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Summary of Refinements; Design of the National Water Quality Network for U.S. Coastal Waters and their Tributaries

Introduction

In 2004, the U.S. Commission on Ocean Policy recommended a national monitoring network to improve management of ocean resources. In response to this report, the Council on Environmental Quality (CEQ), the National Science and Technology Council (NSTC) Subcommittee on Water Availability and Quality (SWAQ), and the Joint Subcommittee on Oceans Science and Technology (JSOST) charged the Advisory Committee on Water Information (ACWI) with the task of designing a national water quality monitoring network. ACWI is a federal advisory committee, which has membership representing federal and non-federal interests with a wide range of responsibilities for water resources. ACWI formally accepted the charge in February 2005 and delegated leadership for the effort to the National Water Quality Monitoring Council (Council), a subcommittee of ACWI which was asked to preparing a design by early 2006. The Council worked with about 80 individuals who represented 40 different organizations, including federal and state agencies, academia, interstate organizations, and the private sector to design the Network.

The report describing the Network design, "A National Water Quality Monitoring Network for U.S. Coastal Waters and their Tributaries" (hereinafter referred to as the Network), was accepted by ACWI in April 2006 and presented to CEQ, SWAQ, and JSOST. The full report can be found at http://acwi.gov/monitoring/network/design. Because of the scope and scale of the Network design, ACWI recommended one or more Pilot Studies to test and refine the design. ACWI also recognized the need to engage the monitoring community to refine some elements of the design by further developing core measurements and approached, including nutrients, contaminants, biological parameters, wetlands and atmospheric deposition. The refinements to the Network design are summarized in this report. These refinements were accomplished with the help of over 25 individuals representing about 12 Federal, state, and local agencies, universities, and non-governmental organizations who worked as volunteers on 5 workgroups. The full reports of each workgroup can be found at http://acwi.org/monitoring/_____

Nutrients

Issues related to nutrients that the Network was designed to address include nutrient enrichment, oxygen depletion, and habitat degradation. The Network design report indicates that the following resource components should be monitored for nutrients: estuaries, near shore coastal waters, offshore coastal waters, Great Lakes, rivers,

groundwater, and atmospheric deposition. The design report did not, however, specify the list of nutrients that should be tested for or appropriate detection limits.

The Nutrients Workgroup has developed a three- tiered list of nutrient parameters with corresponding analyses. Tier I parameters represent the required constituents; Tier II parameters represent the constituents that would add significant value but may not be essential to some programs. The Nutrients Workgroup also recommends that specific response variables and ancillary variables should be monitored; these measurements make up the third tier of monitoring. Chlorophyll *a* and dissolved oxygen concentrations are critical response variables. Salinity or conductivity, while not response variables, are critical parameters that should be monitored. Some of these related analyses will differ between freshwater and marine systems. For example, conductivity will be measured in freshwater systems, while salinity will be measured in marine systems. For all of the environmental components except wetlands, the Nutrients Workgroup recommends water sampling only. The Nutrients Workgroup does not recommend nutrient analysis in sediments except for wetlands, in part because sediments can be very heterogeneous on quite small spatial scales (meter or less).

As the Pilot Studies began to apply the recommendations of the Nutrients Workgroup, they pointed out that nutrient concentrations in many freshwater streams and rivers far exceed the detection limits listed in the workgroup report while recognizing that nutrient concentrations in many estuaries and coastal areas are near or below these limits. As a result of feedback from the Pilot studies, the original recommendations were modified. If 90% of the Network samples are above the method detection limit, that method detection limit may be used rather than the detection limit in the workgroup report. However, if some areas within the sampling region or some times of year are consistently below detection, a better method with a lower detection limit needs to be used.

Contaminants

The Network design report gave examples of contaminant groups to be included in Network monitoring: metals and metalloids, bulk organics, volatile organic compounds, pesticides, halogenated hydrocarbons, polycyclic aromatic hydrocarbons, and contaminants of new and emerging concern but did not list specific contaminants. Monitoring water resources is complicated by the fact that about 80,000 chemicals are produced and used in the world today, and few of them have been carefully assessed for their environmental impact. To compile a list of the contaminants that should be included in the Network design, the Contaminants workgroup reviewed the chemicals that are included in various national and regional programs. Their list of Network contaminants includes 243 specific compounds, identified by CAS number and by whether the compound should be tested for in water, sediments, fish tissue, or atmospheric deposition. The numbers of compounds by category is as follows:

- 28 metals and metalloids,
- 47 volatile organic compounds,
- 40 pesticides,

- 57 halogenated hydrocarbons, and
- 71 polyaromatic hydrocarbons.

The Network does not envision that regional and national monitoring will play an initial role in assessing contaminants of emerging concern because these are often without adequate risk profiles and often need to have laboratory methods developed before they can be adequately monitored. For this reason, the Network design assumes that Federal research programs will perform these functions and does not specify contaminants of emerging concern among its analytes.

As the Pilot Studies began to review the list of contaminants, they recommended that some flexibility should be introduced into the Network design for contaminants. Specifically, there is a need to remove some compounds or reduce the frequency of testing based on non-detects in the study area and knowledge of chemical use in the watershed. The Network design has always included flexibility to add second tier of contaminants based on local issues and occurrence of contaminants in the study area.

Wetlands

The Network design document did not specify an approach for wetlands monitoring due to a lack of consensus within among wetlands experts about which wetland characteristics were most important for a national and regional design. The complexity of wetland ecosystems, the intense and increasing pressures of human activities in coastal watersheds and water bodies, and different views on the wetland structure and function are significant impediments to creating a consistent suite of monitoring parameters and assessment techniques that could be applied widely, if not nationwide. It is generally understood that water quality-related monitoring of coastal wetlands is highly varied, both in terms of spatial scales and parameters. A systematic effort to develop a suited of key monitoring parameters is underway, in anticipation of a probability based survey of wetlands by the U.S. Environmental Protection Agency and its partners in 2011.

The Wetlands workgroup recommends a three-tiered approach as the best course of action for developing a coastal wetland monitoring strategy. Each tier has a different level of spatial resolution and scientific detail. Tier-1 observations which include landscape-level observations may be most useful to decision-makers. Those observations should be backed by scientific data and understand of the processes that culminate in landscape level changes. Ideally, lower-tier indicators, which include site specific measurements should be highly correlated (or associated with) with Tier-1 indicators.

Examples of the types of measurements under a tiered approach are as follows

Tier 1: National Wetlands Inventory data as supplemented by region-specific observations from satellite or aerial reconnaissance including:

a) Change in spatial coverage

b) Patch metrics; size and formation of interior ponds
c) Rotten spots / brown marsh / die-offs
d) Coastal watershed use (agriculture, urban, etc.)

Tier 2: Rapid Assessment and field testing of "visible indicators" by trained personnel including:

a) Water availability [floods, droughts, diversions, impoundments]
b) Extent of Hydric soil
c) Habitat loss
d) Recreation / harvest
e) Habitat restoration
f) Invasive species
g) Parasitic infestations
h) Gross pollution

Tier 3: Intensive observations such as detailed, laboratory based measurements focusing on a particular wetland including:

a) Soil / sediment characteristics [grain size, bulk density, organic carbon, toxic chemicals and trace elements, etc.]
b) Porewater characteristics [salinity, dissolved organic and inorganic nitrogen and phosphorus]
c) Channel water characteristics [tide range, salinity, temperature, pH, dissolved oxygen, chlorophyll, dissolved organic and inorganic nitrogen and phosphorus, suspended particulate matter characteristics]
d) Primary producers [dominant vegetation, chlorophyll and estimated productivity, percent native species, and amount harvested]
e) Habitats and biological community structure [bird census, fish assemblages, animal scat surveys, habitat affinities of "signature" species, indicator parasites (for example, trematodes), ecological process indicators (for example, production: biomass ratio, biomass-size spectra, trophic structure, carbon-nitrogen-phosphorus ratios (for example, Redfield ratio and Atkinson ratio), carbon source identification (e.g., isotopic signatures), species-abundance-biomass or SAB relationships), etc.]

Biology

The Network design document lists several kinds of biological assessments including chlorophyll *a*, algae, bacteria, macro-invertebrates, and fish but is not specific about the individual measurements and frequency of observations that will be appropriate in different resource compartments, e.g., estuaries, coastal ocean, etc. The task of the Network refinement workgroup for biological measurements was to define a small set of water-quality measurements that would be most fruitful for assessing the condition and forecasting response of coastal ecosystems to natural and anthropogenic stressors. The environmental compartments that included the workgroup report are biological

measurements for estuaries and coastal bays, nearshore and continental shelf waters, the Great Lakes, wetlands, and rivers.

Largely due to conceptual limitations, varied thresholds and criteria, and different computational schemes, the workgroup report does not have a prescribed set of indices or derived parameters for assessing ecological conditions, ecosystem services, or degree of impairment of water bodies. Rather, it provides primary and ancillary data that may be used for developing such assessments or environmental indicators with broad regional or nationwide application. Several "biological" variables are covered in other refinement subgroups, for example water color and chlorophyll in the "nutrient workgroup" and levels of toxic chemicals in sentinel species in the "contaminant workgroup." Thus, these variables did not need to be considered by the biology working group.

General criteria for selection of parameters included the following:

1. They are measurable with a low margin of error, such that a "change" can be detected after a reasonable sampling effort and decision-making time-frame.
2. They are not costly to obtain; at least the cost should be related to the value of information being provided.
3. They are based on consensus and "expert counsel."
4. They are responsive to environmental conditions (or stressors), preferably in a monotonic way.

Top priority biological measurements and observations recommended by the biology workgroup includes:

- habitat mapping, such as benthic habitat and changes in the shoreline;
- microalgae density as determined by aerial reconnaissance and selected field sampling;
- seagrass cover;
- incidence of pathological conditions and deformities in fish;
- sediment quality triad which integrates levels of toxic contaminants, toxicity tests, and benthic infaunal distribution; and
- dissolved oxygen.

Tier 1 Network measurements have specific sample methods and frequency. Lower priority measurements have less specificity and rely more on local knowledge. Foe example, the San Francisco Bay Pilot currently includes bird community assessments and the presence of non-indigenous species because of the importance of these biological resources in the study area.

Atmospheric Deposition

It is not feasible to make all of the necessary complex measurements at all locations where data are needed to estimate atmospheric deposition to a large number of water bodies via direct deposition to the water surface and to the land areas adjacent to water bodies (below the last gaged inflow). Therefore the Atmospheric Deposition workgroup recommends an approach that includes benchmark stations, where a number of complex

(wet, dry, micrometeorology, speciated mercury, PBTs etc) measurements are made, and an array of simpler sites (supporting stations) surrounding them where measurements can be used to extrapolate and estimate across the broader area of interest. At present, it is unlikely that comprehensive all-constituent wet and dry deposition monitoring sites exist in the areas of interest needed by the Network. Thus, if a two-tiered approach to monitoring is impractical because of resource limitations, modeling atmospheric deposition components, supported by verification from station measurements may be the only viable alternative.

There is currently no over-water deposition monitoring network (with one exception-Smith Island, MD). Therefore if resources allow, at least one over water, weekly wet deposition collection site should be deployed in each of the identified estuaries, as is appropriate and feasible. Platforms to consider are: buoys, islands, extended piers, or fixed platforms. This would be the minimum spatially for direct over-water observations and weekly collection would be the minimum temporally. This approach would enable testing of the hypothesis that near on-shore wet deposition is regionally representative of near off-shore wet deposition. Occasional ship based measurements on platforms of opportunity (i.e. cruises for other purposes) are also recommended to evaluate model validity for offshore deposition. If buoy technology is available, buoys may be used as platforms for deposition measurements; however, ship/small boat time expenses to service/sample collectors will be large unless it is leveraged against other existing monitoring efforts. Absent over-water monitoring locations, utilize islands (barrier beach etc) whenever possible to get better routine measurements away from shore. Use models to interpolate where measurements can not be made, however the errors associated with modeling deposition results over a water surface remain as a significant knowledge gap in this endeavor.