CHAPTER 15:
CREATING A NATIONAL WATER QUALITY MONITORING NETWORK

Ongoing monitoring is essential to assess the health of ocean and coastal ecosystems and detect changes over time. More than any other measure, monitoring provides accountability for management actions. The nation needs a coordinated, comprehensive water quality monitoring network that can provide the information necessary for managers to make informed decisions, adapt their actions as needed, and assure effective stewardship of public resources. In developing such a network, the National Oceanic and Atmospheric Administration, the U.S. Environmental Protection Agency, the U.S. Geological Survey, and other federal agencies as appropriate, should collaborate to ensure adequate monitoring in coastal areas and the upland regions that affect them. Input from states, territories, tribes, counties, and communities—where much of the monitoring will be conducted—is also essential. In addition, because of the inherent overlap among inland, coastal, and open-ocean monitoring and observing, the national water quality monitoring network should be closely linked with the Integrated Ocean Observing System and, ultimately, incorporated into a broad Earth observing system.

RECOGNIZING THE VALUE OF WATER QUALITY MONITORING

Pollution of the nation's coastal waters has led to beach closures, oxygen depletion, health impacts from toxic contamination, and many other problems described in Chapter 14. Despite these threats to coastal waters, there is no national network in place to monitor water quality changes and their causes, facilitate estimates of their economic impact, and measure the success of management efforts. Increased monitoring is needed not only along the nation's coasts, but also inland where pollutants make their way downstream, ultimately impacting coastal waters. A national water quality monitoring network is essential to support the move toward an ecosystem-based management approach that considers human activities, their benefits, and their potential impacts within the context of the broader biological and physical environment. While current water quality monitoring helps track specific substances, it has been less effective in helping understand how various ecosystem components interact and change over the long term.

Monitoring information will be useful to many people including beachgoers, fishermen, scientists, water providers, and others. Coastal managers need to understand the scope of the problems they are facing before they can effectively respond. After responding, monitoring information will also help assess the effectiveness of the selected management approaches.

An essential step toward controlling pollution will be to strengthen and coordinate monitoring efforts. Questions have been raised about the comparability and accuracy of information produced by disparate monitoring programs and about the practical value of the information to stakeholders. Federal and state agencies around the country will need to work closely together to achieve a fully effective national system.

MONITORING AT THE FEDERAL LEVEL

A number of monitoring efforts are currently conducted by federal agencies, state governments, research institutions and academia, nongovernmental organizations, and individual volunteers. Existing monitoring programs vary in many respects, including sampling design and intensity, parameters tested, analytical methodology, data management protocols, and funding. Even when the same properties are measured, different data management protocols may make the integration of that information difficult. Consequently, while a number of monitoring programs exist, they are not designed to support a comprehensive and coordinated national monitoring network. To make matters worse, budget constraints have resulted in significant reductions in monitoring of coastal areas.

Responsibility for monitoring and assessing natural resources is divided among a number of agencies whose activities are focused on achieving specific programmatic objectives or agency missions.

Federal Programs

The main federal agencies involved in water quality monitoring include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the U.S. Environmental Protection Agency (EPA). The U.S. Department of Agriculture (USDA) and the U.S. Army Corps of Engineers also conduct some limited monitoring.

The mission of NOAA's National Status and Trends program is to determine the status of, and detect changes in, the environmental quality of the nation's estuarine and coastal waters. The program conducts long-term monitoring of contaminants and other environmental conditions at approximately 280 sites. In addition, within NOAA's National Estuarine Research Reserve System, a monitoring program was designed to support state-specific, nonpoint source pollution control programs and to develop a nationwide database of environmental conditions in estuaries.

USGS operates the National Streamflow Information Program, a network of about 7,000 stream gages nationwide. About 6,000 of these stations are linked to an Earth-satellite-based communications system. The majority of the stream-gaging stations are jointly funded in partnerships with more than 800 state, local, and tribal governments or other federal agencies. The data are available in real time to conduct water resource projects and for NOAA's National Weather Service to forecast floods. Streamflow data are needed at many sites on a daily basis for forecasting flow extremes, assessing current water availability, and managing water quality and quantity. In addition, USGS conducts long-term water quality and quantity monitoring through the National Stream Quality Accounting Network at fixed locations on large rivers around the country. USGS also operates the National Water Quality Assessment, which uses a regional focus to study status and trends in water, sediment, and biota in forty-two major river basins and aquifer systems. This effort has made considerable progress toward assessing current water quality conditions and long-term trends.

EPA's Environmental Monitoring and Assessment Program aims to develop the tools and science needed for a state-based statistical monitoring framework to determine trends in the condition of all the nation's aquatic ecosystems. This program uses a probabilistic sampling design that relies on data from many sites of similar habitat type as the best estimate for overall condition of that habitat. A variety of information is collected through this program, including water column parameters, sediment chemistry and toxicity, and measurements of benthic communities. While the program provides the benefits of a probabilistic approach, the design is not as well suited for trend analysis. EPA also conducts monitoring through its National Estuary Program. As National Estuary Program sites were created, they included an extensive characterization phase and an estuary-specific monitoring plan. Although most continue monitoring to evaluate the effectiveness of their implementation efforts, there is no program-wide monitoring strategy. Finally, EPA is authorized to

support microbiological testing and monitoring of coastal recreational waters through the Beaches Environmental Assessment and Coastal Health Act, which was designed to reduce the risk of disease to users of the nation's coastal recreational waters.

Several agencies monitor atmospheric deposition, the process by which chemicals in the air are deposited onto the Earth's surface in wet and dry forms, which contributes significantly to coastal water pollution. The National Atmospheric Deposition Program, a cooperative effort of many different groups, measures deposition of a number of pollutants at more than 200 sites. The Mercury Deposition Network, one component of this program, measures mercury levels in wet deposition. EPA's Clean Air Status and Trends Network also measures dry deposition at about eighty sites.

Shortcomings in Federal Programs

Despite the existence of the many programs described above, their combined efforts do not constitute a comprehensive, coordinated water quality monitoring network. One severe limitation of current efforts is the lack of monitoring in coastal waters.

National monitoring has been greatly reduced, particularly in coastal areas, due to funding cuts at USGS and many partner agencies. The USGS National Streamflow Information Program has eliminated a number of stream gages, including long-term gages that are critical for studying climate change. To fully realize its potential, the stream-gaging network needs to be modernized and gaps in coverage filled. Funding cuts have also affected USGS's water quality monitoring programs, resulting in reductions in the number of sampling sites and sampling frequency. USGS's National Water Quality Assessment's coverage has also been reduced in recent years, leaving out much of the coastal region. A 2001 National Research Council report concluded that while this program has downsized in a logical manner, they cannot continue to downsize and still be considered a national program for assessing water quality.[1]

Budget constraints have also affected the National Stream Quality Accounting Network. At its peak in 1978, this program included 520 fixed-station sampling sites on moderate and large rivers, which provided monthly estimates of flow rates, suspended sediment, nutrients, trace metals, indicator bacteria, and phytoplankton. About 140 of the sites were located in areas helpful to estimating the input of water and materials to estuaries. Currently, this program focuses only on monitoring the water quality of the nation's largest rivers—the Mississippi, Columbia, Colorado, Rio Grande, and Yukon—with a total of only thirty-two stations. Most coastal regions are left out of the monitoring network altogether (Figure 15.1).

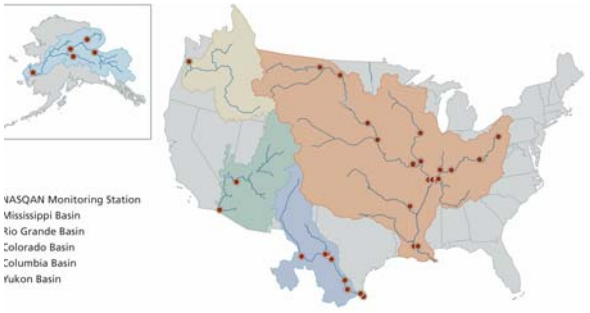
NOAA's National Status and Trends Program is limited by the number of sites sampled per state and the lack of full representation of estuarine habitats in those states. The program samples mollusks for contaminants only every other year, and even less frequently for sediments.

Of the more than 200 sites in the National Atmospheric Deposition Program, very few are located in coastal areas. Less than 20 percent of sites in the Atmospheric Integrated Research and Monitoring Network, a sub-network of the National Atmospheric Deposition Program, are located in coastal areas.

Figure 15.1. Watershed Monitoring is Extremely Limited Near the Coasts

1974-1994

15.1 A. The National Stream Quality Accounting Network program was created in 1974 to develop baseline water chemistry data for the nation. The network started with over 500 stations but by 1994 the program had been reduced to 274 sampling stations throughout the United States. (Not shown are the thirteen stations in Alaska, eight in Hawaii, six in Puerto Rico, and one in Guam.)



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15.1 B. Today, the program consists of only thirty-two stations focused on the nation's five major river basins, leaving almost the entire coastal region unmonitored.

Source: U.S. Geological Survey, U.S. Department of the Interior. <http://water.usgs.gov/nasqan/progdocs/index.html> (Accessed January, 2004).

Much of the monitoring in the United States is conducted by states, territories, nongovernmental organizations, and volunteers. There is considerable variation in the ways states select monitoring sites, the kinds of tests they perform, the methods they use to determine causes and sources of pollution, and the analytical approaches they choose to evaluate water quality. As a result, reports on the quality of a particular water body often differ on either side of a state line. These disparities diminish the usefulness of state monitoring programs for regional or national assessments. To be fully effective, the monitoring data collected by states, territories, nongovernmental organizations, and volunteers should be coordinated with a national monitoring network.

PROMOTING INTERAGENCY COORDINATION

Several interagency initiatives have been proposed for achieving a more coordinated monitoring strategy. The Intergovernmental Task Force on Monitoring Water Quality was established in 1992 to review national water quality monitoring activities and to develop an integrated national monitoring strategy. Chaired by EPA, with USGS as vice chair, the task force recommended, among other things, the development of closer working relationships among organizations that monitor and use water information and the development of comparable technical methods.[2]

The National Water Quality Monitoring Council was formed in 1997 as the successor to the task force, with the mandate to implement the task force's strategy. Jointly chaired by EPA and USGS, the council is composed of thirty-five representatives from federal, state, tribal, local, and municipal governments, watershed groups, academia, and the private sector. The council serves as the major national forum for the coordination of consistent and scientifically defensible federal and state water quality monitoring methods and strategies. Its focus has been on fresh water monitoring, but many of the methods it has developed could also be applied to marine environments.

The National Science and Technology Council's Committee on Environment and Natural Resources has also promoted an initiative to integrate and coordinate environmental monitoring efforts. From this initiative came the 1997 report, *Integrating the Nation's Environmental Monitoring and Research Networks and Programs: A Proposed Framework*. The framework is designed to produce the necessary scientific data and information to produce integrated environmental assessments.

The Coastal Research and Monitoring Strategy Workgroup was formed in 1999 with representatives from federal, state, tribal, and nongovernmental organizations. NOAA, EPA, USGS, and USDA led the development of the workgroup's Coastal Research and Monitoring Strategy, published in 2000, which called for addressing problems of coastal water quality and coastal resources by replacing single-issue, single-agency, single-discipline problem solving with a coordinated, multi-agency, interdisciplinary approach.

While these interagency initiatives are moving in the right direction, they have not resulted in the comprehensive and coordinated national monitoring network resource managers need, particularly in coastal areas. Significant obstacles include a lack of focus on the coast, the absence of some agencies with relevant responsibilities, inadequate follow-through, and a lack of commitment at the highest levels of government.

ENSURING COMPREHENSIVE, COORDINATED COVERAGE

The nation's coastal margin is the most densely populated and developed region of the nation, and its waters have been significantly degraded by pollution. Yet in recent years, due largely to lack of funding, monitoring has been extremely sparse along the coasts. Much remains unknown about the status of coastal waters, and increased monitoring will be required to make informed management decisions about this economically and ecologically valuable region. Yet the close connections between coastal and upstream waters dictate that any water quality monitoring network must be national in scope. Despite decades of monitoring efforts by many agencies, the nation still lacks such a national network.

Because of the inherent overlap between inland, coastal, and open-ocean monitoring and observing, the national water quality monitoring network should be closely linked with the Integrated Ocean Observing System (IOOS; discussed in detail in Chapter 26) and ultimately with a broad Earth observing system. The national water quality monitoring network will provide the capability to observe, analyze, and forecast natural and human-induced changes that affect waters from inland out to the estuaries and coasts. The IOOS will provide the nation with similar information for the coasts and open-ocean environments. Because these systems will overlap in coastal areas, they should be closely coordinated to ensure compatibility of information. At some point, the national water quality monitoring network and the IOOS should both become components of a true Earth observing system that links land, air, and water around the globe.

Recommendation 15-1. The National Oceanic and Atmospheric Administration, U.S. Geological Survey, and U.S. Environmental Protection Agency, working with other appropriate entities, should develop a national water quality monitoring network that coordinates existing and planned monitoring efforts, including monitoring of atmospheric deposition. The network should include a federally funded backbone of critical stations and measurements needed to assess long-term water quality trends and conditions.

Recommendation 15-2. The National Oceanic and Atmospheric Administration should ensure that the national water quality monitoring network includes adequate coverage in both coastal areas and the upland areas that affect them, and that the network is linked to the Integrated Ocean Observing System, to be incorporated eventually into a comprehensive Earth observing system.

CREATING AN EFFECTIVE MONITORING NETWORK

In addition to coordinating existing monitoring efforts, an effective national water quality monitoring network should have specific goals and objectives, reflect user needs, and be helpful in assessing the effectiveness of management approaches. The overall system design should determine what and where to monitor, including definition of a set of core variables. Technical expertise will be needed to standardize procedures and establish quality control and data management protocols. The national monitoring network should be periodically assessed and modified as necessary. Most important, the data collected through the national monitoring network should be useful to managers and stakeholders in evaluating management measures, determining best management practices, and making continual improvements in reaching ecosystem goals. The design and implementation of the national monitoring network will require not only federal coordination, but also significant input from the states.

System Goals and Objectives

The national monitoring network should set clear, limited goals and objectives that reflect national, state, regional, territorial, tribal, and local needs. The goals and objectives should be geared toward the assessment of management approaches, including best management practices, and be based on pressing management issues. Successful monitoring should target issues that policy makers, scientists, managers, and the public consider important, providing a basis for possible management actions. Thus, in designing a coordinated national water quality monitoring network, input will be needed from all of these sectors. However, attempts to be everything to everybody will result in an unfocused and ultimately unsuccessful program. Monitoring results should support adaptive management, allowing decision makers to support approaches that demonstrate measurable success in attaining watershed goals and revise practices that are falling short of achieving those goals.

System Design

Sampling protocols are central to the design of an effective national water quality monitoring network. Because regular sampling of all waters for all contaminants would be unacceptably costly, only a subset of the nation's waters can be monitored. The network's designers should determine what, where, and how often to sample, examining existing monitoring systems at the federal, state, territorial, tribal, local, and private levels to determine gaps. Designers should agree on a set of core variables to be measured at every station, with flexibility for stakeholders to measure additional variables if desired.

A national monitoring network should incorporate various types of measurements, including a broad-scale census of fundamental properties, issue- and resource-specific surveys, and intensive monitoring at higher resolution to support the scientific study of ecosystem processes. The network should include both effects-based monitoring, which measures the current condition of the environment, and stressor-oriented monitoring, which measures parameters that are known or suspected to be associated with a decline in environmental health. In addition, the network should combine probabilistic sampling, which allows for statistically valid assessments of water quality conditions in monitored and unmonitored waters, with fixed-station sampling, which samples fixed areas repeatedly over an extended period of time.

Technical Coordination

The monitoring system should include standardized procedures and techniques. Quality assurance and quality control guidelines should be established so that management approaches can be assessed on comparable terms. Data management protocols should be established and uniform data storage formats specified so data

can be broadly disseminated and easily accessed and understood by agency personnel, the scientific and management communities, and the general public.

Periodic Review and Modification

The monitoring network's design should be evaluated periodically to make sure it is measuring variables that are useful for assessing the health of an ecosystem, to add new variables when necessary, and to make any other changes that would improve the monitoring network. While establishing and standardizing a core set of measurements is important, it is also critical to review this core set periodically to ensure that new substances are added as needed. As new chemicals are detected in the environment and wildlife, their toxicological significance should be assessed and they should be considered as possible additions to the suite of routinely monitored compounds.

Keeping Up With New Contaminants

The nature of chemical detection and measurement rarely permits identification of every chemical within an environmental sample. Therefore, monitoring efforts survey only those compounds selected by the analyst. In the 1970s, the U.S. Environmental Protection Agency established a list of priority pollutants consisting of 129 compounds chosen out of thousands of candidates. The U.S. Geological Survey's Toxic Substances Hydrology Program has conducted research on the analysis and detection of these compounds in surface waters, and recently published the first comprehensive study of them. Although this list remains the standard for environmental assessments, it ignores many highly relevant chemicals.

Recent advances in analytic techniques have allowed the measurement of anthropogenic chemicals in the environment that were not previously readily detectable. Many of these compounds are, or were, produced in high volumes and were introduced to the environment during their production, disposal, or use. Examples include insecticides, pharmaceuticals, antibiotics, hormones, fire retardants, and industrial chemicals. These new compounds—some banned and some still in production—are long-lived and can accumulate to high concentrations in the environment, wildlife, and humans. Due to atmospheric and oceanic long-range transport, several of these compounds have migrated throughout the world, and are even found in distant Arctic areas, where they accumulate in marine mammals and in humans.

Recommendation 15-3. The National Oceanic and Atmospheric Administration, U.S. Geological Survey, and U.S. Environmental Protection Agency, working with other appropriate entities, should ensure that the national water quality monitoring network includes the following elements: clearly defined goals that fulfill user needs and measure management success; a core set of variables to be measured, with regional flexibility to measure additional variables where needed; an overall system design that determines where, how, and when to monitor and includes a mix of time and space scales, probabilistic and fixed stations, and stressor- and effects-oriented measurements; technical coordination that establishes standard procedures and techniques; and periodic review of the monitoring network, with modifications as necessary.

MAKING DATA ACCESSIBLE AND USEFUL

The data collected from the national monitoring network should be deposited in, and available through, a national data management system, as described in Chapter 28. Complete information about what is being analyzed and methods of analysis should be shared. Once monitoring data are collected, they must be translated into timely and useful information products that are readily accessible to decision makers and the public. The regional ocean information programs, as described in Chapter 5, should be helpful in providing coastal managers with the monitoring information needed to inform their decisions.

Recommendation 15-4. The National Oceanic and Atmospheric Administration, U.S. Geological Survey, and U.S. Environmental Protection Agency, working with other appropriate entities, should ensure that water quality monitoring data are translated into timely and useful information products that are easily accessible to the public and linked to output from the Integrated Ocean Observing System.

[1] National Research Council. *Opportunities to Improve the U.S. Geological Survey National Water Quality Assessment Program*. Washington, DC: National Academy Press, 2001.
[2] U.S. Geological Survey. "The Strategy for Improving Water-Quality Monitoring in the United States—Summary." <http://water.usgs.gov/wicp/Summary.html> Accessed January 20, 2004.