FINAL REPORT

on

TECHNICAL INFORMATION AND RESEARCH NEEDS TO SUPPORT A NATIONAL ESTUARINE RESEARCH STRATEGY

to

U.S. Environmental Protection Agency

January 1986

Contract No. 68-01-6986
Work Assignment No. 18
Amendment No. 3

Work Assignment Manager: Dr. Victor Bierman (ERLN)

Prepared by

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P.O. Box 1027
Westford, MA 01886

for

BATTELLE
Washington Environmental Program Office
2030 M Street, N.W.
Washington, D.C. 20036

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EXECUTIVE SUMMARY

This document provides information on research and assessment needs that can be used to develop an estuarine research strategy for EPA's Offices of Research and Development (ORD) and Marine and Estuarine Protection (OMEP). The research strategy that is being developed within EPA, and which this document supports, is directed primarily at the development of analytical tools, and process, effects, and assessment related information that can assist Regional and State personnel charged with the responsibility of managing estuarine water quality and coastal habitats. As such, the research strategy is parallel to and supportive of the estuarine management initiatives being implemented by OMEP.

The overall approach used to identify information and research needs for consideration in the research strategy involved the following steps:

- o environmental issues and associated information needs were identified through discussions with Regional EPA and State personnel and OMEP;
- o current programs (primarily national) designed to address the identified information needs were reviewed;
- o a document was prepared to serve as a framework for a workshop on estuarine research needs; the document included the results of the first two phases and provided a preliminary list of generic and specific research topics which addressed the identified information needs;
- o a workshop on estuarine research needs was conducted; workgroups were established for major topic areas and these groups focused on the research needs within that area; the initial document was used as a resource;
- o the initial document was modified to reflect the input and research recommendations of the workgroups.

Based upon discussions with State and Regional personnel several general topic areas emerged with regard to environmental concerns and estuarine research needs. These included:

- o Toxics (in sediments and water);
- o Nutrients (in particular their role in eutrophication and the occurrence of anoxia);
- o Microbial Contamination (in shellfish, shellfish waters and recreational waters);

- o Estuarine Habitat Modification (habitat loss, mitigation, as well as the role of wetlands as wastewater treatment systems);

- o Estuarine Characterization (including physical characterization of "non classical" estuaries as well as indicators of the "health status" of estuaries.

These five topical areas are used to organize information presented in this document and served as the basis for establishing workgroups at the estuarine research workshop.

Where appropriate, this document has used as a framework the Risk Assessment Approach utilized previously by the EPA Research Laboratory at Narragansett to assess ocean dumpsite designation, evaluation of hazards posed by ocean disposal, and identification of research needs related to disposal of specific wastes into the ocean. The risk assessment approach provides a means of identifying critical pieces of information and organizing them into a comprehensive but focused assessment of the fate and probable effects of pollutants in marine systems. Because the approach outlines the kinds of generic information and analytical methods that are needed to conduct assessments, it also provides a tool for identifying critical information gaps and areas where analytical methods development are needed.

At the workshop, the workgroups were asked to develop Problem Statements which related to the information needs identified by State and Regional personnel. For each of these problem statements one or more Broad Objectives and associated Specific Objectives were identified which best addressed the various components of the Problem Statement. The workgroups then considered the extent to which the specific objectives were met or could be met by existing information. If information was available but not in a form that was directly useful to State and Regional regulatory personnel, the workgroups were directed to identify Assessments that would involve organizing or synthesizing existing information into appropriate support documents. If information was not available or if there was a need for additional research to address an information need, the workgroups identified specific Research Needs. The workgroups were asked to describe the anticipated results under each of the Broad Objectives and how these related to management or regulatory activities.

Summaries of the problem statements identified at the workshop and addressed within this document are presented below for each of the five broad topic areas.

TOXICS

Concerns related to the potential environmental and human health effects of toxics, especially in sediments, were expressed by all the EPA Regional and State personnel contacted as part of this program (see Appendix A). The discharge of toxics to estuarine systems and the presence of toxics in sediments affect a broad range of regulatory and estuarine management decisions. As outlined in Section 3 of this report, a risk assessment framework provides a rational and technically supportable basis for such decisions. Yet, there is no well established, validated risk assessment method(s) for toxic chemicals in estuaries.

The workgroup for toxics recommended that efforts be made to 1) develop and validate exposure assessment models, 2) develop and field test appropriate methods for assessing effects of toxics, and, 3) conduct a field validation of exposure and effects assessments. The latter was considered particularly critical for linking exposure and effects assessments. An emphasis was placed on information needs related to dealing with toxics in sediments. This was viewed as a problem that affected a broad range of management activities. One aspect of this focus is the development of technically sound sediment quality criteria.

NUTRIENTS

A major deficiency in current understanding of the effects of nutrient loading on estuarine water quality and estuarine-dependent species is how nutrients are recycled within and lost from estuarine systems. This lack of information impedes the development of technically sound waste load allocations and accurate predictions of nutrient-related impacts.

The workgroup on nutrients recommended that information be developed on 1) nutrient residence times and cycling in estuarine systems, 2) the effects of nutrients on critical biological components in estuarine systems, 3) oxygen dynamics in estuaries and the effects of reduced oxygen on estuarine biota, and 4) the effects of increased nutrient levels on the bioavailability and effects of toxics. The group recommended that a combination of field, mesocosm, and laboratory approaches be used to meet the information needs.

MICROBIAL CONTAMINATION

The risk of gastrointestinal illness due to ingestion of shellfish harvested from waters contaminated by non-human fecal waste (i.e., from wild and domestic animals and birds) is unknown. This information gap precludes the promulgation of scientifically defendable guidelines for shellfish waters by regulatory bodies. The workgroup on microbial contamination

recommended that a health effects water quality criterion be developed which relates the quality of shellfish harvesting waters contaminated by non-human fecal waste to gastroenteritis associated with shellfish ingestion.

Because there is no adequate microbiological indicator system that can differentiate between human and non-human sources of microbial contamination (pollution), the workgroup suggested that a microorganism, group(s) of microorganism or by-product be identified that would originate solely from humans and be indicative of human pathogens. The workgroup also noted that improved methodology is required for locating and characterizing sources of microbial pathogens in estuaries and that there is a need for a generalized effluent model for determining the microbial indicator levels in wastewater effluents (site-specific effluent guidelines or standards) needed to achieve the water quality guidelines and standards at potentially affected recreational or shellfish growing areas. Finally, the workgroup stated that there is a need for treatment systems that will be effective at reducing levels of pathogens, including viruses.

ESTUARINE HABITAT MODIFICATION

The workgroup on estuarine habitat modification noted that the inability to predict the long-term cumulative impacts of habitat changes makes habitat protection difficult. In connection with this they recommended that 1) the feasibility of developing a comprehensive, national inventory of permitted and actual alterations of estuarine habitats be evaluated, the effects of cumulative estuarine habitat modifications and losses be examined, 3) a technical basis be developed for predicting and minimizing wetland losses or modifications under conditions of accelerated sea level rise which may occur during the next 50 years, and 4) the causes of declines in submerged aquatic vegetation be reviewed.

The workgroup noted that little is known regarding the effectiveness of estuarine habitat mitigation, restoration and management practices on valued resources, such as support of fisheries and wildlife or waste assimilation. Therefore, they recommended the development of a technical basis for effective mitigation, restoration and management practices. They also recommended the development of a procedure for assessing functions and values of various estuarine habitats for management, protection, and/or restoration of estuarine resources.

Finally, the workgroup observed that while wetlands are widely recognized as potential sinks for certain nutrients, toxics, and sediments, the current knowledge in this field is both fragmentary and contradictory. They recommended that an effort be made to develop the ability to predict the retention and processing characteristics of specific estuarine wetlands.

ESTUARINE CHARACTERIZATION

The workgroup on estuarine characterization noted that there is no widely accepted process by which managers can assess estuarine status relative to protection of human health and protection or restoration of biological resources. They recommended that appropriate indicators, measures, and methodologies be developed for providing this information. Such information should enable an estuarine manager to compare the status of different estuaries as well as to assess the rate of change of a particular estuarine system. The workgroup also noted that at present, no adequate system exists for accessing environmental data on estuaries that have been collected through a variety of State and Federal monitoring and experimental programs. They recommended improvements in this area.

Each workgroup also provided recommendations on how specific objectives might be carried out. Overall, the effort is one that will require careful coordination within EPA as well as among the various agencies (e.g., NOAA, Fish and Wildlife Service) that have responsibilities for various aspects of marine and estuarine research. The present document is the product of considerable input from a number of individuals from a number of agencies and academic affiliations and is indicative of what can be accomplished in the spirit of cooperation.

1 Introduction

1.1 Statement of Objectives and Scope

The objective of this document is to provide information that can be used to develop an estuarine research strategy for EPA's Offices of Research and Development (ORD) and Marine and Estuarine Protection (OMEP). The document will be used as a resource by these offices and by the Consolidated Water Research Committee in the planning process for estuarine and near coastal water quality research in FY 87 and beyond. A major objective of this document is to focus on environmental issues, information needs, and related research that have been identified by Regional EPA and State personnel inasmuch as these individuals are the eventual users of the research outputs.

The research strategy that is being developed within EPA, and which this document supports, is directed primarily at the development of analytical tools, and process, effects, and assessment related information that can assist Regional and State personnel charged with the responsibility of managing estuarine water quality and coastal wetlands. As such, the research strategy is parallel to and supportive of the estuarine management initiatives being implemented by OMEP. Emphasis has been placed on information needs that are common to many estuaries throughout the United States as well as on needs that are narrower geographically but for which information is greatly needed.

1.2 The Need for an Estuarine Research Strategy

The need for an estuarine research strategy is predicated upon the following:

1. There are a myriad of environmental issues that have been identified with regard to estuarine water quality and coastal wetlands (see Appendix A). With regard to allocation of resources, strategy guidance provides a means of identifying issues that are particularly important and common to many estuaries throughout the United States as well as issues that are narrower geographically but for which information is greatly needed.

2. Estuaries are complex physical and chemical environments which differ from freshwater and open ocean systems. In EPA's Technical Guidance Manual for Performing Waste Load Allocation for Estuaries (Southerland et al. 1984) it is noted that estuaries are among the most complex of all aquatic systems. Estuarine water chemistry is dominated by the existence of both vertical and longitudinal gradients in salinity. Such gradients are transient, and vary with changes in freshwater discharge into the estuary and tidal fluctuations at the ocean boundary.

These gradients can have pronounced effects on chemical and physical processes which in turn affect the fate of materials discharged into the estuary. For example, as suspended particles transported downriver encounter the increased salinity of the estuary they may begin to form flocs and settle more rapidly to the estuarine sediments. The physical and chemical variability brings about a corresponding variability in the estuary's natural biota. In fact, there are some estuarine species whose life cycles are closely tied to the complex chemical and physical regimes encountered within the estuary.

Thus, assumptions concerning fate and effects of pollutants based upon studies in freshwater or open ocean systems may not apply directly to estuarine environments. The need for information specific to estuarine systems was mentioned by Regional EPA and State personnel who provided input to this document.

3. Many estuaries are especially important as productive nursery areas for fish and invertebrates and many coastal marine species depend on estuaries during either part or all of their life cycle. These species include many that are of great importance to commercial and recreational fisheries. Research related to providing the necessary information to those charged with managing estuarine quality is, therefore, particularly critical.

4. Finally, because estuaries often provide good harbors, human population centers and industrial development have tended to concentrate around these marine areas. As a result, estuaries can be subject to heavy inputs of a variety of wastes emanating from both point and non-point sources. In addition, heavy development has resulted in extensive wetland loss in various parts of the country. Therefore, the effective management of estuaries and associated wetlands is especially important if these areas are to be maintained, preserved, or enhanced. This may involve determining the desirable uses of an estuary, developing criteria for the most stringent of the desired use, and applying these criteria so all other uses are maintained. A carefully developed research strategy will help support estuarine management initiatives along these lines.

2 Approach

2.1 Outline of Basic Approach

The overall approach used to identify information and research needs for consideration in the research strategy involved the following steps:

- o environmental issues and associated information needs were identified through discussions with Regional EPA and State personnel and OMEP;
- o current programs (primarily national) designed to address the identified information needs were reviewed;
- o a document was prepared to serve as a framework for a workshop on estuarine research needs; the document included the results of the first two phases and provided a preliminary list of generic and specific research topics which addressed the identified information needs;
- o a workshop on estuarine research needs was conducted; workgroups were established for major topic areas and these groups focused on the research needs within that area using the initial document as a resource;
- o the initial document was modified to reflect the input and research recommendations of the workgroups.

The major elements of the approach are described in subsequent subsections. The conceptual framework used for the document and the guidance provided to workshop participants are described in Section 3.

2.2 Identification of Issues and Information Needs

This first step in the approach was considered the most critical. OMEP together with Regional EPA and State personnel are the eventual users of the research products and, thus, it is essential that research efforts be focused on the information needs identified by these personnel. OMEP has the overall responsibility for coordinating estuarine management programs. The research effort within ORD should serve to provide analytical tools and information that will support management initiatives as discussed below. Meetings and discussions were held with OMEP, Regional EPA, and State personnel in order to obtain a broad range of input on overall research strategy, environmental issues in estuaries, and information needs.

Technical Support for Management Decisions

OMEP has prepared a Draft Guidance Manual for Estuary Protection Programs (USEPA, 1985a) which identifies the various regulatory activities that may be integrated within an estuarine management program. With regard to EPA's direct responsibilities these include:

- o Construction Grants and Related Programs
- o NPDES Permitting, Compliance and Enforcement
- o 208 Water Quality Management Planning, use designations, and water quality standards. (Note: OMEP believes that estuary programs may ultimately require the States and EPA to review and revise 208 plans in response to program findings.)
- o Water Quality Management Related to State Applications for Grants Under CWA Sections 106 and 205(j)
- o Combined Sewer Overflows
- o Groundwater/Nonpoint-Source Control Trade-offs
- o Ocean Dumping (e.g. dredged material)
- o Dredge and Fill Activities
- o 301 (h) Waiver Applications
- o Environmental Impact Statements for Activities of Other Federal Agencies
- o Superfund-Related Activities Near or In Estuaries
- o RCRA-Related Activities Near or In Estuaries

Management decisions are involved in all of the above regulatory activities within EPA's responsibility for permitting or review. Based upon discussions with OMEP, EPA Regional, and State personnel, there are certain areas that are in particular need of support from a research standpoint. These include:

- o Water Quality-Based Nutrient and Toxics Control. These would be based on regional waste load allocations. Implementation of load allocations would involve the NPDES permit system and diffuse source controls where necessary.

- o In-place toxics (within sediments).

- o Wetlands functions (e.g. pollutant buffering capacity) and impacts of development including dredge and fill operations.

OMEP's Guidance Manual for Estuary Protection Programs (USEPA,1985a) notes that, "research projects will typically be needed to supplement existing scientific knowledge of processes determining the fates and effects of pollutants in specific estuaries. In estuary protection programs, it is only necessary and appropriate to support research efforts into subjects where understanding of an estuary's environmental processes is insufficient to predict results of potential alternative pollution control programs. For example, there will typically be

a need for research efforts to help set values on hydrological or water quality model components such as pollutant transport and transformation rates.

Research, involving for example experimental manipulation of test systems, or collection of data from new locations or under previously untested conditions, is sometimes the only method that can test hypotheses about causal relationships between particular pollutants and environmental effects, when analysis of historical trends and correlations alone cannot distinguish between one hypotheses and another." It is reasonable to expect that some of these research needs will be common to a number of estuaries and regions of the country and, therefore, a research strategy focused at these common needs represents an efficient approach towards providing information needed by EPA Regional and State personnel.

Issue Identification and Information Needs at the Regional Level

Input on environmental issues and research needs in each of the EPA regions with coastal states was obtained primarily through meetings with Regional EPA and State personnel with additional input being obtained via telephone. Detailed trip reports are presented in Appendix A and have been reviewed by the EPA, State, or other personnel who were involved in the meetings. Information on the Chesapeake Bay Program was provided by OMEP and is summarized in a presentation made by Thomas DeMoss of OMEP (Appendix B). Based upon these discussions several general areas emerged with regard to environmental concerns and estuarine research needs. These included:

- Toxics (in sediments and water);
- Nutrients (in particular their role in eutrophication and the occurrence of anoxia);
- Indicators of Microbial Contamination (in shellfish, shellfish waters and recreational waters);
- Estuarine Habitat Modification (habitat loss, mitigation, as well as the role of wetlands as wastewater treatment systems);
- Estuarine Characterization (including physical characterization on "non classical" estuaries as well as indicators of the "health status" of estuaries.

These five topical areas have been used to organize information presented in this document and served as the basis for establishing workgroups at the estuarine research workshop.

2.3 Review of Current Programs

Individuals and organizations currently involved with research related to the identified information needs were contacted in order to obtain additional information on their programs and to learn about the future direction of their research efforts. Among the documents that were utilized in identifying current research efforts were National Marine Pollution Program: Catalog of Federal Projects (NOAA, 1984) and FY-1985 EPA Research Program Guide (USEPA, 1984). It was beyond the scope of this project to identify all ongoing work that related to estuarine research issues but an effort was made to consider federally-funded programs that related to information needs identified by Regional EPA and State personnel. The major programs reviewed for this document are listed in Table 1. Summaries of these programs were provided to workshop participants for their review prior to the workshop. The participants at the workshop utilized the reviews and supplemented them with their own experience in their evaluation of research needs.

2.4 Document and Workshop

Generic and specific research and assessment topics were identified in the initial document provided to workshop participants. This involved an initial evaluation of the extent to which information needs were being addressed by existing programs and making preliminary judgements on where additional emphasis should be placed to supplement ongoing programs or to address areas that were not receiving adequate attention.

The initial document received a limited review by selected individuals within EPA ORD and OMEP, and NOAA. Initial review comments were addressed and the document was provided to workshop participants to serve as a resource. All participants were asked to conduct a technical review of the document prior to the workshop.

A three-day Estuarine Research Workshop was held in November, 1985 in Rhode Island. Five workgroups were established to address the topical issue areas identified through discussions with State and Regional regulatory personnel (Section 2.2). The Workgroups and associated chairmen included:

Workgroup	Chairman
Toxics	Dr. Dominic DiToro Environmental Engineering Manhattan College

Table 1. Information reviewed for document preparation.

- O NOAA'S NATIONAL MARINE POLLUTION PROGRAM: CATALOG OF FEDERAL RESEARCH IN THE U.S.
- O EPA TECHNICAL SUPPORT DOCUMENTS FOR WATER QUALITY BASED PERMITS, TOXICS CONTROL, WASTE LOAD ALLOCATION
- O ACOE NATIONAL WETLANDS FUNCTIONS AND VALUES STUDY PLAN
- O ACOE EFFECTS OF DREDGING PROGRAM
- O DEPARTMENT OF AGRICULTURE STUDY PLANS
- O NOAA PROGRAMS
  - INDICATORS OF ENVIRONMENTAL HEALTH
  - NATIONAL STATUS AND TRENDS
  - CONSEQUENCES OF CONTAMINANTS
  - STRATEGIC ASSESSMENTS
  - SEAGRANT PROGRAMS
  - REGIONAL STUDIES ON FISH AND SHELLFISH
- O EPA PROGRAMS AND INITIATIVES
  - NARRAGANSETT ERL PROGRAMS
  - GULF BREEZE ERL PROGRAMS
  - ROBERT S. KERR ERL PROGRAMS (GROUNDWATER)
  - RESEARCH INITIATIVE - COMPLEX MIXTURES
  - EPA RESEARCH PROGRAM GUIDE
  - RESEARCH INITIATIVE - HEALTH EFFECTS ASSOCIATED WITH SHELLFISH CONSUMPTION
  - RESEARCH INITIATIVE - WETLANDS
  - BAYS PROGRAM PLANS AND REPORTS
  - TECH SUPPORT DOCUMENTS
  - ODES DOCUMENTATION
- O FISH AND WILDLIFE SERVICE PROGRAMS
  - IMPACTS OF CONTAMINANTS ON STRIPED BASS
  - CONTAMINANT TRENDS AND EFFECTS IN BIRDS/MAMMALS

Nutrients	Mr. Garry Powell, Director Bays and Estuaries Program Texas Water Development Board
Microbial Contamination	Dr. Alfred Dufour Environmental Protection Agency Health Effects Research Lab Toxicology & Microbiology
Estuarine Habitat Modification	Dr. Donald Boesch Louisiana Universities Marine Consortium
Estuarine Characterization	Dr. Robert Biggs College of Marine Studies University of Delaware

An effort was made to ensure that each workgroup included representatives from State or Regional regulatory offices, EPA ORD and/or OMEP, and key technical personnel from various federal agencies and academic research institutions. Participants at the workshop are listed in Appendix C.

Thomas DeMoss of EPA OMEP presented a keynote address outlining the objectives and needs of OMEP as they relate to estuarine programs (included as Appendix B). DeMoss pointed out to the workshop participants that two levels of research should be considered. First, there is a need for research that can provide answers now or in the immediate future regarding pressing management questions. DeMoss noted that to address these questions an effort should be made to build upon the data base that has been developed over the past 15 to 20 years with a focus on synthesizing this information. The second level of research described by DeMoss involves the generation of new, basic information on estuaries. He observed that there were a number of basic and critical processes about which there was limited information. DeMoss pointed out that such basic questions could take a long period of time to address and could require substantial expenditures. Given fiscal constraints, it is necessary, therefore, that approaches to addressing these second level questions be creative and efficient. Finally, DeMoss recommended to the participants that they maintain a system-wide approach in considering research needs and objectives.

Although workshop participants were requested to review the entire initial resource document, they were directed to focus on the identification of research needs that would address the information and management needs identified at the state and regional levels. Workgroups met separately to develop their recommendations for assessment and research needs. Information was exchanged among the workgroups and at general meetings during the workshop. Workshop participants were given guidance on how

to address and organize assessment and research needs within their topical areas. The conceptual and operational frameworks for this guidance are described in Section 3.

The initial document was modified to reflect the input of the workshop participants and distributed for review. The present document represents the revisions to the initial document.

3 Conceptual Framework for Identifying Research Needs

Where appropriate, this document has used as a conceptual framework the Risk Assessment Approach utilized previously by the EPA Research Laboratory at Narragansett to assess ocean dumpsite designation, evaluation of hazards posed by ocean disposal, and identification of research needs related to disposal of specific wastes into the ocean. The risk assessment approach, described in Section 3.1 of this document, provides a means of identifying critical pieces of information and organizing them into a comprehensive but focused assessment of the fate and probable effects of pollutants in marine systems. Because the approach outlines the kinds of generic information and analytical methods that are needed to conduct assessments, it also provides a tool for identifying critical information gaps and areas where analytical methods development are needed. It is in this context that the Risk Assessment Approach has been used in the identification of information and research needs.

Guidance was provided to workshop participants for use in structuring research needs. In essence, this involved establishing the links between information needs (identified by State and Regional personnel), the degree to which information currently exists, the need for research or assessments of existing information, and how the results relate to management or regulatory activities. This operational guidance is described in Section 3.2.

3.1 Risk Assessment for Estuaries

The risk assessment framework was found to be useful for organizing and evaluating information for three of the five broad topics: toxics, nutrients, and microbial contamination. It was also useful in a more general sense in considering research needs related to estuarine habitat modification; it did not apply directly to estuarine characterization inasmuch as this is primarily an information gathering activity and not risk assessment per se. The basic characteristics of the risk assessment approach for estuaries are considered below.

The EPA has recently initiated a variety of activities designed to implement an overall strategy for risk assessment and risk management of toxic substances in the environment (USEPA, 1984). The risk assessment approach for organizing technical information and research needs for estuaries is an outgrowth of the hazard assessment approach developed by EPA-Narragansett for addressing the potential impacts from ocean-dumped wastes (Bierman et al., 1985). This hazard assessment approach has been applied to a case study involving dredged material disposal in Central Long Island Sound (Gentile et al., 1986), and to the potential impacts of sewage sludge disposal at the 106-Mile Ocean Disposal Site (Paul et al., 1986). Assessments are also being

conducted of potential environmental and public health risks associated with chemical contamination in Puget Sound, New Bedford Harbor, and along the California coast.

The risk assessment framework approach applied to estuaries is illustrated in Figure 1. This framework describes the complete causal chain from source inputs, through transport, transformation, and fate, to an assessment of potential environmental or human health risks. In turn, the assessment provides the technical basis for a regulatory decision in the form of a waste load allocation, or an individual permit. Within this framework, monitoring is viewed as a broad support activity which provides necessary information during each phase of the assessment.

Characterizations of source inputs, and of the potentially impacted site, are primarily information-gathering phases. The objectives of source characterization are to determine the physical and chemical properties of the sources which control their environmental transport and fate, and to determine if the sources are toxic, or if they contain any constituents which may be bioaccumulated. The objective of site characterization are to determine those physical and chemical properties of the site which control the environmental transport and fate of the sources, and to determine the distributions of commercially and ecologically important resource populations and their sensitive life stages.

The exposure and effects assessment phases involve data synthesis, and the development of causal linkages. The objective of exposure assessment is to quantify the relationships between source inputs and environmental concentration distributions. These relationships need to be expressed in terms of intensity, frequency, and duration. Exposure assessment involves the synthesis of information from the characterization phases. Mathematical models frequently provide a convenient framework for this synthesis.

The objective of effects assessment is to develop functional relationships between environmental exposure concentrations and adverse ecological or human health impacts. Ecological effects can be expressed in terms of acute and chronic toxicity, impairment of growth or reproduction, or in terms of changes in population and community levels of biological organization. Human health effects can be expressed in terms of accumulation of toxic constituents in fish and shellfish, and direct exposure to pathogenic organisms.

Risk assessment is the synthesis of results from the exposure and effects components and it provides an estimate of the probability of harm to the environment or to human health. This estimate is expressed in terms of the source inputs to the system.

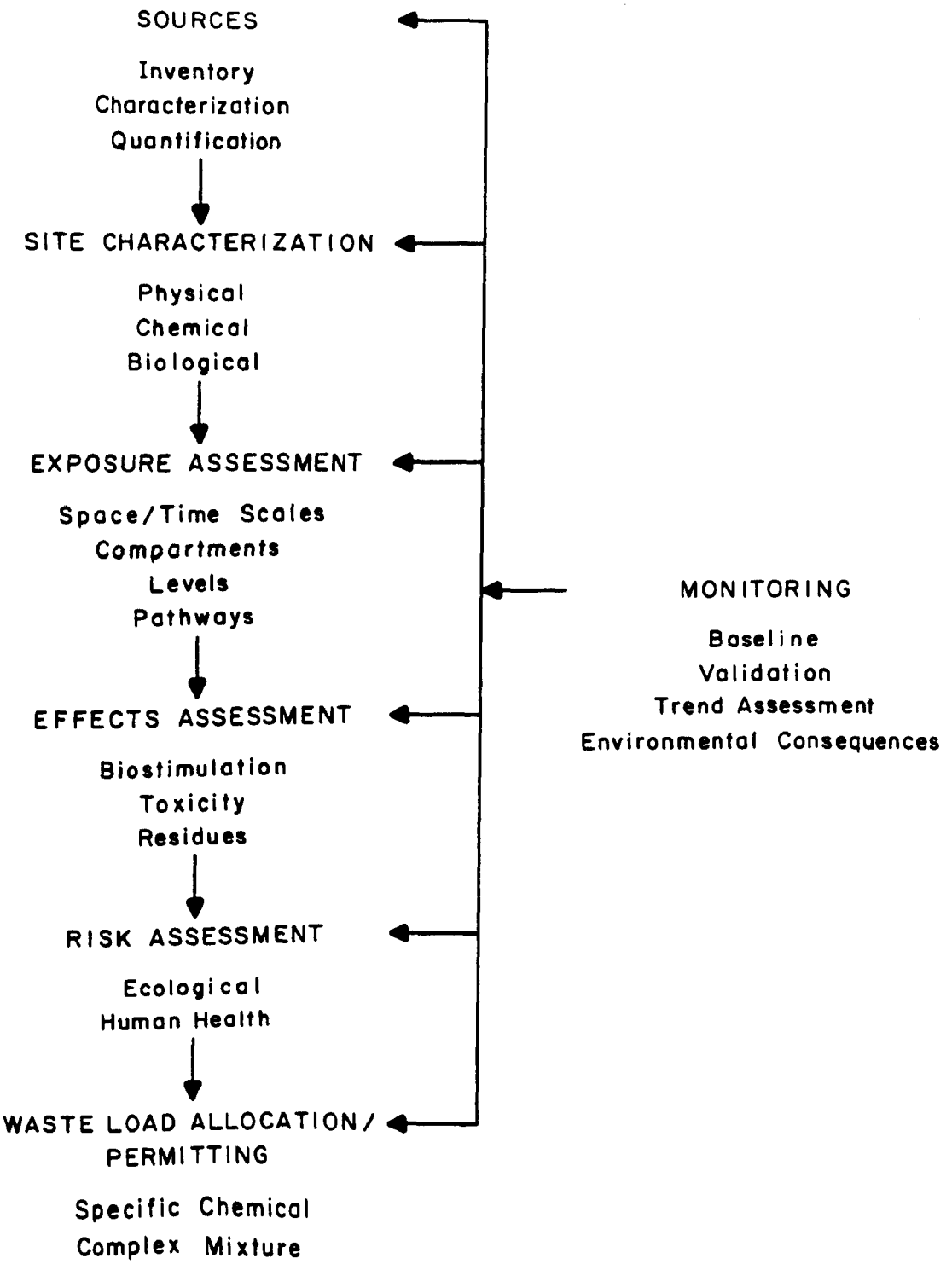

FIGURE 1. MARINE RISK ASSESSMENT STRATEGY

The actual waste load allocation, or permitting decision, is part of risk management. Risk management involves judgements based upon social, economic, and technical factors, which lead to decisions on controlling source inputs and/or in-place toxics. These decisions are usually designed to achieve a specific set of environmental results.

3.2 Identifying Research and Assessment Needs

Operational guidance was provided to the workgroups on how to organize and identify assessment and research needs (Figure 2). The workgroups were asked to develop Problem Statements which related to the information needs identified by State and Regional personnel. For each of these problem statements one or more Broad Objectives and associated Specific Objectives were identified which best addressed the various components of the Problem Statement.

The workgroups then considered the extent to which the specific objectives were met or could be met by existing information. Through discussions with state and regulatory personnel it became clear that although information might be available (e.g., in scattered research reports), it might not be in a form that addressed the managers or regulators information needs. If this was thought to be the case, the workgroups were directed to identify Assessments that would involve organizing or synthesizing existing information into appropriate support documents.

If information was not available or if there was a need for additional research to address an information need, the workgroups identified specific Research Needs. In addition, the workgroups provided initial recommendations on how the research should be conducted (i.e., specific laboratory or field studies).

The workgroups were asked to describe the anticipated results under each of the Broad Objectives. These results were then related to management or regulatory activities.

In summary, the initial information needs were identified by State and Regional personnel and relate to their ability to carry out their management and regulatory responsibilities. The degree to which information was already available to address these needs was evaluated and recommendations were made either for assessments of this information or for new or additional research. The anticipated results of these activities were identified and related back to specific management or regulatory responsibilities.

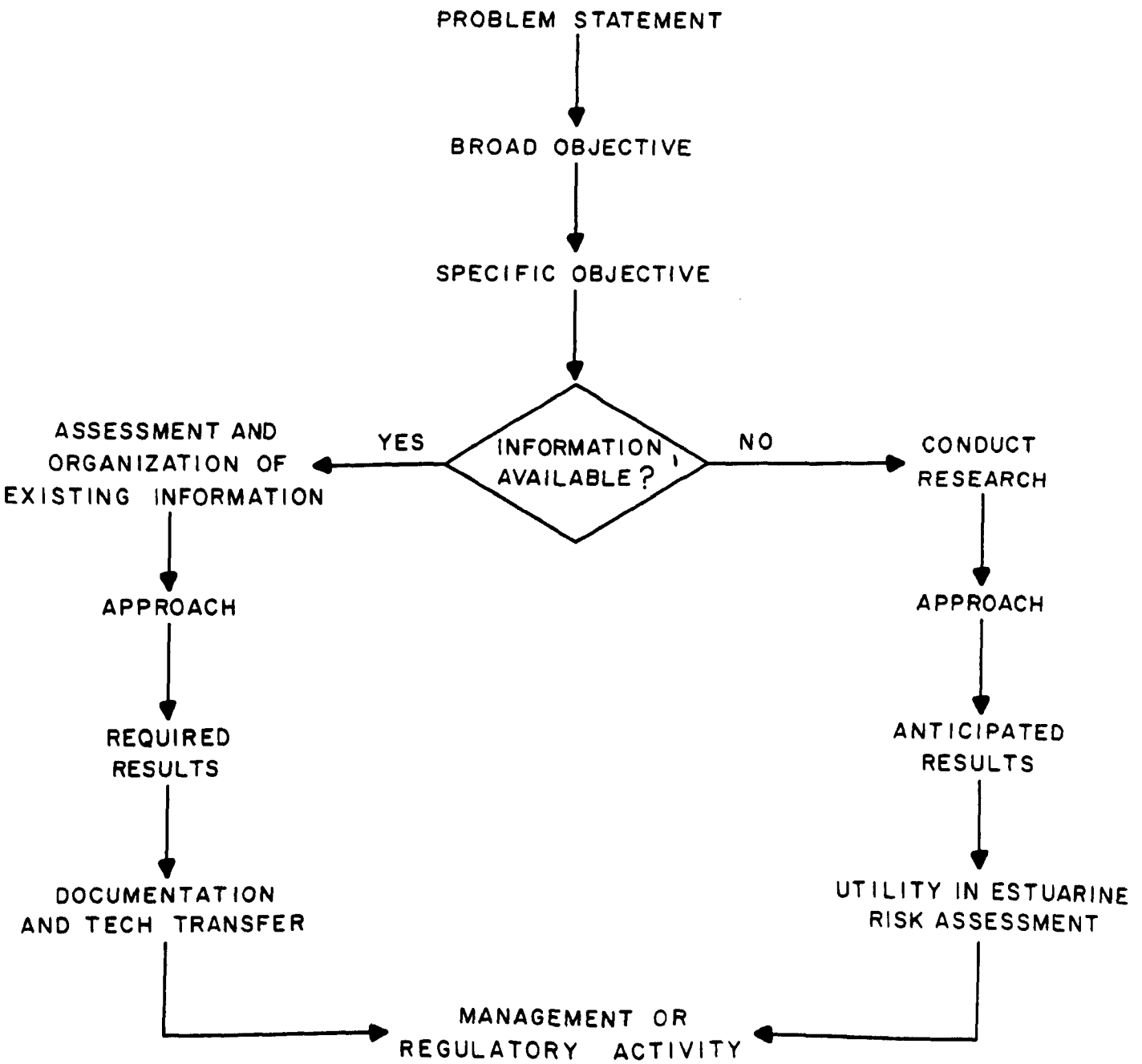

FIGURE 2. ORGANIZATION OF INFORMATION AND RESEARCH NEEDS

4 Toxics

4.1 Information Needs

Information needs identified by Regional EPA and State personnel are organized below according to the major categories in a marine risk assessment.

Source Identification

Based upon discussions with EPA Regional, State, and municipal personnel as well as private contractors, it appears that source identification and quantification are often major problems and this is particularly true for nonpoint sources. However, much of the work that is needed involves the application of basic manpower in gathering needed information or carrying out appropriate monitoring programs. In other words, given sufficient support it would be possible with existing techniques to establish estimates of loadings. Still, there were several areas mentioned that represent potential generic information or analytical needs. These include:

1. Screening techniques for determining sources of toxics found in sediments. This would involve a methodology for assessing the locations and relative contributions of particular sources.

2. The source of contaminants observed in shellfish and fish.

3. The role of contaminated groundwater as a source of toxics to estuarine areas.

4. The characterization of complex effluents.

5. Upland hydrologic models that can be tied to or used in conjunction with estuarine circulation models.

6. The ability to delineate the effects of individual discharges in situations where there are multiple discharges.

As noted above, most information needs at the state and Regional level involve obtaining site-specific data using standard techniques. The Jones and Stokes (1984) report outlined these kinds of needs for Puget Sound, a system that has received extensive attention with respect to input of toxics and appropriate sections of that report are incorporated into the Region X trip report (Appendix A).

Site characterization

A number of issues related to site characterization are considered in Section 8, Estuarine Characterization. However, a major issue related to site characterization with regard to

toxics is, "How do you define a problem sediment?" The issue of sediment criteria was raised in discussions with each of the regions. It was noted that the development of reasonable sediment criteria is a national issue. The applications of such criteria were succinctly described by Jim Krull of the Washington Department of Ecology. The needs outlined by Krull are as follows:

- o Sediment criteria to define contaminant and/or effects levels at which sediments become a problem.

- o Remedial action alternatives
  - criteria for determining whether to dredge, leave in place or cap contaminated sediments,
  - criteria for disposal,
  - criteria for disposal site selection,
  - criteria for disposal site design,
  - relationships between discharge loadings and sediment contamination (long-term cumulative effects)

In addition to the need for sediment criteria or a procedure for identifying "problem sediments", State and Regional personnel all identified site-specific research needs related to establishing levels of toxics in sediments and organisms.

Exposure Assessment

A number of generic information needs were identified with regard to exposure assessment related to toxics in estuarine water and sediments. These are as follows:

1. The major information need mentioned by State and Regional personnel concerned the bioavailability of toxics in estuarine water and sediments. They felt that this area of research should be emphasized especially with regard to uptake of contaminants in brackish water situations.

2. Another critical information need was the physicochemical fate of toxics in brackish water environments. This involves a range of issues including the following:

- o establishment of equilibrium partition coefficients for organic and inorganic pollutants between sediment, pore water, and surface water;

- o the physical and chemical processes affecting the fate of toxics in the "null zone" of estuaries. This is the region where the surface charges of particles transported downriver are changed as salinities increase, resulting in flocculation and more rapid settling of the particles. As a result, toxics associated with the particles become deposited;

- o the fate of substances which upon discharge are not simply mixed into the water column but can rise to the surface and become concentrated in surface microlayers; in particular certain toxics associated with oil and grease;

- o analysis of pollutant reactions at the freshwater/saltwater interface; data are needed to improve reliability of transport model predictions. Studies should be designed to determine reactions and compartmental shifting of pollutants in the freshwater/saltwater mixing zone, the extent of floc formation and its role in pollutant transfer, and the effects of the freshwater/saltwater interface on chemical speciation;

- o analysis of distribution and fate processes for pollutants in sediments in particular mobilization of metals and organics from sediments and degradation processes;

- o development of a solids settling model that could describe coagulation and settling characteristics of solids in seawater;

- o information is needed on sediment transport processes in estuaries as well as the modeling of these processes;

Effects Assessment

There were a variety of issues mentioned by State and Regional personnel with regard to toxic effects assessment. Many of these are similar to those raised in connection with effects associated with other situations involving discharge of waste to marine environments (ocean disposal, 301 (h), oil and gas operations), and, therefore are of interest for a number of reasons. The generic needs include the following:

1. Appropriate toxicity test methods need to be developed for marine and estuarine systems. Regional personnel noted that case studies were needed in different areas. In some discussions it was pointed out that techniques and methods should be simple and cost effective but should have good technical basis and adequate documentation.

2. There is a need to account for the relative uncertainty in fate and effects of toxics.

3. There is a need for information concerning the "significance" of body burdens of toxics.

4. Information is needed on sublethal and chronic effects.

5. Although not specifically mentioned as an information need, work related to declines in the populations or reproductive success of striped bass and other fish was noted. This is an area where additional information is needed.

6. Information is needed on the causal relationships between sediment contamination and demersal fish diseases. In particular, laboratory studies are needed to test hypotheses based on field observations. It would be desirable if "no effects levels" could be developed.

7 Information is needed on the effects of sediment contamination and organic enrichment on benthic invertebrate community structure.

8. Information is needed on the potential human health effects of contaminants in fish and shellfish.

9. There is little information on recovery rates. Such information would be useful for assessing the overall benefits of various actions and what can be expected with regard to rate of recovery following actions.

Risk Analysis

Risk analyses related to human health and environmental effects were identified as key areas by State and Regional personnel who have been dealing with toxic problems. Risk assessments will be used in assessing the status of coastal contamination problems (e.g. Superfund sites) as well as the discharge of toxics via point and non-point sources. However, with one exception, other than ensuring that sound methodologies are available and good input data obtained, no specific recommendations were made concerning information needs.

The area that is problematic involves certain populations who fish for recreational or subsistence purposes in areas that may contain toxics and who are unlikely to abide by fishing or shellfishing restrictions. While this was identified as a problem, no specific research need was identified in connection with this problem.

Waste Load Allocation

Waste load allocation efforts in most areas of the country have focused on BOD. There have been few attempts to conduct waste load allocations for toxics in estuaries. Therefore, this lack of first hand experience limited the kinds of information needs that could be identified by State and Regional personnel. Information needs identified for the other categories described above all bear on wasteload allocation. One important issue that emerged through discussions with State and Regional personnel concerned the efficacy and cost effectiveness of water quality modeling for toxics. For example, in Louisiana

it was noted that the state of the art of water quality modeling is simply not advanced far enough to support technically sound modeling of the state's complex estuarine systems and that the state cannot afford to advance the state of the art. In Washington State, where toxics have been identified as a predominant issue, there is some uncertainty as to how and when to proceed with modeling activities as well as with regard to what level of modeling is appropriate.

4.2 Current Programs That Address Information Needs

A number of federal agencies as well as state agencies and municipalities have been conducting studies related to sources, fates, and effects of toxics in estuarine and marine systems (see Table 1 in Section 2.3). An overview of the national programs was provided to workshop participants for their review and information prior to the workshop. Detailed documentation of these programs is not repeated here but some examples are provided.

Research on sources of toxics has included such programs as EPA's Nonpoint Source Program, the Nationwide Urban Runoff Program (USEPA, 1983), the USGS studies of the Potomac River and San Francisco Bay, USDA programs, EPA's groundwater research programs, and NOAA's programs. In fact, one of the most comprehensive studies on assessing sources of pollutants to coastal areas and estuaries is being conducted by NOAA. The Strategic Assessment Branch of the Ocean Assessments Division has been working toward the development of the National Coastal Pollutant Discharge Inventory (NCPDI). When completed the NCPDI will include all point, nonpoint, and riverine sources of pollutant discharges into estuarine, coastal, and oceanic waters of the contiguous United States.

EPA has been conducting a number of programs that address questions related to exposure assessments for toxics. These have been carried out primarily at the Narragansett and Gulf Breeze Laboratories. The work includes verifying the accuracy of exposure assessment model prediction and lab test methods, evaluation of laboratory based predictions of environmental effects, and development of a research strategy and supporting methodologies for predicting the bioavailability and bioaccumulation potential of organic and inorganic contaminants controlling the phase partitioning of organic contaminants from complex wastes. In addition, the EPA laboratory at Narragansett is also involved in a field verification program to validate exposure assessments for dredge material disposal in Long Island Sound.

NOAA has supported a number of studies on transport and fate of toxics. For example, the research group at the NOAA Seattle Laboratory has been investigating the bioavailability of sediment-associated pollutants. In controlled laboratory studies,

phylogenetically diverse species have been exposed to sediment from areas of high and low contamination and to sediment-associated water and chemicals extracted from sediments. A number of other studies have been designed to investigate mechanisms of contaminant metabolism and detoxification.

Much of the current effects-related work within EPA involves the development and analysis of various testing methods including a program to develop, field test, and verify toxicity testing methodologies for complex effluents and their receiving waters and field validation programs.

NOAA programs on the effects of toxics include such studies as evaluating effects of estuarine degradation and chronic pollution on populations of anadromous striped bass in the San Francisco Bay Delta, and the relationship between pollutant body burdens of the starry flounder and its reproductive capacity. The issue of effects of toxics and other factors on populations of striped bass are also being studied by the Fish and Wildlife Service.

The Army Corps of Engineers Waterways Experiment Station also conducts research on the long term effects of dredging operations (LEDO) and this work continues to provide information on the effects of toxics in estuarine systems. Research involves methods related to bioassays, bioaccumulation, biomagnification, cumulative impacts, and management techniques. Additional research is being conducted on methods for predicting potential sediment resuspension and release of contaminants for various types of dredging equipment.

4.3 Research Needs Related To Toxics

The working group for toxics concluded that research should focus on outstanding issues related to the fate and effects of toxics in estuarine systems. These were viewed as the critical components of an overall risk assessment methodology and are the areas for which generic information is needed for application of a methodology to the nation's estuaries. Other risk assessment components (see Figure 1 in Section 3) are either more site-specific in nature or are less readily addressed as part of a research program.

Problem Statement A

Concerns related to the potential environmental and human health effects of toxics, especially in sediments, were expressed by all the EPA Regional and State personnel contacted as part of this program (see Appendix A). The discharge of toxics to estuarine systems and the presence of toxics in sediments affect a broad range of regulatory and estuarine management decisions. As outlined in Section 3 of this report, a risk assessment framework provides a rational and technically supportable basis

for such decisions. Yet, there is no well established, validated risk assessment method(s) for toxic chemicals in estuaries. (Field validation refers to those activities that serve to test and document predictions based on laboratory studies and/or mathematical models.)

The workgroup for toxics outlined three broad objectives:

- o To determine the exposure of estuarine organisms to chemicals;
- o To evaluate the effects of these chemicals;
- o To establish and validate linkages between exposure and effects.

Broad Objective A1: Exposure Assessment

The specific objective here is to validate the fate of chemicals using field data sets for major chemical classes including non-polar organics (e.g., PCB homologs and kepone), metals (e.g. Cd, Ni, Pb), organic carbon and other particles. It is anticipated that this work would involve specific case studies, chosen to incorporate the proper suite of critical factors. Although information presently exists on some of the critical processes affecting these chemicals, it needs to be brought together and assessed. Such assessments are envisioned in the following areas:

1) the role of estuarine circulation processes as it affects dissolved and particulate matter;

2) sorption processes (e.g.,pH effects for metals);

3) chemical degradation via physicochemical and biological processes; and,

4) the relative importance of episodic events in sediment and associated contaminant transport.

Available information was considered limited for several critical processes and for these additional research is recommended. These include:

1) processes affecting particle transport and fate in estuarine systems (e.g. resuspension, settling, deposition, physical armoring) inasmuch as these affect the fate of associated contaminants;

2) diffusive exchange rates between sediments and the overlying water column;

3) anaerobic metal interactions;

4) a means of estimating and quantifying the exchangeable metal fraction;

5) the effects of bioturbation and biological armoring on the release of toxics from sediments.

Anticipated Results

The exposure assessment related work should provide calibrated (and validated if sufficient numbers of chemicals are present) exposure assessment models for case study sites. The results of the assessments and research activities will provide a better understanding of various exposure processes as well as enable investigators to evaluate the significance of the processes in the risk assessment methodology.

Management or Regulatory Activity Affected

The three major regulatory areas that would benefit from the research include:

1) water quality based permit control for toxics in estuaries (NPDES, nonpoint sources);

2) dredging and dredged material disposal activities within and near estuaries;

3) remedial investigative studies and management plans related to in-place toxics (includes CERCLA).

The research will provide information on contaminant exposure fields that would be used for the effects assessments in the case studies.

Broad Objective A2: Effects Assessment

Three specific objectives identified with regard to assessing the effects of toxics in estuarine waters are presented below.

Specific Objective 1: Develop sediment quality criteria for evaluating single chemicals and complex mixtures of contaminants in sediments.

The toxics workgroup recommended that an assessment be made of the relative species sensitivity of water column and benthic estuarine organisms. Such information would be used to assess the applicability for benthic organisms of water quality criteria that have been developed largely to protect water column organisms.

In addition There were several areas where the workgroup identified specific research needs and these included:

1) the development of single and multichemical toxicity tests;

2) the development of normalization procedures for determining the bioavailable fractions of metals and organics in estuarine sediments;

3) use existing field data on the character of biological communities to conduct field verifications of bioassay results.

Specific Objective 2: Determine relationships between the characteristics of contaminated sediments (e.g., sediment type, degree of organic enrichment, levels of toxic chemicals) and the population structure of the associated benthic community. The objective would be to determine the degree to which it is possible to discriminate among factors affecting spatial patterns in benthic community abundance and structure. Such information would be used to evaluate the efficacy of using data on the benthic community as a means of assessing the effects of toxics.

The toxics workgroup recommended that available information from the 301(h) programs be assessed with respect to organism/sediment relationships with particular attention given to the effects of load reductions. The workgroup identified several areas of research including:

1) supplementing existing 301(h) monitoring studies so that these existing studies can be used to address research questions beyond the site-specific monitoring requirements;

2) collection and analyses of field data from industrial outfalls dominated by single or a few chemicals; such studies would provide clearer information on the effects of specific chemicals;

3) application of Pearson-Rosenberg correlations with total organic carbon and toxic chemicals;

4) design of studies including those suggested above that would discriminate among factors affecting benthic community structure and abundance (e.g., sediment characteristics, organic levels, toxics).

Specific Objective 3: Determine the relationships among sediment contamination, tissue concentrations of those contaminants, and the possible environmental and human health implications of the tissue concentrations.

The toxics workgroup suggested that available information on health-related effects of toxics in food (in particular seafood) be gathered and assessed. This would provide the technical information base needed for risk assessment. It is recognized that there are gaps in information on effects of ingested toxics to human health; however, this is not envisioned as an area for research within an estuarine research strategy.

The workgroup suggested several areas where there are critical needs for research. These include:

1) determine relationships between levels of contaminants in sediments and concentrations of those contaminants in fish tissues; this research would address parent compounds and metabolites;

2) determine relationship between tissue residues of toxics and reproductive success of selected fish and shellfish;

3) determine relationships between levels of contaminants in sediments and diseases in fish and shellfish; it is recognized that such relationships may not be direct and may need to be translated into more appropriate exposure fields; such information would be generated through the research recommended under Exposure Assessment.

Anticipated Results

The effects assessment related work would provide information on various biological effects associated with exposures to toxics via sediment or water column. Emphasis has been placed on toxics in sediments inasmuch as this is a recognized problem within many of the nation's estuaries. Research results will include data on effects of toxics on reproductive success and diseases in fish and shellfish, benthic communities, and testing methodologies.

Management or Regulatory Activity Affected

The three major regulatory areas that would benefit from the research are the same as those described under exposure assessment related work.

Broad Objective A3: Field Validation of Exposure and Effects Assessments

The workgroup concluded that there remains a need to field validate the overall exposure and effects assessment methodologies with special emphasis given to the linking of these assessments. It is envisioned that the field validation activities recommended under broad objective A1 would be extended

to include verification of the effects predicted from the exposure fields. The lack of such verification is viewed as a critical information gap. However, it is recognized that such work is difficult. Therefore, the workgroup recommended that for selected case studies a tiered approach be adopted:

1) the validation should be conducted first with organic carbon and particulate material;

2) assuming that the first step is successful, the validation should be extended to consider one or a few chemicals; this would involve selecting case studies where contamination is limited to a few major chemicals;

3) after validation has been accomplished or shown to be feasible in the first two steps, the validation could be extended to situations where contamination has resulted from multiple chemicals; this would probably involve a different case study than that used in 2.

The chemical classes that would be considered in the field validations of effects assessments are the same as those considered under exposure assessment and include non-polar organics (e.g., PCB homologs and kepone), metals (e.g. Cd, Ni, Pb), organic carbon and other particles. It is recommended that a few cases where data sets exist be selected for the verifications.

Anticipated Results

The products of this research would include a validation of two critical components of a marine risk assessment protocol for estuaries (i.e., the linking of exposure and effects assessments). This will aid in the development of waste load allocation procedures for toxics and in the development of management/decision frameworks for dealing with in-place toxics. The work would serve to identify the strengths and limitations of the risk assessment method(s) and thus provide investigators with information concerning the level of uncertainty in their estimates. The work would also serve to identify critical information gaps in our present understanding and ability to predict exposures and effects. This would provide a basis for identifying areas where additional research should be conducted and the cost/benefits of that research.

Management or Regulatory Activity Affected

The regulatory areas that would benefit from the research are the same as those previously mentioned and include:

1 Water quality based permit control for toxics in estuaries (NPDES, nonpoint sources);

2) dredging and dredged material disposal activities within and near estuaries;

3) remedial investigative studies and management plans related to in-place toxics (includes CERCLA).

5 Nutrients

5.1 Information Needs

State and Regional EPA personnel provided input on information needs with regard to nutrient-related issues in estuaries. In general, those information needs were organized into various categories corresponding with the Risk Assessment framework (Figure 1 in Section 3.1). However, topics related to wasteload allocation have been incorporated under the fate and transport, and/or effects categories.

Source Identification

1. Some estuaries, especially those in the southeast and Gulf, are subject to large natural inputs of organic matter and other factors that tend to result in periodic natural depressions in oxygen. These sources need to be taken into account when considering appropriate water quality criteria.

2. A need was identified with regard to being able to relate nutrient/biota relations to changes in land use. Information on land use changes on nutrient and sediment loads to estuarine systems was identified as a critical need.

Site Characterization

State and Regional personnel generally expressed a need to characterize general conditions or health of their estuaries. This will be considered under Section 8, "Estuarine Characterization". No specific research issues are recommended in this section.

Transport and Fate of Nutrients

Information needs related to transport and fate of nutrients in estuarine systems include some of those mentioned with regard to the fate of toxics, in particular those relating to the behavior of suspended solids. Several important information needs were raised during the discussions with State and Regional personnel. These include the following.

1. Recycling of nutrients within some estuarine systems has been difficult to quantify.

2. Information and guidance is needed on establishing nutrient budgets. The following were mentioned by Texas State personnel in connection with obtaining necessary input for the "ESTECO" ecosystem model:

- Better measures of benthic biomass are needed which include mircoorganisms as well as standard macrofauna. How much of the sediment TOC is alive and how do we partition what's in the sediments into

a) the contributors to nutrient dynamics and b)nutrient storage?

- o If the sediments are conceived as a flywheel or battery for the ecosystem - what are the parameters of input needs, depletion rates, etc.?

- o How should oyster reefs and seagrass beds be incorporated into estuary models?

- o How many migratory animals (e.g. fish) are there? Do they cover the entire estuary? How much material do they export from the estuary?

- o Can we classify areas within an estuary efficiently with respect to habitat types in a way that would fit in with modeling?

- o How do we deal with detritus in nutrient budgets and processes? How do we measure detrital mass?

- o What kind of diurnal patterns occur during different seasons?

3. Information is needed on nitrification and denitrification rates in estuaries to provide input to waste allocation efforts involving model verifications.

Effects Assessment

State and Regional personnel identified information needs related to several topics. These are described below.

1. Better information is needed on the relative degree to which nutrients are limiting primary production in estuarine systems.

2. Information is needed on the effects of nutrient loading on estuarine food webs due to shifts in the composition and abundance of primary producers (in particular the development of phytoplankton assemblages dominated by one or a few species) and the effects this has on estuarine and coastal fisheries.

3. Information is needed on optimal nutrient loadings with regard to the support of fisheries. It was noted in Texas, for example, that freshwater inflow issues are related in part to adequate provision of nutrients to the estuaries.

4. The processes resulting in coastal anoxia were identified as an area where additional information is needed; in particular, information is needed on benthic oxygen demand and natural reaeration.

5. Some estuaries, in particular those in the Gulf of Mexico and southeast United States, are subject to large natural inputs of organic matter and other factors that tend to result in periodic natural depressions in oxygen; the need for more flexible, realistic, or appropriate oxygen water quality criteria for estuaries was identified. One question posed was, "Given a set of EPA standards does that translate into a healthy biotic system?" The possibility of developing seasonally adjusted water quality criteria was mentioned.

6. Information is needed on the potential for shading and light limited growth of submerged aquatic vegetation due to enhanced phytoplankton and periphyton growth.

5.2 Current Programs That Address Information Needs

As noted in the section on toxics, an extensive discussion of current programs was provided to workshop participants prior to the workshop. That discussion is not repeated here but some examples of ongoing programs directed at the identified information needs are presented.

There has been much ongoing work related to transport and fate of nutrients. Numerous projects are underway at the state level and much work is being carried out at universities throughout the country. Since the work of Ryther and Dunston (1971), the biostimulatory effects of nutrient enrichment upon marine systems has been clearly recognized. Well-documented examples of these effects have been summarized for Chesapeake Bay, New York Bight, San Pedro Bay, San Francisco Bay, Kaneohe Bay, the Baltic, Aegean, and Adriatic Seas, Oslo Fjord, and several bays in Japan and Long Island, New York.

EPA's Office of Marine and Estuarine Protection (OMEP) is currently addressing nutrient-related problems as part of the Bays Program. A good example of a program where nutrients are a major issue is the Chesapeake Bay Program.

Marine Ecosystem Research Laboratory (MERL) tank experiments supported by EPA and other agencies have demonstrated depressed zooplankton fecundity and abundance under nutrient enrichment probably as a consequence of various chemical changes resulting from increased primary production. There has been ongoing work on nitorogen cycling in estuaries. For example, Horn Point Environmental Laboratory, Cambridge MD, has been investigating the role of estuarine sediments in nitrogen cycling and the implications for effective nutrient waste management strategies. The Sea Grant Program is funding a number of programs related to nutrient cycling in estuaries.

EPA together with NOAA and other agencies have been supporting an effort to examine nutrient-related effects in marine mesocosms that are designed to model a northeast estuary.

These studies are designed to examine the fates and effects of nutrients and heavy metals along a simulated estuarine nutrient gradient. The purpose of the project is to develop a strategy for the management of wastes which cause nutrient enrichment so as to maximize the benefits and minimize the potential for anoxia and living resource damage.

As already discussed for toxics waste load allocation, EPA is currently emphasizing work on water quality-based permits and this includes nutrient loadings. The EPA has prepared a Technical Guidance Manual for Performing Waste Load Allocations for Estuaries (Southerland et al., 1984). The manual presents information on the characteristics of a number of models that can be applied to waste load allocations in estuaries. BOD-DO reactions are included in all but the toxics models; nutrient cycling and algal photosynthesis-respiration are simulated in HARO3, FEDBAKO3, WASP, DEM, MIT-DNM, EXPLORE-I, RECEIV-II, and CHEN.

5.3 Research Needs Related to Nutrients

The working group on nutrients developed a set of recommendations that generally addressed issues related to how nutrients are recycled within and lost from estuarine systems. This initial set of recommendations has been further revised and developed through discussions with EPA ERL-N personnel and used as the basis for developing research recommendations concerning the fate and effects of nutrients in estuarine systems.

Problem Statement A

A major deficiency in current understanding of the effects of nutrient loading on estuarine water quality and estuarine-dependent species is how nutrients are recycled within and lost from estuarine systems. This lack of information impedes the development of technically sound waste load allocations and accurate predictions of nutrient-related impacts.

Four broad objectives have been identified:

- To develop information on nutrient residence times and cycling in estuarine systems
- To develop information on critical biological components (primary production, food webs, submerged aquatic vegetation) in estuarine systems as these relate to the effects of nutrient cycling and external nutrient loads
- To develop information on oxygen dynamics of estuarine systems

- To assess the effects of increased nutrient levels on the bioavailability and effects of toxics.

Each of these is discussed below and assessments or research needs are described.

Broad Objective A1: Develop information on nutrient residence times and cycling in estuarine systems

Two specific objectives were identified with regard to the transport, fate, residence time, and recycling of nutrients in estuarine systems. Such information is needed to predict the effects of nutrients in these systems.

Specific Objective 1: Determine nutrient residence times and cycling times within estuaries; this information is needed to determine relative importance of internal vs external nutrient sources; the relative importance of sources has implications for expected response times of the system in the event that external inputs are changed.

It is recommended that information be assessed on the following aspects concerning nutrient residence time and cycling:

1) the relative importance of benthic versus water column nutrient regeneration in the nutrient budgets of common estuary types;

2) the importance of geomorphology and flushing times on nutrient residence times and cycling; this should include considerations of water depth, freshwater inflows, and other factors (tides, winds) affecting flushing of estuaries.

The nutrient workgroup also concluded that research was needed in the following areas:

1) investigate and evaluate rates of benthic/water column nutrient exchanges and subsequent vertical transport into the euphotic zone;

2) investigate how rates of nitrification and denitrification vary with benthic metabolism and nutrient flux processes in estuaries;

3) evaluate effects of episodic high energy events (e.g., tropical storms and hurricanes) on nutrient loading and the time scales of nutrient biogeochemical cycling;

4) develop methods for systematically determining nutrient losses from estuaries;

5) the effects of hypoxia/anoxia on ratios of essential nutrients and their rates of biogeochemical cycling.

The workgroup recommended that laboratory, mesocosm, and field measurements programs be utilized to conduct the research.

Specific Objective 2: Evaluate the influence of special subsystems such as oyster reefs, seagrass beds, and emergent marshes, on nutrient cycling. Such information is needed in order to account for the effects of these subsystems on overall nutrient cycling, to develop technically sound system models, and provide guidance on the efficacy of particular nutrient source controls.

The nutrient workgroup recommended that an assessment was needed of information on the role of the benthos as a potential mediator of estuary eutrophication.

Specific research was indicated by the workgroup on the effects of seagrass beds, emergent marshes, and benthos on estuarine nutrient cycling. This research would incorporate mesocosm and field studies.

Anticipated Results

Research and assessments related to nutrient fate, transport, and cycling will provide information on processes that are critical to evaluating how and at what rates nutrients are being processed within estuaries and how the characteristics of estuaries (including special subsystems) can affect nutrient cycling and availability. Results of these studies will be used as input to or will provide guidance for wasteload allocation activities carried out by State and Regional personnel.

Management or Regulatory Activity Affected

The following regulatory and management activities would benefit from the recommended research and assessments on nutrient cycling:

1) water quality based controls (NPDES, diffuse source controls); waste load allocations;

2) 208 water quality management planning, use designations, and water quality standards; note - OMEP believes that estuary programs may ultimately require the States and EPA to review and revise 208 plans in response to program findings;

3) environmental impact statements for activities of other federal agencies;

4) dredge and fill activities to the extent that these will effect nutrient cycling and the overall nutrient budgets of estuaries.

Broad Objective A2: Evaluate the effects of nutrients on critical biological components in estuarine systems

Three specific objectives were identified with respect to possible effects on critical biological components (primary production, food webs, seagrass beds).

Specific Objective 1: Evaluate processes affecting nutrient limitation of primary producers in estuaries and develop methods for determining which nutrients are limiting; this information is needed to determine which nutrients to control as well as to determine the most cost-effective combinations of point and non-point source controls.

The workgroup on nutrients suggested that available information be assessed in the following areas:

1) effects of nutrient ratios on primary production and floristics;

2) nutrient ratio differences associated with point versus non-point sources to estuaries as this may relate to possible effects on primary production and floristics;

3) the relative bioavailability of nutrients from point and non-point sources as this relates to primary production;

The workgroup also recommended several areas where research was needed including:

1) the influence of nutrient regeneration rates on ratios of essential nutrients in the water column and sediments; this information would be used to link regeneration rates with potential primary production levels and the development of particular floristic groups;

2) the relationship between various concentrations of single or multiple nutrients and both the rate of primary production and composition of principal floristic groups;

The workgroup suggested that this research be carried out through a combination of laboratory and mesocosm experiments together with field measurements.

Specific Objective 2: Determine the potential implications of shifts in primary producers to estuarine food webs. Special emphasis should be given to food webs that support desirable species. This specific objective is based on the recognition that nutrient loadings can produce shifts in the composition and abundance of primary producers and subsequently affect the food web structure.

The workgroup on nutrients recommended that an assessment be made of information concerning the characteristics of food webs within estuarine environments. The assessment should evaluate the relationships of desirable as well as undesirable species to these food webs. Sources of primary production and organic matter should include salt marsh vegetation, submerged vegetation (e.g. eel grass), benthic algae, diverse phytoplankton communities, low diversity or monospecific phytoplankton communities, and allocthonous inputs of organic matter.

It is anticipated that there will be critical information gaps in existing information and the workgroup has suggested research in several areas including:

1) determine spatial and temporal importance of detritus versus phytoplankton to estuarine food webs; It may be possible to use isotopic ratios to trace essential nutrients through food chains and into desirable species;

2) determine how anthropogenic nutrient loading influences estuarine food webs leading to production of seafood organisms;

3) determine the role of bacteria as producers of organic material;

4) determine the relative importance of bacteria versus metazoans in the metabolism of organic matter in low and high nutrient estuarine systems.

It is anticipated that a combination of laboratory, mesocosm, and field studies will be needed to accomplish the research goals.

Specific Objective 3: Evaluate effects of nutrient loadings on the viability of submerged aquatic vegetation (SAV). Such information is needed to assess the relative importance of nutrients/solids relationships (point and non-point) in comparison to non-point sediment load in reducing light levels in estuaries and the possible effects this has on reducing the growth of SAV.

It is recommended that assessments be made of:

1) information on the relative contribution of phytoplankton growth to the reduction of light levels in estuarine systems;

2) available information on the role of periphytic algae in shading of rooted aquatic vegetation to which they are attatched.

It is recommended that additional research be conducted on light limitation of rooted aquatic plant species that characterize estuarine systems. This research should be related to the role of elevated nutrient loadings and resultant loss of light levels due of growth of phytoplankton and periphyton. This research should involve controlled experiments and the results compared to field observations.

Anticipated Results

The research and assessments outlined above will provide information on the relationships between critical components of the estuarine system (primary producers, food webs, SAV) and how these are affected by changes in nutrient levels. For primary producers, information will be provided on how to determine which nutrients are limiting and on how to assess the sources of these nutrients. In the case of food webs information will be provided on the relationships between nutrient loadings, food web structure, and the support of desirable species. For SAV, information will be provided on the relative contribution of phytoplankton and periphytic growth to attenuation of light and on the light limitations of specific submerged rooted aquatic plant species (e.g. Zostera, Thallasia).

Management or Regulatory Activity Affected

The results generated on primary production/estuarine food web/nutrient relationships and on the possible light limitation of SAV due to increased growth of other primary producers will be beneficial to regulatory personnel charged with the management of estuarine water quality as well as fisheries management. The protection or recovery of desirable fish and shellfish stocks and important habitat formers such as SAV may be an objective of an estuarine management program. To the extent that these have or may be threatened by shifts in food webs or loss of light associated with nutrient loadings, the results will support regulatory activities already outlined under Broad Objective A1. These include source controls and evaluations of proposed construction and other activities within or adjacent to the system.

Broad Objective A3: Develop information on oxygen dynamics in estuaries and effects of reduced oxygen on estuarine biota

Four specific objectives have been identified with regard to oxygen dynamics in estuaries and the effects of nutrients. These are presented below.

Specific Objective 1: Evaluate the relative importance of allochthonous versus autochthonous material as contributors to biochemical oxygen demand in estuarine systems. Such information provides guidance on selecting appropriate source control measures where the management objective is to maintain or enhance oxygen levels.

The workgroup recommended that research was needed on the relative importance of allochthonus versus autochthonus organic inputs as substrates for oxygen demand in estuaries. Research should incorporate laboratory and field measurements.

Specific Objective 2: Determine the importance of chemical oxygen demand (COD) due to nitrification and sulfide oxidation. Such information is needed in order to determine if nitrogen should be controlled and to assess the efficacy of such control measures (i.e. should nitrogen be controlled in order to prevent prolific algal growth and associated oxygen demand or because of nitrification.)

The group recommended that research be conducted on nitrification and sulfide oxidation in estuaries in order to determine the chemical oxygen demand associated with these processes.

Specific Objective 3: Determine relative contribution of sediment oxygen demand to total oxygen demand. Because sediment oxygen demand influences the rate of recovery following changes in external nutrient/BOD loads, information is needed on this process in order to estimate responses following source controls.

It is recommended that available information on sediment oxygen demand be assessed and contrasted to data on total oxygen demand in selected estuarine systems. Factors contributing to the sediment oxygen demand should be identified within this assessment.

Specific Objective 4: Evaluate effects of hypoxic/anoxic condition in estuaries on estuarine biota.

The nutrient workgroup suggested that an assessment be made of the available information on the effects of hypoxia/anoxia on the viability and productivity of benthic organisms and nekton. The workgroup also recommended that

information be assessed on the effects of reduced oxygen levels on larval survival during transport, as well as on the migration and avoidance behavior of adult and juvenile organisms.

Anticipated Results

The recommended research on oxygen dynamics will provide environmental managers with documentation concerning the relative importance of various sources of oxygen demand. In addition, the results will provide information on possible effects of reduced oxygen levels as well as recovery rates following source controls.

Management or Regulatory Activity Affected

The following activities will receive the major benefits from the recommended research on oxygen dynamics:

1) water quality based permits (NPDES, non-point sources);

2) 208 water quality management planning, use designations, and water quality standards.

Broad Objective A4: To assess the effects of increased nutrient levels on the bioavailability and effects of toxics.

Two specific objectives were identified.

Specific Objective 1: Evaluate the effects of the fertility/productivity of an estuarine system on the transport, fate and bioavailability of toxic compounds within estuaries.

It is recognized that the fertility and productivity of estuarine systems can affect the characteristics and concentrations of solids and dissolved organic matter within the environment. These, in turn, are known to affect the transport, fate, and bioavailability of toxics such as metals, high molecular weight hydrocarbons, and halogenated organics. Thus, for a given loading rate of toxics, the fate and exposure fields for these chemicals could be quite different in physically similar estuaries that experience different levels of fertility and productivity. It is recommended that an initial assessment be conducted to evaluate the possible relationships between the fertility and productivity of an estuarine environment on the one hand and the factors that affect the fate, transport, and bioavailability of toxics on the other.

It is recommended that the assessment outlined above be used to develop a research program which specifically examines the fate and bioavailability of toxics in systems that vary in terms of fertility (e.g. nutrient levels) and productivity. Such

research should focus on the factors that will directly affect the fate of toxics, i.e. solids levels and dissolved organic matter.

Specific Objective 2: Examine how the environmental effects of toxics vary as a result of differences in the fertility and productivity of estuarine environments.

Under specific objective 1 it was noted that the fate and bioavailability of toxics can be potentially affected by the fertility and productivity of estuarine systems. Specific objective 2 considers the environmental effects of toxics in these systems. It is anticipated that processes of uptake, bioaccumulation, and biomagnification will vary among systems as could the toxicity of chemicals. It is recommended that research be conducted to examine how the effects of toxics vary among systems that differ in fertility and productivity. Mesocosms would provide ideal experimental systems with which to conduct this research.

Anticipated Results

The research would provide information on how fate and effects of toxics are influenced by nutrient/organic processes in estuarine systems. Data will indicate the degree to which the availability or toxicity of toxics are enhanced or reduced under various fertility and productivity scenarios.

Management or Regulatory Activity Affected

The results of the work will be beneficial to managers involved in point and non-point source controls where both toxics and nutrients are being introduced into estuarine environments. The information will help guide these regulatory personnel in developing appropriate control strategies. In addition, the work will assist in the evaluation of fate and effects of toxics released to the environment as a result of various activities. The regulatory and management activities that would benefit from the proposed research include:

1) water quality based permit control for toxics and nutrients in estuaries (NPDES, nonpoint sources);

2) dredging and dredged material disposal activities within and near estuaries to the extent that prevailing nutrient conditions may affect the fate and effects of toxics released by these operations.

3) 208 water quality management planning, use designations, and water quality standards.

6 Microbial Contamination

6.1 Information Needs

Disease transmission from human waste through shellfish consumption or bathing beach waters is an established fact. The risk of disease through these pathways is proportional to the level of human waste in the water. Removal of shellfish harvesting and bathing activities from the immediate area of identifiable wastewater sources reduces the risk and the National Shellfish Sanitation Program has been effective in reducing shellfish related disease by taking some action along these lines. However, increasing populations in coastal areas and changes in human waste disposal patterns have impacted shellfishing and recreational areas in new ways requiring new approaches to health risk assessment.

Microbial contamination of recreational and shellfish waters with the associated risks to health and loss of recreational and fishery areas was a major issue in all parts of the country. While there are a number of issues at the local level related to sources and outstanding questions related to actual health risks, all State and Regional personnel expressed a basic need for better indicators of microbial contamination of shellfish and shellfish/recreational waters and better indicators of potential health risks posed by pathogens. Some state agency personnel described the situation as "desperate".

Coliform bacteria are seen as an unsatisfactory indicator of potential environmental and human health risks. In addition, one of the conclusions reached in the EPA's National Urban Runoff Program (USEPA 1983) was that coliform bacteria may not be a good indicator of human health risk when the sole source of contaminants is urban runoff; it was concluded that this area required further investigation. Developing appropriate Indicators of microbial contamination is considered to be the primary research need in connection with microbial contamination of recreational and shellfish waters. Once these have been developed, appropriate questions on sampling and control strategies can be addressed.

6.2 Current Programs That Address Information Needs

Several agencies are currently developing or implementing plans to address issues related to microbial contamination problems. For example, EPA is currently participating in a joint agency effort to establish better indicators of microbial contamination of shellfish and shellfish waters. Efforts include those of EPA, NOAA, FDA, and state agencies. The overall objective will be to relate water quality as measured with microbial indicators to health effects associated with the consumption of shellfish harvested from these waters.

A number of individual projects related to the fate and effects of microbes in marine environments have recently been completed or are underway at various academic institutions. Some of this work is focused on bacteria and some on viruses. Summaries of some of these projects were provided to the workgroup on microbial contamination in advance of the workshop.

6.3 Research Needs Related to Microbial Contamination

The workgroup evaluated the available information on microbial contamination utilizing the risk assessment framework (Section 3 of this report) and have identified five major problem areas with regard to assessing and managing risks posed by microbial pathogens introduced to estuarine environments. The workgroup on microbial contamination recommends that these problem areas be approached in a sequential manner inasmuch as some address target area guidelines (risk characterization) while others address management or reduction of risks (e.g. disposal strategies, source controls).

Problem Statement A

The risk of gastrointestinal illness due to ingestion of shellfish harvested from waters contaminated by non-human fecal waste (i.e., from wild and domestic animals and birds) is unknown. This information gap precludes the promulgation of scientifically defendable guidelines for shellfish waters by regulatory bodies.

Broad Objective A1: Develop a health effects water quality criterion which relates the quality of shellfish harvesting waters contaminated by non-human fecal waste to gastroenteritis associated with shellfish ingestion.

The specific objectives identified by the workgroup relate to the set of research and assessment activities required to carry out an epidemiological study of the health risks posed by "barely acceptable quality" shellfish harvesting waters contaminated with non-human fecal wastes.

The workgroup recommended that available information be assessed to identify candidate sites for carrying out the epidemiological study. The objective of this assessment is to identify two shellfish harvesting areas. One would have water quality judged to be barely acceptable by currently used standards and the other would have relatively pristine waters. The sites would be identified by contacting State personnel, reviewing historical water quality data, and supplemental on-site surveys.

The workgroup recommended several specific research activities as part of the epidemiological survey:

1) characterize the water quality of the selected sites over a 9-12 month period for bacterial indicators in surface and bottom waters and sediments; additional information should be gathered on physical and chemical characteristics of the water column and sediments;

2) identify and select epidemiological survey group (ESG) by circulating RFP to public health schools or other public health agencies;

3) conduct feeding/health risk study; a volunteer study group would be selected for study; shellfish harvesting waters would be monitored for 10 days/month and shellfish from the sites would be fed to the test and control panels; incidence of gastroenteritis would be determined.

Anticipated Results

The anticipated results of this epidemiological study will be a data base that indicates whether or not the ingestion of shellfish taken from barely acceptable quality shellfish harvesting waters contaminated with non-human fecal wastes is associated with gastroenteritis.

Management or Regulatory Activity Affected

The results of this project can be used by regulators to promulgate guidelines for shellfish harvesting waters.

Problem Statement B

There is no adequate microbiological indicator system that can differentiate between human and non-human sources of microbial contamination (pollution). Such information is needed in order to manage shellfish and recreational waters and to assess the efficacy of point or non-point source controls.

Broad Objective B1: Identify a microorganism, group(s) of microorganism or by-product that would originate solely from humans and be indicative of the potential presence of human pathogens.

Several specific objectives were identified by the workgroup on microbial contamination.

Specific Objective 1: Evaluate known indicators of microbial contamination as candidates for human-specific indicators.

This effort would initially involve an assessment of existing information.

The workgroup suggested several areas where additional research was needed. These include:

1) additional research on the human-specificity of the known indicators;

2) research on the applicability of genetic and/or biotechnological techniques for assessing human-specificity of known indicators;

3) additional research on possible human/microbiological by-products.

Specific Objective 2: Identify other microorganisms or group(s) of organisms as possible candidates as human-specific indicators.

The workgroup recommended that several assessments be made to address this specific objective:

1) review current information on microflora of human and other warm blooded animals in order to identify possible candidate organisms;

2) evaluate the feasibility of developing methodologies for potential candidates;

3) evaluate the use of genetic, biochemical, or serological markers if the potential candidate is not strictly human in origin;

4) determine if the candidate organism meets the criteria of an ideal indicator;

5) evaluate the applicability of potential candidates to both recreational and shellfish growing waters;

Specific Objective 3: Determine if the organism is geographically and demographically applicable.

The workgroup recommended three areas where research was needed on candidate organisms once these had been identified:

1) evaluate viability of the organism under varying wastewater treatment practices and environmental conditions (e.g., temperature, salinity);

2) determine if organism is universally carried throughout the human population;

3) utilizing epidemiological studies, establish correlations between concentrations of the organism and human disease; identify specific pathogens to which the indicator relates.

Anticipated Results

The research and assessments outlined above will identify organisms that can serve as validated indicators of human health risks posed by the ingestion of shellfish contaminated by microorganisms introduced with human wastes.

Management or Regulatory Area Affected

The human indicator organism would serve as a tool for:

1) determining potential health risks associated with estuarine water use;

2) setting applicable water quality standards for estuarine waters supporting recreational or commercial stocks of shellfish;

3) developing appropriate wastewater treatment standards related to indicator bacteria and pathogens in effluents discharged to estuarine waters.

Problem Statement C

Improved methodology is required for locating and characterizing sources of microbial pathogens in estuaries.

Broad Objective C1: Develop methodology for quantifying inputs of microbial pathogens from various sources and for establishing guidelines for appropriate remedial measures.

Two specific objectives were identified.

Specific Objective 1: Develop methodology for quantifying inputs.

The workgroup on microbial contamination identified several areas where assessments were required:

1) using existing information, develop a protocol for assessing the public health risk of harvesting shellfish from an area with non-point source inputs;

2) develop a protocol for assessing effects of rain events on health risks posed by eating shellfish;

3) synthesize available information on loadings of microorganisms due to boats and marinas;

4) synthesize available information on loadings from septic systems and contaminated groundwater in various soils;

5) develop a model for assessing relative importance of inputs from CSOs, septic systems, boats, etc; specify variables that need to be measured and how to estimate or measure them.

Two areas where research needs were identified included:

1) determine the viability of Epidemiologically Important Viral Agents (EIVAs) in estuarine water and sediment;

2) determine the viability and transport of EIVAs in various soils and groundwater.

Specific objective 2: Develop guidelines for identifying and implementing appropriate remedial measures.

Two assessments were recommended by the workgroup:

1) assess economic value of shellfish harvesting beds so that potential resource losses can be contrasted with economic issues associated with other uses (e.g. marina development);

2) develop recommendations for management of boat wastes and enforcement measures to ensure that regulations are followed.

Anticipated Results

The recommended studies will provide information on how to assess the relative importance of various sources of microbial contamination including point and non-point sources. Results will also provide information that can guide remedial measures.

Management or Regulatory Activity Affected

Results of the proposed studies will be beneficial to those local, state federal personnel responsible for the management of shellfish and recreational waters. Specific regulatory areas addressed by the studies include:

1) point source controls (NPDES permits);

2) non-point source controls (best management practices).

Problem Statement D

There is no generalized model for developing wasteload allocations based on acceptable risks of swimming- or shellfishing-associated infectious disease and, hence, epidemiologically derived guidelines at potential target resources. This problem statement includes three assumptions: 1) models will be site-specific; 2) a site-specific hydrodynamic model or comparable information will be available; 3) the best indicator/sample combination will be determined from the epidemiological studies.

Broad Objective D1: Develop a generalized effluent model for determining the microbial indicator levels in wastewater effluents (site-specific effluent guidelines or standards) needed to achieve the water quality guidelines and standards at potentially affected recreational or shellfish growing areas.

Specific Objective 1: Develop site-specific transport and fate models at a number of meteorologically and hydrographically different locations and evaluate the models by comparing the predicted to observed indicator levels at a number of locations between the target species and source.

The group recommended that a research project be undertaken to evaluate site-specific transport and fate models at 3 to 4 disparate locations by comparing predicted to observed levels of indicator organisms through statistical analyses.

Specific Objective 2: examine and characterize the processes that affect the fate of pathogens in estuarine systems; such processes would include sedimentation, die-off in the water column, sediment transport to the target, indicator die-off in the sediments, and resuspension of the sediments at the target.

The workgroup recommended that an assessment be made of available information on sedimentation and die-off of indicator microorganisms and pathogens.

Less information is available on the other factors and the workgroup recommended that research be carried out to examine the processes of sediment resuspension and transport, and die-off in the sediments as they affect the fate of indicators and pathogens (i.e. exposure to target species).

Specific Objective 3: Develop and field validate an effluent model for microbial indicators.

It is anticipated that specific objectives 1 and 2 will provide the basic information needed for developing an effluent waste load allocation model related to microbial contamination.

The model should be field validated at one or more locations by predicting effluent microbial levels needed to achieve given indicator levels at various distances from the source. Observed and predicted values should be compared over various source strengths where microbial/pathogen levels in wastewater are controlled by physical means or through disinfection.

Anticipated Results

The major products provided through the recommended assessments and research are a waste load allocation model related to microbial contamination and a description of the processes that affect the fate and effects of indicators/pathogens in estuarine waters.

Management or Regulatory Area Affected

The primary regulatory and management areas that would benefit from the proposed work include:

1) water quality based permits for estuarine waters (NPDES);

2) 208 areawide management plans;

3) local and state shellfish management plans.

Problem Statement E

There is considerable evidence to suggest that the processes employed to treat human waste before discharge to the estuary have limited impact on the densities of epidemiologically important pathogenic agents. At present, the agents are predominately viral in nature (infectious hepatitis, acute gastrointestinal illness). There is a need for treatment systems that will be effective at reducing levels of pathogens.

Broad Objective E1: Provide the information needed to identify and select appropriate treatment systems for reducing densities of human pathogens and, thus, the risk of disease transmission via direct contact or through ingestion of shellfish from estuarine waters.

The workgroup on microbial contamination reviewed the available methods on removal and inactivation of human pathogens by wastewater treatment and concluded that approaches are available for removal and inactivation of conventional indicator bacteria and enteric bacterial pathogens. However, data are not available for EIVAs.

The workgroup recommended that research be carried out in the following areas:

1) methods development for assaying and recovering EIVAs;

2) laboratory and in situ studies to determine the removal and inactivation of EIVAs and likely surrogates by conventional, advanced, and innovative treatment schemes;

3) evaluate effects of common and alternative disinfectants on EIVAs and indicators under laboratory and field conditions.

Anticipated Results

The results will provide information on the removal of EIVAs at sewage treatment plants as well as provide data on the effectiveness of indicators as a predictive tool.

Management or Regulatory Activity Affected

The proposed assessments and research will provide guidance on selecting appropriate treatment technologies for reducing health risks posed by microbial contamination in wastewaters discharged to estuaries. The primary regulatory area concerns NPDES programs for point sources.

7 Estuarine Habitat Modifications

7.1 Information Needs

Effects of physical habitat modifications are typically long-lasting and frequently permanent. The legacy of physical alterations on coastal wetlands is well documented. Habitat and ecosystem recovery, if achievable, often must be enhanced by human activities. Estuarine habitat alterations are often insidious and result in cumulatively significant impacts as a result of numerous small and seemingly innocuous activities. Consequently, regulators and environmental managers are confronted with the dilemma of evaluating individual proposals with negligible individual impact but significant cumulative impact without a sound understanding of how much habitat can be lost or altered before unacceptable effects on valuable resources result. In addition, managers and regulators require a sounder base of information to plan and gauge the effectiveness of rehabilitation and other management practices.

Information needs related to estuarine habitats and coastal wetlands were emphasized by State and Regional personnel in the southeast United States and Gulf Coast areas (Appendix A). The needs are described below.

1. Particular concern was expressed regarding the impacts of oil and gas canals on estuarine habitat, wetland, and marsh loss in coastal areas. A critical information need related to this is what constitutes good mitigation. It was pointed out that there are a number of small projects being conducted on mitigation but that there has been no concerted effort to bring the results of these various efforts together. In part, as a result, EPA personnel are uncertain about what to recommend in terms of mitigation related to maintaining or enhancing wetland and marsh areas.

Furthermore, there is an increasingly realized need to rehabilitate already-damaged habitats in an attempt to restore values or prevent further habitat deterioration (e.g., due to saltwater intrusion or hydrological dysfunction). Various management practices are commonly pursued, particularly in wetlands, for waterfowl enhancement (impoundments and weirs), aquaculture, insect control (ditching), and prevention of saline intrusion. There is uncertainty concerning the effectiveness or consequences of such management activities.

It was suggested that it would be very worthwhile if an effort was made to pull together the existing information on the systems and success or failure of various mitigation, management, and restoration measures in order to develop a mitigation guidance document for estuarine habitats, wetlands, and marshes.

2. Extensive estuarine habitat, especially wetlands, have been lost or modified as a result of dredging and filling activities which come under permit authority of Federal and State agencies. These activities include the construction and maintenance of navigation channels (e.g., the Intracoastal Waterway), shoreline developments, and oil and gas exploitation (particularly extensive in Louisiana). Although many of these activities individually affect only small areas, there is a concern about the cumulative impacts of habitat loss or degradation on the valuable resources the habitats support. It was suggested that it would be useful to document piecemeal loss of habitats and relate this to decline in fisheries.

3. Information is needed on the role or ability of wetlands and marshes to remove contaminants from water as well as the fate and effects of contaminants in wetland systems. It was noted that some wetlands can have or play an important role in wastewater treatment. If this role can be further demonstrated and documented it would help establish the beneficial aspects of wetlands within residential developments and help support the case for preserving them. In addition, information was needed on ways to sort out how and when to use wetlands for wastewater treatment.

The fate and effects of toxics in marsh/wetland systems were identified as a critical information need inasmuch as Mississippi River diversion projects of various kinds are being planned. These would involve diverting river water and associated sediment into upper reaches of coastal wetland systems in order to offset salt water intrusion and provide a source of sediment to the wetland. However, the river and its associated sediment load contain a variety of inorganic and organic contaminants. The NURP program noted that use of wetlands as a control measure is of interest but the necessary information on design performance relationships has not been adequately documented. The environmental impacts of such activities upon wetlands is a critical issue which, at present, has not been adequately addressed.

4. Information is needed on the causal mechanisms for loss of seagrass habitat. This was identified as a critical issue within EPA Region IV and there are obvious similarities between this problem and the Chesapeake Bay experience. It has been possible to document changes (e.g. losses) of these beds but it has not been possible to determine the causal mechanisms.

7.2 Current Programs That Address Information Needs

The workgroup on habitat modification was provided with summaries of current programs prior to the workshop. The entire summaries are not repeated here but some of the major ongoing programs are identified here.

Wetlands research is currently being supported by the Army Corps of Engineers Waterways Experiment Station (WES), NSF, NASA, and a number of state agencies. With regard to impacts of 404 programs on wetlands, most of the active research is being supported by WES.

A number of projects related to the general ecology of saltwater wetlands are being funded through the Sea Grant Program. These studies are valuable in helping establish the functions of saltwater wetland systems.

A number of federal and state agencies have developed wetland classification systems. For example, the state of Louisiana has developed an approach that involves using vegetation as indicators for marsh/salinity types. This information serves as a management tool and a means of assessing the status and change in status of coastal wetlands. Much of the work related to this has been done at the LSU Center for Wetlands Resources.

EPA presently has no research program related to tidal wetlands although there had been a program several years ago. However, there may be a research initiative in the future. A FY 1987 Wetlands Research Initiative has been prepared; the program is designed to provide support to the Office of Federal Activities (OFA) as well as other EPA offices. The EPA's Office of Marine and Estuarine Protection (OMEP) is planning some joint workshops with the Fish and Wildlife Service to consider estuarine habitat and wetlands management issues. These should help focus research needs related to coastal and tidal wetlands.

7.3 Research Needs Related to Estuarine Habitat Modifications

Three discrete problem areas were identified: 1) the effects of cumulative losses; 2) the effectiveness of mitigation, rehabilitation, and management practices; 3) the role of wetlands in maintaining estuarine water quality. In addition, a fourth methodological problem was identified that relates to these problem areas as well as to estuarine characterization objectives (Section 8) - assessment of the relative resource values of estuarine habitats.

Habitat modification issues affect several of the topics considered by other workgroups. The relationships among the issues in the four problem areas identified under estuarine habitat modification and these other topics are depicted in Figure 3.

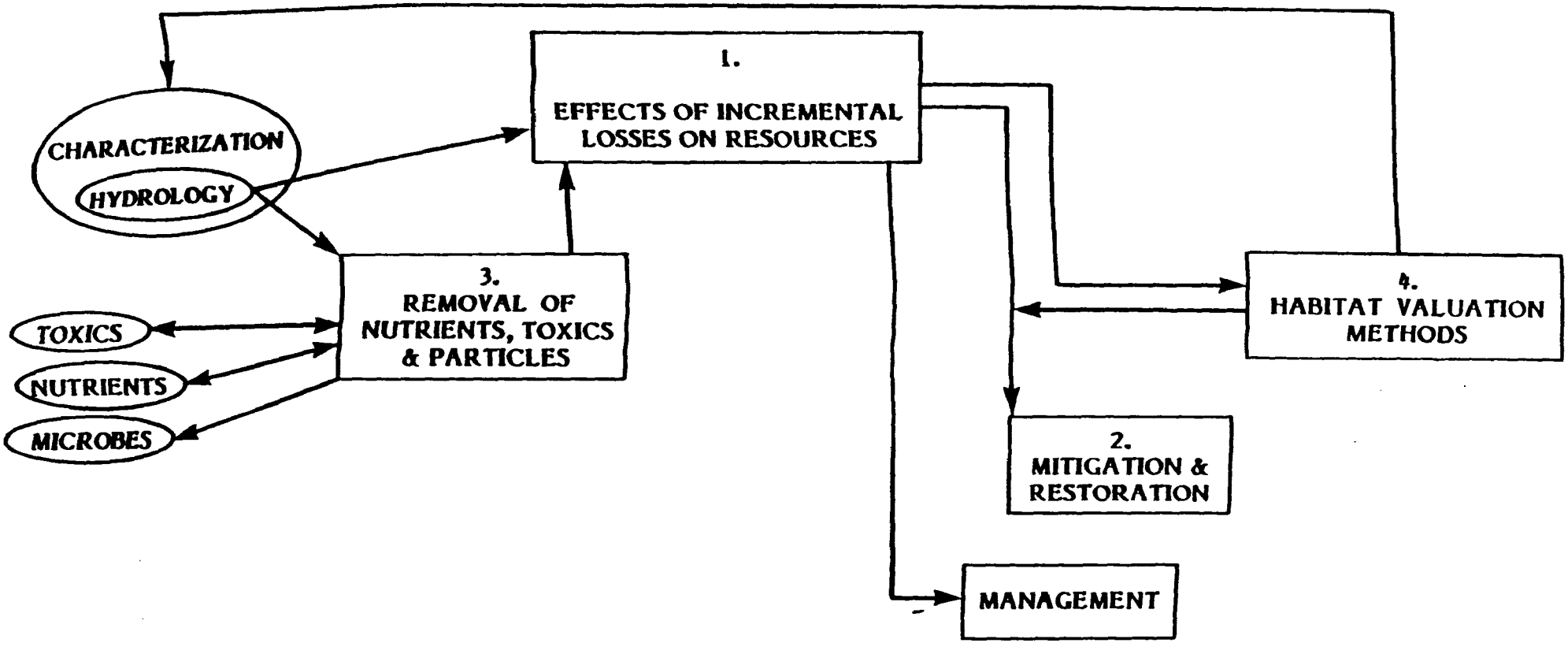

FIGURE 3. ESTUARINE HABITAT MODIFICATION

Problem Statement A

There does not exist a comprehensive and up-to-date inventory of cumulative habitat changes based on records of actual area impact as well as the extent of permitted alterations. Furthermore, the inability to predict the long-term cumulative impacts of these changes makes habitat protection difficult, especially where there are substantial short-term economic benefits to development, e.g., in oil and gas exploitation or commercial shorefront development.

Broad Objective A1: Evaluate the feasibility of developing a comprehensive, national inventory of permitted and actual alterations of estuarine habitats.

The workgroup recommended that assessments be made of the following:

1) existing inventory systems maintained by Corps of Engineers district offices or state agencies;

2) methods to relate the extent of actual impact of dredge and fill activities to permit stipulations; such methods may include aerial surveillance such as used in North Carolina;

3) the development of a comprehensive inventory system and evaluation of the appropriate role of cognizant Federal and state agencies.

Anticipated Results

The assessments will provide the basis for a comprehensive plan for documenting cumulative losses of estuarine habitats with emphasis on tidal wetlands.

Management or Regulatory Area Affected

The areas that would benefit from the inventory include:

1) wetland use permitting;

2) regional and national estuarine status and trend assessments.

Broad Objective A2: Evaluate the effects of cumulative estuarine habitat modifications and losses.

The workgroup identified several specific objectives related to cumulative modifications or losses.

Specific Objective 1: Evaluate the effects of cumulative estuarine habitat modifications on fish and wildlife resources.

The workgroup on habitat modification noted that complete resolution of this issue will be difficult and illusive. However, they concluded that significant advances can be made by carefully conducted research aimed at assessing the trends in fish and wildlife resources on a regional basis and by quantifying habitat utilization at a local scale. The workgroup recommended research in two areas:

1) statistical modelling assessments of population trends as deduced from direct census (e.g., waterfowl) or effort-adjusted catch data (e.g., fishery stocks) for key species presumably dependent on wetlands in areas experiencing significant habitat losses;

2) carefully designed field studies of fish and wildlife utilization of habitats of various scales and degrees of alteration.

Specific Objective 2: Evaluate effects of cumulative wetland losses on increased storm surge and tidal flooding of inhabited areas.

Two assessments of existing information were recommended:

1) compile and evaluate trends in tidal and storm surge flooding in areas of wetland loss or channelization;

2) synthesize these results with existing storm surge models.

Anticipated Results

Results will provide information on how cumulative wetlands losses can be related to potential for effects on resource species and the potential for increased flood damage. An effort should be made to express these relationships quantitatively.

Management or Regulatory Area Affected

The following management or regulatory areas would benefit from the proposed assessments and research:

1) wetland use permitting;

2) establishment of and support for mitigation requirements;

3) management plans for fisheries and wildlife;

4) FEMA regulations and planning;

5) development of flood protection projects.

Broad Objective A3: Provide technical basis for predicting and minimizing wetland losses or modifications under conditions of accelerated sea level rise which may occur during the next 50 years (1 mm/yr at present to 1 cm/yr).

The workgroup on habitat modification recommended that an assessment be made of methods to enhance accretion of sediments and peat, including river diversions and management of drainage within wetlands by investigating sedimentation rates in freshwater diversion areas, ditched marshes, and marshes in which water level is controlled.

The workgroup also indicated that research was needed in two areas:

1) comparisons of wetland accretion rates during late Holocene transgression and the present with sea level rise and fluctuations;

2) investigations of contemporary sedimentation (post-Colonial) in subsiding environments (e.g., Louisiana marshes and some Chesapeake Bay marshes) in relation to water level fluctuations.

Anticipated Results

The results will aid in the evaluation of risks posed by atmospheric warming due to the buildup of CO2 and other greenhouse gases as they affect sea level rise.

Management or regulatory Area Affected

The research would support the following:

1) national and international policies regarding control of greenhouse gases;

2) wetland protection policies and permitting (e.g., should greater protection be provided to those wetlands which have a greater potential for survival);

3) wetland management practices: drainage and impoundment.

Broad Objective A4: Evaluate causes of declines in submerged aquatic vegetation.

The workgroup recommended that an assessment be made of existing information on losses of submerged aquatic vegetation. Data should be extracted on a) locations of the seagrass beds by estuary, b) extent of the losses (in acres or percents), and c) if possible, identification of the cause(s) of seagrass loss.

The workgroup anticipates that there will be gaps in the information base and recommends the following research areas:

1) supplement existing information in estuaries where seagrass losses are occurring by monitoring water quality indicators and by looking for causes identified in the literature;

2) identify other estuaries which support seagrass beds and where similar factors resulting in seagrass bed loss can be expected; determine the extent to which these estuaries are experiencing seagrass losses.

Anticipated Results

The results will provide information on the factors that cause losses of seagrass beds in estuarine systems and on the characteristics of these losses.

Management or Regulatory Area Affected

The information will benefit those state and federal personnel who are responsible for estuarine and water quality programs. Specifically, the information can be used to help identify causal factors and, therefore, provide guidance on the efficacy of proposed remedial programs.

Problem Statement B

Little is known of the effectiveness of estuarine habitat mitigation, restoration and management practices on valued resources, such as support of fisheries and wildlife or waste assimilation.

Broad Objective B1: Develop a technical basis for effective mitigation, restoration and management for optimizing their efficacy for enhancing valued resources.

The workgroup recommended that an assessment be made of available information concerning the effectiveness of mitigation, rehabilitation and management strategies and practices with emphasis on estuarine wetlands and seagrass beds. The adequacy and technical bases for the practices should be assessed. Several federal agencies and professional groups are already active in reviewing and recommending wetlands mitigation practices.

The workgroup indicated that additional research was needed to evaluate wetland function (including self perpetuation and water quality effects) and habitat utilization by fish and wildlife of damaged, rehabilitated, and managed habitats compared to comparable unaltered habitats. Conditions which should be evaluated include channelized wetlands, wetlands with backfilled or plugged channels, weired impoundments managed for waterfowl, wetlands with barriers erected to slow saltwater intrusion, ditched wetlands, and wetlands regularly burned to promote wildlife utilization.

Anticipated Results

Information will be developed on the efficacy of various mitigation measures and how these will contribute to the support of biological resources.

Management or Regulatory Activity Affected

The following activities would benefit from the proposed assessments and research on mitigation measures:

1) permitting of dredge and fill activities and impoundments;

2) developing technically sound mitigation requirements;

3) cost:benefit analyses of estuarine rehabilitation projects;

4) management plans for estuarine systems supporting multiple and potentially incompatible resources.

Problem Statement C

While wetlands are widely recognized as potential sinks for certain nutrients, toxics, and sediments, our current level of knowledge in this field is both fragmentary and contradictory.

Broad Objective C1: Develop the ability to predict the retention and processing characteristics of specific estuarine wetlands with regard to toxics, nutrients, and sediments.

Two specific objectives were identified.

Specific Objective 1: Evaluate the interaction between factors which control material fluxes in estuarine wetland systems. Factors to be considered include hydrological, geological, chemical, and biological; fluxes include retention, export, and internal processing of materials.

The workgroup recommended that research be focused on understanding the interactions between factors such as basin geomorphology, sediment type, tidal characteristics, surface hydrology, sub-surface hydrology (e.g.,hydraulic conductivity), retention times/loadings, water chemistry, wetland plant community characteristics (e.g., root/rhizome type), surface litter dynamics, microbial activity, and climatology. Three specific areas recommended for research included:

1) studies of "sediment" retention related to previously mentioned factors; sediment includes the particle together with the toxics and nutrients that may be associated with the particle;

2) studies of flux characteristics by varying one or more variables using controlled microcosms, mesocosms and flumes (open ended mesocosms which cross wetland from tidal creek to upland regions).

3) compare fluxes among wetland habitats (e.g., Spartina, Juncus) by using the same methodology.

Specific Objective 2: Determine long-term assimilative capacities of estuarine wetlands.

The workgroup recommended that research be conducted using comparative microcosm uptake studies in which labelled material would be introduced to wetland surfaces that vary in their history of exposure to "excessive" loadings. For example, wetlands of Ø, 5, 1Ø etc. years of exposure could be selected for the comparative studies.

Anticipated Results

The results of these studies will provide information on the ability of coastal wetlands to retain and/or process materials that enter them from point but predominantly non-point sources.

Management or Regulatory Activity Affected

The results will be beneficial to local, state, and regional personnel involved in wetland and estuarine management programs. In particular the information will be helpful for:

1) evaluating dredging and disposal programs;

2) evaluating shore development proposals;

3) evaluating impacts of various federal activities;

4) evaluating proposals for non-point source controls;

5) evaluating marsh creation projects.

Problem Statement D

A system is needed for assessing functions and values of estuarine habitats relative to management, protection, and/or restoration of estuarine resources.

Broad Objective D1: Develop a procedure for assessing functions and values of various estuarine habitats for management, protection, and/or restoration of estuarine resources.

Two specific objectives were identified.

Specific Objective 1: Review and adapt existing habitat valuation strategies for estuarine wetlands. (Note: this is to a large extent being done in an evolutionary fashion.)

The workgroup recommended that an assessment be made of available valuation strategies that may have potential application to estuarine wetlands. Although more than forty systems exist, two promising candidates include the Federal Highway Administration (Adamus) technique and the USFWS Habitat Evaluation Procedure (HEP).

Once candidate valuation method(s) has been identified it is anticipated that the following research will be needed to adapt it for use in estuarine wetlands:

1) testing the basic assumptions of the method and determining if the method is based on currently available technical data;

2) refine the method by adjusting the basic assumptions, adding additional technical data, developing a sensitivity analysis that defines the level of confidence, and computerizing the system to facilitate its use;

3) field test the method and make additional refinements.

Specific Objective 2: Develop procedures for comparing resource values among different estuarine habitats (e.g., saltmarsh, tidal flats, oyster reefs).

The workgroup recommended that assessments be made in several categories including:

1) the development of procedures for assessing functions and values of estuarine habitats other than wetlands;

2) for the various estuarine habitat types apply the approach outlined under specific objective 1;

3) develop a common qualitative or quantitative base for comparing values of different estuarine habitat types.

Anticipated Results

Results would provide an objective procedure for assessing the functions and values of wetlands and other estuarine habitats. A standardized procedure for assessing functions and values would be established. A framework would be provided for comparing relative values of different estuarine wetlands and other habitats.

Management and Regulatory Activity Affected

The products of the assessments and research would benefit the following regulatory activities:

1) dredge and fill activities (404 Programs);

2) development of mitigation plans;

3) development of restoration plans;

4) determination of cumulative impacts;

5) land acquisition programs.

8 Estuarine Characterization

8.1 Information Needs

Several issues were raised by State and Regional personnel with regard to characterizing estuaries (Appendix A).

1. There is considerable interest regarding methods to measure or express the "health status" of an estuary. The Index of Biological Integrity, used in freshwater, was mentioned as a possible tool but work would have to be done to determine whether this or other approaches are applicable to estuaries. Only one of the difficulties in using a single index is the short-term variability that estuaries experience. Others noted that research should focus on identifying early warning indicators of problems, especially those resulting from chronic effects of toxics or changes in land use. It was noted, for example, that it was extremely difficult to bring back seagrass beds which bears out the adage, "An ounce of prevention is worth a pound of cure." Thus, early indicators of problems would be extremely useful. It was suggested that it would be helpful to have a protocol for assessing the "health" of estuaries on a comparable basis.

2. There is a critical need to develop an understanding of the hydrologic and hydrodynamic processes of the coastal estuarine and bay systems found in the Gulf of Mexico. These differ from the classical "estuarine" systems described by Pritchard inasmuch as there is little tidal forcing in the Gulf systems. There, meteorological events strongly affect advection and residence time of surface waters. (Note: this is also the case in selected estuaries in other parts of the country.) A framework for characterizing and expressing the hydrodynamic processes of these systems is basic to addressing questions related to salt water intrusion, overall water quality, nutrient loading, and fate and effects of toxics.

3. A need was expressed for data management systems that could be implemented at the state, regional or national level.

8.2 Current Programs That Address Information Needs

The workgroup on estuarine characterization was provided with expanded summaries of ongoing programs designed to characterize estuarine conditions. This review is not repeated here but some of the major programs are provided as examples.

Several of the major ongoing programs are being conducted by NOAA. For example, the Ocean Assessments Division within NOAA is currently developing a national data base on characteristics of about 100 estuaries accounting for 90% of either the freshwater inflow or estuarine surface water area in each of the three major coastal regions of the contiguous United States. At

present physical, hydrologic, and land use data are being gathered; economic and biological data will be added in the future.

NOAA's Office of Oceanography and Marine Assessment has been coordinating a program to develop indices of marine degradation and to assess their utility. Each of the eleven indices proposed are constrained by the following design criteria: socially relevant, simple and easily understood by laymen, scientifically defensible, quantitative and expressed probabilistically, and acceptable in terms of cost.

NOAA's Ocean Assessments Division is currently implementing a new program entitled the "National Status and Trends (S&T) Program for Marine Environmental Quality". The S&T Program involves a series of activities intended to quantify the current status and long-term, temporal and spatial trends in the nation's coastal and estuarine environments. To this end, the program focuses on key contaminants, water quality parameters, and biological indicators. NOAA's National Marine Pollution Program Office and the U.S. Council on Environmental Quality are also contributing effort towards the development of useful indices of marine environmental quality. The Sea Grant Program also has funded numerous studies that provide information on estuarine characterization primarily with respect to the general ecology of estuaries.

Under EPA's 301(h) program, municipalities which discharge sewage to marine waters and are granted waivers from secondary treatment are required to monitor a variety of biological and chemical parameters. These data are input to EPA's Ocean Data Evaluation System (ODES) data base and can be used to help characterize estuarine and coastal areas. A data base management system was developed as part of the Chesapeake Bay Program and OMEP is in the process of developing a similar system as a national data base. Various other data base systems have been or are being developed for coastal and estuarine systems. Examples include those developed for coastal Superfund sites.

8.3 Research Needs

The workgroup on estuarine characterization chose to consider the three broadly defined information needs identified by State and Regional EPA personnel. These included methods of evaluating estuarine status, a classification scheme for non-Pritchardian coastal embayments, and a system for accessing environmental data on estuaries.

Problem Statement A

There is no widely accepted process by which managers can assess estuarine status relative to protection of human health and protection or restoration of biological resources.

Broad Objective A1. Develop indicators and a methodology with which estuaries can be compared to one another so as to help determine priorities for preservation, protection, and restoration. The approach should improve technical guidance for more consistent management definitions of "unreasonable degradation", i.e., to help decide when something should be done.

Three specific objectives were identified.

Specific Objective 1: Develop the indicators that will serve as the basis for comparison.

The workgroup on estuarine characterization identified two groups of potential indicators. The first group included potential indicators for which there exists information on a regional or national basis. The second group included those potential indicators that were considered to be valuable and whose use is worth pursuing, but for which data presently available may be either limited or of poor quality. The two groups were as follows:

Indicators for which information exists:

- o pathogens, as represented by standard monitoring of coliforms;
- o concentrations of certain toxicants in marine food organisms;
- o dissolved oxygen;
- o turbidity;
- o estimated total loadings of nutrients and some classes of toxics for coastal and estuarine regions, as compared to estimated retention times for those regions.

Indicators for which data are limited:

- o body burdens of toxicants other than those for which FDA Action Limits exist;
- o fecundity of key species over broad geographic regions;
- o disease incidence in key species over broad geographic areas;
- o field and lab measures of early life mortality;
- o reproductive success of marine birds;
- o water column toxicity and pathogens in bathing waters and shellfish.

The workgroup recommended that assessments be made of existing information in several areas:

1) characterize the status of estuaries on the basis of indicators for which data exist (first group); this would involve establishing a data inventory for estuaries so that information gaps in basic indicators can be identified;

2) develop Risk Reference Dose values (of carcinogenicity/toxicity) for chemicals commonly found in fish and shellfish for which such values have not yet been developed; such information is needed to evaluate the human health implications of body burdens of several toxics in fish and shellfish; a list of candidate toxics should be developed;

3) collect and evaluate existing data on potential indicators for which data have not been adequately assessed;

4) utilizing existing information, develop an evaluation procedure for estuarine environmental quality.

Several areas have been identified where additional research is required:

1) develop better measures of shellfish pathogenicity;

2) derive hypoxic mortality and growth reduction curves for sensitive fish and shellfish;

3) distinguish between effects of toxics and organic enrichment on benthic community structure; such information is needed to evaluate the utility of using benthic community structure as an index;

4) develop and/or field validate potential indicators of pollutant stress in sediments (e.g., Swartz amphipod field bioassay);

5) identify "early-warning" indicators of effects; changes in the indicators themselves should be relatively inconsequential for the system as a whole and should be detectable in advance of changes in critical indicators or other key components of the system;

6) obtain supplemental data with which to complete evaluations or strengthen the use of potential indicators cited in the 3rd assessment under specific objective 1.

Specific Objective 2: Develop a comparative methodology useful to estuarine managers.

The principal objective is to develop a framework or methodology which utilizes the indicators developed in specific objective 1 to assess the health and condition of an estuary in comparison to other estuarine and coastal systems. This is best approached by conducting a series of assessments:

1) evaluate the utility of existing comparative methodologies for use in assessing the status of an estuary's health and condition as compared to other estuarine systems; such methodologies could include those developed for non-environmental issues (e.g. economic indices);

2) adapt a method or combination of methods which would achieve the stated objective.

Specific Objective 3: Apply the methodology to a regional or national set of estuaries.

The objective here is to "field test" the methodology by applying it to a regional or national set of estuaries. These could include a well defined set of estuaries within a particular geographic area (e.g., northeast U.S.) or estuaries selected from various parts of the country. It is recommended that the estuaries include those in the OMEP Bays Program. This effort is envisioned to involve primarily an assessment of existing information on the indicators identified in specific objective 1 and applying the methodology developed in specific objective 2. Some additional data may be required for specific estuaries to facilitate the application of the methodology.

Anticipated Results

The primary products of the proposed assessments and research will be a validated set of indicators that can be used to evaluate the health status of an estuary and a comparative methodology for applying these indicators.

Management or Regulatory Area Affected

The products will be beneficial to state and federal regulatory personnel involved in a wide range of activities associated with estuarine management. These include:

1) permitting of dredge and fill activities and impoundments;

2) developing technically sound mitigation requirements;

3) cost:benefit analyses of estuarine rehabilitation projects;

4) management plans for estuarine systems supporting multiple and potentially incompatible uses;

5) water quality based permit control for toxics and nutrients in estuaries (NPDES, nonpoint sources);

6) remedial investigative studies and management plans;

7) fish and wildlife management plans;

8) environmental impact statement preparation and evaluation.

Developing of a framework for assessing the status of particular estuaries will aid in the allocation of resources for study, restoration, and protection. It will help legislatures and the public understand the implications of estuarine conditions and, thus, provide them with more consistent and reliable scientific guidance as to what to do.

Broad Objective A2: Detect temporal trends in individual estuaries so as to assess historical changes, protect future conditions, develop early warning monitoring strategies, and evaluate success of protection/restoration activities.

Several specific objectives were developed to address this broad objective.

Specific Objective 1: Identify estuaries experiencing rapid change.

The workgroup on estuarine characterization recommended a series of assessment activities to meet this objective:

1) contact State and Regional personnel to develop a list of candidate estuaries where rapid change has or is believed to be occurring; assessments of information would be made on this selected set of estuaries with emphasis on the information categories outlined below;

2) historic data analysis on indicators developed under broad objective 1;

3) trends in fish/shellfish, pollutant loadings, and catch/effort;

4) trends in closures of shellfish beds;

5) habitat loss;

6) chemicals and fossils in sediment cores;

7) land use changes;

8) freshwater inflow and salinity changes.

Specific Objective 2: Use inter-estuarine comparisons to project intra-estuarine trends.

The workgroup recommended that the following assessments be made:

1) using existing knowledge regarding physical, chemical, and biological characteristics of different estuarine systems in different parts of the country, develop an inter-estuarine classification scheme;

2) apply indicators and rank estuaries by "health status" within classification types;

3) for each classification type, develop descriptions of the generic characteristics of "health status" ranging from estuaries judged best to worst.

Specific Objective 3: Identify critical species most sensitive to man-induced alterations.

The workgroup recommended that an assessment be made to identify species that fit two key criteria: a) they are important to the public, b) they are sensitive to man induced changes. Lists of such species would be developed on regional and national levels.

There are only limited data on some species which are believed to be sensitive to man induced changes. Where additional documentation is required, it is recommended that consideration be given to carrying out the necessary studies. These might involve a series of challenge experiments.

Specific Objective 4: Relate indicator trends to man induced changes.

The workgroup recommended that simple models be validated. These include models of historic indicator trends as they relate to measures of man induced change. Basically, this would involve a synthesis of information gathered under specific objective 1, "Identify estuaries experiencing rapid change."

Specific Objective 5: Evaluate the success of restoration and protection programs.

The ability to assess temporal trends in estuaries using the approaches outlined above has clear value for evaluating the efficacy of restoration and protection programs. It is

recommended that the methodology be applied to selected programs in order to assess the effectiveness of these programs and to provide additional information on the potential usefulness of the methodology.

Anticipated Results

The products of this work will include approaches for assessing the temporal changes within estuaries and for relating those changes to man-induced activities.

Management or Regulatory Area Affected

The management and regulatory areas affected are the same as those outlined under broad objective A1. The products of the research and assessments under A2 will be particularly beneficial to managers who wish to determine which estuaries are experiencing rapid adverse change and should be targeted for protective strategies. In addition, the approaches will assist managers in demonstrating the degree to which estuarine systems are being maintained or enhanced and at what rate. The work would also serve to establish what rates of recovery can be expected following control or mitigation measures.

Problem Statement B

There is no hydrodynamic classification scheme that characterizes circulation in non-Pritchardian coastal embayments.

Broad Objective B1: To develop a hydrodynamic classification that can be employed to understand the effect of circulation on saltwater intrusion, particle distribution, and the spatial distribution of living resources in non-Pritchardian estuaries.

Three of the specific objectives identified by the workgroup are presented below.

Specific Objective 1: Identify the hydrodynamic parameters that would be used in the classification scheme.

The workgroup recommended that the following assessments be made using existing information.

1) screen non-traditional systems to develop geomorphological groupings;

2) discern the relation between data on salinity and meteorologic/hydrologic, tidal, and geometric parameters characteristic of the estuaries;

3) using the information generated by the first two assessments, identify the parameters that would be used in the classification scheme.

The workgroup recommended that the information generated on geomorphological groupings and hydrodynamic parameters be used to establish long-term monitoring sites for salinity, wind, water level elevation, and currents.

Specific Objective 2: Adopt or develop representative real-time hydrodynamic models for each geomorphological grouping.

The workgroup recommended that the following activities be undertaken based on an assessment of available information:

1) assess applicability of existing models for the various geomorphological groupings;

2) adopt or modify existing models where possible;

3) assess adequacy of existing data for model calibration/verification; if data are judged to be inadequate, design and implement appropriate data acquisition programs;

4) calibrate and verify the model(s); test model(s) applicability to other estuaries within the same geomorphological grouping.

The workgroup noted that in the event that no existing models are available for adoption or modification, then an effort would be needed to develop a new one. The need for such an effort should be carefully reviewed based on the evaluation of existing models and the efficacy of developing a new model.

Specific Objective 3: Develop an approach that can be used to estimate the dynamics of particle transport in non-Pritchardian estuaries.

The workgroup recommended that available information be assessed and the models developed under specific objective 2 be used to examine the time scales associated with short and long-term particle transport in non-Pritchardian estuaries. An assessment should be made concerning the ability of existing models to predict the behavior of particles in these systems.

It is anticipated that there may be a need to develop sediment resuspension, transport, and deposition submodels for these systems. Assuming that progress can be made in the first two specific objectives, then consideration can be given to the development of the particle transport and fate models.

Anticipated Results

Products will include: a) a hydrodynamic classification scheme for non-Pritchardian estuaries; the scheme will infer general circulation characteristics and provide the framework for estimating more detailed circulation features from systems that have been modelled; b) real-time hydrodynamic models for geomorphological groupings of non-Pritchardian estuaries; c) sediment transport and fate models for non-Pritchardian estuaries.

Management or Regulatory Activity Affected

The products will be beneficial to those State and Regional personnel responsible for management of non-Pritchardian estuarine systems. Such systems are typically found in the Gulf of Mexico but occur elsewhere within the United States. The specific regulatory and management areas affected are the same as those already described under Broad Objective A1.

Problem Statement C

At present, no adequate system exists for accessing environmental data on estuaries that have been collected through a variety of State and Federal monitoring and experimental programs.

Broad Objective C1: Improve access to environmental data on estuaries.

Two specific objectives were identified.

Specific Objective 1: Develop an accessible database locator indexed by both subject category and region.

The objective is to develop a document that would list sources of information and contacts regarding how and where to access environmental data. This would involve an assessment of available information and contacting state and federal agency representatives.

Specific Objective 2: Develop approaches using uniform or convertible data codes and formats to facilitate the use of environmental data from various sources.

The workgroup recommended that two approaches be considered for meeting this objective:

1) develop software systems to read and write commonly used data formats;

2) create interagency task force to inform data users of conversion system availability and encourage adoption of a single format.

Anticipated Results

The products will be tools that will enable investigators to identify sources of environmental information and access such data using a common format.

Management or Regulatory Area Affected

The tools will be helpful to technical personnel involved in all aspects of estuarine environmental management where data acquisition from existing data bases is required.

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APPENDIX A: TRIP REPORTS

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To: Vic Bierman, Dick McGrath
From: C. Menzie
Date: Sept 5, 1985
Subject: Trip Report for EPA Regions I and II (May 29, 1985)

The objective of this visit was to meet with EPA and state personnel to learn about paraticular estuarine problems encountered in Regions I and II and to obtain input regarding rsearch needs. This information will be used to help develop the estuarine research strategy within the EPA's Office of Research and Development. Input from regional and state personnel is considered critical to the strategy inasmuch as these individuals are the eventual users of the research outputs.

Meetings were held with the following: EPA Region I and II and the States of Connecticut and New York at Boston, MA. The overall visit was coordinated by Dr. Mike Connor of EPA Region I.

Issue Identification and Information Needs

Several issues were identified as particularly important in Regions I and II. These are described below:

1. Microbial Contamination of Shellfish and Swimming Waters: this was considered one of the highest priority issues. Such contamination affects numerous uses of estuaries in the northeast. There is a clear need for appropriate indicators of health risks. There is a need for information on whether the relationship between indicator levels and risks is linear or displays a threshold level. Information is needed on the fate of the microorganisms and how fate is affected by suspended sediment load and other physical or chemical factors. Information is needed on how microorganisms are taken up by shellfish, i.e. directly from the sediment, from water, or both. Depending on how microorganisms are taken up, and on the spatial and temporal variability of the microorganisms in the marine environment, information and guidance are needed on appropriate sampling strategies. Information is needed on the effects of soil type and land use on the apparence of microorganisms in the water. Information is needed on wastewater system designs that can be affective in reducing levels of microorganisms (e.g. septic tanks, CSO designs, catchment basins). Information is needed on the effectiveness of chlorination on reducing actual health risks.

2. Toxic Contamination: this is also considered to be a high priority issue with high visibility in the northeast. Information is needed on human health impacts of chronic low doses of organic toxics in seafood. Information is needed on biological effects of toxics on reproduction of marine organisms, and development of diseases in organisms as a result of elevated body burdens of toxics and their metabolites. It was noted that in estuaries, metals levels often exceed EPA Water Quality Criteria. Information is needed on the actual biological effects of metals copper and Silver at concentrations above 1-2 ppb. Information is needed on the importance of metal speciation; can the effects be predicted? Whole effluent toxicity testing needs to be field validated for estuaries. Information is needed on possible synergistic effects among toxics or between toxics and reduced oxygen levels.

Information is needed on where monitoring assessment should be made in estuaries, i.e., sediments, water column, body burdens. Information is needed on the transport of suspended sediments and the role this has in the transport of toxics in estuaries.

3. Eutrophication: this is a problem in some coastal areas and is a particularly problematic for western Long Island Sound and embayments located around some of the major municipalities (e.g. New York City). Information is needed on the seriousness of eutrophication-related effects on estuaries in the northeast. What are the effects on anoxia and changes in food web? Simple measures to assess the health status of the estuary are needed. The establishment of "ecological standards" would be helpful. Information is needed on the effects of eutrophication on commercial and recreational species of fish and shellfish.

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To: Vic Bierman, Dick McGrath
From: C. Menzie
Date: May 6, 1985
Subject: Trip Report for EPA Region IV (April 25 to 26, 1985)

The objective of this visit was to meet with EPA personnel to learn about particular estuarine problems encountered in Region IV and to obtain input regarding research needs. This information will be used to help develop the estuarine research strategy within the EPA's Office of Research and Development. Input from regional personnel is considered critical to the strategy inasmuch as these individuals are the eventual users of the research outputs.

Meetings were held with the following: EPA Region IV at Atlanta, GA and Region IV Environmental Research Group at Athens, GA. Summaries of these discussions are pesented below and are supplemented with information provided in reports and documents furnished by Region IV personnel. The overall visit was coordinated by Reginald Rogers of EPA Region IV.

EPA Region IV at Atlanta, GA

Discussions were held with Reginald Rogers, Bob Howard, Ted Bisterfeld, Bill Kruczynski, Lee Pelej, and John Marlar. A number of issues were discussed; these are summarized below.

1. Land use impacts: this was identified as one of the most important factors affecting estuaries within Region IV. Reference was made to the large scale clearing activities in coastal North Carolina associated with the establishment of "megafarms" some of which can amount to 22,ØØØ acres. Urban and residential development are also placing pressures on the estuarine systems and are resulting in losses of wetlands. One aspect of the land use issue is the effect on nutrient loading to the estuaries especially from nonpoint sources. This is discussed below under "nutrients".

It was noted that declines in fisheries were probably related to losses of wetlands. A major current problem with regulating land use as it relates to wetlands loss is that proposed projets are handled in a piecemeal fashion. It was suggested that it would be useful to document piecemeal loss of wetlands and relate this to decline in fisheries.

Changes in hydrologic conditions associated wth changes in land use are believed in some cases to be as and perhaps more important than changes in pollutant load to the estuaries. It

was suggested that there is a need for upland hydrologic models that can be tied to or used in conjuction with estuarine circulation models. Discussions are underway with the Army Corps of Engineers concerning such models.

It was acknowledged that EPA had only a "secondary" handle on dealing with land use issues. The state of North Carolina has been in the process of developing an approach for dealing with these problems. Region IV personnel indicated they were quite concerned about the long-term effects of large scale changes in land use.

2. Loss of seagrass habitat: this was identified as another critical issue within Region IV. There are obvious similarities between this problem and the Chesapeake Bay experience. It has been possible to document changes (e.g. losses) of these beds but it has not been possible to determine the causal mechanisms. This is an area where research is needed.

3. Nutrients: nutrient loadings from point and nonpoint sources were identified as a concern and was linked, in part, to the general land use problem. One issue in particular that was mentioned was the change from detrital based to phytoplankton based food webs within estuaries. A need was identified with regard to being able to relate nutrient/biota relationships to changes in land use. It was also pointed out that with regard to "nitrogen removal", some states within Region IV want to limit nitrogen input. EPA Headquarters has taken the position that they are not willing to help fund systems to limit nitrogen if it can't be shown to be clearly impacting the estuarine environment. Also, Headquarters has not and can not identify any situation where they believe nitrogen removal is warrented.

4. Health status of estuaries: a need was identified with regard to being able to assess the health status of an estuary. It was noted that research should focus on identifying early warning indicators of problems, especially those resulting from chronic effets of toxics or changes in land use. It was noted that it was extremely difficult to bring back seagrass beds which leads to the adage, "An ounce of prevention is worth a pound of cure." Thus, early indicators of problems would be extremely useful. It was suggested that it would be helpful to have a protocol for evaluating an estuary.

5. Wetlands/wastewater treatment: it was noted that some wetlands can have or play an important role in wastewater treatment. If this role can be further demonstrated and documented it would help establish the beneficial aspets of wetlands within residential developments and help support the case for preserving them. In addition, information was needed on ways to sort out how and when to use wetlands for wastewater treatment. Region IV is actively assessing the role of wetlands treatment.

6. Toxics: it was noted that toxics were not as major an issue in Region IV as they were in some other parts of the country although mercury in the St. Johns River and inputs of agricultural chemicals were mentioned. However, it was noted there is a need for appropriate estuarine/marine bioassays with particular reference to the short-term chronic bioassay.

7. Shellfish contamination: a desire was expressed for better indicators (than fecal coliform) of contamination of shellfish and recreational waters. More study is needed to distinguish nonpoint vs point sources resulting in closures of shellfish areas.

8. Information dissemination: it was noted that the dissemination of information concerning applicable estuarine studies in other areas was not efficient. This decreases the overall utility of those studies. It was suggested that a better mechannism be developed for disseminating appropriate information to appropriate EPA and state personnel. The MMS OCS program was mentioned as a good example of an information dissemination program.

9. Program integration: it was noted that EPA has a variety of regulatory programs that relate to estuaries. It would be useful if there could be better integration of these programs so that they address the estuary as a system.

EPA Region IV, ESD Laboatory

Discussions were held with Lee Tebo, Bill Peltier, Paul Frey, Bill Walker, and Ron Rasche; Reg Rogers EPA IV, Atlanta also participated in the meeting. A number of the points presented above were also raised at this meeting and will not be repeated. Additional issues that were discussed or expaned upon are presented below.

1. Wastewater discharges: there is a need for more precise detection of fate and effects; dye studies are considered critical. Problems are encounted when attempting to delineate the effects of individual discharges in situations where there are multiple discharges as well as in assessing the cumulative effects of the multiple discharges.

2. Toxics: a number of issues were identified as outlined below:

- o techniques (bioassays) were needed to get answers quickly;
- o techniques and methods should be simple and cost effective but should have good technical basis and adequate documentation; very sophisticated approaches are difficult to implement at the regional or state level;

- there is a need for information concerning the bioavailability of toxics in sediments; this area of research should be emphasized especially with regard to uptake of contaminants in brackish water situations;

- there is a need for sediment criteria;

- there is a a need for information concerning the "significance" of body burdens of toxics;

- there is a need for better sampling methods for quantifying nonpoint sourcecs; these methods need to be simple to use;

3. Methods: a recurrent theme in the discussions was the need for "quick and dirty" but sound methods for going in and assessing the health status of the estuary with the objective of identifying problem areas. One area mentioned with regard to such tools related to the use of chlorophyll a.

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To: Vic Bierman, Dick McGrath
From: C. Menzie
Date: May 6, 1985
Subject: Trip Report for EPA Region VI, Texas and Louisiana (April 22 to 24, 1985)

The objective of this visit was to meet with local, state and federal personnel to learn about particular estuarine problems encountered in Region VI and to obtain input regarding research needs. This information will be used to help develop the estuarine research strategy within the EPA's Office of Research and Development. Input from regional and state personnel is considered critical to the strategy inasmuch as these individuals are the eventual users of the research products.

Meetings or telephone conversations were held with the following: EPA Region VI, Texas Department of Water Resources, Texas General Lands Office, Texas Department of Health (Shellfish Sanitation Division), Louisiana Office of Water Resources, Center for Wetlands Resources of Louisiana State University and Louisiana University Marine Consortium. Summaries of the discussions with each of these are presented below but first some general information is presented to illustrate the range of conditions found in Gulf of Mexico systems.

The Gulf of Mexico is represented by many diverse estuarine systems. The climate ranges from humid to arid and from temperate to tropical, some systems experience little freshwater inflow while others such as the deltaic plain of the Mississippi receive a considerable volume, and the size of the estuaries varies from very small to one of the largest in the United States. Deegan and Day (1983) have described six geomorphologic types of estuaries in the Gulf of Mexico:

- Drowned lacustrine plain - typified by numerous mangrove islands surrounded by wide shallow submerged areas;
- Drowned alluvial plain - drowned river mouths;
- Drowned calcareous plateau - typified by irregular steep coastline with broad shallow offshore plateau;
- Deltaic coastal plain - typified by extensive low lying emergent vegetation areas, shallow mud bottom bays, turbid water, and little seagrass development;
- Chenier plain system - formed by marine reworking of

recently deposited river sediments and usually found adjacent to and downcurrent from deltaic systems;

- Strand plain systems - formed by development of offshore sand barriers which enclose bodies of water.

EPA Region VI

Weather-related problems prevented a scheduled meeting with Region VI personnel with the exception of Kathy Gillmore with whom I met in Louisiana. The following EPA Region VI personnel were contacted by telephone in order to discuss estuarine related issues: Phil Crocker, Bob Vickery, Rus Bowen, and Barbara Keeler. Results of these discussions are summarized below.

1. General: It was clear from these discussions that estuarine issues along the coasts of Louisiana and Texas differ in emphasis from those identified in Regions in the northeast and northwest United States. The major issues along the Texas and Louisiana coasts are related to the physical and chemical habitat of the estuary and adjacent wetland/marsh regions. In particular, wetland and marsh loss and/or formation is probably the single most important issue. For example, due to past practices related to canal construction and control of freshwater outflow in Louisiana, it is estimated that this state is losing weland/marshes at a rate of 46.8 square miles per year. Other issues discussed with Region VI personnel included wasteload allocation and toxics. Much of the detail on these is presented in the discussions with state and university personnel.

Two general comments were made with regard to research needs. One was that research should be tied to management initiatives. Another related to a question concerning the relative roles of the EPA laboratories (including Gulf Breeze) and the regions in the research.

2. Wetlands/marshes: As noted above this has been a major issue in Region VI. Particular concern was expressed regarding the impacts of oil and gas canals on wetland and marsh loss in coastal Louisiana. A critical issue related to this is what constitutes good mitigation. It was pointed out that there are a number of small projects bing conducted on mitigation but that there has been no concerted effort to bring the results of these various efforts together. In part, as a result, EPA personnel are uncertain about what to recommend in terms of mitigation related to maintaining or enhancing the wetland and marsh areas. Such measures might involve backfilling channels but there are numerous questions related to the type and depth of material to be used and the appropriateness of filling particular channels. In addition, it is difficult to assess the impact of channels. It was suggested that it would be very worthwhile if an effort was made to pull together the existing information on

the systems and success or failure of various mitigation measures in order to develop a mitigation guidance document for estuarine wetlands and marshes.

The role of freshwater inflow has been identified as a critical issue along the entire coastline. It has become a sensitive political issue especially in Texas. Competition for freshwater pits estuarine needs (overall quantities and seasonal fluctuations in freshwater input) against those of upstream users (especially those who want to establish permanent recreational reservoirs.) It was suggested that freshwater inflow issues are more of a management problem than a research problem. However, it was also noted that better information was needed on the optimum salinity ranges of estuarine species.

3. Wasteland Allocation: It was noted that a considerable amount of work on wasteload allocation was being done in relation to BOD and NH3-N but that toxics (especially metals in certain areas) have been largely ignored.

4. Toxics: It was acknowledged that there may be problems with toxics in some coastal systems. This is detailed further in the discussions with the state and university personnel. Several comments were made regarding research needs related to toxics. These are summarized below:

- o There is a need to understand better the fate of pollutants in waters of different salinities;
- o There is a need for marine water quality criteria and sediment criteria;
- o There is a need for information on the form and availability of toxics in marine systems;
- o Appropriate bioassay methods need to be developed for marine and estuarine systems. It was noted that the present ERL-N approach was interesting but that it was not a proven technique in all areas of the country. Case studies were needed in different areas.
- o It was noted that the water quality based permit approach to toxics in estuaries sounded like a very good idea but that implementation of this approach would be difficult and might only apply in certain situations.

Texas Department of Water Resources (and other departments)

Meetings were held with the following individuals: Jeff Kirkpatrick, Gary Powell, Bruce Wiland, Larry Hauck, David Brock, B.R. Crittendon, and D. Buzan.

1. General: Four general environmental areas that were discussed include freshwater inflow, waste load allocation, closures of shellfish beds, and toxics. Freshwater inflow has been a major issue with regard to the health and productivity of Texas estuaries and has been the focus of much research. Broadly considered, freshwater inflow has been viewed as the single most important factor affecting the salinity characteristics of the estuaries as well as nutrient input. Local concerns have not been that there is too much nutrient input to the estuaries but that there may be too little due to upstream diversion of freshwater; periodic flooding of marshes due to freshwater inflow has also been considered as an important source of nutrients. The Texas Department of Water Resources has developed a strategy for maintaining or enhancing the integrity and productivity of estuaries based on annual and seasonal freshwater flows. The inflow of freshwater is viewed as critical to the production of key fish and shellfish as well as for survival of marshes and wetlands.

Waste load allocation has focused on Biochemical Oxygen Demand. There have been no attempts to conduct waste load allocations for toxics. The Houston Ship Channel is recieving attention with regard to oxygen levels and the degree to which water quality criteria (1.Ø mg/l oxygen) can be met with more stringent controls on discharges. There has been considerable debate over the benefits of trying to reach a 1.Ø mg/l criterion for oxygen in the upper portion of the confined channel. The D.O. criterion for the mid-portion of the confined channel is 2 mg/l while that of the lower portion of the confined channel is 4.Ø mg/l.

Approxiamately one-third of Texas' estuaries are closed to oyster shellfishing due to microbial contamination or the potential for contamination. There was a recent outbreak of cholera that was believed to be related to oysters in Galveston Bay.

Toxics have received some attention in several systems along the Texas coast. These include the Arroyo Colorado Segment 22Ø1, Corpus Christi Bay and Corpus Christi Inner Harbor Segments 2481 and 2484, and Neches and Sabine Rivers Segments Ø6Ø1 and Ø5Ø1. It is acknowledged that other systems (e.g. Houston Ship Channel/Galveston Bay) probably contain various toxics due to the presence of many industrial discharges.

These four environmental issues are discussed further below.

2. Freshwater Inflow: As noted above this has been one of the major issues in Texas. Several major studies have been conducted to examine the effects of freshwater inflow on bays and estuaries. These were directed by Texas Senate Bill 137, 64th Texas Legislature. Analyses were conducted on seven systems with the following objectives:

- Describe and quantify the freshwater inflow/salinity/ biological relationships of the estuarine environments;

- Estimate the annual and seasonal freshwater inflows associated with the production of finfish and shellfish at observed historic levels.

In order to estimate the influence of freshwater inflows on estuarine ecosystems several assumptions were made. A main premise is that the relationships and interactions between freshwater inflows and estuarine productivity can be indirectly examined through analysis of the following key indicators: frequency of delta marsh inundation, salinity near major freshwater inflow points, historical commercial harvests of estuarine-dependent fish and shellfish. Freshwater inflow needs were developed for three alternatives: subsistence, fisheries harvest maintenance, and fisheries harvest enhancement. It was also noted from these studies that, "In addition to freshwater entering an estuary in the needed volume and at the appropriate time, it is also necessary that the inflows be relatively free of toxic pollutants and contain sufficient nutrient materials to insure continued reproduction and growth of estuarine organisms."

Several important research issues were raised during the discussions of freshwater inflow and are presented below.

- Recycling of nutrients within the system has been difficult to quantify and makes it difficult to assess nutrient input "needs" to Texas estuaries;

- Urbanization is causing problems with regard to assessing the relationships between freshwater inflow and estuarine health and production. This includes possible impacts of nonpoint sources, toxics, and wastewater inputs. The effects of these on estuarine health must be better understood;

- The freshwater inflow/salinity regression equations developed by the Department of Water Resources have been criticized and there is need for technical support relating freshwater flows to salinity characteristics in estuaries of the Texas Gulf Coast;

- The regression equations used by the department to relate fishery (e.g. shrimp) yields to freshwater inflow have been criticized. There is a need to develop a better understanding of these relationships and to develop appropriate methodologies for relating biological conditions to physical and chemical factors.

The department has been working with an estuarine ecosystem model "ESTECO" in order to examine relationships among freshwater inflows, nutrient loadings, and overall health and production of the estuaries. They have had only marginal success with this model to date. It was described as "bulky and difficult to use". In addition, there are problems with inadequate data especially as these relate to rate processes and verification of the model. I was provided with a list of research needs with regard to "Estuarine Research Models". These are presented below:

- Better measures of benthic biomass are needed which inlude micoorganisms as well as standard macrofauna. How much of the sediment TOC is alive and how do we partition what's in the sediments into a) contributors to nutrient dynamics and b) nutrient storage?

- If the sediments are conceived as a flywheel or battery for the ecosystem - what are the parameters of input needs, depletion rates, etc.?

- How should oyster reefs and seagrass beds be incorporated into estuarine models?

- How many migratory animals (e.g. fish) are there? Do they cover the entire estuary? How much material do they export from the estuary?

- Can we classify areas within an estuary efficiently with respect to habitat types in a way that would fit in with modelling?

- How do we deal with detritus in nutrient budgets and processes? How do we measure detrital mass?

- What kind of diurnal patterns occur during different seasons?

3. Waste load allocation: As noted above, waste load allocation has focused on BOD. There have been no attempts to conduct waste load allocations for toxics. Exerpts from the 1984 Water Quality Inventory are presented below to give an indication of the degree of wastewater discharge problems and wasteload allocation activities in selected systems:

Nueces-Rio Grande Coastal Plain - classified as water quality limited based primarily on historical violations of D.O. standard. Nutrient enrichment (phosphorus and nitrogen) promotes high primary productivity with algal metabolism contributing to periodically depressed D.O. This occurs primarily in the tidal portion of the segment where a number of fish kills have occurred. A number of toxics have been observed (discussed

below). An oxygen resource model and waste load evaluation are currently being developed. Municipal effluents appear to be the major contributor of nutrients and oxygen-demanding substances.

San Antonio River Basin - classified as water quality limited. The river experiences generally poor water quality conditions (low dissolved oxygen) throughout the upper 60 miles. Problems include elevated nutrients, dissolved solids, and fecal coliform. Treated municipal wastewater appears to be the most significant contributor. A wasteload evalution has been approved requiring treatment level of 5mg/l BOD and 3mg/l ammonia N.

San Jacinto - Brazos Coastal Basin - classified as water quality limited. Disslved oxygen levels are occasionally below 4mg/l. Total and ortho-phosphorus levels in water are persistently elevated, and inorganic nitrogen levels are frequently elevated.

San Jacinto River Basin - Water Quality progressively deteriorates toward the lower part of the basin, especially in the Houston Ship Channel, due to the large quantity of industrial and municipal wastewater discharges, urban runoff, and nonpoint source loads from the Houston metroplex. (See below for discussion of wastewater treatment for Houston Ship Channel.)

Neches-Trinity Coastal Basin - The lower portion of Taylor Bayou experiences persistently low dissolved oxygen levels and high nutrient levels. The exact causes of these poor water quality conditions have not been evaluated. The lower tidal segment is condsidered water quality limited. Studies to examine the relationships among dissolved oxygen, benthic demand, background BOD, and macrophytes were recommended by the wasteload evaluation.

The Houston Ship Channel which feeds into upper Galveston Bay has posed problems with regard to achieving water quality criteria. A general plan of study has been developed by the Texas Department of Water Resources. Several components of this study plan remain to be determined and were identifid by department personnel as areas where additional research was needed for the channel in particular and estuaries in general. Thse include:

- Nitrifier Study - to quantify the number of nitrifiers; data will be utilized to verify model;
- Benthic Study - to quantify benthic oxygen demand and ammonia source rates for use in the water quality model;
- Reaeration Study - to quantify reaeration for use in the water quality model. The department is also interested in studies involving instream aeration technologies.

A general issue that has been raised is the relationship between improving water quality in the Houston Ship Channel and benefits in upper Galveston Bay as well as the side bays (tertiary estuaries). The Department feels that these relationships must be better established in order to defend more stringent discharge requirements.

4. Shellfish Beds: As noted above one-third of the shellfish beds are closed due to potential microbial contamination. Richard Thompson of the Shellfish Sanitation Division of the Texas Department of Health indicated that there has been considerable discussion concerning the adequacy of the fecal coliform indicator and expressed a desire to have better indicators including those that address viruses. He referred to the joint EPA/NOAA program involving enterococci. His personal feeling was that it may not be possible to come up with a single "magical" indicator but that combinations of indicators may need to be developed on a regional basis.

5. Toxics: As noted above, toxics (priority pollutants) have been looked for and found in several systems. The Department established criteria for determining if these toxics were of primary or secondary significance and summarized this information for three riverine/estuarine systems as presented below.

System	Number of Toxics Primary Significance	Secondary Significance
Corpus Christi Bay/Inner Harbor	11	7
Arroyo Colorado	17	
Neches/Sabine Rivers	11	8

Metals, phthalate esters, and PAHS were amoung the toxics considered significant in the Corpus Christi area; chlorinated solvents, phenols, metals and pesticides were considered significant in the Arroyo Colorado while metals, phthalate esters and pesticides were considered significant in the Neches/Sabine Rivers. The 1984 Water Quality Inventory pointed out a number of sources for toxics to Texas estuarine areas. The following exerpt is taken from the description provided for the Nueces-Rio Grand Coastal Basin, "Elevated levels of arsenic, DDD, chlordane, lindane, heptachlor. tetrachloroethylene, and trichloroethylene have been detected in water; elevated levels of copper, mercury, DDE, and chlordane have been found in fish tissue. Agricultural runoff is the suspected source of most of these contaminants, although no specific nonpoint sources have been identified. The significance of these contaminants has not been adequately determined."

The presence of toxics was noted throughout the Water Quality Inventory. However, it was also noted that the significance of these inputs was not known. Sources of toxics have been generally described as "agricultural, industrial, urban runoff, etc.". Mass loadings have not been estimated. While the presence of toxics is recognized, and ongoing studies are planned, this general environmental issue has not been a primary focus of studies in Texas estuaries or in waste load allocation considerations to date.

Louisiana Department of Environmental Quality

Discussions were held with Dugan Sabins and Robert Hannah. The following general environmental issues were discussed - coastal wetlands, water quality problems, research needs.

1. Coastal Wetlands: The significance of wetlands loss was emphasized and the following is taken from material provided by the Loiusiana Department of Natural Resources. Louisiana represents one of the most extensive regions of marsh and wetland in the United States. Louisiana contans 41% of the nations coastal wetlands and 25% of all wetlands in the nation making it one of the largest and richest estuarine areas in the world. As noted earlier, Louisiana is experiencing a serious loss of wetlands and marshes (46.8 sq. miles per year or Ø.6%). Between 1956 - 1978 the Department of Natural Resources noted that national wetland losses totaled 11.5 million acres which is equivalent to 14 times the size of Rhhode Island.. In Louisiana, 183,ØØØ acres of saltmarsh was converted to open bays. Swamp losses in the lower Mississippi Delta (Louisiana, Mississippi, and Arkansas) have totaled 4.5 million acres.

The Department has indicated that The Louisiana coastal land loss may be caused by both natural and man made forces including:

- o natural phenomena of subsidence, sea level rise, storms, erosion, and lack of sedimentation;
- o man made causes associated with dredging and spoil disposal, saltwater intrusion, draining and filling, levees, canals, mineral extraction, agricultural practices, and industrial and urban expansion.

The Department of Natural Resources has pointed out that wetlands losses can mean losses in fish and wildlife resources as well as direct disruption of man's activities by increased flooding and pollution from the loss of the protective functions of wetlands in providing buffer from storms and a filter for pollutants.

The numerous canals created by the oil and gas industry have been identified as one of the major causes of wetland loss. In addition, these canals exacerbate anoxic conditions within the marsh systems. Dugan Sabins discussed the Mississippi River diversion projects proposed by the Corps of Engineers. These projects would involve discharging freshwater from the river to the upper reaches of the coastal marshes. This is expected to offset salinity intrusion to some degree and alo provide sediment to the marshlands. The Corps has prepared Environmental Impact Statements for these projects.

One issue that must be considered with regard to any of the diversion projects is the introduction of toxics and pathogens associated with river water and sediment to the marsh and open water regions. At present there is a major accretion of marsh and wetlands in the Atchafalaya River Delta. This river basin itself supports an important fishery for crawfish.

The state is also using vegetation as indicators for coastal marsh/salinity types and this information serves as a management tool and a means of assessing the status and change in status of coastal wetlands. Much of the work related to this has been done by Louisiana State University and the Louisiana Department of Wildlife and Fisheries.

2. Water Quality Problems: Several general water quality problems were identified. These are associated with a broad range of causes including saltwaer intrusion, nonpoint sources, industrial and mumicipal point source discharges, and heavy residential development in certain areas. The state has been studying problems in several systems. Three of these are discussed here to illustrate the kinds of problems that are occurring: Lake Pontchartrain, Calcasieu Lake, and the Barataria Estuarine Complex.

The Louisiana Department of Environmental Quality Water Pollution Control Division has reported interim findings for a water quality investigation of Lake Ponchartrain. The conclusions are summarized below:

- Levels of toxic substances in the lake are not condisered deleterious to aquatic organisms or human health;
- the lake chronically receives input of a broad spectrum of conaminants associated with urban, domestic, and commercial develoopment. Most impacted are nearshore areas near mouths of major drainage and navigation canals;

- higher levels of nutrients and oxygen consuming substances have been associated wih sewage input while higher levels of chemical contaminants are associated with areas receiving urban runoff and greater industrial development;

- areas of low benthic diversity have been observed. These are believed to be associated with salinity stratification and oxygen depletion rather than toxic contamination;

- large areas of the southeastern and east central regions of the lake are subject to severe dissolved oxygen depletions in the lower water column in the warm water months. Anoxic conditions result from non-mixing characteristics brought by pronounced salinity stratification associated with the intrusion of highly saline waters from the Gulf of Mexico via the Mississippi River Gulf Outlet;

- the lake is not "dying" but is impacted by many man-made influences, many of which can and must be reversed, if the lake is to remain an important natural resource.

Another pressing issue associated with Lake Pontchartrain is the extensive development that is currently taking place along the northern shoreline. This activity is increasing runoff to the lake and is also placing increasing demands on sewage treatment facilities. There is concern that this rapid development will exceed the capacity of the local treatment facilities; development around the lake has also resulted in the destruction of much wetland. A water quality effect from loss of wetlands is the reduction of a buffer zone between open waters and developed areas on higher ground. In this respect, the interim report noted that loss of wetlands has expedited the increases in turbidity and pollutant levels that have occurred during recent years.

The Calacasieu Lake system receives discharges from large industrial point sources and is experiencing a variety of water quality problems, particularly with low dissolved oxygen. These are associated, in part, with the construction of the Calcasieu ship channel and subsequent salinity control structure near Lake Charles upstream from Calcasieu Lake.

Several agencies have been evaluating for toxics in the Calcasieu system (state, EPA, NOAA). All the facts are not in yet but there is evidence of elevated metal concentrations, in particular mercury. Although there is national attention on the Calcasieu system, studies are not well coordinated although a Management Conference was held at McNeese State University in December 1984. The state is planning to conduct a wasteload allocation (BOD only) for the system.

The Barataria Estuarine Complex is an important resource to Louisisana. It is a very productive region for seafood harvesting, water commerce, mineral extraction and recreation. In recent years the Barataria Complex has experienced a variety of water quality problems mostly related to expanding populations along the west bank of the Mississippi River. The water quality problems have been categorized as follows:

- o Nonpoint sources - agricultural runoff from sugarcane and soybean lands; urban runoff from developments; saltwater intrusion from the Gulf and lower estuaries through navigation channels and access canals;
- o Point sources - sugar refineries and oil and gas facililities; sewage treatment plants;
- o Natural sources - runoff from swamps and marshes;
- o Accidental spills.

These problems have been responsible for exceedences of dissolved oxygen and coliform bacteria criteria. Anoxic conditions have reulted in fish kills primarily in the upper basin while high coliform bacteria levels have caused closures of productive oyster grounds in the mid basin. Among the management activities planned for the area is the development of wasteload allocations for municipal and industrial discharges.

3. Research Needs: The following were mentioned by state personnel with regard to estuarine research needs:

- o There is a need for a systematic way of defining the hydrodynamics of these complex estuaries;
- o Water quality modeling is considered cost prohibitive and difficult to do for these systems; the state of the art is simply not advanced far enough to support technically soound modeling of Louisiana's systems; the state cannot afford to advance the state of the art;
- o Louisiana estuaries are subject to large natural inputs of organic matter and other factors that tend to result in periodic natural depressions in oxygen; there is a need for more flexible, realistic, or appropriate oxygen water quality criteria for estuaries; there is a need to understand rates of reaeration and benthal demand;
- o The need to understand bioavailability of toxic contaminants in esturies was identified as a key area for research; there is also a need to account for the relative uncertainty in fate and effects of toxics;

- There is a need to understand the role of marshes as treatment systems and as buffers for pollutants.

- There is a need to understand the mode of transport and survival of disease-causing bacteria in the Barataria and adjacent estuarine systems and the contamination of productive oyster grounds and other seafood products. Such studies will lead it is hoped to appropriate controls of bacteria sources.

- There is a need to study the potential for marsh treatment of municipal sewage treatment plants as an alternative to point source discharge of traditionally treated effluent in tidally influenced coastal water bodies.

LSU Center for Wetlands Resources (LSU) and Louisiana Universities Marine Consortium (LUMCON)

Discussions were held with Bruce Thompson, Gary Fitzhugh, and Linda Deegan of LSU and Don Boesch of LUMCON. The topics discussed are summarized below:

1. Index of Estuarine Health: There has been interest in Louisiana regarding a way to measure or express the "health status" of an estuary. The Index of Biological Integrity, used in freshwater, was discussed as a possible tool but work would have to be done to determine whether this or other approaches are applicable to estuaries. One difficulty in using a single index is the predominanat seasonal as well as short-term variability that estuaries experience.

2. Water Quality Criteria: There was some discussion concerning the applicability of existing water quality criteria and, in particular, those for dissolved oxygen. The question was posed, "Given a set of EPA standards does that translate into a healthy biotic system?" Naturally occurring variations in dissolved oxygen within estuaries was noted and questions were raised with regard to the possibility of developing seasonally adjusted water quality standards.

3. Environmental Issues: Much of the discussion of environmental issues was similar to that with the state personnel (see above). The key areas are as follows:

- Wetland Loss - due to a combination of many man-made as well as natural causes. Activities that have resulted in wetland loss include the construction of levees and canals (especially for oil and gas operations) which affect the hydrodynamics of the overall system and the degree of saltwater intrusion,

Dredge and fill operations have also resulted in wetland loss. It was also noted that discharges from oil and gas operation (drilling muds, cuttings, produced water) occur directly into the marshes.

- o Anoxic Events - these have occurred in Lake Pontchartrain as well as in smaller bays and canals, Their occurrence is thought to be related to combinations of organic loading, salt water intrusion (enhanced by the canals) as well as other factors.

- o Toxics - the state is beginning to get a handle on this for some systems. Many of Louisiana's estuaries are remote from sources of toxics. However, several large estuarine systems are receiving inputs of toxics from point sources as well as nonpoint sources. Pesticides and agricultural chemicals are especially important in the latter category. The diversion of some portion of the Mississippi River into the upper reaches of some of the marsh areas (to offset saltwater intrusion) has been an issue from a water quality standpoint. The river contains a broad mix of chemical toxics including an estimated 77 carcinogens. A critical question concerns the fate and effects of toxics in these estuarine systems.

- o Shellfish Beds - the harvestable oyster beds have been shrinking due, in part, to a combination of two factors. First, saltwater intrusion has pushed the habitat for successful oyster growth further up nto the estuary. Second, there is a trend toward decreasing water quality further up into the estuaries with regard to coliform bacteria. Thus, portions of these new beds are closed.

4. Research Needs: Research needs are implied throughout the summary of the discussions presented above. However, LSU and LUMCON personnel emphasized a few key areas. These are as follows:

- o There is aa critical need to develop an understanding of the hydrologic and hydrodynamic processes of the overall bay-estuarine-canal systems. These differ from the classical "estuarine" systems described by from the Pritchard in as much as there is lettle tidal forcing. Meteorological events strongly affect advections and residence time. This need is basic to addressing questions of salt water intrusion, overall water quality, nutrient loading, and fate and effects of toxics. There is a need for a classification system and methods for predicting (perhaps using probabilistic hind cast models) the behavior of water. Flora Wang at LSU is conducting wome work along these lines.

- The fate and effects of toxics in marsh/wetland systems were identified as other areas where research was needed. Such information is critical in as much as Mississippi River diversion projects of varous kinds are being planned.

- The processes resulting in coastal anoxia were identified as an area for further research.

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To: Vic Bierman, Dick McGrath
From: C. Menzie
Date: May 2Ø, 1985
Subject: Trip Report for San Francisco, CA Visit (March 27-29, 1985)

The objective of this visit was to meet with local, state and federal personnel as well as consultants to learn about particular estuarine problems encountered in San Francisco Bay and Region IX and to obtain input regarding research needs. This information will be used to help develop the estuarine research stategy within the EPA's Office of Research and Development. Input from regional personnel is considered critical to the strategy inasmuch as these individuals are the eventual users of the research outputs.

Meetings were held with the following: EPA Region IX and the California Regional Water Quality Control Board. Summaries of the discussions with each of these are presented below.

EPA Region IX

Meetings with EPA as well as state personnel were coordinated by Dr. Brian Melzian. Other EPA personnel who participated in the meetings included Phil Oshida, Bill Pierce (Branch Chief, Permits and Compliance), Pat Eklund (Section Chief, Oceans and Estuaries), Jeremy Johnstone and Dr. Mark Metcalf (both with the bay program). Summaries of these discussions are presented below.

1. General: to date EPA has not had a major role with regard to major rsearch programs in San Fancisco Bay. I was provided with an overview of work being conducted by others, in particular the San Francisco Region Water Quality Control Board, U.S. Corps of Engineers, and U.S. Bureau of Reclamation. Regional EPA personnel are eager to contribute in developing a better understanding of the bay and in managing or helping coordinate programs for the bay. This is reflected, in part, by their efforts to have San Francisco Bay added to the list of bays currently being given special attention by OMEP.

There are a number of complex problems involving pollution or multiple uses within the bay. The bay, which receives 40% of the drainage in California, experiences a broad variety of organic and inorganic inputs, especially from agricultural areas and industrial and municipal discharges. There are extreme demands on fresh water throughout California and as these continue to increase they affect the freshwater discharage into the bay and circulation within the bay and, as a

result, the salinity characteristics within the bay/estuary complex. Because of the high sediment load to the bay, regular maintenance dredging is needed and there are also plans for deepening ship channels. There are concerns regarding the direct or indirect discharge of selenium contaminated agricultural wastewater to the bay. The southern region of the bay abuts Silicon Valley and there is the possibility of contaminated groundwater from this area entering the bay. There are numerous point and nonpoint souces around the bay itself and these discharge various contaminants. Monitoring programs have revealed the presence of toxics (e.g., PCBs and PAHs) in marine organisms within the bay. Shellfish beds are closed during most of the year although some beds have been opened on a trial basis during the past two summers.

2. Source identification: some work has been done on source identification by various agencies and environmental groups but as noted above there are numerous point and nonpoint sources to the bay. These will pose problems for making quantitative estimates of toxic inputs.

Selenium has been identified as a problem pollutant but there are others that may turn out to be particularly important. Arsenic was mentioned as one possibility and other metals (Cd, Cu, Ni, Hg, and Zn) are found in the sediments and biota. Reopened mines represent a potential source of metals loadings to the bay.

3. Site characterization: there is a need to conduct good site characterization including biological resources and the presence of toxics in sediments and fish. There is a need for a comprehensive fishery study (recreational and commercial). Toxic "hot spots" have been identified and these need to be better defined.

4. Exposure assessment: a critical aspect with respect to exposure is the role of freshwater inflow to the bay and its importance directly to the survival of key recreational and commercial fish and other organisms as well as to the fate and distribution of toxics within the bay (e.g., by affecting floculation and sedimentation processes). The need for a good hydrodynamic model was cited. The creation of a deep ship channel is a concern with regard to the occurrence of anoxia.

Much information is needed with respect to exposure to toxics. Some work (benthic coupling research project) is being funded by EPA Newport with regard to the toxic hot spots and is being carried out by Bob Speis. This work involves sediment analyses for PAHs and PCBs as well as analyses of these chemicals in flounder tissue. This work can be considered analogous to the sediment criteria research being carried out in Puget Sound and in need of the same kinds of basic research support.

5. Effects assessment: thre is a critical need for appropriate bioassay testing procedures; Steve Schimmel (EPA/ERLN) has visited with the regional and state personnel and efforts are now underway in this area. This need includes testing related to the water-quality based permits. There is a need for information on the factors affecting striped bass populations and other fishry resources within the bay (work is being carried out by the U.S. Bureau of Reclamation, California Department of Fish and Game, U.S. Fish and Wildlife Services, State Water Resources Control Board as well as other agencies). The crab Cancer magister used to be abundant within the bay and there is need for information on its stocks and on the factors affecting its survival and reproductive success; high levels of petroleum hydrocarbons have been observed in crab tissue in the upper bay.

An important aspect with regard to toxic inputs to the bay is that secondary treated effluents have been more toxic than expected.

Selenium contamination of agricultural drainage water which enters tributaries (e.g., San Joaquin River) to San Francisco Bay has become a major environmental issue in the region. There are other priority pollutants which may have caused problems in the past or will in the future and research efforts are needed to characterize and quantify the extent of any real or potential problems.

6. Risk assessment: public health concerns have been raised with regard to the presence of toxics in fish and shellfish. Some of the issues are: 1) presence of toxic contaminants (PCBs) in striped bass and the recreational importance of this species (4 million user days/yr); 2) pier fishing for fish and probably also shellfish that may contain toxics; and 3) some population groups within the area will tend to use these sources of food and are unlikely to abide by fishing or shellfishing restrictions.

7. Waste Load Allocation/Water Quality Based Permits: at present the State Water Resources Control Board is working on water quality based permits for San Joaquin River.

8. Management/Coordination: EPA personnel are in the process of developing a management program for the bay. A recommendation was made that EPA become linked into the NOAA Status and Trends Program, especially the work related to QA/QC. It was noted that EPA presently does not have protocols for sediment criteria; regional EPA IX personnel are pushing to have such protocols developed (in connection with 301 (h) programs) in addition to priority pollutant protocols for the analyses of marine sediment and tissue samples.

California Regional Water Quality Control Board

Mike Ammann and Richard Whitsel participated in the meeting. Discussions related to characterization and monitoring are presented first because this represented the primary topic discussed.

1. Site characterization/monitoring: there is a basic need to characterize conditions in the bay and to assess trends in these conditions. The Regional Water Quality Control Board has established the Aquatic Habitat Program (AHP) which has two features: a water quality monitoring and research plan to determine chronic, long-term effects of pollutants on beneficial uses of San Francisco Bay and an instructional framework for implementing the monitoring plan.

The goals of AHP are to:

- o assess the health of aquatic life in the bay in relation to the effects of pollutants
- o determine the specific causes of any adverse changes in the health of the bay that appear to be pollutant-related.
- o obtain the maximum use of funds by coordinating activities of this program with all other monitoring and research activities in the bay.

As part of this effort a water quality monitoring and research plan has been developed and is entitled, "Plan for Assessing the Effects of Pollutants in the San Francisco Bay-Delta Estuary". It is based on the premise that it is more useful to monitor directly the responses of aquatic organisms to wastewater effluent than to rely only on water quality measurements. The plan consists of six elements:

- o Local effects monitoring - to detect changes in the immediate vicinity of a wastewater outfall
- o Regional effects monitoring - to determine baywide long-term effects of pollutants from all sources including point and nonpoint sources
- o Effluent assessment - to identify specific pollutants in a wastewater responsible for harming test organisms used in local and regional effects testing
- o Hydrodynamics - to gain a more complete understanding of how pollutants move in the bay
- o Coordination
- o Research - to determine the extent and effects of unusual events such as treatment plant upsets and oil and chemical spills and other water quality concerns.

This element is also needed to understand the processes that affect the uptake of environmental pollutants by plants and animals and the mechanisms which regulate the interactions between organisms and their environment.

Possible uses of these data by the San Francisco Bay Regional Board include: amending water quality objectives, relaxation or tightening of effluent requirements, enforcement action, dissemination of information to the public, determining sources of pollution, and determining assimilative capacities of receiving waters.

2. Nutrients: the state personnel expressed concern regarding nutrients in the Bay. How are these nutrients partitioned? Although large algal blooms are not observed, they feel they may be sitting on a "time bomb" as far as nutrients are concerned. They note the turbidity of the Bay may be keeping algal growth in check. They would like to know if there is a sink for these nutrients.

3. Source Identification: several issues were discussed in relation to sources. One question that was raised was, "How do you identify the source of contaminants observed in shellfish and fish?"

A potential source of contaminants to the south bay could be groundwater discharges. Leaking underground tanks have been identified in that general area and because of a soil subsidence problem, water is now being brought in and discharged to the south basin area. The result could be increased discharge of groundwater to the Bay. Among the important sources that have already been mentioned are the rivers draining into the bay, nonpoint sources adjacent to the bay, and numerous point sources to the bay. Cattle were identified as a problem in certain areas with regard to microbial contamination. Agriculture in general represents one of the most important sources of solids and chemicals to the bay.

4. Exposure Assessment: state personnel mentioned the following issues related to exposure assessments:

- how are toxics being bioaccumulated or partitioned into various compartments in the bay system
- there is interest in doing a carbon budget for the bay
- sediment/water quality relationships were identified as an important research area
- there is a need for good hydrodynamic work
- there is a need to understand physical and chemical processes in the "null zone"

- there is a need to understand the role that marshes and wetlands have in removing contaminants and nutrients

5. Effects Assessment: a number of issues were raised with regard to effects assessment. The major comment was that thre was a need to document the degree to which the bay was degraded; to address the question, "What is the health and status of the bay?" The key issues rlated to effects are a) those related to pollutants entering the bay system, and b) those related to the delta outlfow and the role of freshwater inflow.

A field sampling program has been estblished to examine "effects" on marine organisms based on the premise that it is easier to monitor effects on organisms directly. The primary components of this program are the sampling of plankton, maroalgae, and benthos, the collection of supporting water quality data, and the use of a striped bass health index.

The striped bass health index is an area where additional research is needed. Health of the striped bass population is thought to be related to the delta outflow and contaminant levels. The index is an outgrowth of past assessments and is still in the process of being developed by Janette Whipple. A number of parameters are incorporated into the index including toxics in the liver and histopathology. A critical research need is a study of the factors responsible for the decline in the striped bass population.

Concerns were also expressed with regard to effects of toxics on the flatfish fishery. Toxics of concern include pesticides, PAHs and PCBs. Nonpoint sources are suspected to be important. Possible effects include decreased reproductive ability and increases in MFO activity.

A decline in the crab population has also been observed. However, it is thought that this may be related more to changes in ocean currents rather than pollution. Still, this indicates a need to be able to discriminate between natural and man-made effects.

It is noted that eel grass is making a come back in the bay after it had declined 1Ø to 15 years ago.

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To: Vic Bierman, Dick McGrath
From: C. Menzie
Date: May 2Ø, 1985
Subject: Trip Report for Seattle, WA Visit (March 25-27, 1985)

The objective of this visit was to meet with local, state and federal personnel as well as consultants to learn about particular estuarine problems encountered in San Francisco Bay and Region IX and to obtain input regarding research needs. This information will be used to help develop the estuarine research strategy within the EPA's Office of Research and Development. Input from regional personnel is considered critical to the strategy inasmuch as these individuals are the eventual users of the research outputs.

The Puget Sound Water Quality Management Program prepared by the Washington Department of Ecology and the U.S. Environmental Protection Agency (1983) outlined the following basic problem areas:

- o toxic contamination of the urban-industrial bays
- o bacterial contamination of Puget Sound shellfish
- o longer-term effects of waste discharges to the sound
- o coordination among environmental control and investigative agencies.

Meetings were held with the following: EPA Region X, the Washington Department of Ecology, the Municipality of Metropolitan Seattle (Metro), Tetra Tech, and Envirosphere. Summaries of the discussions with each of these are presented below.

EPA Region X

The following EPA personnel participated in the meeting: John Underwood, Rick Albright, Jan Hastings, Bruce Duncan, and Marsha Lagerloef. John Armstrong was unable to attend. I was provided with a copy of the Jones and Stokes reports concerning the water quality management program in Puget Sound; information presented in these reports has been incorporated below where appropriate. These reports serve as key water quality management guidance documents for EPA Region X.

1. Source Identification: a considerable amount of work has been done and is still underway on identifying loadings associated with point sources. Non-point sources remain a problem

for quantification. In general, the approach to source identification involves identification of a specific problem (e.g., the presence of specific toxic contaminants in sediments) and then an assessment of what might be the source(s) of those chemicals. Basically, this involves working back from the problem. "Sediment criteria" play an important role in the overall source identification process. Other than research related to sediment criteria and a recognition of the difficulty associated with quantifying non-point source inputs, no specific research needs were recommended during the course of these discussions. Several studies specific to Puget Sound were recommended in the Jones and Stokes report (Part III).

The Jones and Stokes report notes that, "Data are available primarily for point sources.... Conventional and extended conventional water quality parameters comprise the bulk of the available data; with the exception of heavy metals, information on most of the priority pollutants is often limited to a few analyses. Information on other toxicants which are not considered of sufficient national priority to be listed as EPA priority pollutants (e.g., CBDs) is almost nonexistent. Loading for nonpoint sources is not documented... primarily because their diffuse nature does not easily lend itself to source identification and/or monitoring...The relative contribution of nonpoint sources to Puget Sound is expected to increase as permit programs bring point source discharges increasingly into compliance with water quality objectives."

Jones and Stokes recommended the following studies pertaining to critical data gaps in mass loading:

- Development of high priority pollutant lists for local geographic areas. There is a need to provide water quality managers with a list of pollutant species, isomers, and their metabolites most appropriate for monitoring or research analyses in localized areas.

- Documentation of input from urban runoff.

- Documentation of pollutant loading from urban rivers.

- Documentation of pollutant loading from industrial discharges. The problem here is that the existing NPDES limitations and monitoring requirements are usually limited to conventional pollutants. Few data exist on concentrations of toxic chemical compounds that could occur in the discharges.

- Analyses of CSO effluent volume and composition. Limited data currently exist on discharge quality and volumes.

- o Documentation of pollutant loading from municipal treatment plants. This is basically a complex effluent problem. An initial screening approach is suggested followed by quantification of high priority pollutants.

- o Documentation of pollutant loading from atmospheric flux.

- o Review of historical spills.

- o Identification of problems associated with septic tank leachate. WDOE and DSHS have decertified certain shellfish beds because of violations of fecal coliform standards.

A preliminary list of high priority pollutants has been developed based on seven criteria. These include the following: a) Pesticides - DDT and its metabolites, possibly aldrin/dieldrin, and endrin; b) Polychlorinated biphenyls - particularly the more heavily chlorinated tetrachloro- through nonochlorobiphenyls; c) Halogenated aliphatics - particularly chlorinated butadiens (CBDs), and possible tri- and tetrachloroethylene; d) Monocyclic aromatics - particularly chlorobenzenes; e) Polychlorinated dibenzofurans and pentachlorophenol; f) Polycyclic aromatic hydrocarbons; g) Heavy metals.

2. Site Characterization: work is underway to characterize several bays within Puget Sound as well as open water areas. Work is being conducted in Commencement Bay and is planned for Elliot Bay and Everett Harbor. A focus of these studies has and will be sediment criteria, i.e., the identification of problem sediments. This remains a critical research area.

3. Exposure Assessment: a key aspect of exposure assessment mentioned by EPA Region X personnel was bioavailability of potentially toxic chemicals in sediments. Theoretical partition coefficients were discussed in this regard. However, there is interest in moving away from using such coefficients and relying more on site-specific data related to actual uptake and observed effects. There is a need to establish the relationships between contaminants in sediments, presence of those contaminants in organisms, and biological effects. Some consideration should also be given to those substances which upon discharge are not simply mixed into the water column but can rise to the surface and become concentrated in surface microlayers.

The Jones and Stokes report recommended the following studies related to transport and fate:

- o Development of a circulation model for Puget Sound. It was suggested that the most appropriate approach should take advantage of the dominant features of the system by matching these with the best use of existing state-of-the-art modeling technology.

- o Development of a circulation model for the Central Basin and urban embayments.

- o Analysis of pollutant reactions at the freshwater - seawater interface.

- o Analysis of distribution and fate processes for pollutants in sediments.

- o Development of a solids settling model.

- o Examination of advection of organic compounds in the surface microlayer.

- o Description of organic pollutant fate processes.

4. Effects Assessment: this was identified by Region X personnel as the most critical research need. Among the research areas discussed were effects on the microlayer and associated organisms, the measurement or assessment of chronic effects, the processes and significance of bioaccumulation, and effects of toxics transported via the food chain (e.g., potential effects on harbor seals). With regard to chronic effects, a number of studies have been conducted in various bays within Puget Sound and these provide data which can be examined with regard to relating environmental (e.g., sediment) characteristics in the bays with observed effects or body burdens. It is/was hoped that this would help identify specific cause/effect relationships. This may still be the case. However, EPA personnel noted that there were no bays that were "clean" and that this confounded the identification of cause/effect relationships. Assessment of long-term effects remains a major problem.

5. Risk Assessment: risk analyses related to human health and environmental effects were identified as key areas by Region X personnel. Other than ensuring that sound methodologies be available and good input data be obtained, no specific recommendations were made concerning specific research needs.

6. Waste Load Allocation/Permitting: this relates back, in part, to some of the issues already discussed under previous categories insofar as research needs are concerned. EPA Region X has established priorities for dealing with water quality issues. Several bays and harbors have been placed in the high priority category. Here, the approach involves identifying "problem

areas", locating the source(s) of these problems and addressing these directly. Formal waste load allocation or risk assessment are not being performed as necessary elements of this process. Waste load allocation and risk assessment may become an integral part of the, "Puget Sound, Long-term Effects" program. There is some uncertainty as to how and when to proceed with modeling activities as well as with regard to what level of modeling is appropriate.

7. Data Management: this has been identified as a critical area. There has been some discussion concerning the development of national and/or regional data base management systems for estuaries. At present, Region X is considering a regional data base that would include all appropriate information for Puget Sound. However, reference was made to the national data base being developed with the 301(h) program.

8. Monitoring: EPA personnel suggested that to the extent possible, ongoing monitoring should be tied into the research strategy. The Jones and Stokes report has recommended what is essentially a trend assessment program.

Washington State Department of Ecology

I met with Robert Monn, Acting Supervisor of the Water Quality Management Division. The areas covered are summarized below.

1. Source Identification: in general, nonpoint sources represent the biggest problem from a source identification standpoint. In particular, attention should be focused on developing and improving methods of monitoring for nonpoint sources. The 208 effort in Puget Sound was successful as far as it went but they are still limping along in the nonpoint source area. There is a critical need to work with local governments on a one-on-one basis to communicate how their local practices are impacting water quality. Bob mentioned urban runoff, failing septic tanks, and "hobby" farms (small scale farms) as potential sources. Bob pointed out that one of the difficulties with management of pathogen inputs is source identification.

2. Exposure Assessment: the key issue identified by Bob Monn was in identifying what a problem sediment is. There is a lack of adequate information for determining what problem contaminants are in these sediments. Bob noted that the development of reasonable sediment criteria is a national issue. Bob provided a paper by Jim Krull of his department (presented on 2/9/85) which outlined some of the needs with respect to filling knowledge gaps. The needs outlined by Jim are as follows:

- o Sediment criteria to define contaminant and/or effects levels at which sediments become a problem.

- o Remedial action alternatives
  - criteria for determining whether to dredge, leave in place or cap contaminated sediments,
  - criteria for disposal,
  - criteria for disposal site selection,
  - criteria for disposal site selection,
  - relationships between discharge loadings and sediment contamination (long-term cumulative effects)

- o contaminant mobility/availability

- o cause/effect information relating contamination to biological effects

- o contaminant fate and transport

- o biotransfer and biotransformation of contaminants

- o biota toxicity and human health risk levels for biota tissues

- o sampling and analysis and quality assurance, quality control procedures

- o data management systems development.

Bob Monn also discussed problems related to the fate of pathogenic organisms. In particular, he mentioned that there was not good information on the rates of die-off and regrowth of these organisms. He also noted problems with the use of fecal coliform bacteria as a measure of potential problems associated with the input of pathogens. He indicated there may be a need for more appropriate indicators of the presence of pathogens.

Bob also expressed concern regarding the fate of discharged material that tends to become associated with surface microlayers. This includes pathogenic organisms as well as certain toxics (e.g., those associated with oil and grease). He would like to see a program that examines the potential environmental and public health implications of such material.

3. Effects Assessment: Bob indicated that there was a lack of data on bioconcentration factors that might cause some contaminants to pose problems. He discussed problems with assessing effects associated with potential shellfish contamination. Effects due to the presence of viruses remain an unknown.

The comparative bays work being done within Puget Sound was mentioned as a program that might yield information useful for assessing long-term effects of contaminants. We discussed the possibility of conducting a program like this on a much larger geographic scale (i.e., among the various estuarine systems).

Bob discussed various shellfish-related issues in Puget Sound. Much of the coastal area is presently closed to commercial shellfish operations but are still used by recreational shellfish collectors. He also noted that some consideration has or is being given to discharging wastewater into deeper waters and he expressed concern with regard to the possible closures of Geoduck shellfish beds as a result of these discharges.

Bob noted there was a situation in Budd Inlet, at the southern most section of the sound, that involved eutrophication problems and associated anoxia. This appears to be the only region within the Sound where such a problem is most serious. Several other poorly flushed embayments in the Sound also may be susceptible to such problems. Oxygen levels are maintained within the deeper basins of the sound even though these have a sill separating them from the open ocean. Ocean water regularly flows over the sill and flushes the deeper waters of the basins.

4. Risk Assessment: Bob expressed concern for the lack of information concerning the risks posed to recreational shellfish collectors who eat shellfish which may be contaminated by various pathogens. In addition, data gaps related to risk assessment were described in the paper by Jim Krull cited above.

5. Waste Load Allocation: it was noted that modeling was discussed in the Jones and Stokes report. Bob did not feel that modeling was the most effective way of spending resources at this time. He noted that the basic transport and fate mechanisms were not known well enough to develop a model and if basic information on these were lacking then modeling efforts could result in a waste of money. However, he further noted that EPA and the state were laying the groundwork for Sound-wide model development and that various modeling efforts for sub-basins of the Sound had been completed or were underway.

Municipality of Metropolitan Seattle (Metro)

John Lampe (Superintendent of Water Quality) and Ralph Domenowske (Special Projects) participated in the meeting. Summaries of the discussions are presented below.

1. Source Identification: much of the discussion with regard to source identification and other components of overall hazard assessment concerned the importance of clearly stated objectives and focus. With regard to complex effluent characterization, Metro has looked at consequences first (e.g., the occurrence of problem sediments), has generated questions concerning these observations, and has used this as a basis for determining characterization requirements. The Metro personnel emphasized the need to focus on achievable objectives in terms of identifying sources and the steps required to reduce them. They noted that at times EPA appears to be still attempting to "survey the universe" with the anticipation that action steps will fall out of this activity. With regard to nonpoint sources, a case study approach was suggested. Past experience should/could be used to develop typical generation factors for various land uses; Metro has used this approach. Mention was made of the activities that Seattle and Chicago have had concerning viruses.

2. Exposure Assessment: sediment criteria was mentioned as a critical issue, i.e., "do we have a problem?". Metro personnel noted that the identification of beneficial resources and uses should be used to focus programs. For example, if there is no interest in developing commercial fisheries then spending money on this issue is wasteful. Another example mentioned concerned contact recreation (swimming) and the fact that little of this occurs in Puget Sound due to the cold temperature; thus, work or standards development based on a criterion related to contact recreation would not mean that much for the Sound. Metro personnel felt that research should focus on actual uses and actual resources.

4. Risk Assessment: Metro personnel noted that public health risks should be given top priority with environmental risks being of secondary importance. With respect to the latter, nursery and breeding areas should be given priority. The personnel felt that the Toxicant Pretreatment Planning Study (TPPS) funded by their agency had provided much helpful information on sources, fate, and transport and that they were now in a position to conduct risk assessments. They indicated that they already had such experience in connection with sludge disposal issues.

Consulting Firms

Discussions were held with several personnel at Tetra Tech, in particular Tom Ginn. The information presented below is based largely on these discussions. In addition, a short meeting was held with John Butts of Envirosphere. This meeting was very useful in identifying various projects currently taking place within Puget Sound by various agencies and consultants.

1. Source Identification: in general Tom Ginn indicated that source identification was difficult in many instances. He noted that nonpoint sources were not well quantified and this was particularly true for agricultural sources (e.g., hobby farms). Further, there is a real problem with historical loadings data. Data available for point sources have to be drawn from many different places, often there are gaps, and the chemical data that are available through NPDES monitoring are limited. They have suggested a screening approach for assessing contributions from various pipes; this involves pulling sediment out of the drain pipes (serves as a long-term integrator) and analyzing these. A valuable approach in Commencement Bay has been to use chemical composition studies (i.e., chemical markers) to assess source contributors to problem areas.

Contaminated groundwater is a source of toxics to the Sound in at least one of the bays. Sediments have been found to be contaminated with volatile chlorinated organics such as TCE. Ordinarily, these would be expected to be lost rapidly from the system if discharged in surface waters.

2. Site Characterization: much of the effort within Puget Sound has been focused on identifying problem sediments. Toward this end, several criteria have been used to characterize sediments:

- o sediment chemistry
- o sediment toxicity (amphipod and oyster larvae)
- o benthic community structure
- o bioaccumulation in English Sole
- o histopathology in English Sole

Tetra Tech has developed a decision-making approach to identifying problem sediments that involves an integration of these independent measurements.

Work is underway to characterize several bays and harbors within Puget Sound. Attention is being given to developing sampling methodologies (e.g., how to distribute sampling effort), developing methods documents, and standardizing data bases. Less effort is being spent at present on the problems associated with input of pathogenic organisms.

3. Exposure Assessment: sediment criteria is a key issue within Puget Sound. This includes situations involving point and nonpoint sources as well as dredge material disposal. Viruses and other pathogenic organisms remain problems with regard to exposure assessment.

4. Effects Assessment: there are a number of information gaps with regard to establishing cause/effects relationships. The characterization of various bays using the criteria presented above should provide useful information regarding the role of various toxics - bays are contaminated by various contaminants and differences in sediment chemistry among bays may be correlated with differences in toxicity or histopathological conditions. The possibility of extending this comparative bay approach to larger geographic areas was discussed. Tom Ginn indicated that supporting laboratory work was now needed to relate histopathological conditions to various contaminated sediments. Some work along these lines is presently being conducted by the NOAA lab in the northwest. It would be desirable if "no effects levels" could be developed.

There is little information on recovery rates. Such information would be helpful for assessing the overall benefits of various actions and what can be expected with regard to rate of recovery following actions.

Anoxic conditions occur periodically in Budd Inlet as a result of eutrophication. This inlet is poorly flushed in comparison with the rest of the Sound.

It is hard to assess impacts of pollutants on juvenile anadromous fish or fish habitat. This is due in part to the relatively larger effects associated with logging (sedimentation) and overfishing.

5. Risk Assessment: decision criteria have and continue to be developed based on risk assessment; risk to public health is a primary criterion. Such assessments should guide remedial actions.

6. Waste Load Allocation: the water quality modeling aspects of waste load allocation remain a problem for Puget Sound. This appears to be the way to go but progress has been slow.

7. Data Base Management: demonstrations of two data base management systems were provided. These included the Ocean Data Evaluation System (ODES) developed as a national data base for the 301(h) program and the Commencement Bay Data Management System developed for that superfund project. The former is managed by OMEP and has the potential for being accessed on regular terminals or via microcomputers from anywhere in the country. The Commencement Bay system operates at the Microcomputer level and is thought to be appropriate for site-specific situations such as the Commencement Bay superfund

program. A combination of the systems is being considered as an approach for data base management for Puget Sound as a whole. A critical aspect of any data base management program is QA/QC and input of data to ODES, for example, is closely controlled. Such data are entered only after application of QA/QC.

APPENDIX B: PRESENTATION BY THOMAS DEMOSS

Management Principles for Estuaries

Presented By Thomas DeMoss

About one year ago in October 1984, Mr. Jack Ravan, then the EPA Assistant Administrator for Water and now the Regional Administrator in Region IV, created a new office within the Office of Water, the Office of Marine and Estuarine Protection. The Agency recognized that throughout the Office of Water, there were scattered a lot of functions and responsibilities related to marine and estuarine matters. Consolidating these responsibilities in one office, the Office of Marine and Estuarine Protection was charged with developing and implementing national policy on ocean dumping, incineration at sea, estuarine management, ocean discharge evaluations under 403 and the 301(h) waiver program. Tudor Davies is the Director of the Office of Marine and Estuarine Protection (OMEP). I am the Division Director and responsible for the National Estuary Program. My speech will focus on the National Estuary Program.

National Estuary Program

The National Estuary Program has two major components: 1) oversight and implementation of existing "mature programs" such as the Chesapeake Bay and Great Lakes, and 2) initiation of new programs that utilize the experience from the mature programs to protect, maintain and restore the resources in those estuaries. These programs are underway in Puget Sound, Long Island Sound, Buzzards Bay and Narragansett Bay. Specific objectives of the national program are to:

- o maintain, protect and restore water and sediment quality and living resources in the nation's estuaries or in a program estuary;
- o increase public understanding of estuarine processes and facilitate public definition of environmental quality objectives for estuaries;
- o define the environmental problems of the estuary;
- o explore the causes of these problems and alternatives to mitigate them;
- o develop comprehensive basin-wide plans to control pollutant loads from point and non-point sources, to manage living resources and their habitats and to manage water resources (freshwater inflow);
- o facilitate public understanding of public and private costs of pollution abatement; and,

- o transfer managerial, technical and scientific expertise to state and local governments to assist them in developing and implementing the basin-wide plans.

The EPA National Estuary Program uses existing authorities under the Clean Water Act, other federal statutes, and state legislative authorities to control sources of pollution and protect the nation's estuaries. The program emphasizes the need to focus and integrate the efforts of existing programs at Federal and State levels towards environmental goals to maximize the environmental benefits of pollution abatement. For non-point source controls, the estuary programs will need to use new and innovative approaches to reduce pollutant loadings such as cost-sharing programs with the agricultural community to install best management programs. Similarly alternative permitting procedures will be needed to identify and control loadings to combined-sewer overflows (CSOs) and storm drains and other urban runoff. Current legislative authorities to control non-point sources have room for improvement.

Chesapeake Bay Program

Congressionally mandated, the Chesapeake Bay Program began in 1977 as a joint Federal/State partnership intended to:

- o define the environmental problems of Chesapeake Bay;
- o explore the causes of the problem;
- o build a Chesapeake Bay environmental information base;
- o suggest alternatives to mitigate the environmental problems; and,
- o identify and recommend alternative management strategies to improve management of environmental quality in the Bay.

From 1978 to 1982 the problems of Chesapeake Bay were examined with the assistance of regional and national scientists and identified to be:

- o in the upper Bay, an increasing number of blue-green algal or dinoflagellate blooms have occurred;
- o since the late 1960s, submerged aquatic vegetation declined in abundance and diversity throughout the Bay;
- o landings of freshwater-spawning fish such as shad, striped bass and alewife have declined;
- o oyster harvests have decreased Bay-wide;

- o nutrient levels have increased such that the upper reaches of all the tributaries and the main Bay are highly enriched;

- o between 1950 and 1980 the amount of water in the main part of the Bay which has low or no dissolved oxygen has increased fifteen-fold;

- o there are high concentrations of toxic organic compounds in the bottom sediments of the main Bay, river mouths, and areas of maximum turbidity associated with known sources such as industrial facilities; and

- o many areas of the Bay have metal concentrations in the water column and sediments that are significantly higher than natural background levels.

The Chesapeake Bay Program also estimated the sources or causes of the problem and their relative importance (USEPA, 1983b). For example, the relative contribution of total nitrogen and phosphorous loads in the Chesapeake Bay from point (PT) and non-point (NPS) sources of nutrients in wet, dry and average years are as follows:

	Dry Year		Average Yr		Wet Year	
	PT	NPS	PT	NPS	PT	NPS
Phosphorous	69%	31%	61%	39%	36%	64%
Total	6042 tons		6879 tons		11,905 tons	
Nitrogen	38%	62%	33%	67%	19%	81%
Total	61,563 tons		73,112 tons		131,636 tons	

Special attention was also given to assessing relative loads to the Main Bay in an "average year" from the major tributaries (USEPA, 1983c). The results are as follows:

Tributary	Phosphorous	Nitrogen
	% of total	% of total
James	28	14
Susquehanna	21	40
Potomac	21	24
West Chesapeake	17	11
Eastern Shore	6	6
Others	7	5

These data indicate that the major sources of phosphorous were the James, Susquehanna and Potomac rivers and the Western Chesapeake shoreline; nitrogen loads were coming primarily from the Susquehanna and Potomac rivers.

In addition, the Chesapeake Bay Program assessed the relative importance of point versus non-point source pollutant loadings by tributary. This analysis showed the need for alternative pollution abatement and control strategies for different tributaries and basins. For example, the nutrient input from the Susquehanna River basin is primarily from non-point sources, particularly from agricultural lands while the James River loads are primarily from point sources. A control strategy to reduce phosphorous or nitrogen loadings for these two basins would be different and tailored for each system.

Finally, based upon the defined problems and the identified source of pollutants, specific recommendations were made in 1983 to address the environmental problems of the Chesapeake Bay (USEPA, 1983d). The recommendations emphasized that clean-up of Chesapeake Bay would require:

- o institution of land-use controls at or near the Bay shoreline;
- o development of non-point source control programs for agricultural and urban sources;
- o accelerated control of point sources particularly municipal treatment plants; and
- o strengthening of wetlands protection laws and programs.

The Chesapeake Bay Program drew sound technical conclusions and recommended management actions. The uniqueness of the program is that it evolved to, or then grew into an implementation phase. The study findings and recommendations spurred the States to action. For example, the Governors of Maryland, Virginia and Pennsylvania, as well as the Mayor of the District of Columbia, signed a Chesapeake Bay Agreement with the Administrator of EPA. The Chesapeake Bay Agreement commits the States to prepare and implement plans improving and protecting the water quality and living resources of the Chesapeake Bay. Subsequently, the legislatures of Maryland, Virginia and Pennsylvania appropriated new money to implement the recommendations of the Bay program.

The state actions include:

- o Maryland created forty new programs, hired 174 new employees, and appropriated $13.8 million in operating and $22 million in capital funds for point and non-point source controls, resource management, and land use planning;
- o Virginia appropriated $15.Ø million for the same purposes;
- o Pennsylvania appropriated $2.Ø million for a comprehensive agricultural non-point source pollution control program in the Susquehanna River Basin.

The states of Virginia, Maryland and Pennsylvania have institutionalized the FY85 appropriation and it has become part of their base program. They will continue to support these funding levels for several years. What are the state priorities for monies?

The State initiatives fall into four categories:

- o point source controls;
- o non-point source controls;
- o land use management; and,
- o resource or habitat protection.

Specific activities related to point source controls include:

- o increased sharing of municipal sewage treatment costs;
- o grants to POTWs to install dechlorination equipment;
- o stricter enforcement of permit effluent limitations for point source discharges;
- o improved training and certification of sewage treatment plant operators; and,
- o accelerated approval and implementation of pretreatment programs.

Specific activities related to non-point sources include:

- o authorization of additional funds for agricultural cost sharing of Best Management Practices (BMP);
- o demonstration grants to abate urban stormwater pollution in developed areas;
- o increased enforcement of stormwater control laws; and,
- o enhanced efforts to maintain forested lands as buffers in critical watersheds.

Activities related to land-use management includes:

- o the State of Maryland created a Critical Areas Commission to protect shoreline areas and inshore waters against further degradation.

Finally, activities related to resource or habitat protection include:

- o re-establishment of submerged aquatic vegetation (SAV);
- o use of hatcheries to restore stocks of finfish, ducks, and oysters;
- o use of finfish bans and development of comprehensive management plans for major fish species; and,
- o accelerated reopening of closed shellfish areas.

In addition to State resources, the Federal Government has committed resources to assist in Bay clean-up, i.e., a four year, 40 million dollar effort at 10 million dollars per year. About seven and one quarter million dollars per year is put into cost sharing grants to states to implement recommendations of the Chesapeake Bay study. The participating States must match federal funds on a 50:50 basis. We have encouraged the States to use funds to initiate and develop long-range non-point source (NPS) control programs particularly, cost sharing programs with agricultural communities for the implementation of Best Management Practices (BMP). The rationale for the NPS focus is the conclusion that the NPS agricultural loads are a significant problem in the Chesapeake Bay and that no program, except voluntary compliance, was currently in place to address the problem. Additionally, we have tried to use federal money to leverage development of NPS programs because there are substantial funds and authorities currently available to control point sources of pollution but little, if any, monies or authority for NPS control. Thus, since there were no ongoing or in-place non-point source control efforts in the Chesapeake Bay and it was one of the major problems identified as significant, the EPA federal resources are being used to fill this void. The remainder of the 10 million ($2.75 million) annual funding is used to:

- o maintain the CB management system;
- o maintain a bay-wide monitoring network to assess trends and environmental progress. Currently there are about 30 stations, in the main stem of the Chesapeake Bay;
- o continue research and modeling studies; and,
- o support the EPA Chesapeake Bay Liaison Office.

Congress has also appropriated monies to enable other Federal Agencies to assist in Bay clean-up. For example, NOAA will work to improve fisheries statistics and conduct assessments of stocks of Bay fisheries. USGS will work with EPA to develop

the impact of groundwater pollution on the Bay. The Fish and Wildlife Service will evaluate wetlands activities and assist with monitoring trends of contaminants in fish. The Corps will assist in modeling the Bay while DOD will, at several of its installations, review existing land management practices and take action to reduce soil erosion and other non-point source pollution.

Great Lakes Program

The oldest program in the national estuary program is the Great Lakes Program. The program is administered by a Program Office in EPA Region V.

The Great Lakes Program Office has the lead role in coordinating and implementing U.S. programs with Canada in fulfillment of the Great Lakes Water Quality Agreements of 1972 and 1978. The program began in 1970 and has experienced several phases of implementation. Early program findings revealed significant eutrophication problems causing dissolved oxygen depletion and fish kills. In response, several management options were implemented:

- o major municipal treatment plants were required to reduce phosphorous in effluents; and,
- o phosphorous detergent bans were implemented in many of the Great Lakes States.

The early 1970 control programs for municipal treatment plants and the phosphate bans successfully elevated dissolved oxygen levels and some finfisheries were restored in Lake Erie and elsewhere. But, it was recognized that more load reductions were needed to protect water quality and uses of the Great Lakes. Thus, non-point source demonstration projects for phosphorous reduction from agricultural and urban lands began in the late 1970s and early 1980s.

Under Section 108(a) of the CWA, the Great Lakes Program Office, in cooperation with the Soil Conservation Service of USDA, currently funds demonstration grants in 31 counties in Indiana, Michigan, Ohio, and New York to demonstrate voluntary best management practices to reduce phosphorous loadings from agricultural sources, particularly to Lakes Erie and Ontario.

Another major activity is the development of Action Plans to address pollution problems in 18 significantly degraded harbor areas serving the major industrial complexes of the Lakes. The action plans involve the identification of pollution problems, evaluation of alternative solutions, and development of recommendations to local governments for problem abatement. These studies are in addition to the connecting channels studies for the Niagara River, for the Detroit and St. Clair Rivers, and for

the St. Mary's River. The Niagara River study involved New York State, the Province of Ontario, the Great Lakes National Program Office and the federal governments of both countries. Initiated in 1981, the study's final report is a comprehensive and detailed review of the project elements and conclusions. The report assessed toxic chemicals and their sources to the Niagara River, reviewed toxic chemical control programs, recommended improvement to these programs and proposes long-term monitoring. The Detroit - St. Clair and St. Mary's studies are just getting underway; they involve the State of Michigan, the Province of Ontario and federal participation over 3 years.

The Great Lakes Program is now concentrating on implementing a monitoring plan as required by Annex II of the 1978 Agreement. Surveys of the Lakes are being conducted in cooperation with State and Canadian agencies to determine the annual variability of ambient phosphorous concentrations and the level and trends in metals as well as conventional pollutants. The results of the monitoring, including water, fish, and sediment data, will be used to assess compliance with the Agreement objectives, to evaluate the effectiveness of our control programs, and to identify new, emerging problems. The monitoring program includes:

- o fish tissue analyses from nearshore and open water locations;
- o sediment surveys of suspected toxic hot spots in tributary mouths;
- o forty-one atmospheric deposition stations; and,
- o transport and fate modeling to determine maximum allowable loading of pollutants.

National Estuary Program

In FY85, Congress appropriated 4.Ø million dollars to EPA to assess, study and monitor four specific estuaries: Long Island Sound, Puget Sound, Buzzards Bay and Narragansett Bay. The national program responsibility is essentially to transfer the Chesapeake Bay and Great Lakes experience and expertise to these estuaries. We feel that the success of the two programs is the drive for a "master environmental plan" that details specific plans of action to control point and non-point sources of pollution, enhance and/or maintain living resources, and manage freshwater flow into the systems. Most importantly, these master plans have been carefully developed with the support of local environmental managers, scientists, and the public. We want this master plan to be the objective for each of the new Bay studies as well.

Our experience and mandate within EPA is to reduce pollutant loads from point and non-point sources sufficient to protect living resources and water quality uses. Pollution control and abatement are critical to the health of an estuary, but we must also manage the resource itself. The responsibility to manage the resource resides with local and State officials as well as national resource managers such as the National Oceanic and Atmospheric Administration and the Fish and Wildlife Service. Reduction of pollutant loads may make Chesapeake Bay a wonderful place for fish to live, but we could encourage the public to go out and overfish the resource, thus, destroying the stock. My point is that estuary management must be a three-pronged approach:

- o living resource management;
- o water resource management; and,
- o pollutant load reductions.

All three are important and interrelated.

What are the national trends in estuary protection? Some of you in the room have been developing and analyzing scientific information on estuaries for twenty years, if not longer. It must be somewhat irritating to you to see EPA come with an estuarine initiative in 1985. I would ask you to consider this EPA entrance as an awakening, rather than an irritation; the nation is growing more sensitive to estuarine environmental problems and is finally prepared to address them. Perhaps you see us as slow and stupid, but at least we have finally heard your message.

The estuary program has been, to this point in time, dependent on direct congressional appropriations. In FY86 the EPA budget requested 4 million dollars for the four (4) Bay studies, 10 million for Chesapeake Bay and over 4 million for the Great Lakes Program. Within EPA it is believed that the Bay programs will continue in 1987, possibly at an increased funding level. The point is that the national estuary program is part of the EPA budget request for the next two or three years.

What are the goals of the EPA bay studies? I think this might be a surprise to some of you but we basically hope to protect, restore, or maintain living resources. The Bay programs are <u>not</u> water quality studies or just reports of the 208 Water Quality Management Plans. We do care about living resources, we do think the bottom line is to protect them. There are three ways to protect living resources. One is the reduction of loads from pollutant sources, the second is resource management plans, and the third is water resource plans to control freshwater inflow and draw down. These are our three major mechanisms to protect, maintain, or restore estuarine systems.

Environmental Quality Objectives

To protect resources and use these three management mechanisms we must set, with public participation and approval, environmental quality objectives for each estuary system that adequately reflect what the public wants to see achieved. There are four different options to present to the public for current uses of estuaries:

o status quo;

o maintenance of current conditions;

o restoration to some past condition; and,

o restoration to or maintenance of pristine quality.

The first option continues our present managerial and administrative programs within present resources. We might integrate these efforts better and focus them on estuarine problems. For instance, we could build or upgrade treatment plants that contribute the most significant loads to estuaries and reexamine and enforce NPDES permits in estuaries impacted by point source effluents. This option continues voluntary non-point source compliance efforts, and stays away from any land-use management proposals. We would make due with existing resources, improve integration, but few, if any new environmental initiatives would occur. The problem with this option is that it ignores increasing conflicts associated with population growth. Maintaining the status quo will most likely lead to degradation of environmental quality in the estuary due to increased pollution loads from growing populations, industrial development, water use demands, and habitat modification.

The second option is to maintain and protect resources the way they exist right now in the estuary. Maintenance of present environmental quality will require action today to mitigate the impacts of continued growth and development in the watershed. It will require better integration of existing resources, but will also require new initiatives and changes in current practices. Some examples might be the use of construction grants for advanced waste treatment, initiation of innovative non-point source control efforts particularly for agricultural lands, and management of land use in the drainage basin.

The third option would actually maintain current environmental quality for parts of the estuary and restore some targeted areas to a previous desired condition. This option will require even more intensity in new initiatives. For a system as large as the Chesapeake Bay, the objective to return to the conditions of 1950 is very aggressive and it probably will be very expensive. I am not saying that it cannot be done, I am just laying out the facts.

It may be more realistic to return parts of the Bay to 1950 conditions and maintain current quality in other portions. The fourth option is a combination of maintenance of current resources, restoration of parts of the system, and restoration and/or maintenance of some parts of the system to pristine condition. For example, maybe we could identify and set aside pristine areas throughout the Chesapeake Bay system to protect critical habitats for waterfowl and fish, and protect other living resources as they move around the Chesapeake to ensure their continued presence. There are many people talking about the concept, population resource management extended to estuaries, if you will. Thus, for an estuary system, we should specify one or a combination of the four objectives and define the actions that need to be taken to achieve the objective.

Organizational Structure

Every estuary program, to be successful, needs a dynamic management structure. The structure must include state, local, and federal environmental managers, the scientific community, and citizens. A management structure in not put together for the sake of creating a structure; it is put together to create an audience for program findings and recommendations and, to take action.

The scientific community has been collecting information on marine and estuarine environments for 10-25 years. Our mistakes lie in not putting together the audience of environmental managers and the public to use that science and to understand and support the need for action. This audience needs the best scientific information available, but it must be presented to them in an integrated and uncomplicated manner, particularly if they are to become committed to do something with it. That was the philosophy behind the Great Lakes and Chesapeake Bay Programs, first, to create an audience of environmental managers with public accountability and support; second, to analyze and synthesize the best scientific data available; and finally, to develop recommendations for action with managers, the public, and scientists. The belief is that the scientific community, both regional and national, is well equipped to analyze the available information, conduct research where information is not available, and present findings to committed environmental audiences.

What are the specifics of these organizational structures? There are two levels. The first and the highest level is an executive council of political appointees from environmental agencies such as the EPA Regional Administrator and the Secretary of Natural Resources or Environmental Protection for the State(s). The appointed individuals would have direct and immediate access to the Governor(s) and/or EPA Administrator. Direct and immediate access is needed to ensure that discussion can and will occur at the decision making levels if the program findings indicate that administrative, legislative or budgetary

changes are needed. The Executive Council also sets priorities and policy for the program and obtains state and national support for policy, legislative and budgetary change.

The second level of the organizational structure is the "implementation committee", sometimes called the management committee. Membership includes: 1) senior level environmental managers in the system, such as the Water Management Division Director in an EPA region and the head of the Office of Environmental Health Programs or natural resource programs in the states, 2) senior scientific experts in the state(s) and the Region, and 3) representatives of the public including user groups of the estuary. As an operational manager of the estuary program this committee argues over and decides on long-range strategy, annual workplans and budgets, and evaluates and redirects the study effort as needed. The management committee reports to the Executive Council, backs up the political appointees, commits to action, and sees that recommendations are followed through.

Reporting to the management committee are scientific advisory groups made up of scientific experts from the estuary region and citizen advisory groups. Generally the chairperson of both groups sits on the management committee. The managers on the implementation committee need to know that the science upon which their decision will be based has been developed and reviewed by the best scientists. The scientific advisory group has this mission. In addition, there needs to be a public concern or will to take action; a public pressure to resolve a problem. The citizen advisory committee is useful towards this end. Without these four principals - citizens, scientists, environmental managers, and political appointees - the master environmental plan will not succeed. You need all four actors in the organizational structures. You must pull these groups together and get them talking to each other, using each others resources and talents. Good science alone does not seem to marshal action; many of you have experienced that fact. The science needs to have public accountability, understanding, and support behind it.

Problem Definition

Once an organizational structure is in place, the second step is to define what problem you should study. The following questions should drive problem definition:

- Does the problem have a system-wide impact?
- Does the problem impact potential uses of the estuary?
- Are there major or local impacts that are so significant they dominate the estuary?
- Can the cause of the problem be identified?

o Is it likely that you could deal with the problem?

As an environmental manager it is not enough to just know that there is a problem; the environmental manager has to have alternatives to alleviate the problem within reasonable costs. For example, am I going to have to spend five billion dollars on combined sewer overflows in New York to correct an eutrophication problem in Long Island Sound? If I am, how likely is it that I will be able to get that kind of funding? A balancing of the five questions will help define the problems and suggest priority candidates to study.

Estuary Organization

Once an organizational structure is established and priority problems agreed upon, the program should characterize the current conditions and historical trends for the priority problems. Characterization builds on the scientific work done in the estuary for the past 10-25 years, maybe longer. Characterization uses existing and historical data to assess status and trends in water and sediment quality and living resources. The major steps of basin-wide characterization are:

o information gathering and screening;

o synthesis and analysis;

o conclusions on status and trends;

o linkages between pollutant sources and resource impacts; and,

o management recommendations for action.

A partial listing of characterization parameters would include: physical parameters such as land use types and trends, freshwater distribution, inflow, and draw down, shoreline development and erosion rates and frequency and severity of storm events; chemical parameters such as nutrient enrichment and dissolved oxygen parameters including total phosphate, orthophosphate, total nitrogen, inorganic nitrogen, nitrate, ammonium, organic nitrogen, and toxic metals, pesticides, and organics; biological parameters such as data on landings of fish and shellfish, catch per effort, nursery areas, juvenile indices, spawning areas, as well as plant and animal species lists; and, finally, pollutant loadings for point and non-point sources.

In the Chesapeake and Great Lakes programs, we found that if we presented only an assessment of current status, five minutes later 80% of the audience would ask, "Is your finding just a one time freak occurrence? Have these resources been declining for 10-15 or 20 years?" We would have been thrown out of the room if

we just talked about current status without a trend assessment. To determine if the current state is a problem, you must ask if the resource has been degrading over time and to what extent.

Simultaneous with characterization of trends in the water and sediment quality and living resources, we are also trying to characterize the inputs of pollutants - toxics, nutrients, and sediments - into the system. It is important to identify and locate the major point and non-point sources, determine if either or both source types are problems, and estimate loading of toxics and nutrients to the estuary. Several techniques can be used to develop mass loadings estimates.

To assess loads to Chesapeake Bay, we implemented a non-point source model for the entire 64,000 square mile drainage basin. The model estimated the relative magnitude of point versus non-point source loads for different geographic regions of the Bay and concluded that NPS is a significant contributor in the upper Chesapeake Bay, particularly from the Susquehanna River. The model, and generated loading estimates, was not designed to prove beyond a shadow of a doubt that this creek or those five farms along the creek were culprits. That level of detail is now being developed and confirmed by the States and the Soil Conservation Service. Instead, the Chesapeake model and analysis was designed to convince the public that all sources, including NPS, were significant and to identify basins within the Susquehanna making the larger pollution contributions to the Bay.

Through characterization there will emerge voids in the data needed for management decisions or actions. The need for scientific information must be prioritized and research funded accordingly. The best scientific data becomes available through characterization where an assessment of existing scientific data is integrated with scientific findings from new work designed to fill information voids. When this targeted science is completed, management decisions can occur. Similarly, an estuary program must also decide on a sound, long-term monitoring program to assess changes in trends, to pick up new and emerging environmental problems as they occur, and to measure the success or failure of clean-up programs. For example, the Chesapeake Bay monitoring program is designed to assess changes in water quality and living resources over time, to give us better causative relationships between sources and impacts, and provide predictive capabilities. Over time as the states and EPA attempt various control options the monitoring program will track key parameters.

Master Environmental Plans

The blueprint or framework for achieving environmental goals in an estuary is a "master environmental plan". The master plan focuses on different control strategies and resource management plans that EPA and the states are agreeing on for action. The master plan should contain:

- o a brief description of program organization and participants;
- o program findings on status and trends;
- o a statement from program participants of desired environmental quality goals and objectives for the estuary;
- o an analysis of existing statutory and regulatory authorities and their effectiveness;
- o recommendations for new legislative initiatives, programs, and regulations needed to meet specific environmental quality objectives;
- o provisions for a monitoring program;
- o identified research needs; and,
- o procedures for periodic program review, evaluation and redirection.

Since achievement of the environmental quality goals of maintenance, restoration, and/or enhancement will require major new initiatives, it is critical that these goals, be developed with full participation and understanding of all estuary program participants. Federal, state, and local agencies, the academic and scientific community, industry, commerce, public and private organizations, and the general public must adopt the goals and objectives and be prepared to support the necessary actions.

Estuary Environmental Problems

What kinds of problems are we seeing in the estuaries? We see shellfish bed closures due to bacterial contamination as well as toxics; wetlands loss and alterations; the disappearance of submerged aquatic vegetation; in-place toxics contamination threatening living resources; diseased fish; and, reductions and shifts from more desirable to less desirable fish species. We may have the same total catch of fish but it is a different catch, a different ecosystem. We see nutrient enrichment, in parts if not all of the ecosystem, that leads to dissolved oxygen sags severely impacting living resources. We could study everyone of these issues in every estuary. Perhaps, some replication would be scientifically sound, but there is also a need for a national agenda here, for economics of scale. Economics of scale needs to be addressed, that's what this workshop is going to consider over the next few days. In addition, an important factor to consider in your deliberations on the national agenda are two levels of research.

First, there is a need for research that can provide answers now or in the immediate future regarding pressing management questions. To address these questions an effort should be made to build upon the data base that has been developed over the past 15 to 20 years with a focus on synthesizing this information. The second level of research involves the generation of new, basic information on estuaries. There were a number of basic and critical processes (e.g., circulation) about which there is limited information. Such basic questions could take a long period of time to address and could require substantial expenditures. You know as well as I, that a $4.0 million dollar budget in a national estuary program will not cover this type of research. Given fiscal constraints, it is necessary, therefore, that approaches to addressing these second level questions creative and efficient. In the next two or three years we need the scientific community to address current resource problems, while continued long-term research will assist managers 5, 10, and 15 years from now.

I would also suggest that the estuary initiative, you are considering, should not lose a system-wide approach. Too many research initiatives in EPA start out as system initiatives, soon to be broken down into sub-parts, and 20 other programs get involved in turf battles. By trying to please the larger audience, we lose our momentum and the system-wide focus. Then we please no one. Individual programs may be barometers to measure environmental progress or degradation in estuaries, but we need to keep a system focus throughout. Support will come from the Regions and the States for this initiative if we do so. If we keep the system-wide focus and support management decisions now, show the regions what they're going to get, then I anticipate that support in the EPA budget process will follow.

Another important factor to consider in your deliberations is that regional initiatives like the Great Lakes and Chesapeake Bay Programs have, in some instances, molded national policy. These case studies attempted new approaches to environmental problems long before a national policy was set. This argues that an estuarine research initiative should have a strong geographic focus and apply alternative approaches to environmental problems not yet addressed such as wetlands loss in the Southeast.

In short, I have explained our national estuary program goals and approach as well as current status. I have also indicated what out research needs are now and in the future. I appreciate the opportunity to speak with you and look forward to supporting an estuarine research initiative and using the products to make more informed management decisions.

APPENDIX C: WORKSHOP PARTICIPANTS

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