United States
Environmental Protection
Agency
Research and Development

Atmospheric Research and Exposure
Assessment Laboratory
Research Triangle Park, NC 27711
EPA/600/S4-91/026 Oct. 1991

EPA

Project Summary

Example Environmental Assessment Report for Estuaries

Jeffrey B. Frithsen, Jeroen Gerritsen, A. Frederick Holland, Stephen B. Weisberg, Mary C. Fabrizio, and Gary Saul

The Environmental Monitoring and Assessment Program (EMAP) is a comprehensive, multiagency program designed to assess the condition of the nation's ecological resources at national, regional, and subregional scales. Data and information collected by EMAP will be integrated with data from other monitoring programs and environmental information of other types to produce periodic environmental assessment reports. These reports will assess the extent and magnitude of pollution impacts, report trends, describe relationships among indicators of ecological condition, contaminant exposure, and environmental stress, identify the likely causes of poor ecological condition, and evaluate the overall effectiveness of regulatory and control programs on regional scales. This report presents an example environmental assessment report for estuaries, one of seven types of ecological systems or resource categories to be monitored by EMAP. Using hypothetical data and a fictional estuarine system, the example demonstrates the types of information that will be provided by EMAP and how that information can be interpreted in the context of national environmental policy. The preparation of the example report helped to develop an analytical framework for environmental monitoring data and to identify analytical and statistical tools needed to conduct regional environmental assessments. The framework and tools are discussed in separate sections of the report that describe how the example report was prepared and the lessons learned by EMAP scientists in preparing it.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Environmental Monitoring and Assessment Program (EMAP) is a comprehensive, multiagency program designed to assess the condition of the nation's ecological resources. The program is being designed by the EPA and other Federal agencies and is coordinated by EPA's Office of Research and Development. EMAP was initiated out of the need to make conclusive, statistically supportable statements about the cumulative effectiveness of regulatory programs, the overall condition of the nation's environmental resources, and long-term trends in ecological condition. Such statements are not possible using the data and information from existing regulation and monitoring activities.

The monitoring and assessment activities of EMAP are designed to provide answers to the following questions:

- What is the current status, extent, and geographic distribution of the nation's ecological resources?

- What proportions of these resources are degrading or improving, where, and at what rate?
- What are the possible reasons for adverse or improving conditions?
- Are adversely affected ecosystems responding as expected to control and mitigation programs?

EMAP will be implemented in seven types of ecosystems or ecological resources: estuaries and coastal waters, inland surface waters, the Great Lakes, wetlands, forests, arid lands, and agricultural lands. Information on the condition of each resource category will be provided in the form of statistical summaries and environmental assessment reports. Statistical summaries will be produced annually and will provide timely dissemination of EMAP data in tabular and graphic form. Environmental assessment reports will be produced to integrate EMAP data with data from other monitoring programs and with environmental information of other types (e.g., NPDES permit discharge reports, USGS National Water Quality Assessment (NAWQA) data, NOAA Status and Trends Program data). Assessment reports will:

- assess the extent and magnitude of pollution impacts,
- report trends,
- describe the relationships among indicators of ecological condition, exposure, and stress,
- identify the likely causes of poor ecological condition,
- help identify emerging problems, and
- evaluate the overall effectiveness of regulatory and control programs on regional scales.

As currently envisioned, assessments will be conducted at four levels of environmental complexity. At the first level, assessments will be focused on a particular environmental resource (forests, for example) within one biogeographic province or region. At the second level of integration, assessments will focus on a particular environmental resource across multiple regions. For example, an assessment might be made of all east coast estuaries by integrating information collected in the Acadian, Virginian, Carolinian, and West Indian Provinces. The third level of assessment activity to be conducted by EMAP requires the integration of information and data across resource groups, for a complete assessment of conditions within a biogeographic province or region. This level of assessment may be made for particular EPA regions and would not only integrate and compare conditions within multiple types of environmental resources, but also attempt to identify how conditions and changes in conditions in one resource affect another. A specific assessment might address how changes in land use in watersheds impact the condition of surface waters and estuaries. Assessments that require integrating information about multiple resources across multiple biogeographic provinces or regions are the fourth level of assessment activity envisioned for EMAP. These assessments will describe the conditions of environmental resources at the national level.

About a year ago, EMAP scientists assembled to discuss how EMAP assessments might be conducted and what types of analytical and statistical tools would be needed for these assessments. The objective of these discussions was to design and produce an example EMAP assessment report for one ecological resource in one biogeographic region (a first level assessment). The purpose of this document is to outline how the example report was developed, and document the lessons learned in preparing it.

Procedure

Estuaries were chosen as the ecological resource for the example assessment report because the first demonstration project for EMAP was being conducted in estuaries. The development of the example assessment report required the analysis of a data with spatial and temporal scales similar to those expected for EMAP data sets; however, no comparable studies of estuarine systems over large regional scales and decades exist. Most existing datasets that have broad spatial coverage include only a few years of data, and data collected over long time periods usually have restricted geographic coverage. Consequently, a dataset was fabricated to provide the spatial and temporal resolution needed to complete the example assessment report.

The dataset developed for the example assessment spans 12-years, representing three cycles of the four-year interpenetrating sample design of EMAP. The dataset was developed in four steps. First, a subset of the indicators proposed for the estuarine component of EMAP was selected based upon knowledge of the data commonly available for estuaries. The selected indicators included bottom dwelling (benthic) community abundance, biomass and number of species, three contaminants in fish tissues (mercury, lead, and total DDT), and one fictitious fish tissue contaminant (contamexx) representing a contaminant that would contribute to environmental degradation in the future. These indicators of ecological response were supplemented with indicators of environmental exposure (i.e., concentrations of mercury, lead, total DDT, and contamexx in sediments, sediment toxicity, and dissolved oxygen concentrations) and habitat indicators (i.e., salinity and sediment type).

Second, data for the selected indicators from various east coast estuaries were assembled to define spatial and temporal ranges and variability that can be expected in EMAP data. East coast estuaries were selected because more information is generally available and because an EMAP demonstration project was occurring at the same time in the Virginian Province (Cape Cod to the mouth of Chesapeake Bay). Using these data and various interpolation techniques, a one-year base dataset was developed for all EMAP sample stations in the estuaries of the Virginian Province.

The third step consisted of superimposing various trends onto the base dataset for years 2 through 12. Trends were introduced into the fabricated dataset by imposing proportionate changes on values in the base dataset. Trends represented:

- monotonic increases or decreases of a constant amount for each year and for all stations,
- improvements of conditions at the worst stations due to the overall successes of regulatory and control measures,
- degradation of conditions at the best stations due to population growth and urban development,
- significant increase in the manufacture and agricultural use of contamexx in one of the administrative regions of the province.

The fourth step in development of the fabricated dataset was to convolute the geography of the Virginian Province while maintaining the proportionate distribution of the number and area of estuaries among the three classes of estuaries (large estuaries, large tidal rivers, and small estuaries). This convolution was necessary to prevent the example assessment from being mistaken for an actual assessment of estuaries within the Virginian Province. A fictional island was created by rearranging portions of coastline from the Virginian

Province. Land use and watershed boundaries were established arbitrarily, and the island was split into two administrative regions. Collectively, these regions were called Estuaria in the example report.

Early in the development of the example assessment report, it became apparent that information about various indicators would have to be integrated to make meaningful statements about the overall condition of estuaries. Such integrated statements were made using indices, or mathematical aggregations of response indicators. Although individual response indicators provide information concerning specific aspects of environmental condition, overall statements regarding the condition of resources are more useful to managers and non-scientific audiences. Single, integrated statements can be communicated and understood more easily, and are more appropriate for measuring and communicating progress towards environmental goals.

The degree to which information and data will be aggregated by EMAP scientists to create indices of ecological or environmental condition is unknown. In the example report, a benthic community index was developed and used to represent a biological condition index. A human use index based on fish tissue contaminants was developed to represent aspects of estuaries valued by society. However, an overall estuarine condition index was not developed because of reservations concerning combining disparate indices such as the biological condition index and human use index. Most likely, the development of an overall index will involve a cadre of specialists from both the natural and social sciences and will not be completed by resource group scientists alone.

Discussion

The development of assessment methodologies is an important part of the planning and research activities of EMAP. The preparation of this example report represents a first step in this development. It is unlikely that this example report will become the template for future EMAP assessment reports. However, the lessons learned from producing the report will be useful in shaping assessment methodologies and approaches.

The resulting example report is valuable to potential EMAP clients and performs the following important functions. The report provides a "preview" of EMAP data and assessment reports to potential clients; a tool (i.e., the example dataset) for evaluating alternative analytical approaches and selected aspects of the sampling design; identifies technical problems and helps establish priorities for addressing those problems; and begins to educate and train a team of scientists to perform actual EMAP assessments.

The lessons learned in preparing this example report are applicable to other EMAP resource groups. The exercise of producing the example report resulted in the following guidelines for analyzing EMAP data and producing an actual assessment:

- Because of the diverse nature of the data, the approach for analyzing, interpreting, and presenting the data must be flexible. This is especially important for long-term programs, such as EMAP, in which program elements may change over time.
- Assessments of ecological condition that are useful to resource management and policy development require a clear definition of nominal and subnominal conditions and establishment of subnominal-marginal thresholds for indicators and indices.
- Investigation of associations will require data for applicable stressor indicators (e.g., human population density, atmospheric deposition, loadings).
- Statistical methods will need to be identified for investigation of associations between stressor indicators at regional or watershed resolution and exposure and response indicator data at much finer spatial resolution.
- Sufficient time must be allowed for exploratory statistical analyses and for the assessment of information. Analytical investigations of complex and varied data cannot be constrained by rigid strategies for data analysis; analysts must be free to explore the data in ways that may be dead ends but also may lead to a new understanding of the relationship between natural and anthropogenic stresses and environmental condition.

Assessment reports communicate information that culminates years of effort by each resource group. The production of these reports will require far more sophisticated analyses and careful decision-making than data reporting in annual statistical summaries. As an example of this difference, we call attention to the experience of NAPAP (National Acid Precipitation Assessment Program), which required tremendous effort at the end of the program to produce an integrated assessment of acidic deposition. EMAP, with a broader scope than NAPAP, will require not only greater efforts, but continuous dedication to the objective of integrated assessment in order to provide useful information and insightful assessments of ecological condition.

☆U.S. GOVERNMENT PRINTING OFFICE: 1991 - 648-080/40105

Jeffery B. Frithsen, Jeroen Gerritsen, A. Frederick Holland, and Stephen B. Weisberg are with Versar, Inc., Columbia, MD 21045. Mary C. Fabrizio is with Mantech Environmental Technology, Inc., Research Triangle Park, NC 27709. Gary Saul is with FTN Associates, Ltd., Austin, TX 78741.
Linda Kirkland is the EPA Project Officer (see below).
The complete report, entitled "Example Environmental Assessment Report for Estuaries," (Order No. PB92-100338/AS; Cost: $19.00; subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703)-487-4650
The EPA Project Officer can be contacted at:
Office of Modeling, Monitoring Systems and Quality Assurance
U.S. Environmental Protection Agency
Washington, DC 20460

United States
Environmental Protection
Agency

Center for Environmental
Research Information
Cincinnati, OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

Official Business
Penalty for Private Use $300

EPA/600/S4-91/026