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# NOAA Estuarine and Coastal Ocean Activities

## 1987 Annual Report to the Under Secretary

August 1988

U.S. DEPARTMENT OF COMMERCE
C. William Verity, Secretary

National Oceanic and Atmospheric Administration
William E. Evans, Under Secretary

Estuarine Programs Office
Virginia K. Tippie, Director

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## INTRODUCTION

The Department of Commerce instituted the National Oceanic and Atmospheric Administration's (NOAA) Estuarine Programs Office (EPO) in 1984 to provide leadership and coordination for NOAA's estuarine programs. Two years later, under P.L. 99-659, EPO received its legislative mandate from Congress to perform the following functions:

1. develop and implement a national estuarine strategy for NOAA that integrates its research, regulatory, and trusteeship responsibilities;

2. coordinate the estuarine activities of various organizations within NOAA, including activities in estuarine research and assessment, coastal management, and habitat conservation;

3. coordinate estuarine activities of NOAA with the activities of other Federal and state agencies; and

4. provide technical assistance to the Administrator of NOAA, other Federal agencies, and to state and local government agencies in --

-- assessing the condition of estuaries;

-- identifying estuaries of critical national or regional importance; and

-- identifying technical and management alternatives for restoration and protection of estuarine resources; and monitoring the implementation and effectiveness of estuarine management plans.

This Annual Report describes NOAA's estuarine and coastal program activities in 1987. Specific topics addressed include (1) significant accomplishments of EPO, (2) the NOAA Estuarine Research Technical Development Plan (TDP), (3) an overview of NOAA's estuarine activities, (4) a regional perspective of national estuarine issues, and (5) Federal agency activities in the estuarine/coastal environment.

## 2. SIGNIFICANT ACCOMPLISHMENTS OF THE ESTUARINE PROGRAMS OFFICE

### NOAA-Wide Coordination

The NOAA TDP (detailed later in this report) identifies priority research topics and describes how increased NOAA funding for this critical estuarine research will be used. Coordinated by EPO, the TDP was developed by a team of scientists from the Office of Oceanic and Atmospheric Research (OAR), the National Marine Fisheries Service (NMFS), the National Ocean Service (NOS) and the National Environmental, Satellite, Data, and Information Service (NESDIS). The proposed program utilizes expertise and resources available throughout NOAA laboratories, in partnership with the Nation's academic community, to investigate key ecological processes in estuaries. Endorsed by NOAA line offices, the TDP was published by EPO in 1987.

In 1987, EPO also concluded a two-year planning effort that defined critical estuarine and coastal issues for NOAA to address into the next century. These issues were published by EPO in the NOAA Estuarine and Coastal Ocean Science Framework. To coordinate NOAA activities in estuarine program areas, EPO conducted monthly line organization meetings. These helped NOAA develop a unified voice for important estuarine and coastal issues. EPO also coordinates NOAA representation in all major estuarine regions. These regional representatives enhance coordination and communication within NOAA, as well as between NOAA and external organizations.

### National Estuary Program

EPO provides leadership for NOAA's involvement in the Environmental Protection Agency's (EPA) National Estuary Program (NEP). In 1987, the Under Secretary of NOAA designated the Director of EPO as co-chair of an interagency workgroup in which NOAA and EPA coordinate joint responsibilities under the Water Quality Act of 1987.

To date, EPO efforts in the NEP have focused on Long Island Sound, Narragansett Bay, Buzzards Bay, Puget Sound, New York-New Jersey Harbor, Delaware Bay, Delaware Inland Bays, Albemarle-Pamlico Sound, Sarasota Bay, San Francisco Bay, and Galveston Bay. EPO has appointed NOAA representatives to serve on the committees for designated estuaries. EPO also participated in meetings with EPA, state managers, academia, and other Federal agencies to discuss the need for a comprehensive interagency regional approach to the management of estuarine and coastal waters of the Gulf of Mexico and other coastal regions.

NOAA has been an active participant in the Chesapeake Bay Program (CBP) since 1984, EPO staff working closely with the CBP to ensure that NOAA programs support CBP goals. In 1987,

NOAA received $1,500,000 for Chesapeake Bay studies related to the improvement of fisheries statistics, fisheries stock assessment, oxygen depletion, and data management. EPO acts as the agency's coordinator of these efforts.

The Chesapeake Bay Stock Assessment Committee (CBSAC), a Federal and state organization, was set up by EPO in 1985 to develop cooperative agreements between Maryland, Virginia, District of Columbia, and Pennsylvania for addressing fisheries statistics and stock assessment issues. CBSAC is now developing a Bay-wide fisheries stock assessment plan pursuant to a commitment in the 1987 Chesapeake Bay Agreement.

EPO has also worked with the National Sea Grant Program Office and the Maryland and Virginia Sea Grant Programs to conduct cooperative research related to the problem of oxygen depletion in Chesapeake Bay. A report entitled Dissolved Oxygen: Processes and Effects, released in December 1987, includes papers summarizing research findings to date. The Chesapeake Bay Environmental Effects Committee was set up to direct the research priorities for this Sea Grant funding. This committee includes scientific representatives from all the jurisdictions in the Chesapeake Bay Program.

Projects related to Chesapeake Bay data management, remote sensing, and modeling have also been conducted with NOAA funding under the CBP. The report, Chesapeake Bay Environmental Data Directory, was published in 1987. It describes environmental data collection throughout the Chesapeake Bay and states where data can be obtained.

Three other NOAA-funded CBP projects include 1) the development of a microcomputer-based coastal information system for displaying and analyzing environmental data; 2) the application of a numerical circulation model of the Bay to trace the drift of larval blue crabs at the Bay mouth; and 3) the application of satellite data to estimate suspended sediment and chlorophyll data in surface waters of the Bay.

Scientific Assessment Team

Acting under a recommendation of the NOAA Estuarine Policy Committee, the Estuarine Programs Office organized a Scientific Assessment Team to coordinate an analysis of an environmental event that occurred from May to October of 1987. This event, which affected the coastline from New York to Virginia, included wide-spread deaths of dolphins, trash washing ashore on many beach areas, fish kills, and algal blooms. Available meterological, hydrological, oceanographic, and remote sensing data related to the event were analyzed to determine possible causes and climate trends contributing to the situation. The remote sensing analysis proved particularly useful, having the spatial and temporal coverage necessary to investigate the

wide-spread environmental event. To date, cause/effect relationships have not been finalized for all of the observed; therefore, further analysis is necessary to develop a more complete assessment.

Seminar Series

EPO supports Estuary-of-the-Month Seminars for scientists and resource managers dealing with important issues in selected estuaries. The Estuary-of-the-Month Seminar series provides a mechanism to gather and synthesize the necessary information for a coordinated national approach to estuarine science and management. Most recently seminars have been held for Albemarle/Pamlico Sounds, Tampa/Sarasota Bays, Barrier Island Salt Marsh Estuaries of the Southeast U.S. Atlantic Coast, Galveston Bay, and Lake Erie Estuarine systems. Seminar proceedings published to date include Narragansett Bay, Delaware Bay, Long Island Sound, Boston Harbor, Massachusetts Bay, San Francisco Bay, and Puget Sound.

During 1987, EPO also sponsored informal weekly luncheon seminars on estuarine-related scientific topics and management issues. A range of topics were addressed, with presentations given by staff from several NOAA line organizations and by non-NOAA employees.

NOAA Involvement Series

The Office has published and disseminated a series of "NOAA Involvement Papers" that describe NOAA program activities for specific estuarine regions. The series now includes Chesapeake Bay, Albemarle/Pamlico Estuaries, Long Island Sound, Narragansett Bay, Gulf of Mexico, San Francisco Bay, Southeast, and Hudson/Raritan estuaries. Papers now being developed include Buzzards Bay, Great Lakes, and Puget Sound.

Special Publications

EPO has also written and published a number of special publications that address estuarine and coastal ocean issues. A proceedings of a workshop on "The Remote Sensing of Estuaries" outlines state-of-the-art science in this area of estuarine science. Estuaries: NOAA Estuarine Capabilities describes the full range of NOAA's estuarine programs. EPO publishes an annual Estuarine Projects Catalog that describes each project NOAA has had in estuaries during the previous year. A quarterly Estuarine Calendar and Bulletin is also published by EPO, listing current estuarine publications and upcoming events.

## 1987 EPO Publications:

### Seminar Proceedings

Narragansett Sound
San Francisco Sound
Remote Sensing

### NOAA Involvement Papers

Gulf of Mexico
Narragansett Sound
Southeast
Charleston Harbor
San Francisco Bay

### 1986 Annual Report to the Under Secretary

### 1986 NOAA Estuarine Projects Catalog

### Chesapeake Bay Stock Assessment Committee Annual Report

### NOAA Estuarine and Coastal Ocean Science Framework Summary

### NOAA Estuarine Research Technical Development Plan

If you would like copies of any of these publications, please contact:

NOAA/Estuarine Programs Office (CSEP)
Universal Building South
1825 Connecticut Ave., NW
Room 625
Washington, DC 20235
(202) 673-5243

NOAA ESTUARINE PROGRAMS OFFICE
1987 Organizational Structure

Director - Virginia Tippie
Technical Manager - Samuel McCoy
Senior Policy Analyst - Joseph Bishop
Senior Scientist - James Thomas
Operations Research Manager - Carl Berman
Publications Coordinator - Alice Roberson

Regional Coordinators:

Northeast - Carl Berman
Chesapeake Bay - James Thomas
Southeast - Sharon Shutler
Gulf of Mexico - Catherine Mills
Southwest - Joseph Bishop
Northwest - Darlene Finch
Great Lakes - Carl Berman

NOAA EPO/Line Organization Representatives:

NESDIS - Elaine Collins, Kurt Hess, James Zaitzeff
NMFS - James Chambers, Mary Gessner
NOS - Harold Stanford, John Paul Tolson
OAR - Garry Mayer
NWS - Marshall Hansen

NOAA Estuarine Policy Committee:

NOS - John Carey
NMFS - Nancy Foster
OAR - Alan Thomas
Academia - B.J. Copeland

The 1987 NOAA Regional Representatives to the National Estuary Program

Buzzards Bay:

| | |
|---|---|
| Management | - Thomas Bigford (F/NER)* |
| | - Bruce Higgins (F/NEC) |
| Technical | - Marvin Grosslein (F/NEC) |
| | - Robert Murchelano (F/NEC) |

Narragansett Bay:

| | |
|---|---|
| Management | - Thomas Bigford (F/NEC)* |
| | - Carolyn Griswold (F/NEC) |
| Technical | - Kenneth Sherman (F/NEC) |
| | - Larry Buckley (F/NEC) |

Long Island Sound:

| | |
|---|---|
| Management | - Robert Lippson (F/NER)* |
| | - Michael Ludwig (F/NER) |
| Technical | - Anthony Calabrese (F/NEC) |
| | - Frederick Thurburg (F/NEC) |

Chesapeake Bay:

| | |
|---|---|
| Management | - James Thomas (EPO)* |
| | - Robert Lippson (F/NER) |
| Technical | - Aaron Rosenfield (F/NER) |
| | - Robert Lippson (F/NER) |

Albemarle/Pamlico Sound:

| | |
|---|---|
| Policy | - Ford Cross (F/SEC)* |
| Management | - Sharon Shutler (EPO) |
| | - Donald Hoss (F/SEC) |

San Francisco Bay:

| | |
|---|---|
| Management | - James Bybee (F/SWR)* |
| Technical | - Jeannette Whipple (F/SWC) |
| | - Norman Abramson (F/SWC) |

Puget Sound:

| | |
|---|---|
| Management | - Howard Harris (N/OAD)* |
| Technical | - Edward Long (N/OAD) |
| | - Richard Freely (R/PMEL) |
| | - Donald Brown (F/NWC) |
| | - Bruce McCain (F/NWC) |

Puget Sound Water Quality Authority:

| | |
|---|---|
| Research | - Usha Varanasi ((F/NWC) |
| Monitoring | - Howard Harris (N/OAD) |

Gulf Initiative

- Donald Atwood (R/AOML)
- Richard Hoogland (F/SER)

* Indicates Lead NOAA Representative for the Region

## 3. NOAA ESTUARINE RESEARCH TECHNICAL DEVELOPMENT PLAN

### Introduction

NOAA has long been involved in estuarine research. Efforts have focused on subjects as diverse as the roles of estuarine habitats in the life cycles of economically important fish and shellfish species, the dynamics and effects of pollutants in estuarine and coastal settings, and the physical, geochemical, and biological processes responsible for shaping estuarine environments. Although such efforts have resulted in research of excellent quality, the overall result consisted of a patchwork of activities with little integration. NOAA made progress in better understanding estuarine systems, but advances were painfully slow and generally difficult to apply to embayments beyond the study sites. In this regard, 1987 marked a turning-point in NOAA's approach to estuarine investigations as the first NOAA-wide estuarine research initiative emerged.

Although the NOAA estuarine research plan addresses issues traditionally within the realm of "pure" research, findings will be revelant to many of NOAA's advisory and management responsibilities. The proposed research also complements scientific investigations by other Federal agencies, such as the U.S. Environmental Protection Agency's National Estuarine Program, which focuses on water quality management within individual estuaries. In addition, the plan complements major segments of university research accomplished under the aegis of the National Science Foundation (e.g., Long-Term Ecosystem Research efforts and land-sea interface studies). This proposed effort also fits into the more comprehensive NOAA-wide Coastal Ocean Initiative currently being developed through the NOAA Chief Scientist Office.

### The Research Plan

Unlike previous estuarine research programs, the focus on estuarine production will be national in scope and take full advantage of the scientific expertise and resources available through NOAA laboratories, NOAA-supported research facilities, and NOAA interactions with the university community. The plan will focus on comparative studies and on understanding the functioning of local systems in terms of larger (i.e., regional, national, global) phenomena. The goal of the estuarine research program is to permit accurate practices of environmental changes resulting from natural and human-induced factors. To achieve this, NOAA proposes a long-term series of investigations that focus on specific estuarine habitat types. The five target habitats selected for initial attention include:

- Sea grass beds
- Salt marshes
- Water columns
- Unvegetated flats
- Mangrove stands

Studies will focus on the influence of four major factors on secondary production within these habitat types:

* Freshwater/saltwater inflows
* Nutrient loadings/dynamics
* Habitat physical structure
* Tropic dynamics

Following are the central and supporting hypotheses for the NOAA Estuarine Research Plan.

Central Hypothesis:

Changes in estuarine production are functions of human-induced and natural alterations upon habitat structure and food web dynamics.

Sub-hypotheses:

Changes in the volume and/or timing of freshwater and seawater inflows in estuaries alter the physical structure and biological processes within estuarine habitats.

Human-related nutrient loadings to estuarine waters adversely affect estuarine habitat production.

Habitat modification disrupts the physical structure of estuarine environments, leading to reduced capacity for biological production.

Natural and human-related perturbations alter the transfer of energy and lead to changes in the secondary production of estuarine habitats.

A key element of the proposed studies is the generation of models of the interrelations among factors that change production within target habitats. NOAA will develop models early in the study of each habitat type and provide the conceptual framework for planning and carrying out subsequent research. The nature and complexity of the models depends upon the level of understanding for each habitat type.

Initially, models may range from qualitative, descriptive formulations to quantitative, semi-predictive constructs. As research on individual habitat progresses, models will be revised and expanded. Ultimately, they will evolve into tools of sufficient accuracy and sophistication to be used for prediction.

A major shortcoming of modern estuarine science is the inability to readily generalize findings gained from studies of individual embayments. The proposed program will overcome this by de-emphasizing investigations of entire systems and promoting instead research on the functioning of <u>specific</u> habitat types across estuaries.

This comparative approach involves three types of investigations.

* Basic studies of habitat functioning within local systems. Such investigations include both observational and field experimental studies.

* Mesocosm studies that will center on experiments undertaken in large, controllable artifical systems.

* Large-scale environmental manipulations that would involve the temporary alteration (weeks to years) of consequential sections of estuarine habitats.

While the progression shown above represents a series of increasingly complex steps, the actual order of investigations need not follow this pattern. Studies involving any of the techniques may or may not occur simultaneously, depending on the nature and level of understanding for the processes and habitats under investigation.

Research steps will be interactive, with working hypotheses revised and elements of conceptual models developed in increments. As models become more complex and realistic, projections of production within habitats can be checked against observations made by environmental monitoring and surveillance programs.

Habitat-oriented studies must focus on processes within target environments and on interactions with adjacent habitats. Such interactions will be a major factor in explaining why similar habitat-types respond differently within a single estuary or among estuaries. In this regard, mesocosm studies are especially important in the research program. They provide a mechanism for controlling experimental variability not available in the field, and also provide a tool for interpreting and rectifying findings from similar habitats in different settings. The use of realistically-scaled, artifical systems is integral to the development of broadly applicable, predictive understandings of estuarine functioning.

Implementation

The development of a predictive capability for estuarine secondary production requires a commitment to sustained funding for a minimum period of five to ten years. Minimum levels of support are projected at $2 million per habitat per year.

Central to the NOAA Estuarine Research Program are models of the factors influencing estuarine production in each of the habitats under study. These models provide the framework for identifying research priorities and assembling information obtained from

resulting studies. A considerable body of information already exists on the target habitats. For example, each habitat listed in the previous section has been the subject of at least one volume in the U.S. Fish and Wildlife Service Community Profile series. As a first step, therefore, NOAA will fund the development and publication of a synthesis for each target habitat.

Each synthesis will be compiled and ready for publication within twelve months. To accomplish this, NOAA will provide sufficient resources to retain the services of six to eight experts on each habitat (approximately 1-2 months per expert). Adequate funds will be provided for secretarial support, illustrations, peer review, and publication costs. The syntheses will serve as guides for specific investigations funded by the estuarine research program.

NOAA will seek to develop and publish the syntheses jointly with an appropriate scientific professional society. Working with NOAA, the society will (1) identify and retain appropriate experts from academia and government to write sections of the volumes; (2) ensure timely development of documents; (3) oversee peer review and quality control for the volumes; and (4) print and distribute documents. If accomplished as envisioned here, each volume would be valuable to estuarine science in itself, and would form the cornerstone for NOAA-sponsored studies of that habitat.

Issues that the NOAA Estuarine Research Program will examine are highly complex and can best be addressed by a small number of highly qualified, interdisciplinary scientific teams, drawn from academic, government, and private institutions. Teams will be selected competitively on the basis of peer-reviewed proposals. Awards will provide support for three to four years and will be large enough to permit teams to address consequential aspects of secondary production and its regulation in one of the target habitats. Research topics and habitats will be identified in annual calls for proposals.

Sponsored research findings will be made available throughout the course of the program. Principal investigators will prepare materials for publication in the peer-reviewed technical literature. Interpretations tailored for other audiences, including legislators, policy makers, educators, the media, and the general public, will be prepared and disseminated via NOAA-supported outreach services.

Active roles are anticipated in this regard for the Sea Grant Marine Advisory Service, Nation Marine Fisheries Service outreach personnel, and elements of the Office of Coastal Resource Management (such as the National Estuarine Reserve Research System).

In Fiscal Year (FY) 1990, work will begin on the study of three of the five identified target estuarine habitats--seagrass beds, salt marshes, and water column environments. These choices reflect the rationale developed in the 1987 NOAA Estuarine Research Program Development Plan, as modified by the inclusion of the estuarine water column habitats. The decision to include the latter habitat for immediate consideration reflects the importance of water column processes to production-related issues such as eutrophication and hypoxia, the central position of this habitat relative to other estuarine environments in the transfer of ecologically important materials, and the availability of appropriate mesocosm facilities to study water column processes.

Initial efforts will focus on the development of conceptual models/syntheses for the seagrass, water column, and salt marsh environments. The seagrass document will focus on assemblages dominated by Zostera marina (eelgrass), Thalassia testudinum (turtle grass), Halodule wrightii (shoal grass), and Syringodium filiforme (manatee grass). The salt marsh document will focus on communities dominated by Spartina patens and Spartina alteriflora. Work on documents pertaining to the water column and the seagrass beds will be initiated in the first and second quarters of FY 1990, respectively. Work on the salt marsh synthesis will be initiated in the fourth quarter of FY 1990. Staggered starts will permit incorporation of improved procedures for making selections and awards. Findings from the seagrass and water column syntheses will be available for use in preparing the FY 1991 call for research proposals. The salt marsh document will be available for research planning for FY 1992.

Remaining funds will be applied to studies of processes secondary production in seagrass and water column environments. In the absence of conceptual models for these habitats, FY 1990 calls for proposals will reflect the consensus of a panel of NOAA and academic scientists involved in writing the Estuarine Research Program Development Plan. A list of potential issues for each habitat includes:

Seagrass habitat:

* What are the consequential sources of fixed carbon in seagrass habitats? In what form does the carbon occur and how is it used? How efficient are the paths linking primary production and production at higher trophic levels?

* What role does the physical structure have in determining productivity of a seagrass bed? How are rooted aquatics and benthic algae in filling this role?

* What are the time-scales, rates, and magnitudes of natural and man-made changes in secondary production?

* To what degree is carbon produced in seagrass beds utilized within these habitats? Are significant fractions sequestered within or transported from seagrass beds?

Water column habitat:

* What is the relative importance of "new vs. recycled" nutrients in water column systems? How do changes in the chemical form and rates of external nutrient inputs affect internal nutrient cycles? What temporal and spatial lags influence the expression of these inputs?

* Have man-induced changes in the number and composition of estuarine benthic or pelagic filter-feedings faunas affected overall secondary production? What is the significance of greatly enhanced microbial and micro-plankton populations in estuarine water column habitats?

* What is the role of density surfaces (pycnoclines and fronts) in mediating water column secondary production?

Long Range Plans

Process-oriented research on Spartina communities will commence in FY 1992, as will development of the conceptual model/ synthesis for estuarine assemblages inhabiting unvegetated flats (mud and sand). Research on the latter habitat will be initiated in FY 1993. Work on the final habitat type, mangrove stands, will begin in FY 1994. The planning document conceptual model will be completed in time for use in developing a call for proposals in FY 1995.

Research awards generally will extend for periods of three to four years. Calls for proposals published in FY 1993 and thereafter will offer an opportunity to initiate new and follow-up investigations in previously studied habitats.

Interesting research options lie on the horizon for the out-years of the program (FY 1996 and beyond). Habitat types not yet examined, such as hypersaline estuarine communities, and additional examples of previously studied habitat types, such as Juncus-dominated marsh communities, are logical candidates for future attention. Once progress has been made on investigations of several habitat types, it may prove beneficial to focus on interactions among communities. Equally interesting might be an examination of estuarine secondary production in the context of larger global ocean and climate change (e.g., global sea level rise).

NOAA's Coastal Ocean Initiative

In addition to the TDP, a number of NOAA programs and initiatives address estuarine and coastal ocean issues. NOAA believes these efforts should be combined to form a NOAA Coastal Ocean Initiative.

This Initiative, now in preparation, points out that problems of the coastal ocean are numerous and apparently unresolvable; however, the fact that they are interrelated will ultimately allow for their solution. Also, the myriad of "grass fires" and local catastrophes fall into three categories: fish productivity, environmental quality, and coastal hazards. Many important processes and solutions to problems within each category are dependent. In fact, no matter which problem area one examines, the same set of important processes emerge as critical to its solution. NOAA therefore plans to address three critical generic issue areas to solve specific ongoing problems.

1. Fish Productivity - Our skill in optimizing benefits from the Nation's fisheries has been hampered by our limited ability to predict the effects of environmental changes on the productivity of living marine resources. Maintaining a predictable and steady stream of benefits from wise resource use will be likely once relationships between the environment and living resource stocks are defined. This requires data collection and analysis programs oriented toward understanding the effects of climate and shorter-term ocean changes on the dynamics of living marine resource stocks and their interactions. Maintenance of these resources requires intense monitoring of stocks and evaluation of the effects of harvesting, the dependence on the quantity and quality of habitat, and stock interactions.

2. Environmental Quality - The pollution problems of our coastal and estuarine waters have been discussed, debated, and enumerated in a series of meetings, workshops, and other fora over the last decade. From these discussions have come a series of goals presented in preliminary findings for the latest Federal five-year ocean pollution plan published by NOAA's National Ocean Pollution Planning Office. Implicit in our ability to understand the influences of both natural and anthropogenic forces on coastal environmental quality is our ability to predict the results of human-related activities, within the context of natural variation.

3. Coastal Hazards - The intense urbanization of the coastal areas, continued expansion of fisheries, and growth in mineral and oil exploration and development exposes ever-increasing numbers of people and property to the dangers of natural hazards. Local, state, and Federal officials must

be adequately prepared with valid information and recommendations to ensure timely and cost effective actions to protect human and other marine resources, stabilize shorelines, and develop effective protective measures against flooding and erosion. A comprehensive natural hazard predictive capability is needed so local and national decisions can be guided by recommendations based on quality data that support short-term warning and long-term planning and design capabilities.

## 4. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION ACTIVITIES IN ESTUARIES

Historically, NOAA has been the lead Federal agency in the development and dissemination of scientific information and products for the Nation's estuarine and coastal ocean waters. In fact, the Agency's authorities to describe, assess, and support research in these waters and to provide information for wise use and management dates back to the early 1800's. Current mandates require NOAA to provide a widerange of observational, assessment, research, and predictive services for estuarine and coastal ocean regions. With 27 coastal and marine research facilities, 16 National Estuarine Research Reserves, and direct ties to 29 universities and colleges through the National Sea Grant College Program, NOAA has developed an impressive array of programs to address not only national-scale estuarine issues, but also specific problems affecting individual estuarine and coastal ocean systems.

This section of the report summarizes major estuarine activities performed by NOAA line organizations. The Estuarine Projects Catalog, compiled by the NOAA Estuarine Programs Office, and the Appendix to this Annual Report contain a more detailed description of NOAA estuarine projects.

### National Environmental Satellite, Data, and Information Service (NESDIS)

NESDIS has four activities directed toward coastal and estuarine waters. First, the Coastal Dynamics Study develops scientific techniques to study the relationship of circulation to living marine resources. Second, the Marine Environmental Assessment Division (MEAD) provides assessments of the impact of environmental events on estuarine waters. Third, the National Environmental Data Referral Services (NEDRES) Data Management Program for the Chesapeake Bay is a computerized, on-line data base inventory that facilitates environmental data identification and acquisition for the Chesapeake Bay Program. Fourth, the Office of Research and Applications (ORA) is developing remote sensing techniques for estuarine applications.

Although NESDIS conducts studies related to the remote sensing of estuaries by both satellites and aircraft, the majority of NESDIS' estuarine work is done under its data and information program within the National Oceanographic Data Center (NODC) and the Assessment and Information Services Center (AISC). NODC develops an archive of estuarine data, responds to queries, and produces several specialized data catalogues for estuarine regions. The Marine Environmental Assessment Division of AISC generates reports that assess the effects of climate on marine transportation, recreation, and fisheries for several estuarine areas. An estuarine circulation modeling capability also exists within MEAD; this modeling effort examines recruitment of fish and shellfish larvae in the Chesapeake Bay.

National Marine Fisheries Service (NMFS)

NMFS has a strong interest in estuaries; nationally, about two-thirds of the Nation's commercially and recreationally important fisheries are estuarine-dependent. Much of NMFS's interest in estuarine habitat stems from its responsibilities under the Magnuson Fishery Conservation and Management Act, which provides for fishery management within the U.S. 200-mile Exclusive Economic Zone. Since most species under NOAA's management authority spend some portion of their life cycle in estuaries, NMFS is concerned about the ability of our estuarine habitats to sustain these resources. Habitat conservation activities are carried out through the regional offices and fisheries centers under Regional Action Plans. These activities include providing recommendations to reduce degradation or loss of valuable estuarine habitats caused by development. NMFS has a major program directed specifically toward coastal and estuarine waters. The NMFS Habitat Conservation Program carries out management and research activities directed at the conservation of habitats for important fisheries stocks.

National Ocean Service (NOS)

NOS supports a variety of estuarine activities related to the broad mission of NOAA. Many of these efforts are associated with the historical mission related to navigation in estuarine and coastal waters. NOS has a major program in tide and tidal current prediction and in nautical charting. Maintaining accurate charts of U.S. coastal waters is a primary responsibility of NOS. NOS supplements tabulated tidal predictions for selected ports with instruments that provide real-time tidal information to ships. The tidal observation network also provides information for marine boundary determinations and generates records of long-term sea level change. In recent years, numerical modeling combined with observational programs have replaced shipboard surveys as the primary means of generating data for tidal and current predictions.

NOS also manages specific programs directed at estuarine assessment. Within the Oceans Assessment Division (OAD) of NOS, the Strategic Assessments Branch carries out assessments of multiple resource uses. Products include a National Estuarine Inventory and Atlas, and the National Coastal Pollution Discharge Inventory. These studies include information on major estuaries nationwide. The Coastal Estuarine Assessment Branch examines marine environmental quality through the National Status and Trends Program, which monitors contaminant levels in sediments, bottomfish, and bivalves (mussels) in many estuaries nationwide. This Branch also sponsored major regional research programs in Puget Sound and the Hudson-Raritan estuarine system. Located within the OAD, the Hazardous Materials Response Branch provides scientific support for hazardous material spills using numerical modeling and environmental sensitivity analyses.

NOS has a number of programs directed at coastal and estuarine management. Within the Office of Ocean and Coastal Resources Management (OCRM), the States Assistance Program promotes rational use of the U.S. coastal zone, the Interstate Grants Program provides monies to coordinate interstate coastal zone planning, and the National Estuarine Reserve Research System manages estuarine reserves.

In the OCRM, the National Estuarine Reserve Research Program operates 16 research reserves nationwide as natural field laboratories for research and education. Thirteen site-specific research projects are being carried out in these sanctuaries. NOAA also administers the Coastal Zone Management Act (CZMA) of 1972. States participating in coastal management under the CZMA have developed programs designed to ensure effective management and development of the coastal zone. Of particular interest to estuarine management is Section 309 of the CZMA, which allows NOAA to make grants to states to coordinate interstate coastal management activities, as occurs frequently in large estuaries under the jurisdiction of two or more states.

Oceanic and Atmospheric Research (OAR)

OAR conducts research directed toward understanding and predicting coastal and estuarine processes. Estuarine programs are conducted in OAR through four of NOAA's Environmental Research Laboratories (ERLs) and the National Sea Grant College Program. ERL's estuarine activities occur primarily in the Great Lakes and Puget Sound. The Great Lakes Environmental Research Laboratory (GLERL) supports programs relating to contaminant cycling, lake hydrology and ecological succession. The Pacific Marine Environmental Laboratory (PMEL) research in Puget Sound concentrates on pollutant fate and transport, and estuarine circulation. In addition, PMEL cooperates with the Atlantic Oceanographic and Meterological Laboratory (AOML), NMFS, and the University of Miami on the Fisheries-Oceanography Coordinated Investigations (FOCI) program, a study of the recruitment variability of commercial coastal fisheries. Physical processes in estuarine systems are modeled at the Geophysical Fluid Dynamics Laboratory (GFDL).

The National Sea Grant College Program conducts estuarine studies at sites across the country, with major efforts in the Mississippi/Atchafalaya River complex, Narragansett Bay, Chesapeake Bay and Puget Sound. Studies are funded by competitive grants awarded to academic investigators working with Sea Grant programs in their state or region. Programs encourage development of integrated studies of specific estuarine problems by investigations at individual Sea Grant institutions and across the Sea Grant network. Priority research areas are set annually in proposal guidance, and proposals are considered in accordance with this guidance.

Sea Grant estuarine research focuses on several areas. Environmental studies compose the largest segment of the estuarine projects, involving research related to nutrient dynamics and primary production, trophic dynamics, habitat structure and function, pollutant fate and transport, and circulation modeling. Research in fisheries also composes a large segment of the estuarine work. In this area, interests include environmental control of reproduction and recruitment in estuarine stocks, improved management of estuarine fisheries, and relationships of habitat to fisheries production. Smaller efforts in Sea Grant estuarine research range from studies of coastal processes to economic and policy studies.

National Weather Service (NWS)

NWS has three programs directed toward coastal and estuarine waters. The Hurricane Guidance Program, the Tsunami Warning Program, and the Marine Weather Warning Forecast Program provide timely forecasts and warnings for coastal and estuarine waters. Other activities related to coastal and estuarine waters are the marine forecasts and advisories routinely issued by NWS forecast offices. In addition, the National Meteorological Center carries out operational storm surge modeling to announce warnings during the passage of hurricanes. These models have also been used to determine hurricane vulnerability studies in estuarine areas. Many of the NWS' flood prediction and mitigation activities also relate to estuarine regions.

## 5. NATIONAL ESTUARINE ISSUES: A REGIONAL PERSPECTIVE

Water quality, habitat, and living resource conservation issues and concerns apply to all the Nation's estuaries. However, these problems manifest themeselves differently in degree and scope among the various regions of the country. This summary provides a regional perspective to the national estuarine issues of concern developed in the 1987 NOAA Estuarine and Coastal Ocean Science Framework.

### Northeast Region

Northeast estuaries are critical habitats to a number of commercially and recreationally important fisheries. The extreme northern portion of this region supports salmon, sea-run brook trout, shad, and river herring as well as clam, scallop, and lobster. From Cape Cod southward, important fisheries include striped bass, bluefish, flounder, menhaden, oyster, and clam.

Unfortunately, many estuaries in this region also serve as receptacles for human and industrial wastes. The legacy of the American industrial revolution is reflected in high metal concentrations in the sediments of many Northeast estuaries. Historical archives are full with accounts of sewage contamination and typhus outbreaks caused by eating tainted shellfish. Many problems remain today because of outdated and overloaded sewage treatment facilities and inadequate treatment of industrial wastes. High levels of PCBs have been found in New Bedford Harbor, Massachusetts, and in the resident lobsters and finfish. Increased incidences of fish disease in Boston Harbor and Buzzards Bay have led to shellfish bed closures. In Narragansett Bay, major concerns include deterioration of the quahog fishery, beach closures from contaminated waters, and the long-term decline in finfish, oysters, scallops, and soft clams because of eutrophication. The major threat to estuarine quality in the Northeast is contamination, in addition to the physical destruction of estuarine habitats.

Key issues associated with the Northeast region include:

- urban development;
- eutrophication;
- large phytoplankton blooms;
- toxic contamination;
- toxic transport and resuspension;
- microbial contamination (shellfish, for example, in the New York Bight);
- municipal and industrial discharges;
- urban runoff;
- raw sewage discharges;
- combined sewer overflows; and
- point and non-point pollution.

Southeast Region

The Southeastern estuarine region has an abundance of fishery resources. In the Chesapeake, oysters, soft-shell clams, and blue crabs are key shellfish resources; menhaden, bluefish, flounder, and anadromous species such as striped bass, shad, river herring, and both white and yellow perch represent the most important finfish. Extending from North Carolina to Florida, popular shellfish include blue crab, oyster, shrimp, and scallop. Finfish include menhaden, bluefish, anadromous species, croaker, mullet, seatrout, spot, and flounder.

The attractive coastal islands off Georgia, the beautiful beaches of the Outer Banks and intricate estuarine waterways, combined with the pleasant climate of the Southeast make this region a haven for primary residences and vacation homes. This very attraction has led to explosive development pressures from residential construction and industrial relocation. Population projections indicate the Southeast will continue to face problems of balancing growing population and development pressures with the need to protect and preserve the coastal region.

Examples of increasing stress on shorelines can be witnessed in the 50% population growth along the shores of Maryland's portion of the Chesapeake Bay between 1950 and 1980, and by an additional 3,000-4,000 people setting along the Florida coast each week.

Non-point source runoff is a critical problem throughout the Southeast. Runoff from agricultural practices along rivers of the Chesapeake and from "mega-farms" of North Carolina dump loads of sediments, pesticides, and nutrients into these estuaries. Runoff often leads to severe problems of eutrophication, low levels of dissolved oxygen, and changes in fishery structures and fishery habitat. Wetlands and marshes, critical as nursery areas for larval and juvenile fish, are lost to agricultural land conversions and construction at alarming rates.

Key issues for the Chesapeake Bay include:

- -- dramatic increases in anoxic bottom water from nutrient enrichment;
- -- drastic declines in submerged aquatic vegetation;
- -- increases in turbidity;
- -- shift from freshwater spawning fishes to saltwater fishes;
- -- increasing prevalences of shellfish diseases; and
- -- contaminant hot spots in Baltimore Harbor and Elizabeth River.

For estuaries extending south of the Chesapeake Bay through Florida, key issues include:

- -- large scale effects of "mega-farms" in North Carolina;
- -- massive development impacting wetlands;
- -- changes in and movement of nursery areas seaward;
- -- heavy nutrient loadings;
- -- periodic hypoxia/anoxic conditions;
- -- loss of seagrass beds, especially in Tampa Bay;
- -- loss of shellfish caused by residential and urban development;
- -- physical loss of habitat from dredge and fill, especially in Tampa Bay; and
- -- contaminant hotspots in the Savannah River.

During the fall of 1987 the first recorded occurrence of a "red tide" caused by dinoflagellate Ptychodiscus brevis was observed in the coastal waters of North Carolina. Persons in beach areas complained of headaches, irritations to their eyes, nose and throat, lips and exposed skin and chronic coughing. In addition, shellfish beds were closed to the taking of selected species. The closure remained in effect until monitoring data showed the toxin content of the shellfish involved was below the quarantine level. The event continued into January of 1988 and caused a large economic disruption to the local shellfish industry.

NOAA's continued support of EPA's Chesapeake Bay project represents the major accomplishment in the Southeast Region. In addition, work has begun on development of a study plan for Albemarle/Pamlico Sounds.

Gulf of Mexico

The Gulf of Mexico is characterized by low coastal plains, extensive saltwater marshes, and high levels of sediment deposition. It also has the largest volume of wetlands in the country, constituting nearly 50% of the total coastal wetlands in the contiguous United States. Major features include the Mississippi and Atchafalaya River Deltas, where large amounts of land-based sediments are deposited outside the river mouth in adjacent shallow coastal waters forming deltas.

In other areas, sediment transported and deposited by ocean currents has built offshore bars enclosing shallow, sometimes extensive bodies of water known as bar-built estuaries. Entrances to these estuaries tend to be narrow, so that exchanges with the sea are highly restricted. Estuaries of the northern Gulf also have the largest drainage areas in the Nation, receiving runoff from two-thirds of the contiguous United States, primarily through the Mississippi River watershed.

The Gulf is reknowned for its recreational and commercial fisheries, a resource that local coastal economies increasingly depend with the decline in the oil industry. The most important fish and shellfish include menhaden, shrimp, oyster, blue crab, spotted seatrout, red drum, pompano, grouper, snapper, and flounder. The Gulf produces the largest volume of menhaden and shrimp in the country. Total fisheries of this region represent 39 percent of the national total by weight and 28 percent by value. An overwhelming majority of these fish depend on estuaries as critical habitats and food sources.

The coastal wetlands and adjacent inland wetlands of the Gulf are lost at alarming rates. Experts estimate that nearly 50 square miles of these valuable wetlands are lost each year. Subsidence, channelization, pipelines, draining, and levee construction along the Mississippi River combine to further the demise of wetlands and vital fisheries habitat in the region. The Gulf also suffers from extensive hypoxia, believed to be related to excessive nutrients flowing from the Mississippi River and into its delta. In 1985 alone, 8,000 square kilometers of the Louisiana shelf were hypoxic. This severely affected local fisheries resources.

Key issues in the Gulf of Mexico include:

- -- loss of up to 25,000 acres/year of marsh habitat because of oil and gas development, canals, dredging, saline intrusion, levee construction, development, and subsidence;
- -- freshwater diversion leading to changes in salinity levels in estuaries and population levels of fisheries, especially in Texas;
- -- large quantities of industrial and municipal waste water discharges, petrochemicals, and pesticides, adversely affecting water quality to the detriment of public health;
- -- the Barataria estuaries complex in Louisiana, a highly productive region for seafood, water commerce, mineral extraction, and recreation, is becoming anoxic and polluted from expanded urban and agricultural development; and
- -- eutrophication and oxygen depletion (especially as a result of a two-fold increase in nitrogen concentrations from agricultural runoff into the Mississippi River) may be connected to noxious blooms of "red tide" organisms and other noxious phytoplankton that has toxic affects on predators of seafood.

In the Gulf of Mexico, NOAA and EPA have participated in the development of a comprehensive inter-agency regional approach to the management of estuarine and coastal waters. Work on this planning process will continue into the next year.

Southwest Region

Estuarine-related fisheries of long standing regional importance include salmon, steelhead trout, striped bass, and sturgeon. Marine mammals frequent the numerous open bays, including harbor seals and sea lions.

The beautiful estuaries and bays of the Southwest offer scenic vistas of rugged cliffs and headlands with windswept trees above a pounding surf. The beauty of San Francisco Bay and of the semi-tropical palm-fringed bays of Southern California, such as Mission Bay and San Diego Bay, are highly valued.

This region also has significant environmental problems. The San Francisco Bay area, for example, has lost nearly all of its wetlands from diking and levee construction to provide land for massive agricultural development. Irrigated agriculture presents one of this estuary's greatest challenges -- a redirection of 40-60% of the freshwater flow resulting in a decline in water quality, dramatic alteration of fisheries resources and the ecosystem.

In the Southwest, key issues include:

- -- industrial and municipal discharges and agricultural drainage from the Sacramento and San Joaquin;
- -- loss of wetlands caused by diking and filling;
- -- radical changes in fish populations due to large diversions in freshwater inflow;
- -- very high levels of toxic contaminants in shellfish;
- -- reduction of striped bass by 80 percent;
- -- accumulation of toxic contaminants in sediments;
- -- bioaccumulation and/or biomagnification of toxic contaminants in the marine food web;
- -- altered benthic species distribution, including kelp, from sewage and other offshore discharges; and
- -- contamination by pathogens of coastal recreational areas caused by sewage, vessel discharges, and runoff.

In the Southwest Region, NOAA has cooperated with EPA to plan a comprehensive study of the San Francisco Bay.

Northwest and Alaska

In Alaska, 34,000 miles of tidal coasts represents approximately one-third of the total U.S. coastal shoreline. This large area is characterized by glacier-fed fjords (large open low relief estuaries) and hundreds of small bays and inlets. The delta

regions along the Alaskan coast contain broad tidal and freshwater marshes. The Yukon River Delta is comparable in size and complexity to the Mississippi River Delta.

The regional fisheries are directly linked to the estuarine regions of the Northwest Region and Alaska. In the Northwest, key species include Pacific salmon, steelhead trout, shad, flounder, crab, and clam. In addition to these species, important Alaskan fisheries include sablefish and scallop. Both regions support abundant populations of marine mammals including the harbor porpoise, sea lion, and harbor seal. Both support habitat for the endangered humpback whale. Alaska also supports other mammals such as the northern fur seal, sea otter, walruse, and beluga whale.

Problems in the Northwest differ largely in magnitude from those of Alaska. The Northwest area, as typified by Puget Sound, has become increasingly industrialized and suffers from locally high concentrations of contaminants. These contaminants originate from a large number of point sources, including municipal treatment plants, and from industrial dischargers such as oil refineries, pulp and paper mills, aluminum and steel processing plants, and chemical companies. Non-point source pollution from urban areas as well as logging and farming practices supply substantial volumes of metals and fecal coliform. Shellfish bed closures caused by bacterial contamination from runoff are rising even in rural embayments in the Sound. The entire eastern shore, where most of the population in the Puget Sound live, is uncertifiable for shellfish harvesting because of sewage treatment plants, combined sewer overflows, and urban runoff.

Key issues facing Northwest estuaries include:

- -- habitat loss;
- -- toxic concentrations in sediments;
- -- toxic bioaccumulation in food webs;
- -- bacterial contamination of shellfish;
- -- liver tumors and fin erosion in bottom fish, such as English sole;
- -- diminished river flow; and
- -- the adverse effects of salmon rearing pens.

In Alaska, population pressures have yet to exert comparable degradation of estuarine waters and habitat. Resource extraction industries such as fishing, oil and gas, logging, and mining, will continue to be the focus of estuarine management concerns. In addition, changes in sediment and water column chemistry over the past 10 years indicate that source control and pretreatment diminish the severity of point source inputs. However, combined sewer overflow and urban and rural runoff problems are expected to continue or get worse.

Great Lakes Region

The Great Lakes region is of critically important to many species of waterfowl, fish and other wildlife. Freshwater fish include trout, bass, smelt, salmon, whitefish, northern pike, walleye, alewife, lake herring, yellow perch, and many others. Some of the native fish, including longjaw cisco, deepwater cisco, blackfin cisco, and blue pike are extinct, and the lake sturgeon is close to extinction.

The Lakes are migration stops for many species of migratory birds of the Central, Mississippi, and Atlantic flyways. Marsh and upland, bay, and river habitats are also important for game birds and small and big game animals.

Areas of the Great Lakes southern region are heavily populated and industrialized with the accompanying discharge and runoff problems. For example, combined sewer overflows and storm drains in many cities deliver untreated sewage or industrial wastes shunted away from Publicly Owned Treatment Works, together with toxic urban runoff, directly into near coastal waters whenever it rains. Combined sewer overflows (CSOs) along the Rouge River in Detroit, Michigan produce a flow of industrial waste, equal in volume to the Rouge, that enters the Detroit River and the western end of Lake Erie during major storms. Phosphorus loads from these CSOs constitute the third largest municipal load of nutrients to Lake Erie.

For the Great Lakes, experts consider atmospheric deposition a significant source for a number of trace contaminants. Studies indicate that a significant portion of all loadings of metals and synthetic organic compounds to the Great Lakes are through atmospheric deposition (particularly Lake Superior).

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Agricultural runoff, landfills, loss of wetlands, sediment dredging/disposition, and 61 hazardous waste sites that can potentially contribute contaminants to Lake Ontario also create problems for the Great Lakes area.

Key issues for the Great Lakes include:

- -- loss of habitat;
- -- microbial contamination of lake waters;
- -- significant species changes observed in plankton, benthos, and finfish;
- -- fishing restrictions and public health advisories due to PCBs, pesticides and dioxins;
- -- annual anoxic episodes in Lake Erie and Green Bay;
- -- phytoplankton blooms in swimmable waters due to nutrient loadings;
- -- closure of commercial fisheries and sport fishing
- -- consumption advisories due to toxic contaminants;
- -- populations of cormorants and gulls suffering from high proportion of physical deformities; and
- -- relatively high incidences of tumors in fish.

## SUMMARY

Both the Administration and Congress have mandated a strong estuarine program within NOAA. In 1987, the Estuarine Program Office made significant progress in focusing NOAA's efforts in estuarine and coastal ocean issues. The NOAA Estuarine and Coastal Ocean Science Framework Summary outlines future direction in estuarine science and management into 1990s. EPO's publication of the NOAA Estuarine Capabilities paper identifies present NOAA science and management activities.

In 1987, EPO made significant accomplishments in the areas of coordination (especially with EPA) and communication, within the NOAA line offices. Continued progress of the Office in leading NOAA's efforts in estuarine science and management will be enhanced during the next year as EPO has been transfered to the Chief Scientist's Office. Potential for increased funding for estuarine and coastal ocean science makes future growth in NOAA's estuarine programs promising. The NOAA Estuarine Research Technical Development Plan and NOAA's Coastal Ocean Initiative have identified immediate research needs and specific steps needed to meet the goals of these programs.

EPO will continue to plan, coordinate, and communicate NOAA estuarine science activities directed toward wise use and management of our valuable estuarine and coastal ocean waters.

## APPENDIX A

## NOAA's 1987 ESTUARINE ACTIVITIES

This appendix describes NOAA's key estuarine activities during 1987. The Estuarine Projects Catalog contains a more complete listing of NOAA's estuarine programs.

### NATIONAL MARINE FISHERIES SERVICE (NMFS)

#### Northeast Region

1. ESCORT

The Northeast Center (NEC) completed a program development plan for a research initiative to expand and integrate NEC's inshore research program. The initiative is called ESCORT, an acronym for Estuarine and Coastal Research Thrust. ESCORT conducts a coherent, regional inshore research program that addresses issues and information needs relative to the conservation and management of living marine resources of the Northwest Atlantic ecosystem. ESCORT's four major research areas are: 1) data and information, 2) habitat requirements and use, 3) biological effects of habitat degradation, and 4) fishery statistics and stock assessments.

2.. Superfund Settlement

The U.S. Department of Justice and Massachusetts agreed to a $2 million Superfund settlement with AVX Corporation for allegedly disposing polychlorinated biphenyls (PCBs) in New Bedford Harbor. Acting as public trustees, NOAA sued for damages to fishery resources and their habitat. With the settlement, restoration will begin. Settlements of court decisions on cases brought against other New Bedford PCB polluters may enhance the restoration budget. NMFS, acting through the Northeast Region's Habitat Conservation Branch, will work closely with state officials on the restoration effort.

NMFS is also working with Corps of Engineers (COE) on their draft analysis of estimated contaminant released from dredging and disposal activities related to the proposed New Bedford Harbor Superfund pilot study. Major concerns relate to the persistence, toxicity, and bioaccumulation potential of many PCB compounds which may affect health and edibility of fishery resources.

3. Ocean Dumping Workshop

At the request of the EPA, NMFS' Northeast Region participated in a workshop to discuss scientific information needed for EPA's site-specific monitoring program of the ecological impacts of dumping municipal sludge at the 106-mile site. Since the 12-mile dumpsite was phased out in December 1987, EPA is accumulating information for new baselines. Efforts include developing a monitoring program for all activities related to dumping and the marine environment near the dumpsite. Included are tests for bioaccumulation, spatial and temporal extent to sediment plumes, observations of protected species in the area, water chemistry, fish distribution, and deep sea benthos. EPA will continue to develop a monitoring plan and to gather technical information for the 106-mile site.

4. Long Island Sound Study

Northeast Center (NEC) staff represent NOAA at Long Island Sound Management Committee meetings. Many of the technical discussions related to future research plans concern dissolved oxygen levels and hypoxia events in the western sound.

5. NOAA/EPA Estuarine Study

In cooperation with EPA, states, and academia, NEC expanded its research efforts in several Northeast estuaries. Research emphasizes reproductive success, survival, and recruitment of key species subjected to contaminant effects. Major emphasis is on studies of winter flounder (Pseudopleuronectes americanus). Studies are being conducted in Long Island Sound, Narragansett Bay, and Buzzards Bay. Researchers will utilize stock assessment and population modeling techniques to link pollutant effects on individual organisms to population-level impacts.

6. Planning Documents Developed

The Northeast Region has developed a major planning document stressing conservation, an obligation to develop a basic understanding of the productivity of living resources, prediction of the effects of natural and human-induced changes to the ecosystem, and assurance that living marine resource populations can sustsain themselves. A "Framework for Inshore Research" has also been developed to address research in inshore areas where anthropogenic threats to living marine resources and habitats are perceived to be the greatest.

7. Activities Under the Fish and Wildlife Coordination Act

Proposals to locate floating pens in Maine and Massachusetts for finfish aquaculture were analyzed. Unanswered aspects of these projects include impacts of disease, excessive use of antibiotics, eutrophication, and physical impacts related to shading and gear displacements. Projects to impound wetlands or divert waterways for waterfowl habitat, sediment control, stormwater management, or water supply reservoirs continue to be proposed in the Chesapeake Bay watershed. Such projects threaten to inundate wetland habitats and reduce freshwater inflows. With growing pressures to expand public marina capabilities along the northeast Atlantic coast, numerous proposed marina projects have been evaluated. Marina projects raise several concerns: physical impacts associated with dredging coastal water and excavating nearshore uplands, fisheries impacts associated with destroying productive salt marshes, and possible impacts to water and sediment quality. Potential impacts of Navy's test of its defense systems against electromagnetic pulses (EMPRESS II) have been identified as possibly affecting the behavior of marine organisms and displacing fishing and other recreational activities.

Southeast Region

1. Cooperative with COE

Research and management staffs in the Southeast Region (SEC) developed an effective coordination process for habitat-related matters. Examples include input by the Southeast Fisheries Center (SEC) on significant water-development projects and projects requested for elevation to higher levels in the Corps of Engineers (COE), collaboration on preparation and reviews of scientific papers and research proposals, and continued close dialogue on ongoing mitigation studies.

2. Albemarle - Pamlico Study

SEC determined priority management information needs in the region. SEC provided input to draft documents developed by the SEC on the NOAA Estuarine Research Initiative. Discussion of research and management issues relative to the EPA Albemarle-Pamlico Sound program were coordinated among SEC and SER staff.

3. Estuarine Research

Research included recruitment to estuaries; utilization of various wetland habitat types as a measure of relative habitat value; predator-prey interactions; uses of material; evaluation of impacts to fishery habitats, including freshwater inflow and temperatures; the functional value of mitigated and created wetland habitats; and synthesis of information on wetland acreages, and fishery species life histories.

4. National Wetland Inventory

The SEC in conjunction with NOAA's National Ocean Service (NOS), Ocean Assessment Division (OAD), determined the quality of wetland habitat in the coastal U.S. by sampling National Wetland Inventory habitat maps using a dot grid matrix procedure. Mapping of submerged aquatic vegetation (SAV) in the Albemarle-Pamlico Sound area of North Carolina was initiated. NOAA's Photogrammetry Unit will supply, under subcontract to the Beaufort Laboratory, aerial photographs of the study area, and Beaufort will identify, locate and quantify SAV from the photography using video image analysis and ground truthing. These data will be superimposed on NOS topographic maps to produce a chart product.

Investigations with the OAD were initiated during 1987 to compile data on the life history, distribution, and abundance of 35 selected fish and invertebrate species in each of 13 estuaries in the Gulf of Mexico and Florida to Mobile Bay. The completed database will be part of the National Inventory and enable comparisons among species groups, specific life stages, estuaries, and geographic areas.

Southwest Region

1. Habitat Conservation Studies

Southwest Region (SWR) Habitat staff meet regularly with Southwest Fisheries Center (SWC) staff from La Jolla and Tiburon to identify and discuss habitat conservation issues. Current efforts include the joint preparation of a framework to set Northern California habitat conservation/restoration goals and identify tasks to reach those goals. In Southern California, staff coordination focused on SWR/SWC participation in NOAA's Superfund efforts related to possible damage assessment against Montrose Chemical Company for historical DDT discharges to Santa Monica Bay.

2. Symposium on Estuarine Inflow

NMFS helped a symposium on "Managing Inflows to Estuaries." The symposium was divided into two concurrent segments (inflows and economics). Many participants attended the section on management of fresh water inflows into bays and estuaries. In all, nearly 250 participants and 40 speakers attended. In addition to sessions on Southern California and Central coast lagoon systems, the symposium featured indicator and inflow problems at San Francisco Bay and Humboldt Bays.

3. Value of Chinook Salmon

NMFS made significant progress on their contract to determine the value of the chinook salmon habitat in the Sacramento River basin. Northern area office habitat staff met with Messrs, Garcia, Meyer and Huppert to continue coordination on economic issues. Dr. Mike Rozengurt presented his analyses of available river hydrological data bases and calculations for water year type classifications. After his presentation last year at the national symposium in Washington, D.C., NMFS central office contracted with Dr. Rozengurt to prepare a formal analysis paper.

4. Estuarine Coordination Activities

Regional and SWC Tiburon staff participated in management and technical activities with other NOAA offices, state agencies, other Federal agencies, fishing and conservation organizations, and public representatives. An example is EPA's effort to develop a management program for San Francisco Bay. The bay is designated an estuary of national importance through the EPA's National Estuary Program. Coordination occurs with Sea Grant, Estuarine Program Office, National Ocean Service, the Gulf of the Farallons National Marine Sanctuary and NMFS. Southwest Center staff attended a workshop in Annapolis, Maryland to coordinate appropriate NOAA elements (including NOAA Corps) with EPA's National Estuary Program.

5. Cooperative Projects

NMFS staff selected habitat enhancement projects in compliance with a Memorandum of Agreement between NMFS and the Corps of Engineers to restore marine habitat as part of ongoing Corps projects. Projects to restore over 1,200 acres of wetlands in the Sacramento delta are now underway. Two additional Memoranda of

Agreement relate to the use of mitigation banking to offset negative habitat impacts from port developments in Los Angeles and Long Beach Harbors. In total, almost 600 acres of degraded tidal wetlands along the southern California coast will be restored under these two memoranda. A Coordinated Operation Agreement signed by President Reagan makes possible more efficient operation of the Federal Central Valley Project and the California State Water Project. NMFS emphasized that a key element of these projects should be maintaining the quality and quantity of anadromous fish habitat in the Central Valley. Other cooperative projects include discussions with Federal, state, and university represenatitives regarding the status of eelgrass, managing inflows to estuaries, valuation of non-market aspects of natural resources, effects of freshwater diversion on the baitfish resources of Pearl Harbor, distribution of larval fishes near Oahu, the Hawaiian Islands Mapping Program, and a survey of groundfish in Southern California wetland and shallow estuarine habitats.

Northwest Region

1. Study of Tumors in English Sole

The Center's Environmental Conservation Division (ECD) completed a three and a half year study of liver tumors in English sole. During this study, researchers made significant advances in understanding the relationship between liver neoplasms and chemical contaminants. In laboratory studies, a spectrum of liver lesions were produced in English sole following exposure to extracts of urban estuarine sediments. In addition, utilizing data collected in field studies researchers developed a statistical model which accounts for 35 percent of the variation in neoplasm prevalence in English sole in Puget Sound based on fish size and sediment concentrations of selected classes of xenobiotics.

2. Study of Columbia River Dredging

The Northwest Region (NWR) and Center began in FY 86 to work with Corps of Engineers (COE) to study the possible environmental impacts of navigational dredging projects proposed by COE for the Hanford Reach of the mid-Columbia River. The Hanford Reach is the only remaining upriver chinook salmon spawning area of any significance in the Columbia River. Over the past few years the number of chinook salmon returning to spawn in the Hanford Reach has more than doubled. The NWR expressed opposition to the project based on concerns regarding the potential for impacts

on the chinook resource, including elimination or alteration of spawning habitat, disruption of the natural flow of the river, increases in salmon mortality, interference with sport and Indian tribal fisheries, and an overall decline in productivity of the salmon resource in the region.

Alaska Region

1. Alaska Working Group on Coopertive Fisheries-Foresty Research

The Alaska Region participates on the Alaska Working Group on Cooperative Fisheries-Foresty Research. The group supported several studies on habitat requirements of both marine and freshwater organisms affected by timber harvest. Group members include NMFS, Forest Service State of Alaska Departments involved with water quality, lands, forestry, fish and wildlife, Office of the Governor, private timber land owners and fish industry groups. Several studies recommended by the working group were funded, and results are used in management decisions by timber managers and resource agencies.

2. Five-year Plan for Endicott Development Project

A Region staff biologist is formulating the final five-year study plan for the Endicott Development Project's environmental monitoring program. The program will assess impacts of the 4.8 mile long Endicott causeway on anadromous fish species in the nearshore coastal Beaufort Sea. The five-year plan will be used by the Corps of Engineers (COE) and the monitoring program's interagency technical committee to ensure development of studies to assess the project's effects on coastal fisheries and recommend modifications to the existing causeway.

## NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE (NESDIS)

### Assessment and Information Services Center (AISC)

National Environmental Data Referral Service (NEDRES) Program Office

Identification and description of NOAA and Federal and non-Federal data sources for inclusion in the NEDRES data base were completed with the publication of the Chesapeake Bay Environmental Data Directory. The work was a cooperative project of Maryland Sea Grant College, Virginia Sea Grant College, and NOAA funded by the Estuarine Programs Office and Office of Sea Grant. Following the completion of the task, the Chesapeake Bay Program (CBP) Data Subcommittee will review the information for possible conversion and inclusion in the CBP data base or other accessible data base systems, such as the National Oceanographic Data Center.

### National Oceanographic Data Center (NODC)

1. Coastal Information System for Chesapeake Bay

The personal computer-based Coastal Information System for the Chesapeake Bay was nearly complete at the end of 1987. The work is being done at the Marine Sciences Research Center at Stony Brook, Long Island, a part of the State University of New York. When completed, the system will use personal computer hardware and commercially available software to provide environmental and pollutant information for Bay planners and decisionmakers. It will enable users to explore relationships between problems and possible causes without resource to a mainframe computer.

2. Identification of Marine Pollution Data Collection Activities

After evaluating all frderally funded projects described in the National Marine Pollution Information System (NMPIS) and the Federal Projects Catalog for 1978-83, the Ocean Pollution Data and Information Network (OPDIN), identified nearly 400 projects nationwide which could be sources of data. Because of the focus on pollution, most projects concern the estuarine environment. During 1987, efforts commenced in the tasks of location and verification of data collections.

Office of Research and Applications (ORA)

ORA engages in remote sensing programmatic and research applications to estuarine science and management. These include satellite techniques and visible region optical buoy system development for in-situ measurements in the ocean and coastal water. ORA has strong interest in the development of remote sensing techniques directed toward quantification of such parameters as total suspended matter, phytoplankton pigments, and sea surface temperature which could be incorporated into numerical models for understanding estuarine processes. Progress in the above areas includes:

1. Seminar and Workshop: "Remote Sensing of Esturies" was published which contains statements on estuarine management and science issues and recommendations for remote sensing utilization in estuaries. The document also reviews a wide range of remote sensors and techniques available to users for monitoring physical and biological properties of estuaries and surrounding wetlands and drainage basins.

2. Remote Sensing Work Group: A Chesapeake Bay Remote Sensing Work Group was established to lay the framework for a coordinated approach to the use of remote sensing for Bay scientific and technical issues. Group members represented Federal, state, and academic sectors. The design and initiation of a Chesapeake Bay remote sensing demonstration project is an immediate objective of the group.

Marine Environmental Assessment Division (MEAD)

Scientists have developed algorithms for estimating chlorophyll and turbidity levels in surface waters of Chesapeake Bay using AVHRR satellite data. Images were processed to obtain monthly averaged conditions, and to estimate times of occurrences of peak concentrations. The technology developed will establish a climatological catalogue of environmental conditions as seen from space. In another study, a circulation model of Chesapeake Bay was applied by NOAA scientists to trace the drift of blue crab larvae in and out of the mouth of the bay under varying climatic conditions. The results indicate that, neglecting mortality, approximately 40 percent of larvae end up inside the bay.

## NATIONAL OCEAN SERVICE (NOS)

### Office of Oceanography and Marine Assessment (OMA)

#### 1. National Coastal Ocean Circulation Program

The National Coastal Ocean Circulation Program seeks to provide decisionmakers and users of the Nation's estuaries and coastal seas with reliable information about currents and water levels. The Estuarine and Ocean Physics Branch manages the program with support of other OMA groups and the NOS Office of Marine Operations. The program's data and information products are used for efficient pilotage, docking and undocking of ships and recreational craft, rapid cleanup of oil and hazardous material spills, effective search and rescue operations, developing port and harbor engineering plans, and, when coupled with quality or sediment transport models, various environmental assessment applications.

During 1987, OMA conducted the first phase of the Charleston Harbor Oceanography Project (CHOP). This evaluated existing tide and current information to determine the effect of diverting some of the freshwater flow from the Cooper River which feeds the estuary. A leading-edge technology, real-time current and wind measurement system was installed at the entrance to Charleston Harbor (where it will remain in operation through 1988) and current, water level, and wind measurements were made at various locations in the estuary. Large differences were found in the tidal dynamics of the estuary, and scientists developed a plan to remedy the problem. Additional measurements, including those on the adjacent inner shelf, are being made during 1988. A numerical circulation model will be applied to the estuary. The new data will be used to revise traditional tide and current tables and to verify results of the model for a circulation and water level forecast atlas.

OMA developed plans during 1987 to apply circulation and water level measurement and numerical modeling capabilities to Long Island Sound. The Long Island Sound Oceanography Project (LISOP) supports EPA's Long Island Sound Study. The goal of LISOP is to couple the results of a hydrodynamic model with those of a water quality model to provide a powerful tool to test environmental management strategies before implementing them in the Sound.

2. The National Estuarine Inventory (NEI)

The NEI is the framework in NOAA's efforts to assess the health of the Nation's estuaries. It identifies all large- and medium-sized estuaries within the contiguous U.S.; compiles a data base of their important physical, hydrologic, and land use characteristics; and specifies a commonly derived spatial unit, the estuarine drainage area by which data are compiled. The original 92 estuaries identified in the NEI account for approximately 90% of the estuarine water surface area along each of the three coastal regions of the contiguous U.S., and 90% of the freshwater inflow. The National Estuarine Inventory Data Atlas illustrates characteristics of estuaries identified in the NEI. Volume 1 of the Atlas, completed in 1985, specifies their fundamental physical and hydrologic characteristics. Volume 2, completed in January 1987, specifies the area of 24 categories of land use by estuary, counties and hydrologic units. Following completion of Volume 2, a report, "Land Use and the Nation's Estuaries," was published that examines the extent to which the Nation's estuarine resource base may be influenced by specific types of land use. Four additional volumes to the NEI data atlas series will be produced as part of other projects described below. These are: public outdoor recreational facilities by estuary, nutrient discharges by estuary, coastal wetlands in estuaries of the northeeast, and pesticide discharge by estuary.

3. National Coastal Pollutant Discharge Inventory (NCPDI)

The NCPDI is a data base and computational framework containing discharge estimates for all point, nonpoint, and riverine sources of pollutant discharges into the estuarine, coastal, and oceanic waters of the contiguous U.S. (excluding the Great Lakes). Pollutant discharge estimates are for a variety of contaminants including nutrients, metals, petroleum hydrocarbons, PCBs, chlorinated pesticides, fecal coliform bacteria, particulate matter, sludge, oxygen-demanding materials, and wastewater flow. The framework enables nationwide assessments of the impact of pollutant discharges into these waters under different assumptions about economic conditions, pollution control options, meteorologic and hydrologic conditions, and public policies. The NCPDI contains three components: the Gulf of Mexico (completed 1981); the East Coast (completed 1985) and the West Coast (completed 1987). During 1987 the municipal wastewater treatment plant component on over 3,000 facilities was updated and a report produced, titled "Publicly Owned Treatment Works in Coastal Areas of the U.S." Estimates of point and nonpoint source discharges of nitrogen and phosphorus were recompiled for all NEI estuaries and will be published in a volume of the NEI data

atlas series. Use and discharge estimates of 28 agricultural pesticides were completed for all NEI estuaries and will be included in a volume of the NEI data atlas series. A series of information products describing pollutant discharges, sources, and background data for Long Island Sound, San Francisco Bay, Hudson River/Raritan Bay, Albemarle/Pamlico Sounds, Chesapeake Bay, and for estuarine and coastal drainages in North and South Carolina was completed.

4. Estuarine Classification

A preliminary estuarine classification scheme based on pollution susceptibility was developed and applied to the original NEI estuaries. Nine classes of susceptibility were established based on particle retention (trapping) efficiency and dissolved concentration potential. Pollutant discharge estimates for nitrogen, phosphorus, trace metals, and petroleum hydrocarbons from NOAA's National Coastal Pollutant Discharge Inventory were applied to the classification scheme to determine estuaries of high, medium, and low pollutant susceptibility. EPA uses the information as one method to determine which estuaries should be included in its National Estuary Program.

5. National Coastal Wetlands Data Base

In cooperation with the Beaufort Laboratory of the National Marine Fisheries Service (NMFS), the Strategic Assessment Branch (SAB) is developing a national coastal wetlands data base through use of a systematic grid sampling procedure on wetland maps produced for the National Inventory (NWI) of the U.S. Fish and Wildlife Service (FWS). Fifteen habitat types are recorded by 45 acre cells on 1:24,000 scale wetland maps. Acreage estimates and color maps for one or several NWI maps can be produced. Grid sampled data can be intersected with digitized boundaries, such as countries and estuarine drainage areas as defined in the NEI to produce acreage summaries and maps for specific units of interest. Approximately 4,000 of the 5,000 NWI maps sampled to approximately 1,600. Grid sampling of coastal wetlands from Maine to Connecticut, was completed in January 1987. A volume of the NEI data atlas series summarizes these data. Prior to beginning the inventory, NMFS and SAB examined existing state and local wetland inventories and summarized the distribution of wetland types - salt marsh, fresh marsh, tidal flat, and swamp - in the coastal countries of 22 states. A NOAA report entitled "An Inventory of Coastal Wetlands of the USA, describes this work."

6. National Shellfish Register of Classified Estuarine Waters

This project compiles nationwide information on the classification of shellfishing areas by state authorities. Estuarine waters are classified predominantly on the basis of coliform bacteria levels as approved, prohibited, conditionally approved, or restricted. Classification data from 1971, 1975, 1980, and 1985 have been reorganized into the original NEI estuaries. The 1985 data also have been corrected for areas that were classified for reasons other than water quality. A NOAA report titled "National Estuarine Inventory, Classified Shellfish Growing Waters by Estuary" summarizes the information. Beginning in 1986 and continuing in 1987 NOAA, in cooperation with shellfish-producing states, began to identify pollution sources of areas limited to the harvest of shellfish. The first results of this work are presented in a report titled "The Quality of Shellfish Growing Waters in the Gulf of Mexico." It is the first in a series of regional reports that presents information on the administration of state shellfish programs, status of classified waters, sources of pollution affecting harvest-limited waters, and trends in classification between 1971 and 1985.

7. Living Marine Resources

This project develops information on the distribution and abundance of living marine resources in the Nation's estuaries. The information will be developed for approximately 150 species and will be organized initally by three salinity zones depicted for each estuary in Volume 1 of the National Estuarine Inventory Data Atlas plus additional estuaries of biological importance. Data are being collected through literature reviews, consultation with local and regional fisheries experts, and sources in the NMFS, U.S. Fish and Wildlife Service, and NOAA's Ocean Assessments Division. The project is being conducted in three phrases. Phase one covers the West Coast; phase two, the Gulf of Mexico; and phase three, the East Coast. A preliminary component of phase one, to assess the overall feasibility of the project, was discussed in a NOAA report entitled "National Estuarine Inventory, Living Marine Resources Component, Preliminary West Coast Study." During 1987 data collection was completed for estuaries in the state of Washington, nearly completed for estuaries in California and the Gulf Coast of Florida, and started in the Western Gulf of Mexico and the Southeast.

8. Shoreline Characterization

This project develops information on shoreline and bottom characteristics of estuaries in the contiguous USA identified in the NEI. The project distinguishes modified from unmodified shoreline for each estuary and identifies

the length of dredged material disposal sites from NOAA nautical charts. Over 68,000 kilometers of estuarine shoreline, nearly 5,500 kilometers of navigational channels, and approximately 1,000 square kilometers of navigational channels were digitized during 1987. They are summarized in a report titled "Shoreline Modification, Dredged Channels, and Dredged Material Disposal Areas in the Nation's Estuaries." These data will eventually be used to explore relationships between estuarine habitats and their susceptibility to anthropogenic inputs to the estuarine environment.

9. Public Coastal Outdoor Recreational Facilities

This project surveys Federal, state, and local agencies which own and maintain public outdoor recreational facilities in approximately 325 counties in the coastal zone of the contiguous U.S. Information generated from this survey includes acres of public recreational lands and waters; number of facilities such as boat ramps, slips, docks, fishing pier, artifical reefs, and campsites; and miles of public beach. During 1987 follow-up data collection was conducted to finish the survey. The completed data base now contains information on over 27,000 public outdoor recreation areas in coastal areas of 22 states managed by 1,900 Federal, state, and local agencies. These data were aggregated by groups of estuaries for a volume in the National Estuarine Inventory data atlas series to be published in 1988.

10. Strategic Assessment of Near Coastal Waters, Northeast Case Study

This case study is being developed for 17 estuaries in the Northeast to illustrate types of data available for resource assessments of estuaries and near coastal waters around the U.S., and to suggest ways to utilize information to implement parts of Federal statutes such as the Clean Water Act. Most information presented is compiled from data bases in the projects discussed above. Information compiled and organized focuses on seven themes--(1) physical and hydrologic characteristics; (2) land use and population; (3) nutrient discharges to estuaries; (4) classified shellfish water; (5) toxic discharges to estuaries and hazardous waste disposal sites; (6) coastal wetlands; and (7) public outdoor recreational facilities.

11. National Status and Trends Program

The National Status and Trends (NS & T) Program, maintains the information base required to quantify the current status and long-term, temporal and spatial trends in concentrations of key contaminants and in biological indicators of contaminant effects on living resources in the Nation's coastal and estuarine environments. Under this program a nationally uniform set of measurement techniques is used to obtain comprehensive, high-quality, and continuing information about the status and trends of environmental quality in these areas.

The NS & T Program has three major components: (1) Benthic Surveillance; (2) Mussel Watch; and (3) Historical Trends Assessment. The 1986 report highlighted the assessment of historical trends, and a major summary on PCBs and Chlorinated Pesticide Contamination in U.S. Fish and Shellfish was available in 1987. Subsequent sections emphasize current results of the Mussel Watch and Benthic Surveillance Projects, a intensive study in Long Island Sound, and an associated project in sample archival.

Under the overall direction and management of OAD, scientific work in the Benthic Surveillance Project is conducted by NOAA's NMFS laboratories in Gloucester, MA, Sandy Hook, NJ; Oxford, MD; Beaufort, NC; Charleston, SC; and Seattle, WA. Field work for the Benthic Surveillance Project is conducted from NOAA vessels, primarily the ships FERREL (East Coast and Gulf of Mexico) and McArthur (West Coast), both operated by NOAA's National Ocean Service. For the Mussel Watch Project, samples are collected and analyzed under contract by scientists outside NOAA. Data from the projects are stored in a NS & T data base, one of the primary products of the NS & T Program.

During FY 1987, Mussel Watch field sampling of bivalve mollusks and surface sediments was completed at 150 sites nationwide, and approximately 1,700 samples of bottom sediments and benthic fish tissues were collected at 44 Benthic Surveillance sites nationwide, including additional sites in Galveston Bay, St. Jones River and Sapelo Sound for the investigation of regional sample variability in the southeast and Gulf of Mexico region. Intensive studies carried out in San Francisco Bay and Long Island Sound provided an improved basis for interpretation on NS & T data from those regions. In addition, completed laboratory analyses of the 1984, 1985, and 1986 Benethic Surveillance and 1986 and 1987 Mussel Watch samples provided a basis for the first annual progress report of the NS & T Program.

12. Hazardous Materials (HAZMAT) Response Branch

The HAZMAT Response Branch, located in Seattle, Washington, maintains a cadre of technically trained people to respond to releases of oil and hazardous materials in the coastal or estuarine environment. The program has evolved into two types of reponses: those requiring immediate action associated with U.S. Coast Guard (USCG) spill response activities and those that allow a more measured approach and are associated with the EPA's activities with "Superfund" sites.

In order to effectively support the lead agency, HAZMAT has placed (or will be placing) personnel in or nearby regional offices of EPA (only for coastal regions) and district offices, of the USCG. HAZMAT can thus become directly involved in day-to-day planning activities required for an effective response and can influence longer term clean-up and mitigation plans. Personnel placed in USCG offices are termed Scientific Support Coordinators (SSCs) and those supporting EPA are called Coastal Resource Coordinators (CRCs). Regional HAZMAT people are supported through a nationwide communications network by an interdisciplinary group of chemists, ecologists, and oceanographers and a carefully structured information system that enables timely, expert advice.

13. Outer Continental Shelf Environmental Assessment Program (OCSEAP)

OCSEAP is managed by the Ocean Assessment Division's Alaska Office under an agreement between NOAA and the Department of the Interior's Mammals Management Services (MMS). The program conducts environmental studies in Alaska OCS areas designated by MMS for potential oil and gas development. OCSEAP provides MMS and other agencies involved in oil and gas leasing decisions with scientific data and information needed to predict environmental events and to resolve multiple-use conflicts associated with offshore oil and gas development in the Alaska area. OCSEAP carried out significant studies during 1987 to understand the vulnerability and sensitivity of various ecosystems.

14. Water Level Program

The Sea and Lake Levels Branch (SLIB) conducts programs of continuous water level measurements and observations in the continental U.S. and its territories, the Great Lakes, Alaska, and Hawaii.

The mission requires collection, processing, and analysis of ocean and lake data to evaluate and interpret the physical and chemical phenomena of the nation's estuaries, the sea, and Great Lakes of hydrography, nautical charting, Great Lakes water levels, tide coordinated photogrammetry, photobathymetry, tide predictions, circulatory surveys, tsunami and storm surge warnings, long-term sea level means, marine boundary and water level telemetry, and real-time upgrades.

National Water Level Observation Network (NWLON) is a system of 225 water level stations located in coastal areas, estuaries, and Great Lakes of the U.S. and its trust territories. Of these, 171 stations are located along the coast and 54 along the Great Lakes. Water level is measured every six minutes, recorded on a punched paper tape, collected once a month by a NOAA tide observer, and sent for processing and analysis to the Office of Oceanography and Marine Assessment in Rockville, Maryland.

The Next Generation Water Level Measurement System (NGWLMS) is an integrated water level measurement, data acquisition, data transmission, processing, analysis, and information dissemination system that will replace (over the next five years) NOAA's existing National Water Level Observation Network (NWLON) of 225 permanent stations. NGWLMS will consist of acoustic water level sensors, microprocessor-based data acquisition and collection field units, telephone and satellite telemetry communications links, and a central data collection and processing system located in the Office of Oceanography and Marine Assessment. Many of the labor-intensive activities of NWLON will be replaced by the automated, self checking capabilities of NGWLMS; for example, about 90% of the data collected and processed by NGWLMS will be automatic without any human intervention. Also, overall accuracy of water level products will be greatly improved by reduction in sources and magnitudes of systematic errors. NGWLMS will provide near real-time data from all its stations, improve water level data and information product quality, and increase productivity by reducing the time required to generate validated data for navigation applications from 30-60 days to a matter of hours; data for research applications from 90 days to just one day; and tidal datums from 90-180 days to just 7-28 days.

TIDES ABC is a NOAA product that allows users to acquire near real-time water level data from selected NWLON stations equipped with telephone telemetry. Water level measurements from 17 stations can now be interrogated with TIDES ABC.

It can generate graphic and tabular information in both video and printed displays that compare actual water level at a station against water levels predicted in NOAA tide tables. Water level is measured every six minutes at NOAA tide stations.

The application of near real-time water level data from TIDES ABC can benefit a wide range of users involved in navigation, vessel traffic control, channel dredging and maintenance, and coastal management. Currently, the principal users are the nation's port pilot associations for safe navigation of large commercial vessels, the Army Corps of Engineers to monitor dredging depths of shipping channels in the Nation's waterways, and the National Weather Service for coastal storm surge.

National Ocean Pollution Program Office (NOPPO)

The National Ocean Pollution Planning Act (NOPPA) of 1978 requires NOAA to coordinate marine pollution research, development, and monitoring activities funded by the Federal Government and to disseminate information to interested users. These responsibilities are delegated to NOPPO. During 1987, the NOPPO was moved from NOS to NOAA's Chief Scientist Office. This section describes the interagency planning and coordination and information dissemination activities conducted by NOPPO during 1987.

The Omnibus Budget Reconciliation Act of 1986 (P.L. 99-272, enacted April 7, 1986) amended the NOPPA and significantly altered the level of coordination required by Congress among agencies and departments that support research, development, and monitoring related to ocean pollution. The amendments established an interagency National Ocean Pollution Policy Board and specified that NMPPO serve as staff to the Board.

This Board is similar to the previous Committee on Ocean Pollution Research, Development, and Monitoring (COPRDM) but with added responsibilities. Each agency represented in the Federal Plan for Ocean Pollution Research, Development, and Monitoring must, submit to the Policy Board their annual requests for appropriations in support of ocean pollution research, development, and monitoring programs. The Policy Board reviews these requests for appropriations and submits a report to the Office of Management and Budget (OMB) and Congress discussing the extent to which the requests are consistent with the priorities established in the Federal Plan. Under NOPPA, OMB reviews the request and takes into account the review of the Policy Board. The 1986 amendments also give NOPPO the responsibility to coordinate the research necessary to support the preservation and protection of the environmental quality of the Great Lakes, Chesapeake Bay, Puget Sound, and other estuaries of national significance.

Office of Ocean and Coastal Resource Management (OCRM)

The OCRM administers two programs authorized by the Coastal Zone Management Act of 1972 (P.L. 92-583); the Coastal Zone Management Program (Section 306) and the National Estuarine Reserve Research System (Section 315). Coastal zone management programs are comprehensive state resources management programs, developed with technical assistance from OCRM's Coastal Programs Division, and approved by the U.S. Secretary of Commerce.

These programs provide practical, day-to-day management and improvement of estuarine and near shore coastal resources. Program activities include: habitat protection through permitting and reduction of non-point source pollution by both structural and land use control means; habitat restoration through the planting of marsh and submerged aquatic vegetation; development of site specific land and water management plans; and coordination of Federal, state and local regulatory and review agencies such as the U.S. Army Corps of Engineers, the National Marine Fisheries Service and U.S. Fish and Wildlife Service.

The National Estuarine Reserve Research System is administered by OCRM's Marine and Estuarine Management Division (MEMD). The mission of the System is the establishment and management, through Federal-state cooperation, of a national system of estuarine research reserves representative of biographical regions and estuarine types in the U.S. National estuarine research reserves are established to provide opportunities for long-term research, education and interpretation. Scientific and educational programs focus on the development of information for improved management of the Nation's estuaries.

The designation of a national estuarine research reserve signifies a state's commitment to long-term management of an area in accordance with the System's policies and regulations (15 CFR Part 921).

NOAA has designated research reserves in 16 areas and several additional sites are progressing through the pre-designation process. Reserves in developing areas include Great Bay, New Hampshire; Waquoit Bay, Massachusetts; and the Chesapeake Bay, Virginia and Maryland.

In an effort to stimulate high quality research and education within designated sites, NOAA's Office of Ocean and Coastal Resource Management (OCRM) and MEMD provide limited financial support, on a competitive basis, for research and education in national estuarine reserves having approved final management plans.

## The Estuarine Reserve Research Program

The Estuarine Reserve Research Program was initiated in 1984 with a series of information syntheses on the environmental characteristics of various estuarine sites. The initial investment was approximately $80,000. The Program has expanded rapidly and today research funds are primarily used to support management-related research to enhance scientific understanding of estuarine reserve environments, provide information needed by coastal zone and reserve managers and decision-makers, and improve public awareness of estuaries and estuarine management issues. Research projects are oriented to specific sanctuaries; however, some projects may be selected that would benefit other reserves in the national system.

# OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH (OAR)

## ENVIRONMENTAL RESEARCH LABORATORIES

### Great Lakes Environmental Research Laboratory

The Great Lakes Environmental Research Laboratory (GLERL) conducts integrated, interdisciplinary environmental research in support of resource management and environmental services in coastal and estuarine waters, with speical emphasis on the Great Lakes. The research program includes both basic and applied studies and combines experimental, theoretical, and empirical approaches. Field, analytical, and laboratory investigations are performed to improve understanding and prediction of environmental processes and their interdependencies with the atmosphere, land, and sediments. GLERL places special emphasis on a systems approach to environmental problems and the development of environmental service tools. Assistance is also provided to resources managers and others who wish to apply the information, tools, and services GLERL develops.

GLERL's multidisciplinary program supports the Ocean and Great Lakes Prediction Research Project of NOAA. It addresses (1) the need for new and improved simulation and prediction models of ecosystem structure and function, the effects of stresses and proposed remedial options, and (2) the need to assess other options while taking system dynamics and dimensions into account. Two elements of the Ocean and Great Lakes Prediction Research Project provide the focus for GLERL research: Marine Ecosystems Assessment, and Marine Hazards and Lake Hydrology.

Marine Ecosystems Assessment

The Marine Ecosystems Assessment research program at GLERL is designed to (1) improve our understanding of, and predictions related to, natural marine ecosystems, physical phenomena, and the effects of human-induced stresses on the ecosystems, and (2) provide a sound scientific basis for management decisions pertinent to marine resources, marine pollution, and environmentally sensitive marine activities. GLERL projects include investigations into the short- and long-term effects of human, agricultural, and industrial wastes on aquatic life and water quality; the structure and function of aquatic ecosystems and the effects of human activities on those ecosystems; the measurement, analysis, and prediction of physical phenomena such as currents, river flows, and air-water-sediment interactions; and sedimentary flues and processes, especially sediment-contaminant interactions.

1. Cycling of Toxics Organics

The combination of high population and industrial density with slow flushing rates (3-200 years) of the Great Lakes makes toxic organic contaminants a major problem. The problem is compounded by the absorption of many contaminants onto particulate matter, which settles out and thus retains these substances in the system. GLERL has a continuing program in collaboration with EPA, the U.S. Fish and Wildlife Service (FWS) and various Canadian agencies to develop and improve our understanding of the processes that control the cycling and fate of organic contaminants. GLERL's program has focused on particle-contaminant interactions and subsequent processes affecting particles (settling, burial, and resuspension) as the major removal mechanisms. The program also includes research on contaminant bioavailability and effects, and uptake by the bottom-dwelling organisms (bethos), which are highly exposed because of particle-contaminant interactions that make the sediment zone a major reservoir of contaminants.

During FY 1987, studies of the equilibrium distribution (partitioning) of contaminant phases in the open water of the Great Lakes showed that compound solubility controlled the distribution of contaminants between the dissolved and particulate phases, but had only a small effect on the association of the contaminants with dissolved organic carbon (DOC) in the lake water. Also, a new study of the kinetics of absorption and desorption was begun to investigate whether phase distribution, after resuspension, is kinetically controlled or can be modeled more simply as an equilibrium situation.

A sediment trap field program in Lake Michigan, Huron, and Superior continued. Analyses of trap samples collected over the past several years were completed and showed that extensive resuspension of contaminated sediments occurs in all the lakes, and that this appears to be the major process controlling the long-term concentration of many contaminats (e.g., chlorinted organic contaminants) in the lakes. Furthermore, time constants for removal of particle-associated contaminants are decades long, owing to the coupling of the processes of bioturbation, resuspension, and burial.

2. Pelagic Food Web Dyamics

During FY 1987, the Pelagic Food Web Dynamics project replaced the Ecological Succession and Trends project to reflect an evolving research focus.

A comprehensive food-web model, developed to evaluate the relative importance of nutrient loading, competition, and predation in controlling the seasonal dynamics of phytoplankton in offshore Lake Michigan, was used to evaluate and help interpret the results of field and laboratory studies. It indicated that the Lake Michigan ecosystem has been altered

dramatically during the last decade. Summer zooplankton dominance changed from calanoid copepods (Diaptomus) to cladocerans (daphnia), and filamentous blue-green algae were largely replaced by phytoflagellates. This occurred concurrently with reduced phosphorus load, phosphorus concentration, and abundance of alewife, the dominant zooplanktivore. Model simulations to evaluate the influence of changes with time of both phosphorus load and alewife abundance on predation-competition interactions indicated that summer plankton composition and water clarity in Lake Michigan are controlled largely by predation.

New results of the Lake Michigan Ecosystem Experiment, conducted to investigate the dynamics of Lake Michigan phytoplankton and other microbial organisms, yielded a number of findings. Among them was that primary productions rates during thermal stratification in the 1980's were similar to those reported in the 1970's. This indicates that even though major changes have been documented in the upper food web (fish) during this time period, these changes have not translated down the chain to affect the amount of carbon fixed by the primary producers at the base of the food web. Also, the abundance, composition, and production of picoplankton (<3 micrometers) were determined from March through November in Lakes Huron and Michigan. Picoplankton accounted for 44 percent of the total primary production. These findings add to the growing evidence that the "micro food web" is especially important to Great Lakes plankton dynamics.

Field and laboratory studies to understand the feeding dynamics of Great Lakes zooplankton continued in FY 1987, with emphasis on the copepod Diaptomus, the dominant herbivore in the upper Great Lakes.

In regard to winter under-ice ecology, analyses of data collected from the under-ice ecology pilot field experiment on Grand Traverse Bay in FY 1986 resulted in the significant research conclusion that high light levels and high phytoplankton and zooplankton production may be common features of the under-ice ecology of other large lakes and bays.

3. Benthic Food Web Dynamics and Pelagic-Benthic Interactions

Sampling to determine benthic long-term trends continued in Lake Michigan and was initiated in Saginaw Bay. This work will provide an integrated picture of water quality changes in the two locations. An attempt will be made to separate "top-down" predication from "bottom-up" nutrient effects on benthic populations. During 1987, fish exclosures were constructed and placed at the bottom of Whitefish Bay (125-m depth) in Lake Superior to determine the significance of predation in regulating benthic populations.

Studies to evaluate and quantify mechanisms of energy and nutrient transfers between the pelagic (near-surface) and benthic (bottom-sediment) systems continued. Emphasis was placed on amphipod P. Hoyi, the most abundant Benthic animal in the upper Great Lakes and a favored food for fish. The transfer of phytoplankton energy to P. hoyi after the spring diatom bloom appears to represent an important link in the transfer of energy from phytoplankton to fish. Also, food deprivation experiments were conducted to examine the effects of food removal on metabolic characteristics (fat content, nitrogen, and phosphorus release rates) of P. hoyi. Animals survived approximately six months without food. The ability of these animals to accumulate and store lipids in the spring and early summer and to live long periods without food explains why they thrive in the upper Great Lakes where food input to the benthos is highly seasonal.

4. Water Movements and Temperature

Studies of the bottom boundary layer in Southern Lake Michigan continued. Winter measurements of the bottom Ekman layer showed it to be as thick as 40m in water depths of 80 to 100m. Ekman flow in this layer in combination with the prevailing cyclonic circulation of the lake causes a convergence of bottom water, and thus intense upwelling, in the center of the lake. Additionally, at a height of 1m above the bottom, measured current speeds were in excess of 25 cm $s^{-1}$. Bottom stresses caused by these currents were found to be sufficient to resuspend the fine-grained sediments that compose the bottom material at the measurement sites.

Circulation studies concentrated on Lakes Eric and St. Clair. The circulation in the western basin of Lake Eric has a significant effect on the path of water from the Detroit River and, therefore, significant water quality implications. GLERL and the National Water Research Institute of Canada (NWRI) made three launches of six satellite-tracked drifters (three from GLERL and three from NWRI) near the mouth of the Detroit River in September and October 1986 to compare predictions of circulation and particle trajectory models with the observed drifter tracks. These analyses are now underway.

Knowledge of the temperature structure in the water column is a prerequisite to many acquatic environmental studies. However, both theoretical and practical problems hampered progress in identifying numerical models useful for work in the Great Lakes. Therefore, nearly 200,000 observations on water temperature from Lakes Eric and Michigan were used to evaluate four mathematical models. The evaluations showed that surface water temperatures can be simulated by the four models with nearly equal accuracy, if the models are carefully calibrated. Three of the four models were able to accurately track the sequence of breakup of the temperature structure following a late spring storm in Lake Erie. Two of the models were able to reproduce the energy levels indicated by the observations, suggesting that both models are satisfactory for simulating the mixing process. Merging the physics of these models with water quality models should improve the latter.

5. Optimization, Uncertainty, and Risk Analysis Applied to Environmental Systems

Development was started on a modeling approach to address questions about Great Lakes water levels and their effects on regional environmental and economic factors. The approach focuses on understanding environmental and economic trade-offs that may occur as a result of management actions and natural hydrologic variability.

Marine Hazards And Lake Hydrology

Marine Hazards and Lake Hydrology research focuses on (1) improving prediction of environmental phenomena associated with the NWS marine warning and forecasting services and the U.S. Army Corps of Engineers (COE) regulation of Great Lakes water flow, and (2) providing better tools and methods for short- and long-term assessments of water resources of large lakes. GLERL research in these areas includes field and analytical investigations to develop simulation and prediction models of over-water wind and wind waves, water surface oscillations, storm surges, and flooding; lake ice formation, growth, movement, and breakup; hydrologic lake levels, water supplies and balance, and flows in the connecting channels.

1. Surface Waves and Water-Level Fluctuations

The joint study of shallow water wave process in Lake St. Clair, between GLERL and Canada's National Water Research Institute (NWRI) and Atmospheric Environment Service, continued as part of the Upper Great Lakes Connecting Channels Study (UGLCCS) program and is reported in that section. However, another shallow water wave measurement program was carried out in early FY 87 to further investigate the relative importance of shallow water effects and island shadowing on wave generation and propagation in lakes. An instrument tower and a wave buoy were installed in Western Lake Erie along with the regular NOAA-National Data Buoy Center (NDBC) buoy (already there and deployed every year). Data were collected through November 1987, after which the instruments were retrieved before the winter freeze-up.

NDBC has deployed NOMAD buoys in the Great Lakes for surface wave and meteorological measurements since 1979. GLERL has used these well-archived data in a variety of tasks. During FY 1987, a number of accomplishments resulted from a study on long-term wave climate. A wave climate synthesis system was developed for the Great Lakes. Long-term climate extremes of wave heights can be readily estimated from given long-term wind speed statistics where wave measurements are not available. A wave climate experiment was undertaken to measure waves in the western basin of Lake Erie with GLERL's satellite-reporting Waverider buoy. The buoy reported wave measurements during September and October of 1986. The data collected from this experiment will be used in conjunction with shallow water wave studies and for verification of wave prediction models.

At the request of Departments of Natural Resources of Michigan and Ohio, the U.S. Army Corps of Engineers (COE), the Sea Grant Program, and several other agencies with responsibility for Great Lakes shorelines, GLERL developed and distributed a PC-based computer program to assist in planning for storm surges on the Great Lakes. For a given mean lake level, wind speed, and wind direction, the program provides the maximum and minimum expected water level elevations at selected points on the shoreline of the lakes. The program is used extensively as a planning tool for disaster preparedness and storm surge planning.

2. Great Lakes Ice

A study to define the spectral transmittance of solar radiation through ice and snow in the visible and near-infrared ranges was initiated during FY 1987. An underwater spectroradiometer was configured to operate under the ice and in the water column below the ice to a depth of 30m. This is the first time this type of instrument system has been successfully deployed through ice; divers in the Antarctic take similar measurements. Data were collected through a wide variety of ice types. Small amounts of radiation penetrate to 10-12m even on overcast days in relatively turbid waters. Spectral shifts in radiation intensity does not appear to vary widely in spectral composition, although it varies in intensity. Also, a cooperative study was initiated with scientists at NASA's Goddard Space Flight Center to define the reflectance characteristics in the visible and near-infrared ranged for various types of Great Lakes ice and snow, and to build a library of spectral signatures of different ice types for use in satellite interpretation of the ice cover.

A study to analyze and report on the engineering statistics of a nearshore ice thickness data base was completed. The report contained statistics for maximum thickness, growth and dissipation rates, ice cover durations, and average white and total ice amounts and ranges for each of the Great Lakes, as well as for selected individual stations in the network.

GLERL transferred computer code to NWS Cleveland for analysis of freezing degree-days and thawing degree-days and samples of the air temperature files and degree-day data sets. NWS Cleveland and GLERL now uses the same convention for calculating degree-days, and NWS Cleveland can now automate degree-day calculations, access to historic data, and operational use of degree-days for ice forecasts.

A new task, with partial funding provided by EPA, was initiated during FY 1987 to analyze the effects of climate change on Great Lakes ice cycles. Lakes Erie and Superior were chosen as representative of the extremes in climate, water mass, and lake depth. Each lake was divided into basins representative of different heat storage capacities. Basin mean ice concentration, air temperature, and freezing and thawing degree-days were

calculated for three basins of Lake Erie and two basins of Lake Superior over 20 winters from 1960 to 1979. Empirical models to simulate basin mean ice concentration are now under development and evaluation.

Knowledge of the thermal structure of the Great Lakes in the fall and winter is important to studies of ice formation and the water balance of the Great Lakes. During FY 1987, GLERL finished its description of the fall and winter thermal structure of Lake Superior. GLERL, in consultation with NWS, also planned a program to collect Great Lakes temperature profile data at the suggestion of NOAA's National Ocean Service. NOS then installed a Shipboard Environmental [Data] Acquisition System (SEAS) on board a Great Lakes commercial vessel. Temperature profile data collected by SEAS are available in near-real time for operational use by NWS.

3. Hydrological Properties

Outlooks of water supplies to the Great Lakes are used in regulating lake levels and in assessing effects of human activities or climatological change. During FY 1987, GLERL's use of its Large Basin Runoff Model and Hydrologic Response Model continued. Among a number of results, the Large Basin Runoff Model and its applications for the 106 upper Great Lakes watersheds above the Niagara River were integrated with estimates of overlake precipitation and lake evaporation, the Lake Superior regulation plan, and the Hydrologic Response (channel routing) Model to make possible system-wide simulation of the upper Great Lakes water supplies, connecting channel flows, and lake levels. Preliminary assessments were made of the recent high lake levels and effects of diversion management.

Lake evaporation models are needed for lake-level forecasts and simulation, but evaporation estimates are difficult because of data unavailability, process complexity, and lack of heat storage understanding. Model building has always been difficult since no direct observations of Great Lakes evaporation are possible for calibrating or verifying models. Model building, calibration, and verification are now possible with the advent of remotely sensed water surface temperatures for each of the Great Lakes. GLERL developed a model that considers both heat storage and evaporation to extrapolate water surface temperatures for determining evaporation. Lake evaporation can now be estimated for other Great Lakes with confidence, since observed temperatures are available. The improved evaporation models can be merged with GLERL's near real-time forecast packages for the COE Lake Superior water level forecasts and the NWS Northeast River Forecast Center Lake Champlain water supply forecasts.

GLERL's semi-automatic software package for forecasting water levels in near real-time was developed earlier for each of the Great Lakes and Lake Champlain and used experimentally to

generate operational Lake Superior outlooks. These applications were reinstalled for the COE, Detroit District, on its new Harris 800 computer, and GLERL's production of experimental forecasts was terminated. The COE in Detroit is evaluating and comparing Lake Superior forecasts made using the GLERL software package with forecasts made using existing operational methods.

4. Upper Great Lakes Connecting Channels Study

FY 1987 was the third year of activities under the Upper Great Lakes Connecting Channels Study (UGLCCS), an international (U.S.-Canada) and interagency multi-year study of water quality and ecosystem dynamics in the St. Mary, St. Clair, and Detroit rivers and Lake St. Clair. This program ends in early FY 1988.

During FY 1987, a generic contaminant fate and transport model was completed, calibrated, and validated for Lake St. Clair. The model is used to predict and understand the behavior in Lake Clair of contaminants of international concern. Also, development of a model to compare equilibrium and kinetic approaches to modeling contaminant fate and transport was initiated, and a model was developed for understanding ecological processes and their interactions eith contaminants in Lake St. Clair.

The Synthetic Organics and Particle Dynamics Group continued work focusing on contaminant behavior and the use of fallout radionuclides as geochemical tracers and surrogates for contaminant behavior in Lake St. Clair.

During FY 1987 the Ecosystems and Nutrient Dynamics Group conducted a survey of mussel populations in Lake St. Clair. The abundance, biomass, and species compositon were estimated, and the age-structure and production of the most abundant species were determined. This work will provide information on the general "health" of the mussel population and will provide quantitative data needed to estimate the effect of mussel excretion on nutrient cycling.

The Physical Limnology and Meteorology Group worked on determining the circulation characteristics and current dynamics in Lake St. Clair. Final results from field measurements during FY 1985 showed the currents in Lake St. Clair to be dominated by hydraulic flow, but wind-induced changes in the circulation pattern can change residence times from two days to more than 30 days. The average residence time is about nine days.

The joint study (WAVEDISS '85) of shallow water wave processes in Lake St. Clair with Canada's NWRI and Atmospheric Environment Service continued. These efforts concentrated on data analysis of energy spectra; wave attenuation, growth, and dissipation processes; and a modification was developed for the GLERL/Donelan deep-water wave prediction model.

## Atlantic Oceanographic and Meteorological Laboratory

The Atlantic Oceanographic and Meteorological Laboratory (AOML) pursues basic and applied research programs in oceanography and tropical meteorology. Oceanographic investigations center on fluxes on energy, momentum, and materials through the air-sea interface; the transport and composition (thermal and chemical) of water in the ocean; and hydrothermal processes of mineralization at seafloor-spreading centers. Meteorological research is carried out to improve the description, understanding, and prediction of hurricanes. The research program is enlarged by the Cooperative Institute for Marine and Atmospheric Studies (CIMAS), a joint enterprise with the Rosenstiel School of Marine and Atmospheric Science of the University of Miami. CIMAS enables NOAA and university scientists to collaborate on problems of mutual interest, and facilitates the participation of visiting scientists. AOML's current research program concerns processes relating to climate and air quality, weather observation and prediction, marine observation and prediction, and marine resources.

### Marine Research

AOML studies in Marine Research are directed toward determining the chemical and thermal effects on the ocean of hydrothermal venting at the ocean floor from representatives sections of the slow-spreading Gorda-Juan de Fuca Ridge and Mid-Atlantic Ridge. These efforts are central to the objectives of the NOAA VENTS program.

AOML studies in Marine Research are also concentrated in the following: (1) Improving the definition and measurement of the ocean bottom depth for charting, navigation, and bathymetric purposes; (2) Potential operational system evaluation and demonstrations. This research is aimed at improving the observational equipment and techniques used to collect data on the marine environment (particular emphasis is placed on the use of new, advanced, high-technology systems); (3) Improving measurements of naturally occurring water column particle distributions and the distribution of particulate matter produced through human activities (e.g., dumping materials in the ocean).

The Fisheries-Oceanogrphy Cooperative Investigations (FOCI) at AOML seek to understand processes that, either in combination or separately, regulate year class strengths of commercial fisheries. AOML researchers, in cooperation with PMEL, NMFS's Northwest and Alaska Fishery Center, and the University of Miami, attempt to combine emerging technologies in physical and biological oceanography with those in fisheries science and meteorology. By successfully linking all the parameters involved with these various scientific regimes, researchers hope to better predict fisheries stocks.

Of the various programs of research at AOML, the plume studies, the echo formation models and the FOCI programs use most relevant to coastal and estuarine waters.

1. Plume Studies

As part of an on-going program for the study of waste material plumes in the coastal ocean environment, AOML and EPA plume models were installed in the AOML/VAX computer for use in conjunction with a series of waste water plume field exercises to commence in October 1987. AOML plume models were used to analyze plume particulate materials released in an oceanic oil drilling field exercise. A theoretical framework was developed to relate acoustic backscattering intensity levels to particle concentration levels and to the concentration of substances associated with particles.

2. Echo Formation Models

AOML has an on-going cooperative program with NOS to improve echo-formation models and hence improve the quality of bottom-depth charts. In FY 1987, data from an echo-formation experiment in Chesapeake Bay, which presented a variety of bottom types, were processed and analyzed. These data were then used to evaluate theoretical bottom echo-formation models.

The predictions of the theoretical models were generally confirmed by the field data when proper allowance was made for ship motion and other instrumental effects. The best method for timing the echo and hence locating the bottom, was a threshold energy criteria in which the threshold energy is determined by averaging a large number of pulses. This method can be implemented with a microprocessor embedded within the depth-sounder. Further work is in progress on the possibility of using microporcessor "speech-recognition" hardware to extract information about the bottom type from the echo waveforms.

3. Fisheries-Oceanography Coordinated Investigations (FOCI)

The AOML FOCI program conducted three spring cruises during FY 1987. Primary objectives of the initial cruise included delineation of the two-dimensional structure of plankton patchiness by photographic and acoustic methods in conjunction with detailed physical mapping using acoustic Doppler current profiling systems. Sampling occurred within the San Pedro Basin off Los Angeles aboard RV New Horizons of the Scripps Institution of Oceanography. This study was a collaborative effort with investigators from the University of Southern California and Tracor, Inc. The site was selected because of its relative stability within the complex advective system of the California current, and the choice proved to be judicious. A degree of spatial resolution once unattainable was achieved. A new electronics system was far more reliable than previous systems, and more than 95 percent of the deployments were entirely successful.

The second and third cruises were both FOX (Fisheries Oceanography Experiment) cruises. This program sought to apply, to a specific fishery (pollock) with a specific ecosystem (the Gulf of Alaska), the tools and insights generated by recent research programs. The first cruise was scheduled right after the presumed pollock spawning period. For the first time, detailed vertical profiles of the distribution of pollock eggs were obtained. Although this information is critical to the NMFS/PMEL model seeking to explain larval abundance, it was not, for primarily technical reasons, previously available. In addition, considerable data were obtained on the scattering strengths of pollock eggs of different ages and of representative food organisms and planktonic competitors of larval pollock. These data are prerequisite to finalizing designs for the acoustic sensor that will be an integral part of the system being developed for the FY 1988 mixing experiment cruise.

The third cruise repeated the FY 1986 larval abundance cruise. Once again a spawning center was located, and both its vertical and horizontal extent were accurately delimited. It proved to be considerably more dispersed than the egg patch preceding it. The data from the two larvae cruises represent the first truly quantitative assessment of pollock larvae distribution within the Shelikof Straits.

The results of AOML's basic research program highlight the degree to which vertical structure within the organisms of the upper water column can radically change over intervals of a few hours and the potential utility of integrating acoustic Doppler current profiler (ADCP) data with biological sampling. These results have substantially influenced the planning efforts for the FOX program in FY 1988 and the zooplankton research to be conducted within the national GOFS (Global Ocean Flux Study) as proposed to the National Science Foundation.

## Pacific Marine Environmental Laboratory

The Pacific Marine Environmental Laboratory (PMEL) is a mission-oriented government laboratory that conducts interdisciplinary scientific investigations in oceanography, marine meteorology, and related subjects. The current PMEL programs focus on climate, marine observation and prediction, marine resources, and marine environmental assessment. Studies are conducted to improve understanding of the complex physical and geochemical processes that determine the extent of human effect on the marine environment; to define the forcing functions and the processes driving ocean circulation and the global climate system; and to improve environmental forecasting capabilities and other supporting services for marine commerce and fisheries. Products of PMEL's research are environmental information and predictive models disseminated by means of scientific papers, technical reports, and presentations at scientific and public meetings.

Two cooperative institutes, the Joint Institute for Study of the Atmosphere and Ocean (JISAO) and the Joint Institute for Marine and Atmosphere Research (JIMAR), established between NOAA and the Universities of Washington and Hawaii, respectively, provide a bridge between the academic community and PMEL scientists working in climate dynamics, environmental chemistry, tsunami propagation, and estuarine processes.

Marine Environmental Assessment

Marine environmental assessment at PMEL emphasizes understanding the complex physical and geochemical processes that ultimately determine the health of marine systems and their ability to assimilate contaminants. Included are studies of the geochemistry of trace metals and organic compounds, distributions of hydrocarbons and synthetic organics, coastal and estuarine circulation, and modeling of transport processes. Although the geographic focus of these studies has been Pacific Northwest and Alaskan coastal and estuarine waters, the scientific knowledge acquired and methodologies developed are applicable to other marine systems.

In response to the Marine Protection, Research and Sanctuaries Act of 1982 and the National Ocean Pollution Research and Development and Monitoring Planning Act of 1978, PMEL has addressed environmental concerns associated with transport and marine disposal of municpal and industrial wastewater and the reaction of marine systems to continuous influx of contaminants. PMEL is examining the role of suspended particulates in transporting contaminants and removing them from marine systems. Researchers have investigated the mechanisms by which heavy metals and organic pollutants partition between water and particulates and are subsequently buried in sediments or advected from the estuary in dissolved form. As these processes become better understood, the long-term effect of chronic, low-level input of pollutants into the marine system will be assessable. Therefore, studies in the Puget Sound-Strait of Juan de Fuca estuarine system, under way for many years, will lead to a better understanding of the ability of estuaries to accommodate pollutant inputs.

In 1987, increased emphasis was placed on simulation modeling of the present data base and on geochemical process studies; descriptive physical and chemical field studies were temporarily suspended while an assessment was conducted of data and knowledge gaps. This refocusing has led to a new five-year Implementation Plan for Marine Environmental Quality at PMEL.

1. Estuarine Circulation

Puget Sound is the southern most glacially carved estuary in western North America and is surrounded by major urban centers. The entrance sill in this estuary plays a major role in

regulating the replacement of water inside the estuary below the sill. Although salinity (density) at sill depth outside the estuary is always greater than inside, water from outside does not flow continuously into the Sound. Previous studies showed bottom-water inflow events during neap tides when mixing is least over the entrance sill. Other studies, however, implied that inflow occurred on very large spring tides when the tidal excursion could transit the sill on a single flood tide. Recent observations show that this circulation feature is exceeded only by wind effects.

At about fortnightly intervals a pronounced increase in salinity just inside the entrance sill occurs. This is the dominant characteristic of inflow of new bottom water. The onset of these intrusions occurred in all cases before minimum neap tidal currents. Inflow during the largest intrusions is sufficiently strong that the currents at the bottom do not reverse at tidal intervals. Spring tides all coincided with decreasing salinity in the basin. Thus, it seems clear that major inflows occur only during neap tides, but the onset occurs before the minimum neaps.

Because of the relatively large variation in outside salinity and because the increase in inside salinity occurred before neap tides, it seemed possible that variations in the pressure gradient across the sill had a role in the onset of the intrusions. A quasi steady-state balance between the pressure gradient and vertical mixing predicts currents about the same as those observed. A change in salinity of about 1.4 parts per thousand would to initiate intrusions.

2. Estuarine Transport

Trace metals in estuaries are derived from natural and human sources. They can be viewed not only as contaminants, when in toxic concentrations, but also as independent tracers of transport in the water column and in sediments. The assimilative capacity of estuaries for trace metals is a function of the balance between input and removal processes. This balance may be viewed as a dynamic equilibrium between input and removal on a decadal time scale. This view helps in analyzing long-term trends and establishing the dominant processes. However, these trends cannot be simulated and predicted without information on rapid geochemical processes, since the underlying circulation models themselves incorporate high-frequency physical processes. These problems are being addressed over both long and short time scales.

During 1987, PMEL scientists completed individual dissolved and particulate mass balances for manganese (Mn), lead (Pb), Copper (Cu), and zinc (Zn) in Puget Sound. This marks the first time individual dissolved and particulate mass balances have been simultaneously constructed for a U.S. estuary.

The results quantify effects geochemical reactions have on the fate of trace metals discharged into the marine environment. The rapid recycling of Mn between the water column and the sediments produces large quantities of hydrous manganese oxide particles, which can absorb other trace metals. The enrichment of Pb on Mn-rich particles indicates that dissolved Pb is being scavenged onto the newly formed hydrous manganese oxides. The mass balance calculations indicate that 70 percent of the dissolved Pb discharged into the main basin of Puget Sound is being scavenged onto particles. This extensive scavenging results in retention of 72 percent of the total Pb in the sediments of Puget Sound while only 28 percent is advected from the main basin. In contrast, Cu and Zn do not appear to be appreciably scavenged by manganse oxides particles, and their fate is determined mainly by the geochemical form (dissolved or particulate) of the source material. Only 40 percent of the Cu and Zn added to the main basin is retained in the sediments while 60 percent is advected from the main basin. For Cu, the complexion by dissolved organic matter seems to prevent its scavenging. Between 30 percent and 70 percent of the dissolved Cu was was found to be complexed with dissolved organic matter.

Although important geochemical processes can be inferred from field observations, laboratory studies are usually needed to delineate the mechanisms and rates of individual reactions involved in these processes. Knowledge of the rates of geochemical reactions is essential to the accurate modeling of trace metal behavior in estuaries. Laboratory studies on the rates of two important geochemical processes were initiated during 1987. The kinetics of Mn oxidation was investigated using unaltered Puget Sound seawater. Preliminary attempts to model Mn in estuaries indicate that the kinetic oxidation constants derived from these experiments will become a critical part of any successful model developed at PMEL. Experiments were also initiated to investigate Cu's reactivity toward dissolved and particulate organic matter.

Until recently the study of the behavior of polycyclic aromatic hydrocarbons (PAH) was a major feature of our estuarine studies. The data gathering has ceased but analyses will be published over the next few years. PAHs are toxic compounds generated by the combustion of coal, oil, wood, gasoline, and other organic materials. PAHs are hydrophobic and exist largely in particulate form. The unresolved complex mixture (UCM) is a measure of uncombusted petroleum hydrocarbons and can be found in particulate and dissolved forms. These two compound classes are good indicators of human impact on the marine environment.

During this past year, PAH and UCM concentrations on suspended particles and sediments were combined with sediment deposition rates and circulation data to quantitatively assess the transport and fate of hydrocarbons in Puget Sound. The findings from this study indicate that >93% of the hydrocarbons associated with

suspended particulates in the main basin of Puget Sound are deposited in the estuarine sediments. Approximately 63% of the particulate PAH and 100% of the particulate UCM deposited in the sediments settle directly to the sediments from surface waters. The remainder of the PAHs that are deposited to the sediments arrives by horizontal transport from other areas. PAHs were also quantified on suspended particulate matter in Elliott Bay to evaluate the importance of combined sewer overflows as a source of these compounds. PMEL findings show that, although such events occur in Elliott Bay only 10-20 times each year, each event supplies a significant quantity of PAHs to the Bay. The results of these two studies of hydrocarbon concentrations on suspended particles enabled PMEL scientists to construct the first balanced budget for PAHs in Puget Sound.

Chlorinated hydrocarbons are toxic compounds that were routinely used as pesticides and in industrial applications. The conventional technique of analyzing chlorinated hydrocarbons by gas chromatography often overestimates their concentration. In the last year PMEL scientists developed a more reliable method using the positive identification technique of gas chromatography/mass spectrometry. The generally low levels of chlorinated hydrocarbons observed in Elliott and Commencement Bays are consistent with decreased use of these compounds. DDT use was banned in 1972, and the use of poluchlorinated biphenls has been greatly curtailed since 1976. Elevated concentrations of chlorinated hydrocarbons were found, however, near sewage outfalls and in waterways where major spills are known to have occurred. These refractory compounds are apparently still present in municipal pipes and in the sediments of some locales, and continue to be supplied to Puget Sound in small quantities.

A field study of the variability of entrainment rates of fine sediment in Puget Sound was conducted in collaboration with EPA. Measurements were made with a portable shipboard device that resuspends sediment taken from the box cores. A time series of resulting entrainment data was used to infer the rates of erosion as a function of the imposed bed stress. The results are consistent with a thin, easily resuspendable layer underlying a less erodable layer. Spatial differences in erosion rates were unresolvable at the level of definition possible with this device. The results have utility in a regional model of the transport of sediment through the boundary layer of the main basin of Puget Sound.

3. Modeling

Theoretical studies of the transport of tides and tidal currents in Puget Sound using a model incorporating channels with multiple connections of the Sound have been completed. The results show good agreement with tidal height and phase distributions measured by tide gauges at numerous sites in the Sound.

The bottom boundary layer model (one-dimensional numerical model with turbulence closure) provided synthetic bottom stress data, which were fit to a new set of empirical formulas to predict the bottom stress due to steady barotrophic currents in water of finite depth. Accurate formulas are needed for the bottom stress because the erosion of sediment and associated trace metals is a sensitive function of this stress. The formulas show that the coefficient in the drag law depends strongly on total depth and bottom roughness.

NOAA scientists recently found a new way to apply analytic estuarine theory to the mean circulation in Admiralty Inlet, which is the main entrance to Puget Sound. The approach used the vertical eddy viscosity and the mean distribution of salinity to predict the intensity of horizontal mixing in the inlet. The results show that advection causes 90% of the mean horizontal transport in Admiralty Inlet, an amount significantly larger than previous estimates based on surface currents and vertical salinity profiles.

Through a study of the conservation of freshwater and salt, the mean annual transport was deduced, for the first time, over several years at all ten sites in the Strait of Juan de Fuca/Puget Sound estuarine system. For each site, composite current profiles were constructed from several years of observations. These provide kinematically correct weighting functions which, when applied to salinity observations, yield the correct two-layer salinities required for mass transport calculations. An error analysis shows that transport uncertainties result from uncertainties in the runoffs, currents, and salinities. Transports vary from 100,000 cubic meters per second in the Strait of Juan de Fuca to just 1500 cubic meters per second in Saratoga Passage, a fjord arm of Puget Sound. Where sufficient current measurements exist to estimate transports independently, the two techniques agree in general. Paradoxically, at the best sampled site off Point Jefferson near Seattle the mass conservation technique gives transports that are one-third to one-half of those estimated from midchannel current observations. The hypothesis is that at this site midchannel currents substantially overestimate the cross sectional mean because of the complex variation in the cross section of the along-channel current. This reduction in transport over previously estimated values means that the area of maximum refluxing, or recirculation, in Puget Sound is shifted south to a horizontally recirculating region around Vashon Island. The implications of this for the transport of contaminants is the subject of current research.

Fisheries-Oceanography Coordinated Investigations (FOCI)

1. Alaskan Coastal Current

Current meter data from the Shelikof Strait sea valley clearly show that the Alaska Coastal Current (ACC), which flows through Shelikof Strait and across the continental shelf southwest of Kodiak Island, is a relatively narrow (about 20 km) filament thats position in the sea valley varies with time. Year to year changes in how larvae interact with this current may be more important than interannual changes in the magnitude of ACC transport. Transport in the sea valley appears to be highly geostrophic; the difference in bottom pressure across the sea valley accounted for the majority of transport fluctuations. The current meter data also confirm recent findings from CTD data that exists an estuarine-like flow in the sea valley exists. Research determined that the Shelikof farms the principal pollock population in the Gulf of Alaska. Almost no larvae were found upstream in the Alaskan coastal current.

2. Drifter Studies

Eighteen satellite-tracked drifters were deployed during April and May 1987 in a line across Shelikof Strait from Cape Kekurnoi to Middle Cape. All were drogued at 45 meters where the highest concentration of pollock larvae are found. These drifter trajectories allowed examination of current fluctuations that influence transport of pollock larvae. The drifters traveled to the southwest from the deployment site and remained on the shelf a minimum of 45 days, after which some entered the Alaskan Stream. Scientists observed considerable horizontal variability in the currents, and the influence of strong spring storms on the drifters was evident. By July 13, drifters were still functioning; of these, six were in the Alaskan Stream and the rest were aground on the Alaska Peninsula or nearby islands. Of the six drifters in the Alaskan Stream, five originated from the southern portion of the two arrays. After a transit time of 38 to 60 days, three drifters entered the Bering Sea through passes between the Aleutian Islands. These trajectories indicate young pollock originating in Shelikof may enter the Bering Sea by this route.

3. Satellite Image Analysis

A basic processing and analysis system was developed at PMEL to meet the needs of FOCI. This system includes image selection, geographical registration, flow vector generation, and graphics routines for color plots and video loops. Satellite images from a comprehensive 1987 data set were selected and purchased, and research plans were completed to integrate these data with insitu observations. Processing and analysis of selected April 1986 remote sensing images show that the Alaska current is marked by a strong, unstable front along its northern boundary.

A large meander of the Alaska stream, which flows south of Kodiak Island, removes water from the continental shelf near the Shelikof sea valley and returns it to the continental shelf approximately 100 km to the southwest. The mesoscale flow pattern shows a clockwise rotating elliptical eddy with a major axis of 50 km off Wide Bay, inshore of the major ACC flow from the Strait, with a perturbation sea-surface topographic relief of 10 cm. The spatial distributions in the images suggest that sub-mesoscale features as small as 15 km can evolve to dominate the local turbulent environment. This work is in collaboration with Texas A & M University.

4. FOCI Climatology

In support of FOCI a study was initiated to develop and assess several indices describing the large-scale atmospheric circulation over the region. This study provides three qualitatively different environmental indices characterizing the large-scale atmospheric forcing of the ocean circulation in the Shelikof Strait region. These indices will be used to relate environmental conditions, particularly air-sea interactions, to the interannual variability in walleye pollock. Calculation of the indices is directed at the World Data Center-A for Glaciology.

The cyclone frequency and surface winds indices are completed, and several large-scale weather indices such as the north Pacific oscillation have been tested. Autocorrelation analysis of the time series of u and v wind components was performed with the intention of characterizing persistence in the different years. Low numbers of significant autocorrelation were observed in the u-wind for 1980, 1982, and 1985. Years exhibiting a high degree of autocorrelation in the calculated u-wind are 1981 and 1983. The high values indicate a high degree of persistence in the calculated winds, and the low values indicate the frequent passage of cyclonic storms. It was also determined that Pacific basin-wide indices are less valuable to characterize weather variability for FOCI than single location indices, as in this study.

Geophysical Fluid Dynamics Laboratory

The Geophysical Fluid Dynamics Laboratory (GFDL) engages in comprehensive long lead-time research fundamental to NOAA's mission. The goal is to expand scientific understanding of the physical processes governing the behavior of the atmosphere and the oceans as complex fluid systems. These fluids are modeled mathematically and their phenomenology studied by computer simulation methods. The scientific work of the Laboratory encompasses a variety of disciplines: meteorology, oceanography, hydrology, classical physics, fluid dynamics, chemistry, applied mathematics, and numerical analysis. Studies that address estuarine and coastal waters fall in the area of marine quality.

Marine Quality

Research at GFDL related to the quality of the marine environment has these objectives: a simulation of oceanic conditions in coastal zones and in estuaries; modeling of the dispersion of geochemical tracers (tritium, radan, etc.) in the world oceans; and modeling of the oceanic carbon cycle and trace metal geochemistry. For regional coastal studies, two- and three-dimensional models of estuaries such as the Hudson-Raritan and Delaware Estuaries are being developed. The response of coastal zones to transient atmospheric storms, and the nature of upwelling processes (which are of great importance to fisheries), are being studied by a variety of models. Basin and global ocean circulation models are being developed for the study of the carbon cycle and trace metal cycling.

National Sea Grant College Program

1. Environmental Studies

The Sea Grant Environmental Studies Program of 1987 included 184 projects conducted at 29 Sea Grant institutions. A total of $7,359,896 in Federal support and $3,875,950 in matching funds was granted for these efforts. Sea Grant environmental studies were grouped into seven topical areas: environmental characterizaion, nutrient and carbon dynamics, habitat studies, toxicants, human health, environmental management, and special projects. Of these, nutrient and carbon dynamics, toxicants, and environmental management were the largest, representing 29%, 18% and 16% of total funds, respectively.

A major segment of the 1987 Sea Grant environmental program (65%) related to estuaries. In 1987, 117 environmental studies deal the with estuarine questions. These, together with 31 projects sponsored by other Sea Grant divisions, constituted an estuarine program involving 26 Sea Grant institutions. The combined funding level for estuarine projects in 1987 was $8,952,597 (Federal funds + match).

Focal points for environmental investigation during 1987 included studies of trophic dynamics (14.4% of funds), eutrophication (6.6% of funds), wetlands dynamcis (3.5% of funds), the cycling and fate of toxic substances (10.5% of funds; emphasis in the Great Lakes), and environmental quality comparison (5.8% of funds). A burgeioning area of interest in the network during 1987 related to the use of satellite imagery for environmental investigations (4.5% of funds).

Estuarine environmental investigations were undertaken across the northeastern and Gulf coasts, in southern California, and in Puget Sound. Special emphasis was given to investigations of estuarine processes in the Atchafalaya River estuary, Chesapeake Bay, Narragansett Bay, Pamlico and Albemarle Sounds, Delaware Bay, and the Long Island Sound/Hudson-Raritan Estuary.

## 2. Fisheries

Research in the Fisheries Program focuses primarily on fisheries biology and management, and fishing and sampling gear technology. This program, which constitutes approximately 25% of Sea Grant expenditures, consists of 156 projects funded at a level of $5,266,744 Federal funds and $3,439,466 in state matching funds. Only the University of Southern California, MIT, and the University of Delaware do not support research efforts that fall within the scope of this program. A number of subjects require thorough evaluation before substantial additional support is provided. These include: the entire subject of oyster research; determining if progress being made in smoltification research is more in the realm of advancing knowledge in endocrinology than providing information for salmon fisheries and the relevance of toxicity; and pollution studies of susceptible fish population and communities. Program highlights include reports describing: evaluation of Great Lake pink salmon potential (MN); age verification in sharks and rays (CAL); evaluation of a shark fishery in Florida (FL); importance of tidal fronts as habitat for larval fishes (WA); production of bioenergetic model software for microcomputers (WI); and development of a new approach to back calculate fish length (MN). Also included are descriptions of three fisheries research topics considered important enough to be NOAA management-by-objective milestones: the importance of wind-induced currents to fish larvae in reaching suitable habitat; herring recruitment; and determining the dependence of dungeness crab on nearshore habitat.

## 3. Coastal Processes

Coastal and ocean processes research and development is conducted in the following five broad subareas, with a number of projects in each subarea: sediment transport, tidal inlets and estuaries, coastal oceanography, coastal protection, and technology development. During 1987, more than $1,300,000 in Federal Sea Grant funds, matched by more than $1,000,000 from the grantees, was applied to research into the study of coastal oceanographic processes, and the resulting form, manner, and rate of change of the coast and seafloor. Seventeen of the Sea Grant programs had one or more projects in this area, with California having the greatest number eight. A balance of methodologies was represented in 1987, with eight projects involving the collection and analysis of field data; four concerning laboratory or physical modeling efforts; eight on numerical modeling; eight office or analytical studies, and nine on some combination thereof.

The series of hurricanes and "northeasters" which strike the Gulf and Atantic coasts, as well as the storms and tsunamis which affect the Pacific coast, point out the urgent need for better understanding of storm waves, currents, and water levels and their effect upon sediment motion and shorelines. Twenty-five percent of 1987 projects are directed to selected aspects of that

priority topic. Scientists from the global weather and marine communities are increasingly concerned about a projected rise in sea level (as the "greenhouse" effect warms the earth) and subsequent effects on coastal and estuarine regions. Quantifying the role of rising sea level (and Great Lakes level variations) in terms of one to ten decades, and the implications for shore protection and management, are also priority research topics. Related to coastal protection is research to improve the design of coastal structures, and 11% of the FY 87 projects are devoted to this aspect. Tidal inlets are vitally important to navigation, biological, and water quality concerns on the Gulf and Atlantic coasts, while on the Pacific coast harbor entrances and river mouths serve similar needs. Although knowledge and prediction of the hydraulics of tidal inlets are relatively well known, increased understanding of sediment processes and resulting morphologies controlling inlet behavior is required. Thirteen percent of the FY 87 projects address tidal inlet processes. Overall, 66% of the FY 87 projects are directed toward topics identified in last year's annual guidance as priority issues.

## NATIONAL WEATHER SERVICE (NWS)

Coastal and estuarine zones come under consideration of a number of NWS programs. The Hurricane Warning Program, the Coastal Flood Warning Program, and the Tsunami Warning System Program are examples that provide timely forecasts and warnings for coastal and estuarine waters. Hurricane warnings and forecasts are issued by the National Hurricane Center at Miami, while local statements are produced by coastal forecast offices. These same offices issue warnings of coastal flooding associated with extratropical storms. The Tsunami Warning System Program located at Ewa Beach, Oahu, Hawaii, is responsible for issuing warnings to all U.S. Pacific coastal zones, based on seismic activity. NWS and NESDIS personnel combine with Navy staff to keep track of sea/lake ice information and provide guidance that includes the Great Lakes and other estuarine locations, as part of the Joint Ice Center Program.

The River Forecast Program serves as another important source of information for estuarine interests. Between six and ten forecast centers near the coasts issued forecasts of river and flood crest height along with flow data useful in evaluating inflow quantities of fresh water to estuaries.

The NWS also supports a number of special observational programs that can be related to estuary needs. Two of these are the Data Buoy Program and the Marine Observational Program. In the former, a number of moored automated data buoys placed along coastal waterways and in the Great Lakes arecord and transmit information used in Marine Services warnings and forecasts. The Marine Observation Program supplements data from coastal and land stations with randomly located reports from an extensive network of cooperative shipboard observers.

In addition, the NWS supports numerous analytical and research efforts to improve flood prediction and mitigation with indirect bearing on estuarine balances. One such study is a continuing effort at modeling storm surge associated with hurricanes that approach the coasts.

## APPENDIX B

## FEDERAL ESTUARINE AND COASTAL OCEAN ACTIVITIES

The Federal Government, working closely with the states, has a responsibility to address the problem of the deterioration of our Nation's estuarine and coastal resources. Federal legislation related to water quality, coastal zone management, and fisheries conservation and management has provided incentives for states to adopt policies that encourage wise use and management of their estuarine and coastal resources. These incentives have generally been directed toward strengthening state and regional resource management capabilities and making the results of Federal scientific and information programs available for management decisions. With the recent establishment of a National Estuary Program, under the Water Quality Act (WQA) of 1987, Congress has reinforced the Federal role established in the Coastal Zone Management Act of 1972 -- that of providing the management and technical infrastructure necessary for states to address local estuarine and coastal problems of national concern. As a result of these and other legislative actions, a number of important estuarine and coastal programs have evolved in several Federal agencies, in addition to NOAA.

This section provides a brief summary of the major estuarine and coastal ocean activities supported by Federal agencies other than NOAA, including the Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), the Fish and Wildlife Service (FWS), the Corps of Engineers (COE), and the Soil Conservation Service (SCS). While many other agencies have related programs, this section focuses on those perceived to have a central role in Federal estuarine and coastal ocean research and management.

### Environmental Protection Agency (EPA)

The EPA assumes lead responsibility in the Federal Government for identifying, evaluating, and controlling environmental pollutants. Priority elements of the EPA mission are to reduce public exposure to harmful pollutants, protect sensitive ecosystems, regulate hazardous waste facilities, clean-up Superfund sites, and improve management of environmental regulatory programs. The requires the EPA to promote studies of the Nation's estuaries and to report every six years.

EPA's National Estuary Program was originally established in 1985 through a Congressional appropriation under the CWA. Estuaries included in the first year were Narragansett Bay, Buzzards Bay, Long Island Sound, and Puget Sound. San Francisco Bay and Albemarle/Pamlico Sound were added in 1986. The 1987 amendments to the CWA, the Water Quality Act of 1987, established the responsibility for the National Estuary Program in Sections 317 and 320. The Act instructs the Administrator of EPA to give priority consideration to 11 named estuaries (the six estuaries already participating and New York-New Jersey Harbor, Delaware Bay, Delaware Inland Bays, Sarasota Bay, and Galveston Bay). In addition, the Water Quality Act continued funding for the Chesapeake Bay and Great Lakes Programs.

Program Description

EPA has substantial responsibilities in estuarine research, management, and planning.

o Research

Through its laboratories at Narragansett, Rhode Island and Newport, Oregon, EPA conducts research on marine, coastal, and estuarine water quality and marine processes.

EPA's Environmental Research Laboratory, located at Narragansett, responds mainly to legislative requirements of the CWA, the Marine Protection Research and Sanctuaries Act, and to a lesser extent, the Toxic Substances Control Act, Resource Conservation and Recovery Act, and Superfund legislation. The Laboratory is responsible for the following research: (1) estuarine and marine disposal, discharge of single contaminants or complex effluents, dredged materials, and other wastes; (2) water use designation and quality criteria for estuarine and marine water and sediment; and (3) environmental assessment of ocean discharges. These research program areas involve development, evaluation, and application of techniques and test systems for measuring and predicting transport, fate, and biological and ecosystem effects of wastes in estuarine and marine systems.

o Management

Under Section 117 of the 1987 Water Quality Act (WQA), EPA was given statutory authority to coordinate protection and restoration of the Chesapeake Bay. The Act calls for the Administator to establish and maintain in the Environmental Protection Agency an office, division or branch of Chesapeake Bay Programs to --

(1) collect and make available, through publications and other appropriate means, information pertaining to the environmental quality of the Chesapeake Bay;

(2) coordinate Federal and State efforts to improve the water quality of the Bay;

(3) determine the impact of sediment deposition in the Bay and identify the sources, rates, routes, and distribution patterns of such sediment deposition; and

(4) determine the impact of natural and man-induced environmental changes on the living resources of the Bay and the relationships among such changes, with particular emphasis on the impact of pollutant loadings of nutrients, chlorine, acid precipitation, dissolved oxygen, and toxic pollutants, including organic chemicals and heavy metals, and with special attention given to the impact of such changes on striped bass.

o Planning

The Act also provided specific authority, in Section 117, for EPA to provide States with an up to 50% match in grants to implement management mechanisms contained in an interstate plan for the restoration and protection of the Chesapeake Bay.

In addition, EPA Administrator signed the 1987 Chesapeake Bay Agreement, not for the Agency, but for the Federal Government. Therefore, EPA is the lead Federal agency coordinating the Federal-State Chesapeake Bay Program. EPA coordinates the program with other Federal agencies through Memoranda of Understanding, including NOAA. Fish and Wildlife Service, USDA Soil Conservation Service, U.S. Forest Service, Department of Defense, Army Corps of Engineers, U.S. Geological Survey, and Federal Highway Administration.

U.S. Geological Survey (USGS)

The USGS is responsible for the classification of public lands, and examination of the geological structure, mineral resources, and products of the national domain. Over the years, its mission has expanded to include hydrological investigations of water in streams and underground. Some of this work is conducted in estuaries or at the fall line for waters flowing into estuaries. For example, the USGS examines the influence of land uses on the water quality streams flowing into the Susquehanna River.

Program Description

The Water Resources Division of the USGS provides hydrological data on surface and ground water and conducts research to assure competent hydrologic investigations. Programs of particular interest include long-term operations of down-stream gauges on major rivers and streams, site-specific investigations of estuarine circulation, geochemistry, and ecology. Much of this work is conducted in the Potomac River, where hydrodynamic and geochemical processes, as well as long-term changes in wetlands ecology are studied, and the San Francisco Bay, where the USGS research processes that influence water and sediment chemistry.

U.S. Fish and Wildlife Service (FWS)

FWS has general responsibility for maintaining fish and wildlife resources in the United States and providing public access to these resources. Its functions include responsibility for fish and wildlife resources and habitats of national interest through research, management, and technical assistance to other Federal and non-governmental agencies.

Program Description

The operations of FWS include those conducted in the coastal zone, contiguous lands, and the waters that flow into the zone. Major FWS programs involving coastal issues include permit review and resource planning; land acquisition and habitat management (through refuges and easements); management of migratory birds, anadromous fish and endangered species; and broad research activity addressing causes and effects of habitat change and coastal contaminants. These programs provide for collection, synthesis, and interpretation of diverse information on species, populations, and habitats that is assembled, analyzed, and applied for management purposes.

An example of FWS estuarine studies is research in the Northeast Region that includes documentation of coastal wetland changes, migratory waterfowl distributions, and effects of hunting pressures. In addition, FWS conducts special studies on striped bass and American shad; damage to estuarine systems, such as the Chesapeake Bay, from point and non-point discharges; and effects of development activities on important fish and shellfish breeding grounds and waterfowl habitat.

In the Southeast Region, FWS conducts research on endangered species, such as the Florida manatee and various coastal birds and sea turtles. For example, FWS has initiated field studies to evaluate habitat requirements of the manatee. Additionally, FWS personnel examine effects of peat mining in coastal areas on coastal fish and wildlife.

Major research in the Texas gulf coastal area is conducted on the impact of soil deposition on bays and channels, largely through deposition of dredged materials dumped in shallow estuarine waters and from contaminated agricultural runoff. Studies of wetland losses are aided by Geographic Information Systems (GIS). The GIS technology that documented wetland losses of 80% in Louisiana resulted in public recognition of the potential long-term effects of coastal change on fish and wildlife populations. GIS has become a major decision-making tool for predicting potential impacts of development activities on habitats. Prototype methodologies are also being developed to assess cumulative impacts.

Primary research in the Southwest Region focuses on restoration of fish and wildlife to the San Francisco Bay area, the study of impacts caused by diversion and diked systems, and management and restoration of the endangered southern sea otter. Kesterson National Wildlife Refuge research on selenium and other problems is guided by an Interagency Technical Coordination Committee comprised of state, other Federal agencies, and FWS personnel.

Contaminant monitoring in the Great Lakes Region includes examination of fish tumors, research into the causes of declining lake trout populations, and the fate and effects of contaminated sediments. In addition, research efforts focus on the impacts of power plant discharges to the Lake Erie system and biota.

In Alaska, FWS is examining the impact of North Slope oil and gas development on migratory fish and developing techniques for genetic identification of Alaskan and Canadian stocks of salmonids for fisheries management purposes.

Finally, most of the development of analytical tools for estuarine planning and management is centered at the National Wetlands Research Center (NWRC), formerly the National Coastal Ecosystems Team, of Slidell, Louisiana. Principal NWRC activities are: (1) development of habitat-descriptive methods -- their validation and transfer to users; (2) the development of community and species "profiles" to assist with site-specific and regional planning; and (3) special issue studies for FWS operations.

U.S. Army Corps of Engineers (COE)

COE has broad responsibilities in inland waters and nearshore areas stemming primarily from the Rivers and Harbors Act, the Clean Water Act, the Water Resources Development Act, and the Marine Protection, Research, and Sanctuaries Act. These laws provide COE with authority to maintain navigable waterways, and to issue permits for transportation of dredged material for ocean dumping and for discharge of dredged or fill material into waters of the United States.

Program Description

COE missions require coastal engineering expertise in the design, construction, operation, and maintenance of three general types of projects or facilities in and near the surf zones of the U.S. oceanic and Great Lakes shores: (1) harbors for small craft for commercial and recreational fishing; (2) harbors for large, ocean-going vessels for coastal and international commerce; and (3) shore and beach restoration, protection, and stabilization. Research activities in the following areas were underway in 1986: developing methods for predicting sediment transport and shoaling; improving methods to collect littoral data; and improving wave estimation to assess physical factors in beach erosion and nourishment.

A Flood Control and Navigation Program was designed and initiated by COE to improve cost-effectiveness of flood control programs and navigation-related activities including channel or canal construction and maintenance. Research in this area included developing: (1) improved methods for dredging; (2) more effective sediment traps; and (3) estuarine-specific physical models (numerical and physical) to assist with project design and maintenance.

Projects associated with an Environmental Quality Program were undertaken that focused on determining the impact of COE water resources projects on the environment. In particular, research examined methods to mitigate shore-line erosion, identify the ecological effects of rubble structures, and determine the effects of channels and jetties on fish and shellfish migration.

A Wetlands Project was undertaken to address priority wetland research needs in two major areas: (1) development of techniques to identify and delineate wetlands; and (2) assessment and quantification of wetland values for use in evaluation of permit activities. These studies include developing regional procedures in identifying and delineating wetlands during the fall and winter seasons, and evaluating plant tolerance to inundation and saturated soil conditions.

A Dredged Material Research Development, and Monitoring Program was undertaken in 1986. Under Section 404 of the CWA and Section 103 of the Ocean Dumping Act, COE is responsible for permitting the placement of dredged and fill material in the Nation's waterways and the transportation of dredged material for disposal in the oceans. At present, COE receives more than 10,000 permit applications annually under Sections 404 and 103. These permits must comply with criteria and COE's long-term effects of dredging operations provides the information for the criteria. Studies were designed to: (1) determine bioaccumu- lation and biomagnification in the aquatic environment; (2) develop procedures to reduce adverse impacts; (3) develop upland plant and animal bioassays procedures; (4) develop or improve techniques for predicting contaminant concentrations in the effluent from these sites; and (5) improve methods for leachate prediction and control. COE is also examining procedures to identify and assess the elements necessary for a long-term strategy for dredged material disposal and to provide user guidance to permit effective disposal.

To mitigate the impacts of dredging contaminated sediments, COE undertook a Dredged Contaminated Sediments Project to collect data on the re-suspension of sediments and contaminants. COE is also developing guidelines for dredging highly contaminated sediments. COE is conducting a demonstration project at Indiana Harbor-Great Lakes, where innovative foreign equipment will be used in a pilot demonstration for PCB sediments.

A Satellite and Surveying Application Program develops and applies new technology for surveying and satellite remote sensing and positioning interpretation techniques, data handling, and assessing satellite-acquired data for water resource planning and management models. Research activities in the current program include using satellite data for detecting and mapping area wetlands, applying satellite data to solve coastal engineering problems, and evaluating remote sensing techniques to monitor changes in aquatic vegetation in coastal and estuarine environments.

Soil Conservation Service (SCS)

The Soil Conservation Service of the Department of Agriculture has a mission that covers three major areas: soil and water conservation, natural resource surveys, and community resource protection and development. Through its nationwide network of

conservation specialists, the SCS provides technical assistance to farmers, ranchers, and foresters on methods to control erosion and sedimentation through best management practices and to control non-point sources of water pollution. The SCS maintains extensive data archives on wind and water erosion, land-use and cover, conservation practices, and treatment needs. To assist landowners in protecting natural resources, SCS also administers cost sharing programs that offer special assistance for installing certain conservation practices, protecting wetlands, and improving water quality.