North Carolina, C-CAP has helped the state map much of its submerged aquatic vegetation, giving resource managers information needed to protect these sensitive habitats from such disruptions as mechanical clam harvesting. With the success of this effort, the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) is now cooperating with C-CAP to map submerged aquatic vegetation along the Gulf of Mexico coast. Florida's Department of Natural Resources is using satellite data to examine the impact of Hurricane Andrew on the Everglades mangrove forests. In 1992, C-CAP moved into the international arena, initiating a project to analyze changes in wetland and upland areas on both the US and Canadian sides of the St. Croix River estuary. Ultimately, C-CAP will work with states and regional organizations to map the entire US coast, and to analyze watershed and habitat changes every 1 to 5 years.

With the first stage of the protocol completed, C-CAP moves ahead to new challenges. Linking the mapped land-cover-change data with an improved understanding of how these habitats function is perhaps the most difficult, and the most crucial. In addition, COP has also funded studies to advance our understanding of how habitats, especially salt marshes and seagrasses, foster productive fisheries. These studies are essential for managing existing habitats and helping to recreate or restore damaged ecosystems. By supporting the development of models that explain the links between habitat functions and their spatial locations and extents, COP will provide fishery and other resource managers with the scientific tools needed to protect and rebuild the nation's coastal resources.

Nutrient Overenrichment Studies Began in the Gulf of Mexico

Excess nutrients--from sewage, agricultural and suburban runoff, and industrial waste--fertilize coastal waters, often with adverse effects. High nutrient loadings often cause algal blooms that decay in bottom waters, depleting them of oxygen (hypoxia) and harming benthic life. Overenrichment is an increasing problem in many coastal waters, yet the quantitative relationship between nutrient inputs, especially from nonpoint sources, and hypoxia is still poorly understood.

This problem is particularly important in the nation's largest watershed, the Mississippi River basin, which drains one-third of the continental US, including much of its agricultural lands. Nutrient-rich water flows into the Gulf of Mexico, resulting in algal blooms and hypoxic conditions that threaten the region's rich fishery resources. In 1989, COP's first field effort, the Nutrient Enhanced Coastal Ocean Productivity (NECOP) Program, was begun to study this problem. Sampling nutrient loadings at the Mississippi and Atchafalaya river outflows, NECOP researchers relate physical, chemical, biological, and geological observations to changes in primary productivity.

NECOP has demonstrated that extensive hypoxia along the Louisiana shelf is largely driven by nitrogen inputs from the Mississippi watershed. River nitrate concentrations have increased linearly with nitrogen fertilizer applications in recent decades, and models indicate that reducing nitrogen inputs will significantly reduce overenrichment in the Gulf of Mexico.

Measuring pollutant loadings from rivers and streams is relatively straightforward; from the atmosphere, it is more complicated. Yet a surprising portion of the nitrogen entering coastal waters stems from air pollution, primarily from auto emissions and power plants. In 1990, Congress amended the Clean Air Act to require NOAA and the Environmental Protection Agency (EPA) to determine the importance of the atmospheric pathway for hazardous air pollutants entering Chesapeake Bay and other water bodies. While previous studies had estimated that one-third of the nitrogen entering the bay came from the atmosphere, little was known about that assessment's accuracy, or the relative contributions of wet and dry deposition. COP's Atmospheric Nutrient Inputs to Coastal Areas (ANICA) project combines monitoring and modeling to quantify the contributions of both wet and dry nitrogen deposition, integrating deposition rates into atmospheric transport models. In addition to helping managers plan appropriate pollution-control strategies for Chesapeake Bay, ANICA is developing methods for assessing the importance of atmospheric input for other estuaries.

Coastal Ecosystems Research: Helping a Diminished Industry

US fisheries are under siege. Overfished, losing valuable habitat, and subject to contamination from nutrient and toxic pollutants, the nation's fish and shellfish resources are increasingly threatened. Meanwhile, responding to the advice of health advocates, the individual American's consumption of fish has grown by 45 percent in the past 30 years. While other parts of COP's research program concentrate on the environmental quality and habitat needed to maintain healthy fisheries, the Coastal Fisheries Ecosystem (CFE) portion focuses directly on the ecological processes that affect commercial populations.

CFE grows out of a new direction in fisheries science, an integrated approach to understanding fisheries within the context of their ecosystems. The need for such an approach is clear. In the Bering Sea pollock fishery, for example, the largest single-species fishery in the world, the Russian and US 200-mile exclusive economic zones (EEZs) enclose a high-seas "doughnut hole" open to foreign fleets. Since the mid 1980s, this "hole," the central basin of the Bering Sea, has been heavily fished. The Northwest Fisheries Management Council needs to know how this fishery affects stock sizes in the US EEZ. Recruitment, the number of adult fish added to the population each year, varies dramatically in pollock populations, creating enormous uncertainty in stock assessments. To improve these predictions, COP-funded scientists conduct genetic analyses of pollock stocks, to see how much stocks from foreign and US waters mix, and they mount field studies to determine what physical oceanographic and ecological factors affect pollock survival in the critical egg and larval periods. Once these factors have been identified, monitoring programs can be established to improve the scientific basis for pollock management.

In the South Atlantic, COP-funded researchers are looking at a different recruitment problem: What determines the survival and growth of estuarine-dependent fish? Nationwide, about 75 percent of commercial fish species spend part of their lives in estuaries. In Atlantic menhaden, juveniles move into estuaries, presumably assisted by ocean currents, weeks after being spawned in the open ocean. After maturing in the estuaries for several months, the juveniles move offshore to mature and later spawn. Completing its first year, the South Atlantic Bight Recruitment Experiment (SABRE), based at Beaufort, North Carolina, is integrating information on offshore currents, salinity, temperature, and nutrients with seven years of data on migrating menhaden larvae to identify factors associated with recruitment peaks. By analyzing fish otoliths, tiny components of the inner ear that accumulate growth rings, investigators can determine the ages of sampled fish, and correlate strong year classes with particular environmental conditions identified by physical monitoring and satellite data.

Population models are also being used to determine how an individual fish's growth rate affects its chances of being eaten by predators. By modeling the factors that contribute to an individual's survival, SABRE scientists will identify key life stages that seem to control population size.

In 1993, COP will begin work on Georges Bank, which has sustained New England fishermen for generations. Today, the cod and flounder have been fished out, replaced by low-value dogfish and skates. These low-value species, which accounted for only a quarter of the catch (by weight) as recently as 1963, now make up 75 percent of the catch. COP's newest fishery project will focus on whether or not the species composition of this heavily stressed ecosystem can be restored. The Georges Bank effort will consider the effects of fishing and predation pressures on cod and flounder, and develop strategies to shift fishing pressure from the overexploited fisheries to the underutilized species.

In the meantime, fisheries managers must set annual catch limits and allocations based on the best information available. COP's ecosystem approach, while long term, will enable fisheries managers to understand many of the multiple influences on fish stocks. This should bring economic benefits that will help to close the nation's $3 billion trade deficit in fishery products.

Future Directions

As COP enters its fifth year, program participants are evaluating and disseminating completed research, and looking forward to strengthening NOAA/academic partnerships for work on persistent and emerging environmental issues. New areas of research, to meet new environmental challenges, are also underway. They include several approaches.

Developing a Coastal Forecast System. The National Weather Service's prediction of Hurricane Andrew saved lives, illustrating the importance of accurate storm and weather forecasts. Now, NOAA is developing a similar capability for the coastal marine environment. Among COP's new efforts is development of a Coastal Forecast System (CFS) for physical and biological conditions in the coastal ocean, including storms, circulation, and water quality. Made up of linked observation systems, research on coastal ocean processes, and models to integrate this information, the CFS will be a working prototype, updated as understanding of the systems advances and new technologies are developed. The CFS will integrate our knowledge of atmospheric, biological, and physical processes, and upgrade our ability to observe and predict them.

Protecting Environmental Quality. While the US has made great strides in controlling municipal and industrial pollution, the greatest remaining sources are now the most difficult to control. These "nonpoint" sources--agricultural and urban runoff, contaminants entering groundwater, and atmospheric deposition--include nutrients, toxic chemicals, and sediments. Building on experience in the Gulf of Mexico and Chesapeake Bay, COP coordinates a national research effort to predict the impacts of nutrient overenrichment on estuaries and coastal waters.

Another new area of COP-funded research is developing methods to assess the cumulative effects of development. Over the past 20 years, nearly half of new residential development has occurred in coastal counties. Yet managers have only recently recognized the importance of incremental changes that may lead to irreversible degradation. COP's groundbreaking effort will help managers protect water quality and sensitive habitats from this gradual encroachment.

Coordinating Federal Science Efforts. As federal and state budgets are squeezed, the need for cooperative scientific efforts is increasingly urgent. COP actively promotes such approaches, working through the Subcommittee on US Coastal Ocean Science (SUSCOS) created by the Federal Coordinating Council on Science, Engineering, and Technology under the president's science advisor. SUSCOS inventories federal spending on coastal ocean science and evaluates current programs against documented research needs. These findings--coordinated by COP, and completed in early 1993--will serve as the basis for a coordinated federal coastal ocean science strategy.

Coastal problems continue, often driven directly or indirectly by growing coastal zone populations. If the ecologic and economic costs of these problems are to be controlled, a stronger scientific understanding of coastal processes is essential. COP's scientific contribution--enhancing our understanding and predictions of the coastal environment--is a key ingredient for the sustainable development critical to our future use and enjoyment of the coast.

Lauren Wenzel served as a Sea Grant Fellow with the Coastal Ocean Program during 1992. She studied political science at Oberlin College and received an MS in Natural Resources Policy from the University of Michigan's School of Natural Resources and Environment. She is now intent upon building a career around frequent trips to the beach.

Donald Scavia is the Director of NOAA's Coastal Ocean Program. Prior to "dying and going administration," he spent 15 years researching and modeling Great Lakes nutrient cycles and plankton in Ann Arbor at the Great Lakes Environmental Research Laboratory as one of NOAA's freshwater oceanographers. He holds BS and MS degrees in Environmental Engineering from Rensselaer Polytechnic Institute and a Ph.D. in Water Resources Engineering from the University of Michigan. He spends most of his spare time carpooling his two daughters to early-morning swim practices.

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