

The need to assess the condition of aquatic resources in the US

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Abstract. In 1972, the US Congress enacted the Clean Water Act (CWA) to protect US water resources. A critical section (305[b]) of the CWA calls for periodic accounting of the success or failure of efforts to protect and restore US waters. Over the years, several groups have reviewed the available data and concluded that they do not adequately describe the condition of US waters. The Wadeable Streams Assessment presents the first set of results from what will be a long-term partnership between the US Environmental Protection Agency, the individual states, tribal nations, and other federal agencies. The goal of this partnership is to fill critical information gaps that remain a deterrent to our ability to determine whether our policies and investments have resulted in improvement of US water resources.

Background

In 1972, the US Congress passed the Clean Water Act (CWA; CWA 1972) with intent to restore and maintain the physical, chemical, and biological integrity of US water resources. A key goal of the CWA is to ensure that water quality in the US provides for the protection and propagation of fish, shellfish, and wildlife and for recreational activities. In the 36 y since the CWA was passed, the US Congress and other interested parties have asked the US Environmental Protection Agency (EPA) to describe the quality of US waters. These requests include seemingly simple questions: Does a water-quality problem exist? If so, how extensive is the problem? Is the problem widespread or does it occur in hot spots? Which environmental stressors affect the quality of US streams and rivers, and which are most likely to be detrimental?

In 2002, the H. John Heinz Center for Science, Economics, and the Environment (2002) published an assessment of the current condition of US ecological resources and the environment. In the same year, the EPA released a draft of a similar report, the final version of which was published in 2003 (USEPA 2003). In each case, the authors of these reports concluded

that the data needed to conduct their assessments were not available. On 26 September 2002, shortly after the release of these assessments, USA Today, a nationally distributed daily newspaper, published an editorial entitled “Environmental Mysteries.” The editorial cited the Heinz Center’s report on the *State of the Nation’s Ecosystems* (H. John Heinz Center for Science, Economics and the Environment 2002) and indicated that the EPA’s air-monitoring network had documented improvements in air quality. USA Today went on to express the opinion that it was “too bad” that the EPA could not provide similar data on US fresh waters, oceans, farmland, forests, or urban dumping grounds. The editorial called the government shortsighted for not funding collection of comparable data to justify the expenditure of public funds on environmental protection and cleanup. USA Today also noted “by contrast the government has agencies dedicated to measuring the economy, population trends, energy usage, health and crime.” In answer to the question, “Why would we want such measures for our environment?”, the editorial expressed the opinion that “without such information, the public doesn’t know when to celebrate environmental successes, tackle new threats, or end efforts that throw money down the drain.”

The Heinz Center report (H. John Heinz Center for Science, Economics and the Environment 2002) and the EPA’s Report on the Environment (USEPA 2003) were not the first to conclude that, as a nation, the US lacks

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the data necessary to report the current status of its ecological resources, trends in these conditions, and causes of environmental degradation. Independent critiques that called for improvements in monitoring date back to the late 1970s, at least. In 1977, at the request of Congress, the National Research Council (NRC 1977) evaluated the EPA's monitoring programs and found them deficient in 3 ways. They reported that: 1) the EPA did not sufficiently use scientific principles of design, sampling, and evaluation, 2) insufficient emphasis was given to problem discovery and too much effort was given to point-source monitoring, and 3) monitoring responsibilities were fragmented within the EPA and among local, state, regional, and other federal agencies. The NRC recommended greater scientific leadership, better data management (including refined objectives, quality assurance, analysis, and reporting), increased statistical expertise, long-term ecosystem monitoring, and greater coordination of monitoring activities.

The US General Accounting Office (GAO) (USGAO 1981) found that much of the EPA's water-quality data was inadequate because samples were too few and too infrequent, sampling sites were unrepresentative, and conditions could not be associated with causes. In 1988, the GAO (1988) recommended that the EPA state its priorities in measurable terms and rank them, develop measures of environmental quality (such as ambient biological communities) that could be linked with program activities, and improve sampling designs and data quality and accessibility. Also in 1988, the EPA's Science Advisory Board's report, *Future Risk: Research Strategies for the 1990s* (USEPA Science Advisory Board 1988), recommended increased research to develop indicators, improve monitoring protocols, and analyze and quantify uncertainty. The goals of such research were improved detection of ecosystem status and trends and greater capabilities to predict emerging problems.

The NRC (1996) later underscored the need for improvements in US monitoring capabilities. They concluded that "One particular concern relative to achieving a desired state of environmental quality is our understanding of the ecological system in which plants, animals and humans live. Current ecological data and understanding are inadequate to: detect, monitor, and characterize environmental changes; evaluate the consequences of human activities; and provide an information base for sustainable management (i.e., "no loss") of both natural and ecological human-designed systems. Therefore, it is difficult to conduct the comparative analysis of past, current, and future ecological states (as described earlier) to determine what actions are needed to achieve a

desired end of environmental quality. Furthermore, current programs do not address these issues in a sufficiently coherent and comprehensive manner on a national basis." (NRC 1996, p. 6).

The GAO issued a report noting that the EPA and the states could not make statistically valid inferences about water quality and lacked data to support key management decisions (USGAO 2000). NRC (2001) recommended that the EPA and states promote a uniform, consistent approach to ambient monitoring and data collection and adopt biological measures because they best reflect the response of the ecosystem to environmental stressors. The Heinz Center's report (H. John Heinz Center for Science, Economics and the Environment 2002) similarly concluded that water-quality data were inadequate for reporting on fresh-water, coastal, and ocean water-quality indicators at a national scale. The US Commission on Ocean Policy (USCOP 2004) issued similar conclusions, and the National Academy of Public Administration (NAPA 2002) stated that improved water-quality monitoring is necessary to help states make more effective use of limited resources.

Progress and Future Directions

This litany of reviews made it clear that the EPA had to adopt an approach to monitoring and assessment that would provide nationally consistent, statistically valid assessments of the condition of US water resources. The EPA recognized that developing this approach would require partnering with individual states, tribal nations, and other federal agencies and would require research to develop or refine assessment methods. The CWA delegates a great deal of responsibility for water-quality protection, including monitoring, to states and tribes. Other federal agencies and nongovernmental organizations also monitor water resources for a wide range of needs.

Beginning in 1989, the EPA's Office of Research and Development initiated a research program entitled the Environmental Monitoring and Assessment Program (EMAP). The primary purpose of this effort was to develop and demonstrate the scientific tools to monitor status and trends in both the condition of US aquatic resources and the relative importance of stressors affecting them. Over the years, EMAP researchers partnered with the EPA's Office of Water, EPA regions, and states to develop sample survey designs and indicators for lakes and reservoirs, streams and rivers, and wetlands and estuaries. This research effort provided the technical foundation for the Office of Water's efforts to monitor US aquatic systems.

Research in EMAP focused on 2 areas: sample survey design and ecological indicators. The primary challenge in sample survey design was to provide an approach that would allow inferences to all streams and rivers or lakes from a relatively small sample. The approach had to provide enough flexibility that different reporting schemes could be used (reporting by ecological regions, major drainage basins, and geopolitical regions, such as the EPA regions) and results could be summarized at different spatial scales, particularly national, regional, and state, while maintaining the representativeness of the sample to ensure unbiased estimates. Research in EMAP also focused on developing a suite of biological, chemical, and physical measures to address the program objectives. The intent was to rely on biological measures for descriptions of condition that could be consistently generated and interpreted across the country. The chemical, physical, hydrological, and biological measures would then be used to assess the extent and severity of different stressors to the environment. The research accomplishments over the past 19 y have been significant, and room for improvement continues to exist as outlined in the series of papers contained in this special issue.

The Wadeable Streams Assessment (WSA) (USEPA 2006) was the first attempt orchestrated by the Office of Water to partner with the states, tribes, and the EPA Office of Research and Development to fill the information gaps described above. In 2003, the Board of Directors of the Association of State and Interstate Water Pollution Control Administrators and the EPA's Office of Water agreed to survey US streams using consistent methods and a statistical survey design. This collaboration was instrumental in gaining support within the executive and legislative branches of the US government to increase funding to the states and tribes by US\$18.5 million for the specific purpose of water-quality monitoring. The states and tribes used ~\$8.5 million for participation in nationally consistent statistical surveys and \$10 million to enhance state and tribal monitoring programs. These statistical surveys complemented, but did not replace, the targeted monitoring done by states and tribes to diagnose and guide corrective action for site-specific needs.

The current approach to filling the national knowledge gap regarding the condition of US aquatic resources is based on a series of surveys designed specifically for each water resource type (e.g., streams, rivers, lakes, estuaries, wetlands) that are to be repeated on a 5-y schedule. These national surveys use standardized protocols for sampling, processing, and interpreting core indicators of biological condition and of key stressors. Current resource levels support sufficient sample size for national and regional

reporting on the core indicators. The approach is flexible enough to provide states or tribes the option to increase sampling effort or the suite of indicators within their jurisdiction to generate state- or tribal-level assessments. These national surveys will proceed while the EPA, states, and tribes work together to refine longer-term solutions to filling the national information gaps that are effective for federal, state, and tribal programs.

Future national water-quality reporting should have comparable survey designs, a core set of indicators based on comparable field and laboratory protocols, and national assessments that can be derived by combining data from state and tribal programs. This approach is used by the National Agricultural Statistical Service (NASS) and the states to report on crop production (USDA 2007) and is among the long-term options that the EPA is considering. Developing credible national assessments on the basis of this approach will take time, perhaps 5 to 10 y. It has taken the NASS and the states ~40 y to reach their current level of partnership (Carol House, Deputy Administrator for Programs and Products, USDA NASS, personal communication).

The goals of the national assessments are to provide the EPA, states, Congress, and US citizens credible information with which to prioritize decisions regarding water-resource protection and restoration. These surveys describe the condition of US aquatic resources at a point in time. As they are repeated, they will provide information that can be used to detect or track trends in how those conditions change over time. The results of the WSA were included in the most recent State of the Nation's Ecosystems report (H. John Heinz Center for Science, Economics and the Environment 2002) and the EPA's Report on the Environment (USEPA 2003).

These surveys also were designed to describe the extents of key stressors in the population of waters at national and regional scales and to rank key chemical, physical, hydrologic, and biological factors that are likely to be causes of detrimental effects. We recognize that no monitoring program can provide definitive cause-and-effect information, but the surveys could rank most likely potential causes with sufficient rigor that policy makers could use the information to establish protection and management priorities. The WSA report (USEPA 2006) documented that excess N, P, and sedimentation are widespread across the US and affect 32, 31, and 25% of all stream length, respectively. This information on stressor extent combined with the assessment of the likely detrimental effect of excess levels of these stressors on biological communities will help policy makers and managers

prioritize actions aimed at reducing the delivery of these stressors to US waters. Future surveys will allow us to document changes in the extent of waters affected by these stressors and provide insights on the effectiveness of these programs and management actions. When conducted over the years, these assessments will allow us to answer those seemingly simple questions posed by Congress and the public: *How big are the problems we have? Are they getting better or worse? Are they widespread or localized? What are the major causes of the problems? Are our investments in water-resource protection and restoration improving water quality?*

Improving national surveys and assessments over time will require creative thought and insight from state, tribal, and federal scientists in partnership with researchers from academia, nongovernment organizations, and the private sector. The WSA was an important first step toward pulling the science together to produce a scientifically defensible assessment of the status of one type of aquatic resource in the US. The papers in this special issue highlight a few of the many technical issues that were tackled or will have to be addressed in the future to improve this type of national and regional assessment.

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