SOCIETAL RESPONSES

MONITORING THE COASTAL ENVIRONMENT

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Monitoring provides information about the condition of our estuarine and coastal areas and the consequences of human activities for our environmental resources. During the 1990s, hundreds of millions of dollars have been spent to monitor changes to aquatic organisms, wetlands and submerged habitats, pollutants, and other environmental properties. As pressures on our coastal areas intensify, new approaches to environmental monitoring will be required if managers are to balance economic development with conservation for future generations.

The following reference format is suggested:

National Oceanic and Atmospheric Administration (NOAA). 1998 (on-line). "Monitoring the Coastal Environment" by Andrew Robertson, Paul Orlando, and Donna Turgeon. NOAA's State of the Coast Report. Silver Spring, MD: NOAA.

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INTRODUCTION

The coastal and estuarine areas of the United States and their associated resources have become increasingly important to the Nation's economy and to the health and well-being of its citizens. The expansion of population centers in coastal regions reflects our growing dependence on the economic, aesthetic and recreational benefits that these regions provide. As a result of this expansion, however, many coastal areas have suffered declines in aquatic species, losses of critical habitat, contamination of sediments, outbreaks of fish diseases and risks to human health.

Photo 1. Satellite image of the United States at night. Lights from urban areas illustrate their concentration in coastal areas.

Given the importance of these coastal areas and their resources, there is a strong national interest in ensuring their ecological health for the benefit of future generations. In other words, we need to manage our coastal areas and resources for sustainable use. To do this, managers need reliable information on the condition of coastal resources; they need to provide answers to questions such as:

- Are environmental conditions improving or deteriorating? If so, where and during what time of year?
- Are the changes related to human activities? Do some activities (e.g., agriculture, industry, sewage treatment) have a greater impact than others?
- What actions can best correct existing problems or prevent future problems?

Providing answers to such questions requires scientific programs to monitor specific coastal properties that can indicate the health of our coastal ecosystems and document the causes of ecosystem change.

Photo 2. Fish with skin lesions can be a sign of environmental pollution

Photo 3. Because oysters are filter feeders, they accumulate contaminants in their tissues. Chemical analysis of these tissues provides an indication of ecological conditions.

Over the past few decades, a range of monitoring strategies and techniques have been used to address many of the Nation's coastal and estuarine environmental issues. Traditionally, monitoring has involved efforts to inventory the characteristics of coastal and estuarine areas, their resources and the human pressures that threaten them. This type of monitoring quantifies the existing acres of seagrasses and agricultural fields, for example. More recently, the role of monitoring has been expanded to include an examination of the complex cause-and-effect relationships that have developed through human-induced pressures on coastal areas, such as the effects of metals, pesticides and nutrients on fish abundance, reproductive success and ability to feed.

Although monitoring provides critical information about the state of the environment, financial and personnel resources are and will continue to be constrained. New monitoring approaches will be necessary to ensure a return of highly valuable information for this investment.

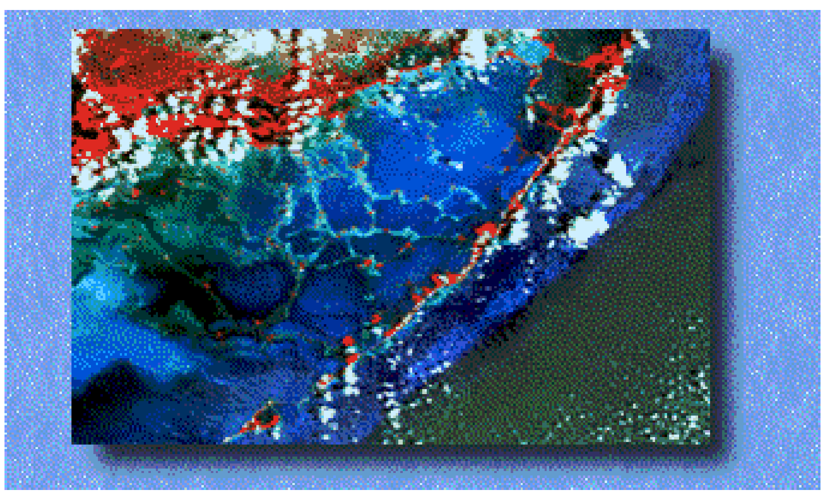

Photo 4. In this false-color satellite image of Florida Bay and the Florida Keys, wetland and mangrove vegetation is red.

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NATIONAL PICTURE

Each day, scientists collect physical, chemical and biological measurements in coastal areas at a variety of spatial and temporal scales (Figure 1). Some environmental issues warrant continuous data collection at multiple sites, while other issues necessitate only measurements at a single site over multiple years. Logistic and technical constraints, as well as fiscal limits on monitoring activities, force trade-offs among the number and types of variables that can be measured, the frequency of measurements and the extent of the measurement locations.

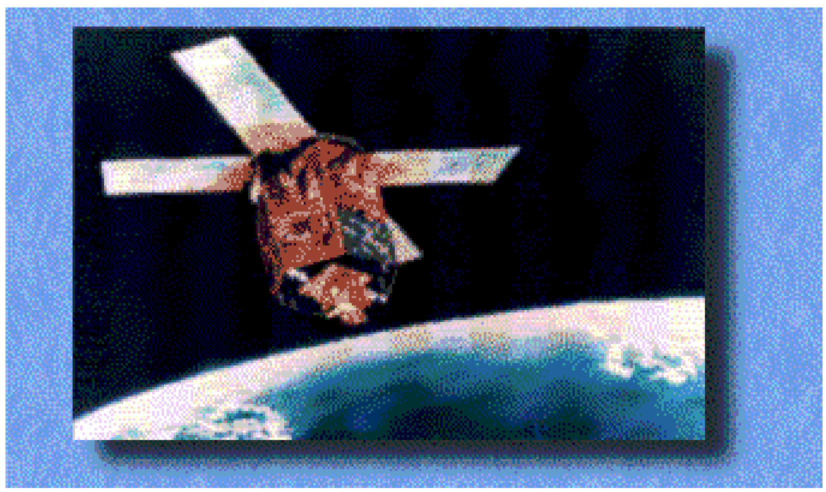
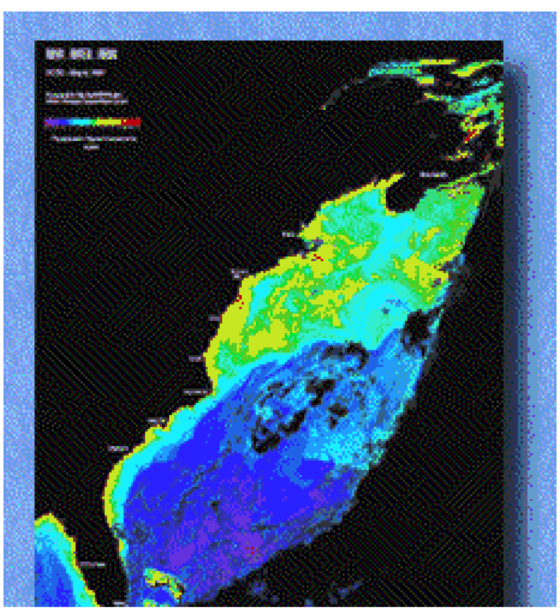


Photo 5. The OrbView-2 remote-imaging satellite provides color images of land and ocean on a global scale in near-real time.



Because of these trade-offs, coastal monitoring programs generally fall into one of three classes that are distinguished primarily by their geographic scale. Those in the first class, inventory programs, measure environmental features simultaneously and synoptically across large areas. Almost always with the use of sensors or instruments (e.g., infrared light) that are carried on airplanes or satellites, these programs monitor environmental features such as shoreline change, sea surface temperature, water color, land-use types and cloud cover. As satellites continuously orbit the earth, their sensors can potentially update measurement readings at frequent (i.e., days to months) intervals. For example, satellites deployed by the National Oceanic and Atmospheric Administration (NOAA) are equipped with infrared sensors that provide frequent charts of sea-surface temperature across wide areas of the U.S. coasts.

Monitoring programs in the second class characterize, with greater spatial and temporal detail, the distribution of specific properties in a region by making repeated measurements at selected sites throughout that region. The purpose of such a program is commonly to collect information regarding specific resources or specific human stresses. It involves periodically visiting the designated sites, obtaining samples of the environment (e.g., soil, water, specific organisms, contaminant concentrations), and analyzing

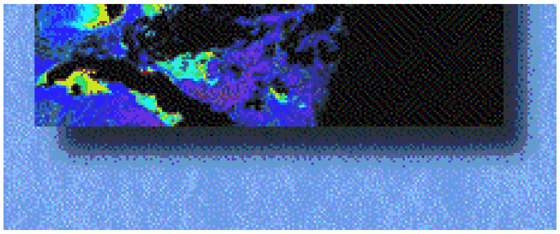


Photo 6. Satellite imagery of phytoplankton pigments from the Arctic to the Caribbean.

them either at the site or in the laboratory. An example is NOAA's Mussel Watch Project, which since 1984 has biennially measured the levels of contaminant concentrations in the tissues of mussels and oysters from over 270 sites along the U.S. coasts and, thus, allowed NOAA to assess trends in contaminant levels.

In the third class are intensive monitoring programs that typically involve very frequent (i.e., hours-days) measurements of numerous environmental conditions at only a few sampling locations. These programs make it possible to identify, measure and potentially link environmental changes detected by the other two types of monitoring with the causes of these changes. For example, an intensive monitoring program may evaluate the effects of increased levels of nutrients that are entering an estuary on the productivity of seagrasses. This class of monitoring is illustrated by the Long-Term Ecological Research (LTER) Program of the National Science Foundation, which supports intensive long-term data collection and related research at sites such as the Virginia Coast Reserve near Oyster, Virginia.

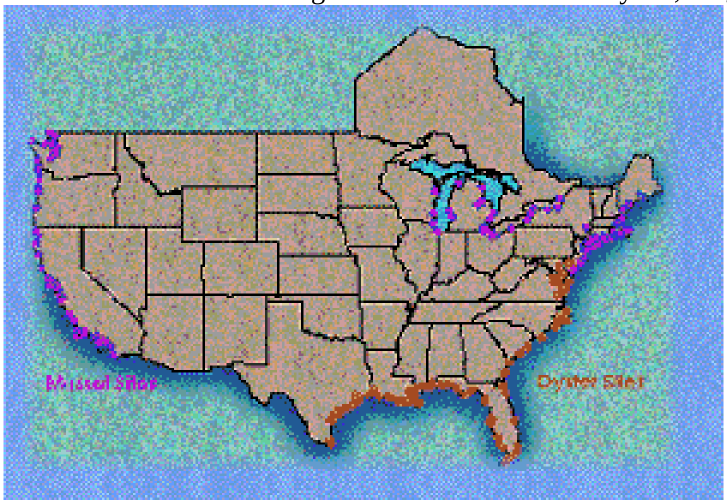


Photo 7. NOAA's National Status and Trends Program monitors sediment contamination at more than 350 sites in U.S. waters. This intermediate scale of monitoring captures properties and processes that cannot be detected by remote-sensing instruments.

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Federal Coastal Science Programs and Objectives

Federal environmental agencies require the type of information derived from all three classes of monitoring to support national policy and management decision-making. During the 1970s and 1980s, Federal agencies initiated several major monitoring programs to provide a national perspective on environmental quality, habitat conservation, living resources and human health protection. These Federal coastal environmental monitoring programs are conducted primarily by four agencies: the U.S. department of the Interior (predominantly through the U.S. Geological Survey (USGS) and the U.S. Fish and Wildlife Service), the National Oceanic and Atmospheric Administration, the National Science Foundation, and the U.S. Environmental Protection Agency (EPA) (CENR, 1995). Efforts of the U.S. Department of Energy, the National Aeronautics and Space Administration (NASA), the U.S. Army Corps of Engineers and the U.S. Department of Agriculture are more limited.

Photo 8. Environmental monitoring programs are conducted by four primary agencies (clockwise from left): the National Science Foundation, the U.S. Geological Survey (Department of the Interior), the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration.

State and local agencies, academic institutions and nonprofit organizations conduct additional, broader coastal monitoring (usually at finer spatial and temporal scales). These efforts typically support locally important programs associated with environmental regulation, public health protection and refined environmental health assessments.
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Direct Federal Spending for Coastal Environmental Monitoring and Research

During fiscal years 1991 to 1993 (CENR, 1995), direct Federal spending for coastal environmental monitoring and related science programs averaged $225 million annually. During fiscal year 1992, the Department of the Interior spent more than $90 million; the U.S. Department of Commerce (NOAA), nearly $70 million; the National Science Foundation, almost $30 million; and EPA, about $25 million. Other Federal agencies spent approximately $10 million in total.

Approximately 45% of funding was directed at environmental quality (e.g., toxins, nutrients, catastrophic spills), 26% at living resources (e.g., fisheries management, marine mammal protection, endangered species recovery), 13% at nonliving resources (e.g., coastal development, energy exploration), 10% at habitat conservation (e.g., loss, conservation, mitigation), and 6% at protection of life and property (e.g., beach erosion, coastal hazards, navigation). Geographically, 47% of these funds were directed at the ocean margins, 33% at estuaries, 15% at the Great Lakes and 5% along the shorelines.

Recently, the major Federal environmental agencies recommended and initiated actions to develop a coordinated national monitoring framework (CENR, 1996). For coastal and estuarine monitoring, NOAA and EPA are integrating their programs with those of the coastal states (Hyland et al., 1996). In addition, they are cooperating with NASA to develop a pilot program for intensive monitoring sites at specific coastal and estuarine sites.
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Major Federal Monitoring Programs

The five programs discussed in the following illustrate the range of environmental monitoring objectives, sampling parameters, and time and space scales provided by Federal agencies.

National Status and Trends (NS&T) Program. In 1984, NOAA initiated its NS&T Program to determine the status of, and to detect changes in, the environmental quality of our Nation's estuarine and coastal waters. It conducts regular, periodic monitoring for more than 70 toxic chemicals in sediments and bivalve mollusks (mussels and oysters) at over 270 sites around the U.S. coasts, including the Great Lakes. The NS&T Program also conducts detailed assessments of the ecological effects of toxic contaminants in areas where relatively high levels of contaminants related to human activities have been detected.

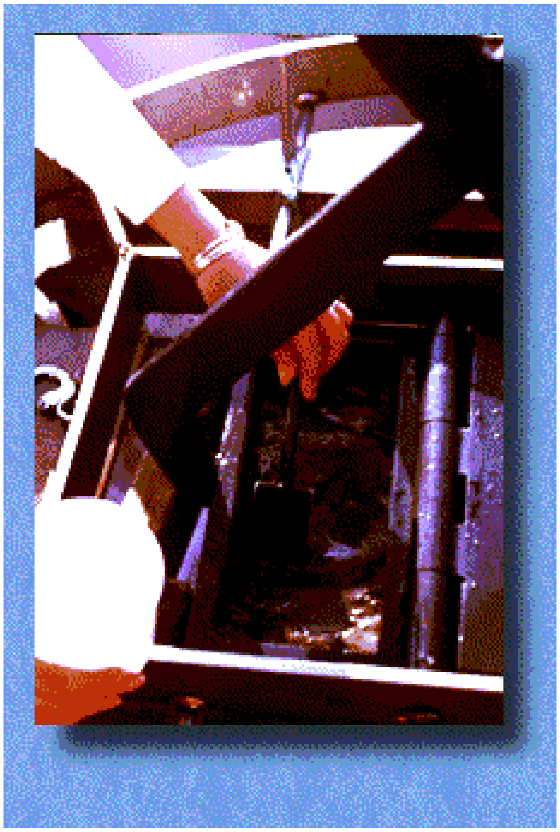

Photo 9. Sediments collected by a "grab" are carefully removed for subsequent toxicity studies in a laboratory.

Environmental Monitoring and Assessment Program (EMAP). The Environmental Protection Agency began EMAP in 1988 to coordinate Federal monitoring efforts to estimate the status and trends in the condition of ecological resources on a regional basis and to seek associations between the condition of these resources and and human-induced stresses. A number of demonstration projects, including several in estuarine and near-coastal waters, took place during the early 1990s. The program has now redefined its goal to focus more strongly on the development of scientific understanding for translating monitoring results into assessments of ecological condition.

National Stream Quality Accounting Network (NASQAN) and National Water Quality Assessment (NAWQA). Since 1973, USGS's NASQAN has provided long-term measurements of surface water quantity and quality. At its peak in 1978, NASQAN included 520 fixed sampling sites on moderate- and large-sized rivers, and it provided monthly estimates of the levels of freshwater flow, suspended sediment, nutrients, trace metals, indicator bacteria and phytoplankton. About 140 of these sites were located where the data obtained can be helpful in estimating the input of water and materials to estuaries. Recently, the NASQAN program has been greatly curtailed. In 1991, however, USGS initiated NAWQA to evaluate the effects of watershed land use on surface water and groundwater conditions at a subset of historical NASQAN locations. The NAWQA network includes 60 small- to medium-sized watersheds that are studied on a rotational monitoring schedule.

National Water Quality Inventory. Section 305(b) of the Clean Water Act requires each state to monitor water quality to determine the overall health of lakes, streams, estuaries and the coastal ocean with respect to several designated uses. Although EPA does not monitor these bodies of water directly, the agency has the responsibility of ensuring consistent application and comparability of 305(b) monitoring activities across all states. Since 1975, EPA has inventoried these monitoring reports every two years to provide a national summary of the extent to which these waters can support aquatic life, drinking water supplies, fish consumption, shellfish harvest, contact recreation and agriculture. The report for 1994

(EPA, 1995) described the condition of more than 615,000 river miles (about 17% of the national total), 17 million acres of lakes (42%), and 27,000 sq mi of estuaries (78%).

CoastWatch-Change Analysis Program (C-CAP). NOAA's C-CAP is developing a nationally standardized data base of land cover and habitat change for coastal areas of the United States. Using remote sensing techniques (satellite imagery and aerial photography), C-CAP classifies types of land cover, submerged aquatic habitats, wetlands and uplands. For some coastal areas, remotely sensed images are available for the past few decades, allowing time-series analysis.

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REGIONAL CONTRASTS

The type and extent of environmental monitoring are not necessarily consistent across all coastal regions of the United States. Historically, the Mid-Atlantic, south/central California and the Great Lakes regions have been monitored more intensely than coastal areas in the South Atlantic, Gulf of Mexico and Alaska. The physical landscape, climate and prevailing ocean currents not only dictate the type of estuaries found in each region, but also determine land use and the extent of urbanization. Thus, estuaries and coastal areas in each region may be morphologically different, support distinct biological communities or exhibit a different response (or susceptibility) to contaminant inputs. In view of these regional variations, three major Federal monitoring programs, administered through NOAA, EPA and the U.S. Fish and Wildlife Service, have adopted a regional (Photo 11) partitioning of U.S. coastal waters based on "biogeographic provinces" (Bailey, 1983; Terrell, 1979). The characteristics of the Virginian and Carolinian provinces illustrate the effect on monitoring strategies.

LINK TO IMAGE

Photo 10. Satellite image of sea-surface temperature along the Atlantic and Pacific coasts. Warmer waters are red, colder are blue.

The Virginian Province includes the coastal region of the northeast United States from Cape Cod, Massachusetts to Cape Henry, Virginia at the mouth of the Chesapeake Bay. This province contains more than 7,000 sq mi of estuarine surface area (NOAA, 1990). It is dominated by three large estuarine systems –Chesapeake Bay, Delaware Bay and Long Island Sound–but it also has a substantial number of small estuaries and tidal rivers. Both the Labrador Current from the north and the Gulf Stream from the south affect this province. It tends to have strongly alternating seasons with a substantial period of greatly reduced biological productivity during the winter months. A number of large urban and industrial centers (e.g., New York City, Philadelphia, Baltimore) are close to the coast. In the Virginian Province, the coastal areas are densely populated, with the coastal population density ranging from over 300 persons/sq mi in Delaware to greater than 1,500 persons/sq mi in New York and Pennsylvania (Culliton et al., 1990). The Virginian coastline areas are extensively used for industrial developments, port facilities, residential and commercial establishments, and recreational activities.

LINK TO IMAGE

Photo 11. U.S. biogeographic provinces reflect regional differences in climate and ocean processes that affect estuarine habitat and environmental conditions.

Photo 12. Sediment toxicity is largely restricted to highly industrialized and urbanized areas, such as this densely populated urban area in the Virginian Province.

The Carolinian Province extends from Cape Henry, Virginia south to the southern end of the Indian River Lagoon on the east coast of Florida. Estuaries occupy more than 4,000 sq mi (NOAA, 1990) with about one-half being in wide, shallow estuarine systems in northern North Carolina (i.e. Currituck, Albemarle and Pamlico Sounds). South of these sounds, there are extensive barrier island systems, interconnecting lagoonal complexes, and broad areas of tidal creeks and coastal marshes. The Gulf Stream dominates the region, giving it a subtropical climate with seasonal changes, but with appreciable biological productivity occurring throughout much of the year. There are relatively few major urban centers near the coast in the Carolinian Province, and major portions of its coastline are devoted to recreational developments. Substantial stretches of the Carolinian coast remain largely undeveloped. The population density for the coastal areas of the Carolinian states ranges from just over 100 persons/sq mi in Georgia and South Carolina to to less than 250 persons/sq mi along the east coast of Florida (Culliton et al., 1990).

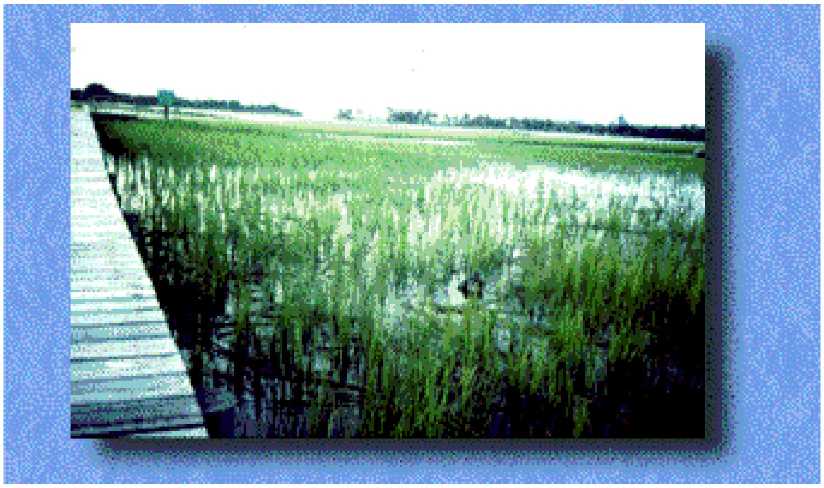

Photo 13. The Carolinian Province has many relatively undeveloped salt marshes such as this one in South Carolina.

In 1984, the latest year for which statistics are available, less than half as much money was spent for coastal and estuarine monitoring in the Carolinina province than in the Virginian province (Caton et al., 1984; NOAA, 1984). Pollutants from agricultural areas threaten both regions, but additional environmental concerns arise in the Virginian Province because of its extensive metropolitan areas. The environmental problems in the Virginian Province (e.g., fisheries declines, wetland losses, algal blooms,

toxic sediments) have long been focus areas for monitoring activities. For example, NOAA's NS&T Program, which monitors contaminant levels around the U.S. coasts, positions a greater number of its sites near large cities like those in the Virginian Province than along the more sparsely populated shores of the Carolinian Province (O'Connor, 1994).
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CASE STUDIES

During the 1990s, a new paradigm for coastal environmental monitoring has emerged. Earlier monitoring programs had generally been tailored specifically to achieve the objectives of a single agency. As environmental problems become more complex and funding for monitoring continues to decrease, a number of agency partnerships have begun to address common environmental concerns. This approach makes it possible to measure more parameters more often over larger geographic areas.

The three case studies discussed in the following demonstrate a range of successful partnership activities that have improved the effectiveness and efficiency of environmental monitoring. The first example focuses on the dozens of organizations that have come together to restore the unique habitat of the Florida Everglades and the adjacent coral reef system, which have been damaged or lost through complex urban and agricultural activities. The second example illustrates the use of standardized sampling methods and a single quality assurance program to ensure that data collected by Federal partners along the Atlantic Coast is both reliable and comparable. The third case, an arrangement between Federal and state partners in the Puget Sound region, reflects a common approach to conduct environmental monitoring that would otherwise be cost-prohibitive.

South Florida Ecosystem Monitoring Integration Project: Gaining Consensus on Critical Regional Issues and Developing an Integrated Monitoring Plan

The South Florida ecosystem has been under severe environmental stress for several decades. Wetland losses, seagrass die-offs, declines in the numbers of wading birds, pervasive algal blooms and damaged corals are symptoms of expanding human populations and economic growth throughout South Florida. The type of information obtained through monitoring programs is essential to developing and evaluating strategies for water and land management that reestablish the natural ecosystems while addressing economic growth and societal needs in this region. Since the early 1990s, an organizational infrastructure (i.e., the South Florida Ecosystem Restoration Task Force and the Governor's Commission for a Sustainable South Florida) has been in place to ensure appropriate oversight of scientific research, modeling, monitoring and Everglades restoration. Within this structure, a Core Group of 12 representatives from Federal, state, and local agencies is carrying out the South Florida Ecosystem Monitoring Integration Project, a partnership among NOAA, the Florida Marine Research Institute and the Florida Bay Program Management Committee.

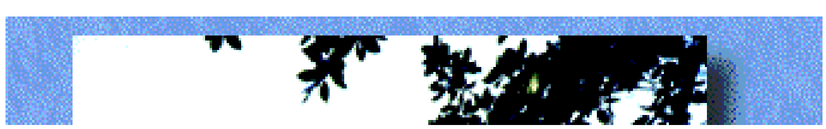

Photo 14. Mangroves benefit the environment by preserving water quality and reducing pollution.

The three goals of the South Florida Ecosystem Monitoring Integration Project are (1) to identify information needed by managers to make decisions on the South Florida ecosystem (e.g., the Everglades Restoration), (2) to gain consensus among managers and scientists on ecosystem-level issues and critical concerns, and (3) to develop an integrated monitoring plan for the South Florida marine ecosystem. Through a structured process involving workshops, focus groups and peer reviews, a strategic plan is being developed that will integrate ongoing efforts to monitor the coastal ecosystem in a more efficient and effective way and provide this important information to South Florida managers. At a January 1997 workshop, 64 regional managers characterized South Florida coastal ecosystem issues, identified information needs, prioritized critical resource concerns and made recommendations for more effective (targeted) monitoring. Information on ongoing regional monitoring projects was organized in a data base and geographic information system (GIS) (Figure 2). At a second workshop in May 1997, more than 70 managers and scientists used the GIS to identify gaps and overlaps in current monitoring and then developed strategies for integrating regional activities and sharing information. Through the work of six focus groups, the strategies are being refined, and a monitoring plan will be written. This fiscal year, NOAA funded several of the activities given the highest priority in the manager/scientist workshops.

Photo 15. Managers and scientists are developing an integrated monitoring plan for the South Florida marine ecosystem.

(top)

Photo 16. Box core sampling is helpful in determining historical trends in chemical contaminants

Environmental Quality of Estuaries of the Carolinian Province: Monitoring Ecological Conditions through Federal Cooperatives

Since 1994, managers and scientists from NOAA's NS&T Program and EPA's EMAP have jointly planned and sponsored activities to monitor environmental quality in the estuaries of the Carolinian Province (i.e., from Cape Henry, Virginia through St. Lucie Inlet, Florida) (NOAA, 1984; EPA, 1992). This cooperative monitoring effort in the Carolinian Province is a comprehensive, interdisciplinary and regionally extensive program that has required the input of literally hundreds of individuals working together. Scientific support for this program comes from partnerships with a combination of state agencies (e.g., South Carolina Department of Natural Resources/Marine Resources Research Institute and Florida Department of Environmental Protection/Florida Marine Research Institute), universities (e.g., University of North Carolina-Wilmington, the Citadel, Clemson University, the University of Charleston South Carolina/Grice Marine Biology Laboratory), and private institutions (e.g., Science Applications International Corporation, Technology Planning and Management Corporation, the Geochemical and Environmental Research Group of Texas A&M University).

A major component of this study examined environmental conditions in benthic areas of estuaries and coastal ocean areas. During 1994-1995, sediments were tested for contaminants, levels of toxicity, and exposure effects on benthic infauna. Pesticides and polychlorinated biphenyls (PCBs) were the most common contaminants in the sediments, although their effects on benthic organisms were detectable at only a small percentage of the sampling sites.

This program uses a probability-based sampling design and, thus, provides unbiased estimates of ecological conditions with known levels of confidence. Standard sampling protocols and the jointly sponsored NS&T Quality Assurance Program (conducted in partnership with the National Institute of Standards and Technology and the Canadian National Research Council), ensure that water and sediment chemistry results are valid, accurate and comparable across sites.
(top)

Photo 17. Researchers sieve sediments for benthic infauna. Tissue samples will be analyzed to determine the effects of sediment contamination.

Spatial Extent and Bioeffects of Contaminants in Puget Sound: Monitoring that Builds on Regional

State/Federal Efforts

The goal of a combined state and Federal monitoring and academic research program in Puget Sound was to measure the accumulation of contaminants in sediments, demersal fishes, marine birds, marine mammals and mussels to help evaluate the effectiveness of pollution control strategies established during the past 20 years. The results indicated that although contaminant levels in some areas have decreased, contaminant concentrations in the deep central Puget Sound basin are still significantly higher than estimated pre-industrial levels. In particular, present levels of contamination near urban areas may be up to 100 times higher than the levels in the cleanest rural Puget Sound bays. No sampling design has yet allowed estimation of the areal extent of contamination and contaminant-caused effects within all areas of the bay.

Photo 18. Contaminant concentrations in sediments in deep central Puget Sound are still higher than estimated pre-industrial levels.

In 1997, NOAA's NS&T Program and the Washington State Department of Ecology began a three-year effort to evaluate more comprehensively the spatial extent of degraded sediment. Analyses of sediment contamination, sediment toxicity and benthic community structure will be performed at a suite of randomly selected locations throughout Puget Sound. In addition, fish tissue analyses will accompany the sediment measurements at some locations, thus allowing the calculation of long-term trends in contaminant concentrations in selected demersal fishes.

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EXPERT INTERPRETATION

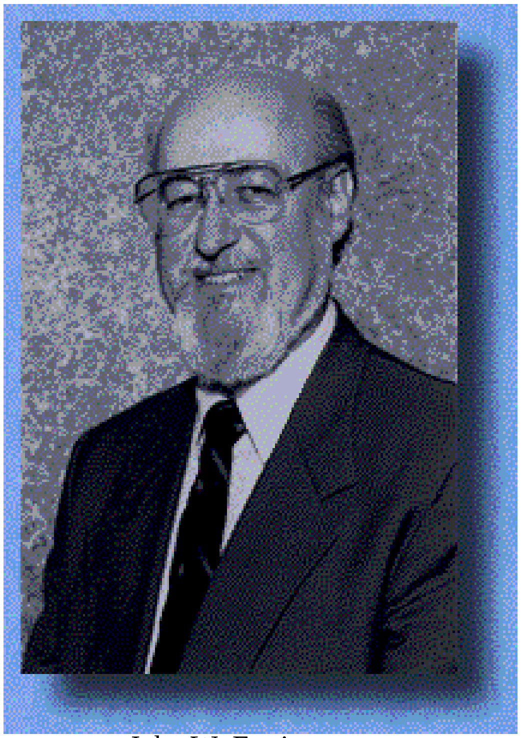
The three individuals below are experts in the topic of Monitoring the Coastal Environment. Here they voice their opinions on two questions relevant to that topic.

Question 1 – Are the existing monitoring programs providing the information required to evaluate and protect the Nation's coastal and estuarine resources?

Question 2 – What are the key components of an integrated monitoring and assessment framework? What are some of the difficulties in implementing an integrated monitoring and assessment framework?

Experts

		
John Farrington	**Suzanne Schwartz**	**Steven Weisberg**



John W. Farrington

Associate Director for Education, Dean of Graduate Studies and Senior Scientist, Woods Hole Oceanographic Institution (WHOI)

Dr. Farrington was appointed Associate Director for Education, Dean of Graduate Studies, Senior Scientist at WHOI in 1990. Since joining WHOI in 1971 he held successive positions in the Chemistry Department for 17 years. He has served on numerous national and international scientific bodies. Dr. Farrington lists more than 100 scientific publications and 15 mainstream publications on research interests that include marine organic chemistry, biochemistry of marine organisms and environmental quality issues.

Response to Question 1

Response to Question 2

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Question 1. Are the existing monitoring programs providing the information required to evaluate and protect the Nation's coastal and estuarine resources?

Click here for audio response

(audio requires RealPlayer, see Using this Site)

My answer addresses monitoring for chemicals of environmental concern; for example, selected trace metals, chlorinated pesticides, industrial chemicals, and selected fossil fuel hydrocarbons. Significant progress in analytical chemistry enables measurement of miniscule amounts of chemicals. This provides great sensitivity and allows for early warning of increasing concentrations of chemicals of concern. It is also disconcerting to an uninformed public who might think that exceedingly low concentrations are always a significant danger. Furthermore, not all chemicals entering the environment from modern society are of concern. We must temper "chemophobia" with factual information; but not go overboard and ignore real and potential dangers from low concentrations of chemicals.

The quality of monitoring programs varies. At state and local levels, funding is often inadequate to provide meaningful data. National assessments, for example, the National Status and Trends Program, provide a reasonable assessment of the geographic extent and severity of contamination by several chemicals of environmental concern when assessing statewide and multi-state regions of the coast. Despite recent progress, translating these concentrations into quantitative risk assessments, especially for the complex mixture of chemicals of environmental concern in coastal and estuarine ecosystems, remains a daunting task for combined research and monitoring efforts.
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Question 2. What are the key components of an integrated monitoring and assessment framework? What are some of the difficulties in implementing an integrated monitoring and assessment framework?

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The key components of an integrated monitoring and assessment program are, first, clearly stated objectives arrived at by taking into account the concerns of individuals or groups–"stakeholders"–with an interest in the geographic area and activity being assessed. Second, matching the objectives with the realism of what can be monitored and assessed within available scientific state-of-knowledge and available funding. Third, providing timely data interpretations that are understandable by the stakeholders. Fourth, flexibility to adapt to new knowledge. This requires close interactions between research and the monitoring and assessment framework.

Implementation difficulties most often evolve from unrealistic expectations given the realities of existing scientific capabilities and available funding. Too frequently, carefully crafted original plans are determined to be too expensive

and compromises ensue without changing the objectives of the program. It is probable that the outcome will be failure to attain the objectives, thereby undermining confidence in the entire process of monitoring and assessment. Meaningful monitoring and assessments are often undervalued by the very society that seeks answers that can only be provided by these types of programs. Education of the public and of elected and appointed officials is the key to resolving this conundrum.
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Suzanne Schwartz

Director, Oceans and Coastal Protection Division, Office of Wetlands, Oceans and Watersheds, U.S. Environmental Protection Agency

Suzanne Schwartz has worked at EPA since 1980. She is reponsible for managing monitoring data as well as status trends data from the National Estuaries Program, managing the Marine Debris Monitoring Program, and implementing the Ocean Dumping and the Dredge Material Management Programs. She is chairwoman of EPA's initiative on air/water deposition, and serves as the contact in EPA for development of a Federal research plan for *Pfiesteria* , a dinoflagellate responsible for numerous fish kills in coastal areas.

Response to Question 1

Response to Question 2

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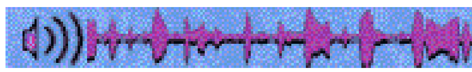
Question 1. Are the existing monitoring programs providing the information required to evaluate and protect the Nation's coastal and estuarine resources?

Click here for audio response

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We have made great strides in improving coastal and estuarine monitoring programs in the last 10 years to ensure that monitoring provides the information required to evaluate and protect the Nation's coastal and estuarine resources. However, we still often fall short of having monitoring programs that provide the integrated, systemwide and watershed perspective that are critically needed to adequately evaluate and protect these resources.

This is important because the health of our coastal and marine waters is important to everyone. Most people in the United States live, work or play at or near the coast, and those who do not still benefit from these valuable resources. Recognition of these problems has led to greater cooperation and sharing among Federal, state, tribal and local organizations. Partnering within the Federal agency community has led to more targeted and productive efforts to provide a coastal monitoring framework.

Integrated, systemwide monitoring plans have been developed by each of EPA's 28 National Estuary Programs as an integral part of their comprehensive conservation and management plans. Increased use of volunteer monitoring is providing a valuable monitoring resource for supplementing professional data in many of these efforts. We have also been working to improve the accuracy, comparability and precision of monitoring data that are essential for evaluation and management decisions. We look to the future in continuing our efforts to improve monitoring programs, increase partnering and improve the quality of data.
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Question 2. What are the key components of an integrated monitoring and assessment framework? What are some of the difficulties in implementing an integrated monitoring and assessment framework?

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There are several key components of an integrated monitoring and assessment framework. One is the development of monitoring objectives and performance criteria. Explicit objectives and performance criteria with which to measure monitoring program success are crucial. Another key component is establishing testable hypotheses and selecting statistical methods. This will ensure that the results of the monitoring program will be unambiguous and can be projected with confidence for the study area. Selecting analytical methods and alternative sampling designs is also an important component of an integrated monitoring and assessment framework. Detailed specifications for each variable of the monitoring program must be developed. These include field sampling methods, laboratory procedures, and quality assurance and quality control procedures.

There are several difficulties implementing such a framework. Applying our monitoring programs to separate components of the ecosystem such as surface water, groundwater, or sediments has often precluded an ecosystem approach to resource management. Also, the traditional monitoring program has often had a very narrow focus, and has been limited by political and economic boundaries unrelated to the ecosystem monitored. This fragmented approach to environmental management has led to duplication of effort; lack of uniform sampling and analytical methods; lack of a consensus on biological, physical and chemical indicators; and an inability to link information systems or to share and interpret data. This is why partnerships and coordination are so important, not only to monitoring, but to the very health of our precious coastal and estuarine ecosystems.
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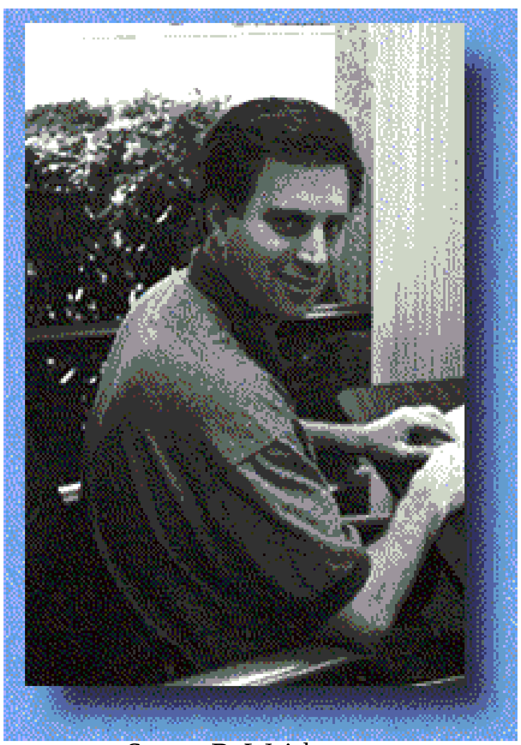

Steven B. Weisberg

Executive Director, Southern California Coastal Water Research Project Authority (SCCWRPA)

Dr. Weisberg has been with SCCWRPA for one year. Prior to his current position, he spent 15 years consulting on matters related to the Chesapeake Bay. He received his Ph.D. from the University of Delaware in 1981 where his work centered on the trophic dynamics of estuarine marshes. For the last 10 years, Dr. Weisberg's research has focused on developing regional monitoring programs.

Response to Question 1

Response to Question 2

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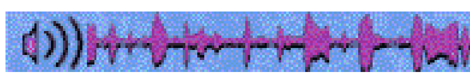
Question 1. Are the existing monitoring programs providing the information required to evaluate and protect the Nation's coastal and estuarine resources?

 Click here for audio response

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Assessing the effectiveness of present monitoring programs depends on the spatial scale of the assessment. Most management decisions are made on a site-specific basis, typically to address adequacy of discharge permit requirements; present monitoring programs effectively support these decisions. The more encompassing management decisions are made on watershed and national scales; existing monitoring programs provide less support for these decisions.

The biggest impediments to regional/national assessments are that the site-specific programs differ considerably in the type and quality of measurements made, and the regional/national programs do not have sufficient resources to achieve adequate spatial coverage on their own. Thus, national reports to Congress, such as EPA's 305(b) report, are based on attempts to piece together discordant data into a cohesive product. Scientists routinely dismiss these reports because of the flaws inherent in joining discordant data. Managers are left to make decisions based on perception rather than fact. The primary failing of the integrated reports is that the

site-specific programs are geared toward measuring conditions at the worst sites, not on assessing overall system condition; thus, they do not provide a balanced or comprehensive assessment of condition. Improving the monitoring and reporting systems will require better integration of the site-specific programs that encompass the majority of present monitoring efforts with regional/national programs that balance the spatial spread of sampling and provide a framework for achieving consistent methods.
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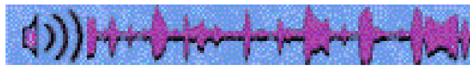
Question 2. What are the key components of an integrated monitoring and assessment framework? What are some of the difficulties in implementing an integrated monitoring and assessment framework?

Click here for audio response

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There are at least three important components to an integrated monitoring and assessment framework. The first is the set of indicators which are measured. An effective framework requires indicators that are easily understood and accepted by decision makers and the general public. For example, in Chesapeake Bay, the striped bass abundance index is less technically complex than many other measures that are sampled, but it is one of the few measures that is understood by legislators who are asked to allocate resources to address bay issues.

The second component is a quality assurance program to ensure that data from multiple sources, or collected over multiple years, are comparable. This is particularly important if the monitoring framework is based on integrating data from numerous sources. NOAA has demonstrated considerable leadership in developing national consistency in the measurement of sediment chemistry, but even this effort has its limitations; EPA's list of priority pollutants that are measured as part of most National Pollutant Discharge Elimination System permits differ from the list of contaminants measured by NOAA.

The third component is an integration and communication strategy to ensure that the information reaches the decision makers in a format that they can understand. Presenting too much data, even if it is of high quality, can be as ineffective as not presenting the data at all. An effective communication strategy must also involve thorough scientific review; managers are less likely to make use of data or reports about which they are receiving conflicting feedback from the scientific community.
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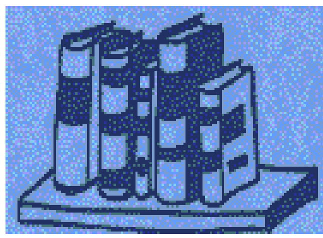

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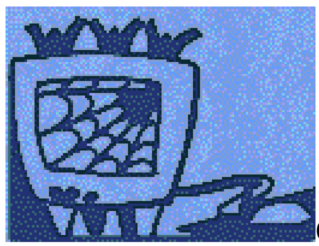

On-line References

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Federal Monitoring and Management Programs

U.S. Department of Commerce/NOAA/NOS. NOAA's National Status and Trends Home Page.

http://seaserver.nos.noaa.gov/projects/nsandt/nsandt.html

Information on the various components of NOAA's National Status and Trends Program, which measures the degree and effects of chemical contamination of the Nation's estuaries and their biota. Provides access, through a searchable data base, to fish, bivalve, mollusc and sediment monitoring data collected at more than 350 sites during the past 15 years.

U.S. Department of the Interior/U.S. Geological Survey. USGS National Water-Quality Assessment-NAWQA-Program.

http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html

Home page of NAWQA Program, a national monitoring effort designed to determine the status of the Nation's freshwater resources. Describes the program's activities (design, implementation, findings) and the areas under study. Provides a national synthesis of information on water resources and delivers this information as publications and maps. For monitoring information about coastal basins, follow the Study Units link to the NAWQA regional study units. A description of monitoring program design and implementation is provided for each basin under study. Monitoring data are provided for a few basins, such as the Apalachicola-Chattahoochee-Flint (ACF) River basin and

Albemarle-Pamlico Drainage, and Western Lake Michigan Drainages.

U.S. Environmental Protection Agency. Environmental Monitoring and Assessment Program (EMAP) Home Page.

http://www.epa.gov/emap

Information on the U.S. EPA's EMAP, a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. Provides explanations of the program's purpose; information on components such as information management, ecological indicator development and regional scales; access to data files such as Coastal Bays Data, California Coastal Water Research Project, EMAP Geographical Reference Database and other documents; project contacts; and a newsletter.

U.S. Environmental Protection Agency/Office of Water. State 305b Water Quality Summaries.

http://www.epa.gov/OW/resources/states.html

Graphic and text summaries of surface water and groundwater quality conditions for each state. Assigns "good," "fair" or "poor" water quality ratings for lakes, streams and estuaries. Information is based on reporting by states, required by Section 305(b) of the Clean Water Act.

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State, Local and Academic Monitoring

California Resources Agency. California's Ocean Resources: An Agenda for the Future, Chapter 5B: Water Quality.

http://ceres.ca.gov/CRA/ocean/html/chapt_5b.html

Reviews types of water pollution impacts, Federal and state standards, and the monitoring programs established by the State of California in its efforts at managing coastal water quality. Addresses point and nonpoint source pollution, beach contamination, ocean disposal of solid waste and other issues. Presents recommendations for state monitoring, assessment, and pollution management within the coastal environment.

Scripps Institute of Oceanography, University of California at San Diego. Coastal Monitoring.

http://www-sio.ucsd.edu/sp_progs/cetc/whc/c_monitoring/

Presents information on coastal monitoring technologies, regulations and policies, and issues and guidance documents. Also provides a diverse list of coastal monitoring programs within the State of California. Cites international, Federal, state, local, private and academic programs, including data bases and monitoring technologies.

University of Rhode Island Coastal Resources Center. Salt Pond Monitors.

http://brooktrout.gso.uri.edu/ProJoSaltPonds.html

Describes involvement of Rhode Island citizens in monitoring the conditions of coastal salt ponds. Shows the growth of a grassroots environmental monitoring program and its importance to efforts to acquire good long-term environmental data.
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Case Studies

U.S. Department of Commerce/NOAA/NOS. South Florida Ecosystem Monitoring Integration Project.

http://www-orca.nos.noaa.gov/south_florida/

Provides facts on the joint NOAA/Florida Department of Environmental Protection's Florida Marine Research Institute, Florida Bay Program Management Committee's South Florida Ecosystem Monitoring program. Provides a common point for decision-makers and scientists to develop an integrated monitoring and measurement project for the South Florida coastal ecosystem to document changes at the ecosystem level, determine the effectiveness of current management activities, and improve monitoring capabilities. Also includes a searchable metadata data base, providing information on over 200 monitoring programs in the South Florida region.

U.S. Department of the Interior/U.S. Geological Survey/Office of the Regional Hydrologist, Southeastern Region. Joint NOAA/EPA Coastal Research and Monitoring Program for the Carolinian Province.

http://fs1rgaatl.er.usgs.gov/public/srnrl_projects/carolini.html

Provides facts on a joint monitoring program conducted by USGS, NOAA and EPA to assess the health of the southeastern U.S. estuaries and to develop methods to manage the environmental conditions affecting coastal ecosystems.

State of Washington. Puget Sound On-line - Puget Sound Water Quality Action Team.

http://www.wa.gov/puget_sound/protectps/protect.html

Through section of Puget Sound On-line entitled "How is Puget Sound Being Protected," provides information on coastal monitoring activities, including local solutions, individual action and involvement, state efforts and assistance, and Federal roles in protecting Puget Sound.
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GLOSSARY

benthic: occurring at or near the bottom of a body of water.

biogeographic provinces: geographic areas having unique physical and biological properties that affect the spatial distribution of organisms and their habitat.

coastal zone: extends from the continental shelf break or 200 nautical miles offshore (the seaward extent of the exclusive economic zone) to the shoreline and up coastal rivers to the head of tidal influence. This range includes coastal and shelf waters, estuaries, estuarine drainage areas, wetlands, flood plains, lagoons, beaches, and the overlying atmosphere.

coliform bacteria: bacteria, present in sewage, that indicate the possible presence of enteric pathogens of sewage origin. Fecal coliform bacteria, a subset of the total coliform bacteria group, indicate specifically the presence of fecal material.

contamination: the presence of a chemical due to human activities.

ecosystem: a discrete environmental unit consisting of living and non-living components interacting to form a stable system. The term can be applied at any scale, from a drop of pondwater to the entire biosphere (e.g., Earth can be viewed as a single ecosystem).

estuary (adj. estuarine): a semi-enclosed coastal water body where fresh water and saltwater mix.

fisheries habitat: under the Magnuson-Stevens Fishery Conservation and Management Act, essential fisheries habitat means those waters and substrate that fish require to spawn, breed, feed or grow to maturity.

habitat: the living place or "home" of a particular organism or biological community.

infauna: benthic fauna (animals) living in the substrate and especially in a soft sea bottom.

man-made chemicals: organic chemicals that would not exist if not synthesized.

mitigation: restoration to compensate for a specific environmental impact, usually off-site.

monitoring: periodic measurements of the same parameters.

natural resource: land, fish, wildlife, biota, air, water, groundwater drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to or otherwise controlled by the United States (including the resources of the Exclusive Economic Zone), any state or local government, Indian tribe, or foreign government.

nonpoint sources: sources of pollution that do not originate at the point where pollution is detected, e.g.:

agricultural runoff: precipitation and irrigation-related runoff of animal wastes and pesticides from crop and pasture lands.

feedlot runoff: primarily precipitation-related discharge of animal wastes from concentrated livestock feeding areas.

individual wastewater treatment system runoff: discharge of partially treated sewage from malfunctioning on-site septic systems.

urban runoff: precipitation-related discharge of septic leachate, animal wastes, etc. from impervious surfaces, lawns, and other urban land uses.

wildlife runoff: precipitation-related runoff of animal wastes from areas with high concentrations of wildlife (e.g., waterfowl).

organic compounds: in general, all chemical compounds containing the element carbon (except as a carbonate).

PCB: polychlorinated biphenyl, a toxic, chlorinated organic compound formerly used as a coolant in electrical transformers.

phytoplankton: microscopic, single-celled plant life (e.g., algae), usually containing chlorophyll, that passively drifts or weakly swims in a water body.

point sources: sources of pollution that originate at or close to the point where pollution is detected, e.g.:

boating source: periodic discharge of untreated or partially treated sewage from vessels under way or anchored offshore.

combined sewer overflows: discharge of untreated sewage/stormwater when sewage system capacity is exceeded during heavy rainfall.

direct discharges: untreated sewage discharged directly to receiving waters by residences, seasonal camps, etc.

industrial facilities source: routine and accidental discharges from production/manufacturing processes and on-site sewage treatment.

marina source: periodic discharge of untreated or partially treated sewage from berthed vessels.

wastewater treatment plants (WTTP): routine and accidental sewage discharge from public and private treatment plants.

sediment: particulate material lying on the sea floor.

status: in the context of chemical concentrations in mollusks, the geographic distribution of concentrations.

toxin (biotoxin): a poisonous substance that is a specific product of the metabolic activities of a living organism.

trace metals: a general term for all elements (even non-metallic elements) that are usually found in concentrations of less than 1,000 parts per million in sediments or animal tissue.

uplands: the elevated, typically forested lands beyond the lowlands that border rivers and coasts.

wetland: a habitat or vegetative community dependent on seasonal, intermittent or permanent flooding.

CREDITS

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One was contributed from outside of NOAA, and we gratefully thank the following institution and individual:

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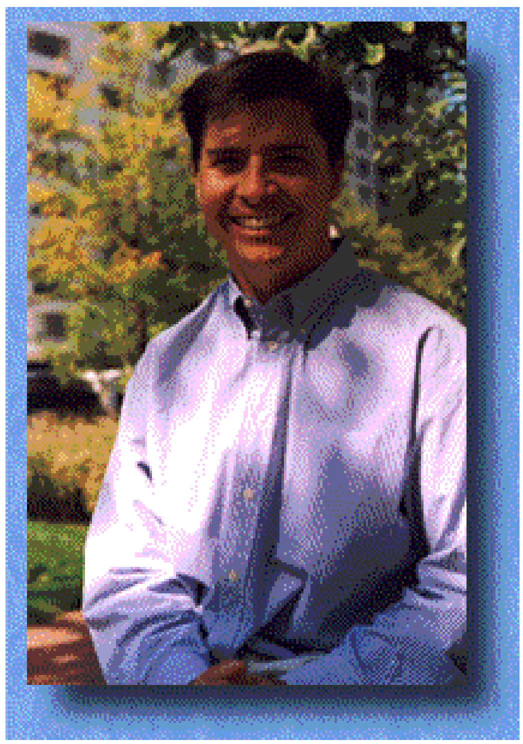
Andrew Robertson is the Chief of the Coastal Monitoring and Bioeffects Assessment Division in NOAA's National Ocean Service. He received a B.S. in chemistry from the University of Toledo and M.A. and Ph.D. degrees in zoology from the University of Michigan. He is responsible for directing NOAA's National Status and Trends Program, which monitors the levels and effects of contaminants in U.S. coastal and Great Lakes waters.

Paul Orlando is a physical scientist with NOAA's Strategic Environmental Assessments Division. He received a B.S. from Mt. St. Mary's College in Emmitsburg, Maryland, and an M.S. in Marine, Estuarine and Environmental Sciences from the University of Maryland. He helped to develop the freshwater, salinity and circulation components of NOAA's National Estuarine Inventory.



Donna Turgeon is an ecologist with NOAA's Coastal Monitoring and Bioeffects Assessment Division. She received a B.S. in biology and education from Bridgewater State College, Massachusetts; an M.A. in biological oceanography from the College of William and Mary; and a Ph.D. in marine zoology from the University of New Hampshire. She is helping to develop an integrated monitoring plan for the South Florida marine ecosystem and a biological quality assurance program for NOAA's National Status and Trends Program.

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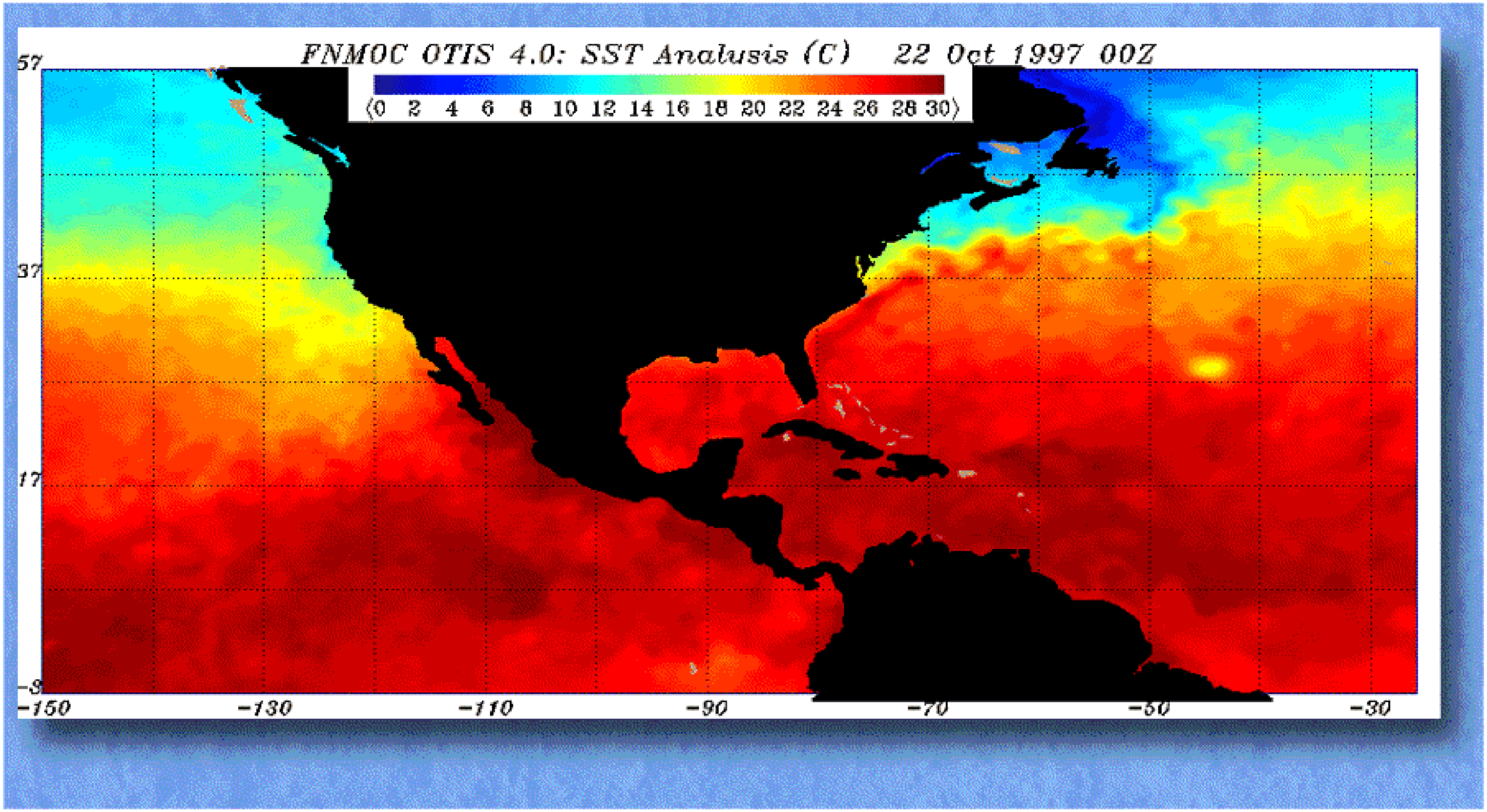

Photo 10. Satellite image of sea-surface temperature along the Atlantic and Pacific coasts. Warmer waters are red, colder are blue.

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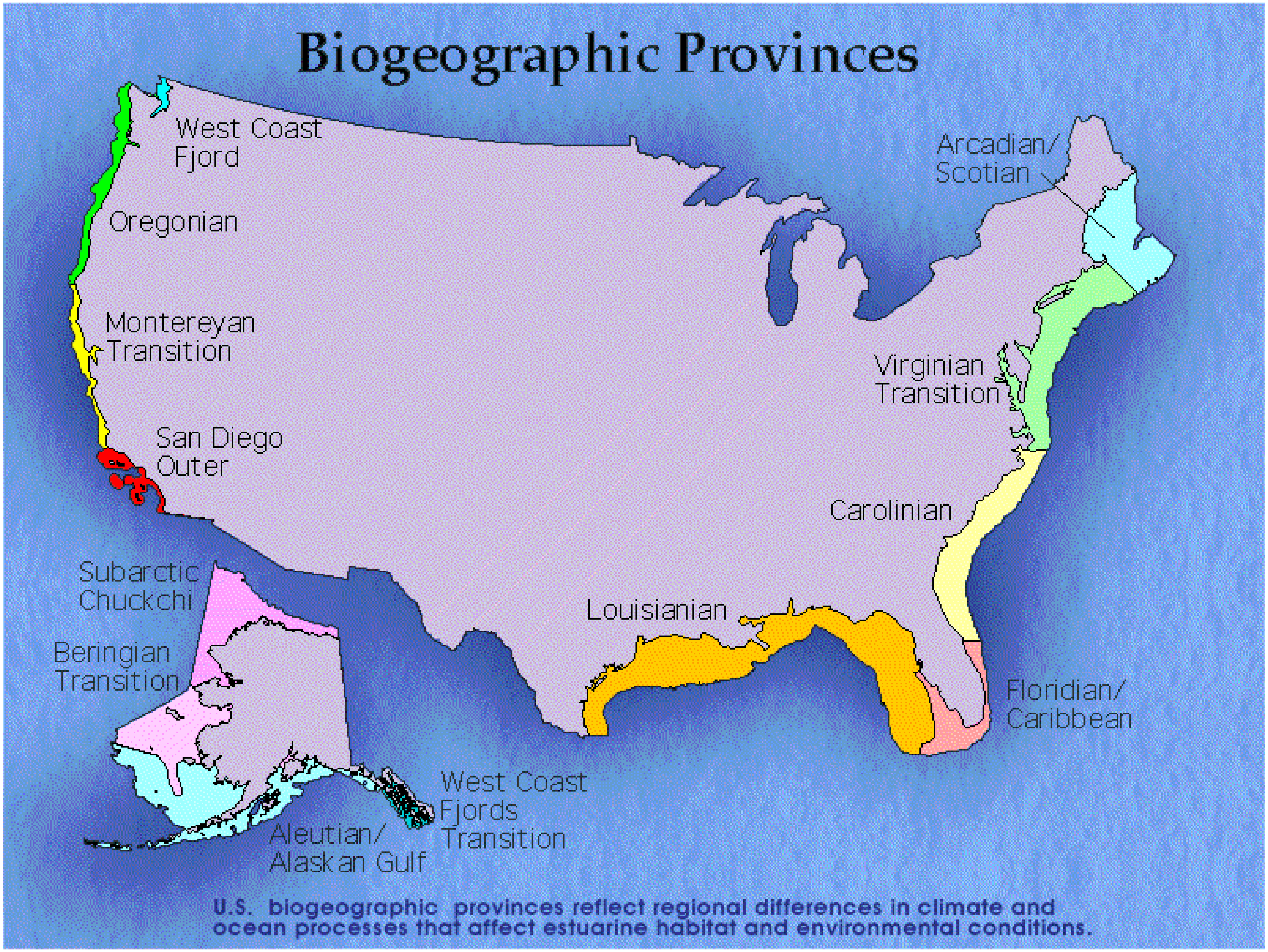

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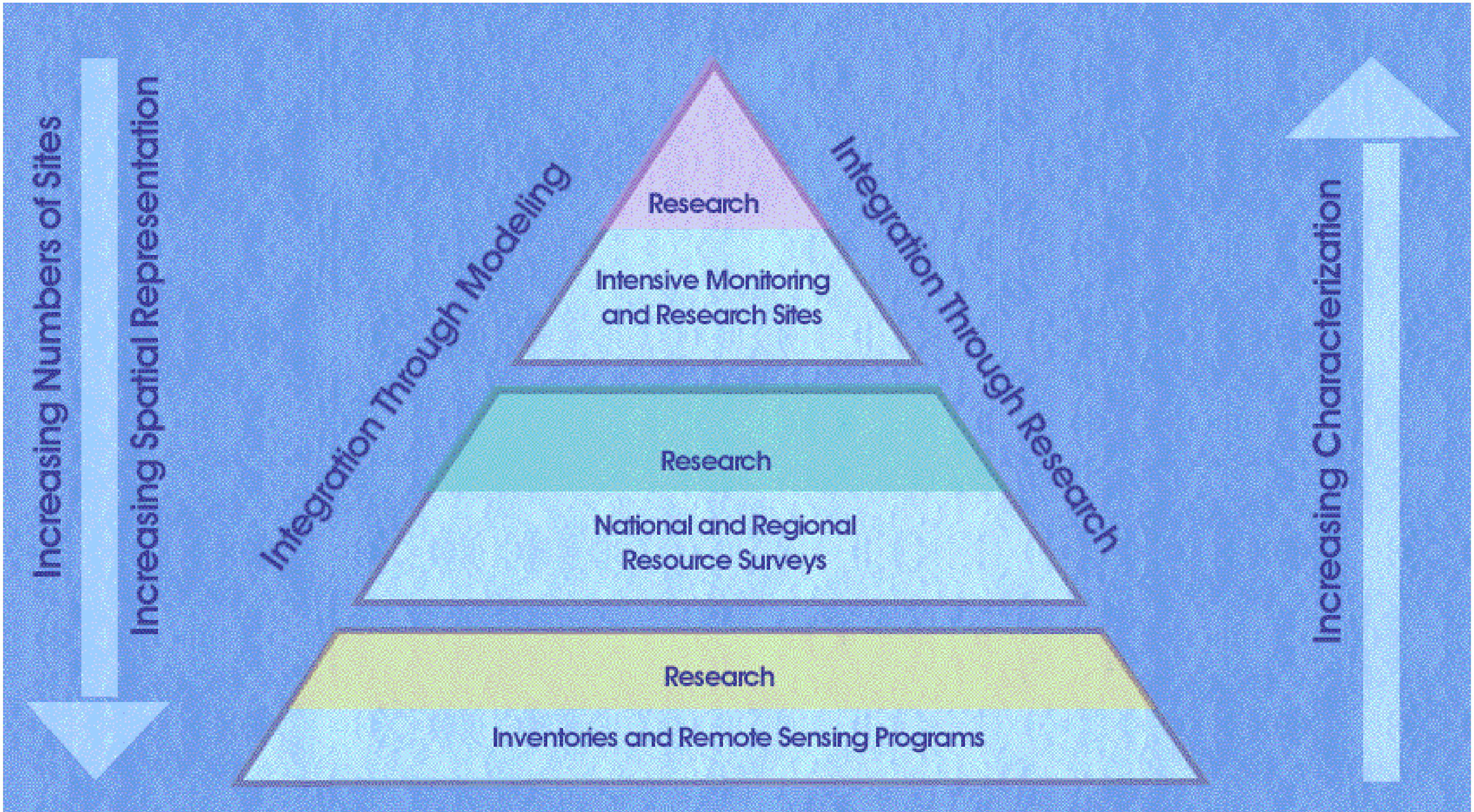

Figure 1. Scales of environmental monitoring as defined by the Committee on the Environment and Natural Resources (CENR,1996)

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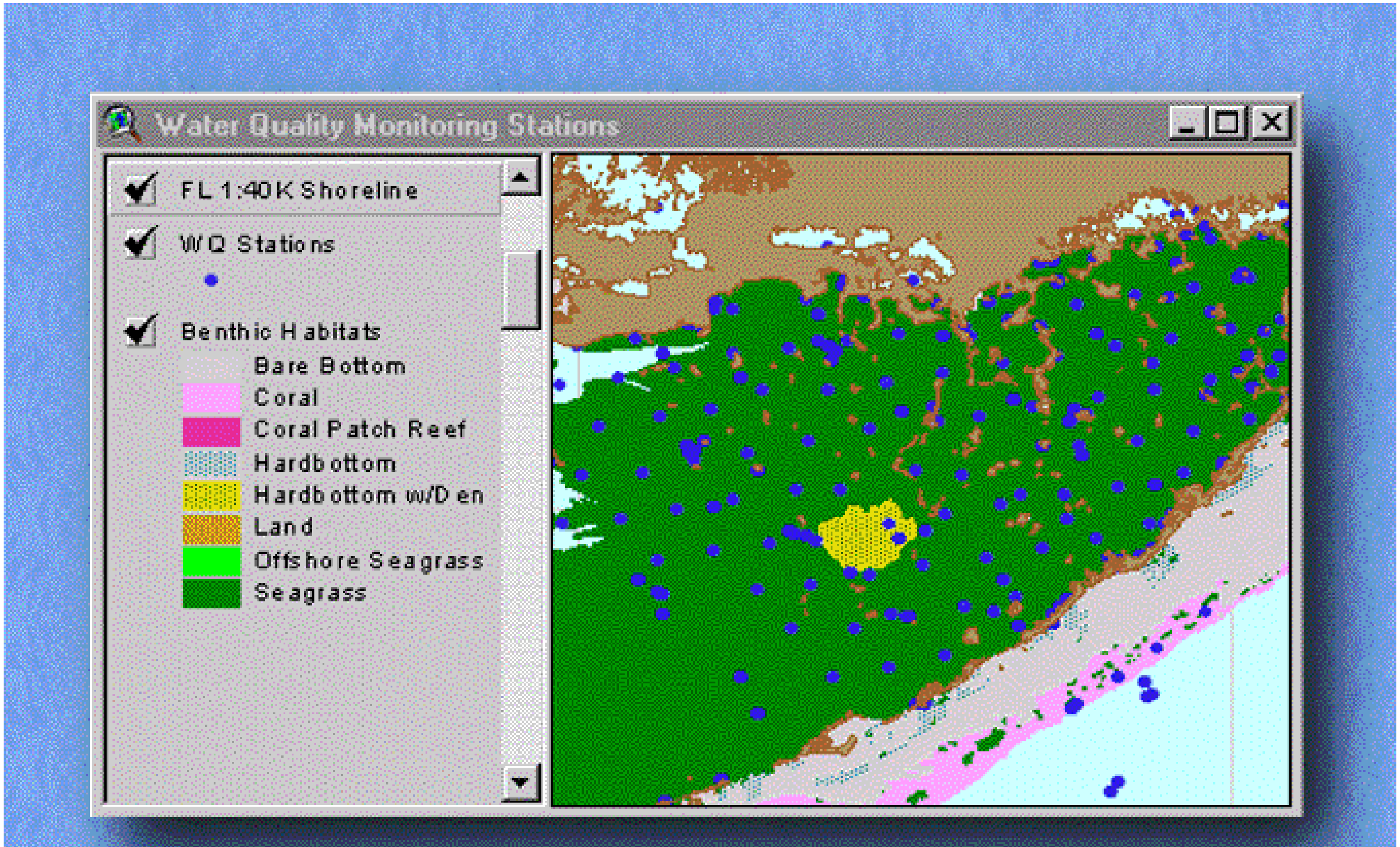

Fig. 2. Water Quality Monitoring Stations