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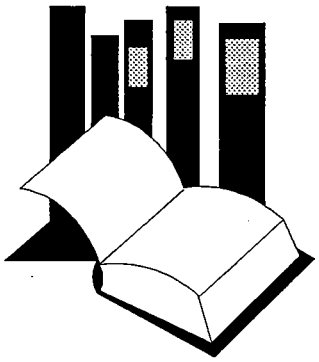
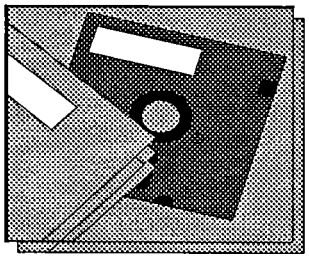
NOAA COASTAL OCEAN PROGRAM
Decision Analysis Series No. 3



BIBLIOGRAPHY OF SYNTHESIS DOCUMENTS ON SELECTED COASTAL OCEAN TOPICS



Elaine V. Collins
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October 1994

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Coastal Ocean Office

The Decision Analysis Series has been established by NOAA's Coastal Ocean Program (COP) to present documents for coastal resource decision makers which contain analytical treatments of major issues or topics. The issues, topics, and principal investigators have been selected through an extensive peer review process. To learn more about the COP or the Decision Analysis Series, please write:

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U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary
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Note to Readers

The NOAA Coastal Ocean Program (COP) provides a focal point through which the agency, together with other organizations with responsibilities for the coastal environment and its resources, can make significant strides toward finding solutions to critical problems. By working together toward these solutions, we can ensure the sustainability of these coastal resources and allow for compatible economic development that will enhance the well-being of the Nation now and in future generations. The goals of the program parallel those of the NOAA Strategic Plan.

A specific objective of COP is to provide the highest quality scientific information to coastal managers in time for critical decision making and in a format useful for these decisions. To help achieve this, COP inaugurated a program of developing documents that would synthesize information on issues that were of high priority to coastal managers. To develop such documents, a three-step process was used: 1) to compile a list of critical topics in the coastal ocean through a survey of coastal resource managers and to prioritize and select those suitable for the document series through the use of a panel of multidisciplinary technical experts; 2) to solicit proposals to do research on these topics and select principal investigators through a rigorous peer-review process; and 3) to develop peer-reviewed documents based on the winning proposals.

Seven topics and associated principal investigators were selected in the initial round. Completed documents on two topics, summer flounder habitat parameters and salt marsh restoration, are in print (see inside back cover). Other volumes will be published over the next two years on the following topics: seagrass restoration technology, coastal watershed restoration, restoring streams and anadromous fish habitat affected by logging, eutrophication and phytoplankton blooms, and management of cumulative coastal environmental impacts.

Bibliography of Synthesis Documents on Selected Coastal Ocean Topics was added to the series after a recommendation from one of COP's management committees that such a document would be useful to coastal managers. The NOAA Library conducted the searches and produced the final document. This work was conducted with the assistance of a COP staff member who made the final selection of citations.

As with all of its products, COP is very interested in ascertaining the utility of the Decision Analysis Series particularly in regard to its application to the management decision process. Therefore, we encourage you to write, fax, call, or Internet us with your comments. Please be assured that we will appreciate these comments, either positive or negative, and that they will help us direct our future efforts. Our address and telephone and fax numbers are on the inside front cover. My Internet address is DSCAVIA@HQ.NOAA.GOV.

Donald Scavia
Director
NOAA Coastal Ocean Program

Introduction

This compilation of references to works which synthesize information on coastal topics is intended to be useful to resource managers in decision making processes. However, the utility must be understand in terms of its limited coverage. The bibliography is not inclusive of all the published materials on the topics selected. Coverage is clearly defined in the following paragraph.

The time span of the bibliography is limited to references that were published from 1983 to 1993, except for a last-minute addition of a few 1994 publications. All searches were done in mid- to late-1993. The bibliography was compiled from searches done on the following DIALOG electronic databases: Aquatic Sciences and Fisheries Abstracts, BIOSIS Previews, Dissertation Abstracts Online, Life Sciences Collection, NTIS (National Technical Information Service), Oceanic Abstracts, Pollution Abstracts, SciSearch, and Water Resources Abstracts. In addition, two NOAA electronic datases were searched: the NOAA Library and Information Catalog and the NOAA Sea Grant Depository Database.

Synthesis of information is not an ubiquitous term used in database development. In order to locate syntheses of required coastal topics, 89 search terms were used in combinations which required 10 searches from each file. From the nearly 6,000 citations which resulted from the electronic searches, the most appropriate were selected to produce this bibliography. The document was edited and indexed using WordPerfect software. When available, an abstract has been included. Every abstract was edited.

The bibliography is subdivided into four main topics or sections: ecosystems, coastal water body conditions, natural disasters, and resource management. In the ecosystems section, emphasis is placed on organisms in their environment on the major coastlines of the U.S. In the second section, coastal water body conditions, the environment itself is emphasized. References were found for the Alaskan coast, but none were found for Hawaii. The third section, on natural disasters, emphasizes environmental impacts resulting from natural phenomena. Guidelines, planning and management reports, modelling documents, strategic and restoration plans, and environmental economics related to sustainability are included in the fourth section, resource management. Author, geographic, and subject indices indices are provided.

The authors would like to thank Victor Omelczenko and Terry Seldon of the NOAA Sea Grant Office for access to and training on the NOAA Sea Grant Depository Database. We are grateful also to Dorothy Anderson, Philip Keavey, and Elizabeth Petersen who reviewed the draft document.

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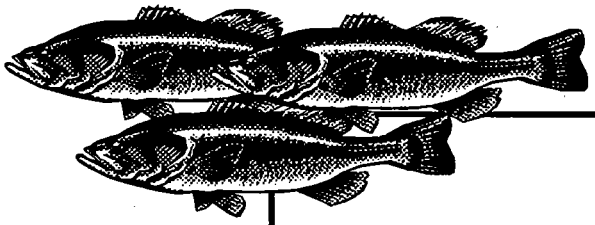

ECOSYSTEMS

1A. EAST COAST ECOSYSTEMS

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1. Able, K.W. and Kaiser, S.C. 1994. Synthesis of Summer Flounder Habitat Parameters. NOAA Coastal Ocean Program Decision Analysis Series No. 1; 68 pp. + bibliography + 3 appendices. NOAA Coastal Ocean Program Office, Silver Spring, MD.

> This document synthesizes habitat information available for the summer flounder, *Paralichthys dentatus*, an important species in commercial and recreational fisheries on the east coast of the U.S.. An overview of the economic importance is presented, followed by the current state of knowledge of distribution, life history patterns, and stock identification. The habitat requirements are presented by general habitat for offshore eggs, offshore larvae, estuarine larvae, estuarine juveniles, offshore juveniles, and estuarine and offshore adults.

2. Albert, R.C. 1988. The historical context of water quality management for the Delaware Estuary. Estuaries 11 (2): 99-107.

> Water pollution of the Delaware Estuary was observable over two centuries ago and progressively worsened until after World War II. Four distinct governmental responses to the pollution have greatly improved the water quality of the bay. A current response is oriented toward existing problems, such as toxic contamination of the water column, bottom materials, and aquatic life.

3. Anderson, E.A. 1989. Economic benefits of habitat restoration: Seagrass and the Virginia hard-shell blue crab fishery. North American Journal of Fisheries Management 9 (2): 140-149.

> Seagrass beds (predominantly eelgrass *Zostera marina* and other submerged aquatic vegetation in Chesapeake Bay) which are the preferred habitat for the blue crab *Callinectes sapidus*, have been disappearing since the early 1960's. There is a statistically significant relationship between the abundance of submerged aquatic vegetation and catch per unit of effort in the Virginia hard-shell blue crab fishery. A simulation model was developed to generate rough estimates of the economic benefits that would accrue with the restoration of seagrass.

4. Army Corps of Engineers, Baltimore, MD, District. 1984. Chesapeake Bay study. Supplement A. Problem identification. Supplement B. Public involvement. Supplement C. The Chesapeake Bay hydraulic model. Army Corps of Engineers

Report No. CHB-84-S-SUPPL-A-B-C, 100 pp. Available from National Technical Information Service, AD-A161 475/9/GAR.

This report includes the following Chesapeake Bay study areas: natural resources, socioeconomic characteristics, institutional framework, existing state and local water resources institutions, water resource activities, water resources problems and needs.

5. Austin, H.M. 1992. Chesapeake Bay stock assessment - Who are they, and where are they? Water Science and Technology 26 (12): 2705-2709.

Many economically important species are seasonally transient in the Chesapeake Bay. The pressure on these fisheries resources due to the demand for human consumption and recreation, industrial activity, and environmental fluctuations has resulted in stock declines by most important species. The only way to separate natural population fluctuations from those of anthropogenic origin is via long-term stock assessment programs (monitoring) in the Bay. These programs will allow for the examination of trends, cycles and stochastic processes between resource and environment for economically important species as well as environmentally sensitive species.

6. Bennett, D.B. and Heaney, J.P. 1991. Retrofitting for watershed drainage. Water Environment & Technology 3 (9): 63-68.

Over the past 8 years, degradation in Florida's Indian River Lagoon has produced fish kills, reduced viability of recreational and commercial fisheries, and loss of seagrass beds. Storm-water drainage practices in the watershed have been identified as the primary cause of the demise of the lagoon. A project was implemented to create a watershed control system and to develop management strategies to relieve stresses resulting from runoff to the lagoon. The Storm Water Management Model was used to evaluate the effectiveness of the proposed watershed control system under existing land use and under maximum buildout. The simulation clearly illustrated that the system would have great difficulty meeting the groundwater discharge and water level fluctuation criteria for all development scenarios.

7. Blumberg, A.F., Johnson, B.H., Heath, R.H., Hsieh, B.B. and Pankow, V.R. 1991. Data Employed in the Development of a Three-Dimensional, Time-Varying Numerical Hydrodynamic Model of Chesapeake Bay. Army Engineer Waterways Experiment Station, Vicksburg, MS, Final Report WES/TR/HL-91-1, 222 pp.

The report describes data sets employed in the development of a three-dimensional hydrodynamic model of Chesapeake Bay. Three relatively

extensive synoptic field data sets were used, from June-July 1980, April 1983, and September 1983. The data are presented in graphic and tabular forms.

8. Bundy, M.M. 1985. Maryland's Chesapeake Bay Program: Responding to the challenge. In: The Chesapeake: Prologue to the Future. Proceedings from The Chesapeake Bay Symposium, National Marine Educators Conference, Willlamsburg, VA, 30 Jul.-3 Aug. 1985. Chase, V.C. (ed.). pp. 70-73.

When the Environmental Protection Agency completed its six-year research program on the Chesapeake Bay in 1983, levels of submerged aquatic vegetation were at the lowest levels ever recorded. High phosphorus and nitrogen levels were strongly correlated with reduced populations of Bay grasses and fish that spawn in Bay waters. High concentrations of heavy metals and toxic organic compounds were identified in northern Bay sediments and Baltimore Harbor.

9. Butt, A.J., Ludwick, J., Johnson, R., Wade, T. and Fiegenbaum, D. 1984. Annotated bibliography of the lower Chesapeake Bay: Current literature of biological, chemical, geological and physical studies. Old Dominion University, Norfolk, VA, Applied Marine Research Lab, 98 pp. Available from National Technical Information Service, AD-A165 064/7/GAR.

The topics include: Biological (benthos, sea grasses, plankton, nekton, pollution, ecology, taxonomy); Chemical (nutrients, organics, trace elements, water quality, synthesis reports, heavy metals); Geological (shore erosion, suspended sediments, remote sensing, sediment distribution, bathymetry and sediment transport, dredging); and Physical (circulation, temperature and salinity, tides and currents, models, remote sensing).

10. Cahill, J. and Imbalzano, K. 1991. Inventory of Organic and Metal Contamination in Massachusetts Bay, Cape Cod Bay, and Boston Harbor Sediments, and an Assessment of Regional Sediment Quality. Environmental Protection Agency, Boston MA, Region I Report EPA/171/R-92/013.

In order to develop Sediment Quality Criteria (SQC) that will protect aquatic resources and human health, EPA has compiled data on sediment metal, chemical, and physical characteristics into a master database and has evaluated the regional distribution of selected contaminants. Applications of SQC include site cleanup and restoration.

11. Cooper, J.S. 1985. EPA and the Chesapeake Bay. In: Wetlands of the Chesapeake. Proceedings of the Conference held April 9-11, 1985, Easton, Maryland, pp. 30-36.

The Chesapeake Bay is a national treasure, but its size and resources sometimes create the impression that someone will always be available to resolve problems of water quality and wetland protection. The Environmental Protection Agency has addressed many of the water quality problems through the Clean Water Act, and will continue working with other federal and state agencies on wetlands protection programs and studies. Wetlands are critical to the Chesapeake Bay's health. Preservation and protection of wetlands requires a joint effort between EPA and local communities, with special emphasis on the following topics: (1) restriction of development; (2) provision of greater expenditure on water pollution control equipment and greater enforcement of stricter water quality standards for large-scale industry; and (3) the ecology of the Bay, with a watershed from six states, cannot be improved without the participation and help of all six.

12. Correll, D.L., Miklas, J.J., Hines, H. and Schafer, J.J. 1987. Chemical and biological trends associated with acidic atmospheric deposition in the Rhode River watershed and estuary. Water, Air and Soil Pollution 35 (1-2): 63-86.

The Rhode River estuarine/watershed system, a tributary of Chesapeake Bay, is located on the inner Atlantic Coastal Plain. Bulk precipitation pH in the spring season declined from 4.95 in 1974 to 3.82 in 1981 and was 4.03 in 1985. The changes in pH of a forested primary stream were more related to changes in bulk precipitation pH than they were to changes in pH of agricultural streams. Surges in acidity in primary (first order) streams reached extremes of pH 3.2. Higher order streams had surges in acidity with pH minima below 5.0, which occurred during accelerated groundwater percolation following storm events and which did not coincide with surface runoff or snowmelt. Rhode River spawning runs of *Perca flavescens* declined drastically from the early 1970s to essentially zero since 1981. Larval bioassays of acidity indicate negligible toxicity to *Hyla crucifer*, significant toxicity to *Perca flavescens*, and drastic effects on *Morone saxatilis* at pH 5.0.

13. Correll, D.L., Jordan, T.E. and Weller, D.E. 1992. Cross media inputs to eastern U.S. watersheds and their significance to estuarine water quality. Water Quality International '92, Washington, DC. 16th Biennial Conference of the International Association on Water Pollution Research and Control, Washington, DC, 24-30 May 1992. Suzuki, M., Ballay, D., Dahlberg, A.G., Gujer, W., Jenkins, D., Kroiss, H., DiPinto, A.C., Zotter, K., Milburn, A., Izod, E.J. and Nagle, P.T. (ed.). Water Science and Technology 26 (12): 2675-2683.

Extensive research on the Chesapeake Bay estuary, its drainage basin, and its airshed have demonstrated that atmospheric deposition and diffuse land discharges are the largest sources for many parameters affecting estuarine

water quality. For example, phosphorus and sediments are transported to the Bay in overland storm flows, nitrate in atmospheric deposition and in ground water, many pesticides and other toxic materials in surface waters and atmospheric deposition, and silicate in ground water. The realization of the magnitude and importance of diffuse sources has led to research on better land use practices in the Chesapeake Bay, such as improved management of forested riparian buffer zones in the coastal plain part of the drainage basin.

14. Dauer, D.M. 1993. Biological criteria, environmental health and estuarine macrobenthic community structure. Marine Pollution Bulletin 26 (5): 249-257.

Biological criteria for defining water quality and the presence of acceptable levels of benthic resources were evaluated for estuarine macrobenthic communities of the lower Chesapeake Bay. Models of expected community values were used as a function of salinity. The models were developed from a five-year data set (1985 to 1989) for stations considered to be minimally impacted in the absence of data from pristine habitats. The models were used to evaluate benthic communities of two regions of the Chesapeake Bay, one exposed to summer low dissolved oxygen events and the other characterized by sediments contaminated with heavy metals and polynuclear aromatic hydrocarbons. Stations exposed to stress from either low dissolved oxygen events or contaminated sediments were characterized by reduced community biomass, reduced species richness, less biomass consisting of deep-dwelling and equilibrium species, and more biomass consisting of opportunistic species.

15. Dauer, D.M., Luckenbach, M.W. and Rodi, A.J. 1993. Abundance biomass comparison (ABC Method) - Effects of an estuarine gradient, anoxic hypoxic events and contaminated sediments. Marine Biology 116 (3): 507-518.

The ABC Method for evaluating pollution-induced stress was tested using data obtained from the Chesapeake Bay, Virginia, collected between 1985 and 1989. Three predictions were tested, and only partial support was found for each, but several problems with the ABC method were identified. A small number of large-sized species, particularly in mesohaline and polyhaline regions of the estuary, greatly affected the analysis. Similar designations of stress could be produced by simply sampling only for these rare, large species, such as the tubiculous polychaete, *Diopatra cuprea*, in contaminated sediments. The authors concluded that no single method or analysis is likely to produce stress classifications without misclassifications and that ecological stress is best measured using multiple methods or analyses with different assumptions.

16. DeMuro, J., Bowman, M., Maxwell, C., Asante-Duah, D. and Meyers, S. 1990. Acid Deposition in Maryland: Summary and Results through 1989. Maryland

Department of Natural Resources, Annapolis, Chesapeake Bay Research and Monitoring Division Final Report CBRM-AD-90-4, 111 pp.

This annual report of acid deposition research of the Chesapeake Bay Research and Monitoring Program includes transport and chemistry of acid deposition; potential impact on streams, fish, crops, and forests; ability of energy conservation programs to reduce emissions of acid-forming pollutants; and mitigation techniques for neutralizing acid waters.

17. Desbonnet, A. and Lee, V. 1991. Historical Trends: Water Quality and Fisheries of Narragansett Bay. Rhode Island Univ., Kingston, RI, Sea Grant College Program Publication P-1258, 100 pp. Coastal Resources Center Contribution No. 100.

The report contains a profile of Narragansett Bay, an overview of Bay issues and management, growth and pollution of the Providence and Seekonk rivers, trends in water quality in upper and lower Narragansett Bay, trends in water quality in Mount Hope Bay, and trends in Narragansett Bay fisheries and shellfisheries.

18. Dial, R.S. and Deis, D.R. 1986. Mitigation Options for Fish and Wildlife Resources Affected by Port and Other Water-Dependent Developments in Tampa Bay, Florida. Report from Continental Shelf Associates, Inc., Jupiter, FL, 171 pp. Available from NTIS as PB87-140703/GAR.

Ten past restoration projects in Tampa Bay were evaluated. Habitats included *Spartina* marsh, mangrove forests, *Juncus* marsh, and subtidal habitat. In-kind losses of habitat occurred in nine of the ten projects. Permanent losses occurred in at least three projects. Restoration of *Spartina* and *Juncus* marshes was recommended, but seagrass restoration was not recommended. Twelve sites were identified as potential restoration sites. The report will be useful to decision-makers concerned with wetland habitat loss and restoration in Tampa Bay, Florida, and other areas with similar habitats.

19. Environmental Protection Agency. 1992. Chesapeake Bay Basin Comprehensive List of Toxic Substances. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD, Report CBP/TRS-72/92, 67 pp.

This comprehensive list documents the finding of or measurement of a toxic substance in some media at some time in the Chesapeake Bay basin. It is the central list of toxic substances around which the Chesapeake Bay Program's Toxics Database has been organized, and it will serve as the base against which all future updates to the Toxics of Concern list will be identified.

20. Environmental Protection Agency. 1992. Comprehensive List of Chesapeake Bay Basin Species. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD, Report CBP/TRS-70/92, 140 pp.

This comprehensive list, which describes the aquatic and aquatic-associated living resources in Chesapeake Bay, supports Chesapeake Bay agencies in determining the presence and status of living resources in the Bay. It will be used to revise the Chesapeake Bay Program's Toxics Database.

21. Environmental Protection Agency. 1992. Progress Report of the Bay-wide Nutrient Reduction Reevaluation: Chesapeake Bay Program. Environmental Protection Agency, Annapolis, MD, Chesapeake Bay Program Report, 69 pp.

This report presents preliminary findings of improvements in nutrient loads, water quality, and habitat based on seven runs of the computer model. Final recommendations will be issued after further model runs and refinements.

22. Evans, D.W., Dodoo, D.K. and Hanson, P.J. 1993. Trace element concentrations in fish livers: Implications of variations with fish size in pollution monitoring. Marine Pollution Bulletin 26 (6): 329-334.

Concentrations of metals in livers of Atlantic croaker (*Micropogonias undulatus*) increased with fish length in a collection of 47 fish from coastal North Carolina. The pattern of increase was expected for contaminant metals such as silver, cadmium, mercury, and lead which are poorly regulated and only slowly excreted, but it was not expected for the biologically essential, homeostatically controlled elements copper, iron, manganese, selenium, and zinc. Copper concentrations in fish collected from Galveston Bay, Texas were used to illustrate bias in estimating mean concentrations when such relationships exist. Adjustment for bias and reduction in variance estimates were made by analysis of covariance, to improve the power to detect spatial and temporal trends.

23. Flemer, D.A., Mackiernan, G.B., Nehlsen, W., Tippie, V.K. and Biggs, R.B. 1983. Chesapeake Bay: A Profile of Environmental Change. Environmental Protection Agency Chesapeake Bay Program Report, 210 pp. Available from National Technical Information Service, PB84-119197.

Trends in water and sediment quality, and in the living resources, including their interrelationships, were used to characterize the current state of Chesapeake Bay. The water quality parameters evaluated included nutrients, dissolved oxygen, organic chemical compounds, and heavy metals. The living resources that were assessed included phytoplankton, submerged aquatic vegetation, benthic organisms (including shellfish), and finfish.

24. Flemer, D.A., Biggs, R.B., Tippie, V.K., Nehlsen, W., Mackiernan, G.B. and Price, K.S. 1987. Characterizing the Chesapeake Bay ecosystem and lessons learned. In: Proceedings of the Tenth National Conference, Estuarine and Coastal Management, Tools of the Trade. New Orleans, LA, 12-15 Oct. 1986. Lynch, M.P. and McDonald, K.L. (ed.). Vol. 1, pp. 153-178.

The Chesapeake Bay Program Characterization Report described trends, correlations, and interacting factors for water and sediment quality and biota of the Bay. Examples of useful approaches and difficulties encountered in data acquisition, organization, analysis, and synthesis were described in the report. The assessment was divided into three topics: 1) Water and Sediment Quality: Current Conditions (1977 to 1980) and Trends, 2) Living Resources: A History of Biological Change, and 3) Relationships among Water and Sediment Quality and Living Resource Trends.

25. Golden, B.F. 1990. Interstate cooperation in dealing with growth-related water quality impacts on the Chesapeake Bay. In: International and Transboundary Water Resources Issues. American Water Resources Association, Bethesda, Maryland, pp. 49-56.

Pennsylvania, Maryland, Virginia, the District of Columbia, the EPA, and the Chesapeake Bay Commission constitute the Chesapeake Executive Council. In an historic agreement, the jurisdictions agreed to reduce the impacts each creates on the Bay and its tributaries. A key component of this effort is a rational approach to land development practices throughout the watershed. A 12-member panel appointed to examine the issues of population growth and development in the Chesapeake watershed to the year 2020 established seven "visions" of how the projected 2.6 million new residents should be accommodated. These visions include concentration of development in suitable areas; protection of sensitive areas; direction of growth toward existing population centers; stewardship of the Bay and the land as a universal ethic; and forced practice of conservation of resources throughout the region. Each vision has a series of implementing actions for state and local governments which are described in the report.

26. Graber, P.H.F. 1984. Law of the coast in a clamshell. Part XIV: The Maryland approach. Shore and Beach 52 (1): 3-10.

As defined in its Coastal Management Program, Maryland's state coastal zone includes Baltimore City and 16 counties bordering the Atlantic Ocean, Chesapeake Bay, and the Potomac River upstream from Washington, D.C. Coastal zone lands include uplands, tidelands and submerged lands. Property boundaries of lands adjoining tidal waters, public rights in tide-covered lands,

public access rights, private littoral rights, and the leasing and regulation of coastal zone lands and waters as currently practiced in Maryland are discussed.

27. Harding, L.W. 1989. Use of aircraft and satellite remote sensing of phytoplankton chlorophyll concentrations in case 2 estuarine waters of the Chesapeake Bay. In: Maryland University, the 1989 NASA-Asee Summer Faculty Fellowship Program in Aeronautics and Research, p. 33.

Two projects are summarized which used remote sensing of phytoplankton concentrations in Chesapeake Bay. The first project used aircraft remote sensing with the Ocean Data Acquisition System (ODAS), a compact radiometer system developed at NASA, which can be flown in light aircraft. Sixteen flights were completed in March-July 1989 in an attempt to increase the spatial and temporal resolution of phytoplankton pigment concentrations in the Bay. The second project involves the revision of algorithms used in open-ocean satellite studies for use in estuaries.

28. Hasbrouck, S. and Lignell, K. 1986. The Maine Seacoast. Maine University Sea Grant College Program Report E-MSG-86-5. 12 pp.

The report describes the coast's history, from the formation the Gulf of Maine 15,000 years ago to current research efforts and management issues. The authors have summarized basic information on Maine's coastal and marine resources, geology and natural history, commercial fisheries, the impact of urbanization and tourism, conservation efforts, and public policy issues.

29. Hershner, C. and Wetzel, R.L. 1987. Submerged and emergent aquatic vegetation of the Chesapeake Bay. In: Contaminant Problems and Management of Living Chesapeake Bay Resources. Majumdar, S.K., Hall, L.W., Jr. and Austin, H.M. (ed.). pp. 116-133.

The Chesapeake Bay supports a diverse assemblage of submerged and emergent aquatic vegetation whose distribution is governed largely by salinity. Both submerged and emergent vegetation contribute to total net primary production and increase habitat and performance in both water quality and sedimentation processes. Research on submerged aquatic vegetation is focused on its role in the estuarine system and determinants of distribution and abundance. Research on emergent vegetation is focused on methodologies for utilization to meet water quality, erosion control and habitat objectives.

30. Horton, T. and Eichbaum, W.M. 1991. Turning the tide: Saving the Chesapeake Bay. xxiv+327 pp. Island Press, Washington, D.C.

In this text, the current status of the Chesapeake Bay watershed ecosystem and the negative impacts on the Bay caused by human activities are examined. Four topics dominate the text: pollution, harvests, resilience, and people. Some successful actions underway to restore the Bay are described, and specific recommendations are made to restore the Bay's productivity.

31. Huggett, R.J. 1985. Toxic organic chemicals in the Chesapeake Bay ecosystem. In: The Chesapeake: Prologue to the Future. Proceedings from The Chesapeake Bay Symposium, National Marine Educators Conference, Williamsburg, VA, 30 Jul.-3 Aug. 1985. Chase, V.C. (ed.). Pp. 56-57.

Over the past several years, scientists who have reviewed biological data from the Chesapeake Bay have become concerned because of the abundance of a class of chemicals called polynuclear aromatic hydrocarbons (PAHs). These compounds, mainly produced by the combustion of carbonaceous fuels, have been shown to be carcinogenic to mammals and toxic to marine life.

32. Jacobson, H.A., Jacobson, G.L., Jr. and Kelley, J.T. 1987. Distribution and abundance of tidal marshes along the coast of Maine. Estuaries 10 (2): 126-131.

Planimetry studies of Maine coastal geology maps showed that there is considerably more tidal marsh area in the state of Maine than previously documented. The highly convoluted coast, approximately 5,970 km long, contains approximately 79 km^2 of salt marsh, far more than any other New England state, New York, or the Bay of Fundy region. Estimates for the per-unit primary productivity of salt marshes lead to projections of total marsh productivity on the order of 10^{10} g dry weight/yr for the Maine coast and 10^{11} g dry weight/yr for the Gulf of Maine as a whole.

33. Jacoby, M.E. (ed.). 1986. The Economics of Chesapeake Bay Management. Conference Proceedings, Durham, New Hampshire, July 1985. University of Maryland Sea Grant Program Publication UM-SG-TS-86-03, 53 pp.

This report summarizes economic approaches to natural resource management. The topics include the economic effects of Bay clean-up efforts, control of nonpoint pollution, waste treatment, and oyster management, and the role of public interests. These summaries are intended to provide insight into highly technical economic analyses.

34. Jensen, J.R., Cowen, D.J., Althausen, J.O., Narumalami, S. and Weatherbee, O. 1993. An evaluation of the CoastWatch change detection protocol in South Carolina. Photogrammetric Engineering and Remote Sensing 59 (6): 1039-1046.

35. Johnson, L.L., Stehr, C.M., Olson, O.P., Myers, M.S. and Pierce, S.M. 1992. National Status and Trends Program for National Benthic Surveillance Project: Northeast Coast. Fish Histopathology and Relationships between Lesions and Chemical Contaminants. National Marine Fisheries Service, Seattle, WA, Northwest Fisheries Science Center Report NOAA-TM-NMFS-NWFSC-4, 107 pp.

Between 1987 and 1989, winter flounder were collected from 22 Northeast coast sites and the relationship between disease occurrence and levels of organic contaminants in sediment, stomach contents, and tissues was examined. More than 1,500 fish were examined.

36. Johnson, L.L., Stein, J.E., Collier, T.K., Casillas, E., McCain, B.B. and Varanasi, U. 1992. Bioindicators of Contaminant Exposure, Liver Pathology and Reproductive Development in Prespawning Female Winter Flounder (*Pleuronectes americanus*) from Urban and Nonurban Estuaries on the Northeast Atlantic Coast. NOAA Technical Memorandum NMFS F/NWFSC-TM-1, 76 pp.

37. Jordan, S.J., Klauda, R.J., Brown, T.C. and Dalpra, C.M. 1992. Living resources: The ultimate result. Water Science and Technology 26 (12): 2695-2704.

The Chesapeake Bay ecosystem is a living network in which the water, the land, the air, the people, and the living resources are interconnected. The Chesapeake Bay Program's Living Resources Subcommittee and Maryland Department of Natural Resources programs are making a difference in the ways the Bay is being managed, monitored, and understood. These programs indicate that the productivity, diversity, and abundance of living resources can improve in response to the positive things being done and the negative things not being done, and they are showing the way towards understanding and managing the Bay as an integrated ecosystem.

38. Jordan, T.E., Correll, D.L., Miklas, J. and Weller, D.E. 1991. Long-term trends in estuarine nutrients and chlorophyll, and short-term effects of variation in watershed discharge. Marine Ecology Progress Series 75 (2-3): 121-132.

For up to 18 years, salinity and the concentrations of nutrients, organic matter, plant pigments, and suspended particles were measured in the Rhode River, a sub-estuary of Chesapeake Bay. Long-term trends and relationships to watershed discharges were examined. The largest and most consistent trend was a decrease in dissolved organic nitrogen. Correlations between watershed flow and concentrations at weekly and seasonal time scales were analyzed, and the influences of the Susquehanna River and local watersheds were resolved. In some cases, nitrate was positively correlated with either local or

Susquehanna flow depending on season, location in the estuary, and time scale.

39. Kahn, J.R.and Kemp, W.M. 1985. Economic losses associated with the degradation of an ecosystem: The case of submerged aquatic vegetation in Chesapeake Bay. Journal of Environmental and Economic Management 12 (3): 246-263.

This study determined the economic losses associated with the reductions in the level of submerged aquatic vegetation (SAV) in Chesapeake Bay. The study examined the indirect ecological consequences of pollution in Chesapeake Bay fisheries, in a manner consistent with the economic theory of benefit measurement.

40. Kerns, W.R. 1985. Management of nonpoint sources of pollution in coastal areas. In: The Chesapeake: Prologue to the Future. Proceedings from The Chesapeake Bay Symposium, National Marine Educators Conference, Williamsburg, VA, 30 Jul.-3 Aug. 1985. Chase, V.C. (ed.). pp. 63-67.

Nonpoint sources of pollution are recognized as the primary source of water quality degradation in many coastal areas. In those areas where nonpoint management programs have been implemented, the effectiveness criterion has been based mostly upon on-site productivity rather than efficiency in management of water quality for use-related activities. To determine the most efficient levels of nonpoint control, programs must utilize site-specific water-use impact analysis as well as on-site productivity analysis. Those programs must also utilize economic analysis to select optimal combinations of point and nonpoint controls for site-specific areas.

41. Klemas, V. 1993. Characterization of Spatial and Temporal Variability of Phytoplankton Blooms in Coastal Waters. Delaware University, Newark, DE, College of Marine Studies Report, 11 pp.

The tide-related water areas and tidal levels of Delaware Bay were determined from space shuttle time-series photographs. The velocity of flood tide at the mouth of the bay was also determined. The resulting velocity, 132 cm/sec, compared well with tidal current charts.

42. Kruer, C.R. 1991. Assessment of Florida's remaining coastal upland natural communities: Florida Keys. Florida Natural Areas Inventory, Tallahassee. Final Report, 253 pp. Sponsored by National Oceanic and Atmospheric Administration, Washington, DC, Office of Ocean and Coastal Resource Management, and Florida Department of Natural Resources, Tallahassee.

Existing data on 20-acre or larger occurrences of some coastal upland natural communities on southeast Florida's barrier islands and ocean-front shores were identified and processed into the Florida Natural Areas Inventory (FNAI) data base. Field surveys were conducted for 63 sites in the Florida Keys, and plant species lists, community structure, presence or absence of uninterrupted transitions between communities, degree of invasion by exotic species, and physical disturbance were recorded. After the data had been entered into the FNAI, the sites were compared and ranked based on quality and condition.

43. Kyzer, I.B. 1988. Management of dredged material disposal areas. In: Water Quality '88. Seminar Proceedings. Charleston, SC, 23-25 Feb. 1988. Pp. 410-413.

After experimenting with several dredged material disposal areas and noting positive results, the Charleston District initiated a disposal area management program with six goals that included design and development of safe, efficient areas; densification and consolidation of sediments; development of techniques to accelerate drying of the material; reduction of mosquito breeding potential; creation of wildlife habitat; and location of off-site uses for the dredged material. Millions of cubic yards of material have been regained from the disposal areas in the Charleston District, thus extending their useful life.

44. Larsen, P.F. 1992. Marine environmental quality in the Gulf of Maine: A review. Review of Aquatic Sciences 6 (1): 67-87.

The Gulf of Maine is widely believed to have the high environmental quality due to its cold, tidally mixed waters. Existing information concerning the environmental quality of the Gulf of Maine is summarized and compared with other coastal Regions.

45. Lignell, K., Campbell, L.A. and Waterman, M. 1991. Troubled Waters: Taking Stock in the Gulf of Maine. Maine-New Hampshire Sea Grant College Program Report R-MSG-91-10, 21 pp.

The Gulf of Maine, one of the world's most productive ecosystems, is being threatened by coastal development, resource use, and pollution. Contamination has been found at several sites in the Gulf of Maine. Boston Harbor, on the Gulf's southwestern rim, is one of the most heavily polluted bodies of water in the country. To ensure that the Gulf of Maine can sustain its productivity, it is critical that research efforts concentrate on the Gulf as a total ecosystem, that water quality be improved, and that coastal and marine resources be developed in a responsible manner. Public involvement needs to be encouraged from the three states and two provinces bordering the Gulf.

46. MacDonald, D.A. 1991. Status and Trends in Concentrations of Selected Contaminants in Boston Harbor Sediments and Biota. National Ocean Service, Rockville, MD, Office of Oceanography and Marine Assessment Report NOAA/TM/NOS/OMA-56, 224 pp.

The report provides a synthesis and evaluation of data obtained from many surveys and programs concerning the concentrations of toxicants in surficial sediments and biota, including bivalves, crustaceans, and fish. The toxicants considered include metals, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls.

47. Mackiernan, G.B. 1990. State of the Chesapeake Bay. Water Environment and Technology 2 (9): 60-67.

In 1983, after a lengthy study, the Environmental Protection Agency (EPA) reported widespread ecosystem degradation of the Chesapeake Bay and warned that trends would continue as development increased unless effective management actions were implemented. These findings led to the establishment of a federal and state Chesapeake Bay Restoration Program. The initial agreement in 1983 outlined actions to reduce nutrient input, control toxic materials, and enhance bay species and their habitats. A cooperative bay-wide monitoring program was also initiated to evaluate environmental trends and to track progress. In 1987, specific commitments and deadlines were established including a basin-wide 40% reduction of both phosphorus and nitrogen from both point and nonpoint sources by the year 2000; bay-wide reduction of toxicant inputs; and restoration, protection, and enhancement of fishery resources and habitats.

48. Malone, T.C. and Bell, W.H. 1991. Environmental research, policy and regulation: The Chesapeake Bay experience. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas - EMECS '90. Kobe, Hyogo Prefecture, Japan, 3-6 aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 497-501.

The importance of clearly defined roles and relationships among research institutions and government agencies is seen in Chesapeake Bay. The Chesapeake Bay Program embodies two major ingredients required for a comprehensive coastal seas' governance initiative: environmental management must reconcile the need to respond to environmental stress with the requirement to understand the underlying causes of the stress; and a holistic view of environmental management must be based on interdependence of a healthy environment and economic development.

49. Murchelano, R. A. 1990. Fish health and environmental health. Environmental Health Perspectives 86: 257-259.

For the past 15 years, surveys have been conducted in the eastern and western North Atlantic to evaluate the health of marine bottom fishes, usually in conjunction with fish stock assessment cruises. The results of these surveys indicate that fish health is poor in polluted coastal water. High levels of chemical contaminants were found in fish tissue and sediments in several coastal areas of the northern U.S.. Liver tissues of winter flounder, *Pseudopleuronectes americanus*, from Boston Harbor, a chemically contaminated site, showed a high incidence of hepatocarcinoma.

50. National Research Council, Washington, DC. Committee on a Systems Assessment of Marine Environmental Monitoring. 1990. Managing Troubled Waters: The Role of Marine Environmental Monitoring. National Academy Press, Washington DC. 125 pp.

Despite spending over $133 million on marine environmental monitoring annually in the United States, decision-makers still do not have enough accurate information to make timely decisions about protecting coastal waters. This book evaluates the current monitoring system; examines the benefits and limitations of monitoring, with case studies of successful programs; evaluates the role of monitoring in environmental management; and describes the need for greater coordination among monitoring programs, with case studies of programs in the Chesapeake Bay and the Southern California Bight.

51. O'Connor, J.M. and Huggett, R.J. 1988. Aquatic pollution problems, North Atlantic coast, including Chesapeake Bay. Aquatic Toxicology 11 (1-2): 163-190.

Contaminated marine coastal areas include Boston, New Bedford, Providence, New York, and Baltimore Harbor, and the Elizabeth River, Virginia. Biota in these and other areas show increased burdens of contaminants such as PCBs, pesticides, phthalates, metals and aromatic hydrocarbons. Health advisories have been posted in some regions regarding the consumption of striped bass, bluefish, and lobster, and the effects of chlordecone (kepone) spills on fisheries in the James River remain after more than 10 years. Long-term biological effects of these contaminants are not known.

52. O'Connor, J.S. and Fleming, D.A. 1987. Monitoring, research, and management: Integration for decisionmaking in coastal marine environments. In: New Approaches to Monitoring Aquatic Ecosystems. American Society for Testing and Materials, Philadelphia, PA, pp. 70-90.

The managerially helpful, simple model presented in the article characterizes the geographical prevalence of fin erosion in winter flounder relative to the sources of plausible causes, from Canada to Delaware Bay. Changing emphasis from laboratory bioassays to field population-level effects is a key step toward the integration of ecosystem-level knowledge into management and regulatory functions. It is now possible to quantify the geographic and temporal associations among waste sources and some of their biological effects, but the use of simple models can provide further understanding of source-fate-effects.

53. Orvos, D.R. and Cairns, J., Jr. 1991. Developing a risk assessment strategy for the Chesapeake Bay. Hydrobiologia 215 (3): 189-204.

If unrestricted use of natural resources continues, water quality will decrease to such an extent that some areas will be unsuitable for economic, social, and environmental uses. Regional risk assessment strategies are necessary so that actual or perceived risks can be evaluated and predicted on a regional scale. This article presents a strategy for the Chesapeake Bay that may be useful to scientists, managers, and elected officials responsible for other bodies of water as well. This article reviews risk assessment practices and proposes a strategy that utilizes appropriate endpoints to determine and predict risk.

54. Polgar, T.T., Summers, J.K., Cummins, R.A., Rose, K.A. and Heimbuch, D.G. 1985. Investigation of relationships among pollutant loadings and fish stock levels in northeastern estuaries. In: Long-Term Estuarine and Coastal Data Sets. Seventh Biennial Conference of the Estuarine Research Federation, Virginia Beach, VA, 22-26 Oct. 1983. Holland, A.F. and Kjerfve, B. (ed.). Estuaries 8 (2A): 125-135.

An analytical method developed for evaluating the dependence of historical fish stock levels on estuarine pollutant loadings was used to evaluate hypotheses on the effects of human population changes and dredging activity on stock histories of the Potomac estuary's striped bass and American shad for the period 1929 through 1976. The American shad stock showed strong dependence on human population levels (but not on dredging activity) compared to climatic factors. Analyses of this type will be done to determine the effects of specific pollutants on other stocks in five northeastern estuaries.

55. Rheinhardt, R. 1992. A multivariate analysis of vegetation patterns in tidal fresh-water swamps of lower Chesapeake Bay, USA. Bulletin of the Torrey Botanical Club 119 (2): 192-207.

The woody and herbaceous vegetation of 23 tidal freshwater swamps was sampled along the Pamunkey River, a tributary of the York River, a sub-estuary of Chesapeake Bay. Tidally driven water level fluctuations were monitored and

recorded. Communities were determined in trees (canopy and sapling sized), woody sub-canopy (shrubs and understory trees), vines, and herbs. Species distribution patterns were related to edaphic factors, a flooding index, and duration of flooding in the root zone. Two tidal swamp communities were found, both subjected to a tidally forced hydroperiod regime within the upper 15 cm of their root zones. *Nyssa biflora - Fraxinus spp.* dominated swamps are best developed toward the more downriver reaches in the wetter sites, which contain more hollows, a higher organic matter content, and higher calcium levels. *Acer rubrum - Liquidambar styraciflua - Nyssa biflora* dominated swamps are more common throughout the mid- to upriver reaches at less wet sites with lower organic matter and calcium levels. *Taxodium distichum* co-dominated in two swamps that may represent relic conditions for the wetter sites. The tidal swamps are rich in herbaceous and sub-canopy species.

56. Robertson, A., Gottholm, B.W., Turgeon, D.D. and Wolfe, D.A. 1991. A comparative study of contaminant levels in Long Island Sound. Estuaries 14 (3): 290-298.

57. Sandes, J.G. and Riedel, G.F. 1992. Sources, cycling and fate of contaminants in Chesapeake Bay. Water Science and Technology 26 (12): 2645-2652.

Many of the geochemical, physical, and biological processes that control contaminant transport, uptake, and fate are well known and are amenable to predictive modeling, while others, less well understood, require further research. Most important for the future protection of the Chesapeake Bay and other coastal ecosystems will be a coordinated approach in research and management, linking scientists of many disciplines with those charged with ecosystem protection.

58. Short, F.T. (ed.). 1992. The Ecology of the Great Bay Estuary, New Hampshire and Maine: An Estuarine Profile and Bibliography. NOAA Coastal Ocean Program Publication, 222 pp. NOAA Coastal Ocean Program Office, Silver Spring, MD.

59. Smayda, T.J. 1984. Variations and long-term changes in Narragansett Bay, a phytoplankton-based coastal marine ecosystem: Relevance to field monitoring for pollution assessment. In: Concepts in Marine Pollution Measurements. White, H.H. (ed.). Maryland Sea Grant Program Technical Report UM-SG-TS-84-03, pp. 663-680.

Natural variation is the baseline against which anthropogenic effects in the ocean can be measured. The natural variations of plankton communities in Narragansett Bay are characterized in terms of species composition, abundance, dynamics and trophic structure.

60. St. John, J.P., Leo, W.M. and Sheldon, A.W. 1985. Impact assessment of organotin chemicals in harbor environments. In: Oceans '85 Proceedings: Ocean Engineering and the Environment. San Diego, CA, 12-14 Nov 1985. Vol. 2, pp. 818-823.

Modeling studies of New York Harbor and Chesapeake Bay were undertaken to determine whether the anticipated increase in use of organotin antifouling paints poses a risk to estuarine biota. The inputs of antifouling toxicant were estimated from vessel traffic data provided by the U.S. Coast Guard. Environmental chemistry parameters were derived from previously published reports. The model results indicated that tributyltin toxicants are likely to be transported to the open ocean or decay before significant quantities accumulate in harbor waters or sediments. For the harbors studied, water column concentrations should not exceed 5.0 nanograms per liter even with 100% of the commercial vessels using the paints.

61. Stumpf, R.P. 1987. Application of AVHRR Satellite Data to the Study of Sediment and Chlorophyll in Turbid Coastal Water. NOAA Technical Memorandum NESDIS AISC No. 7, 50 pp.

62. Stumpf, R.P. 1988. Sediment transport in Chesapeake Bay during floods: analysis using satellite and surface observations. Journal of Coastal Research 4 (1): 1-15.

63. Stumpf, R.P. and Tyler, M.A. 1988. Satellite detection of bloom and pigment distributions in estuaries. Remote Sensing of Environment 24 (3): 385-404.

Using a form of vector analysis of satellite spectral data, it is possible to distinguish variations in water color and pigment concentrations from changes in turbidity. A reflectance model based on the vector expression is discussed. This method apparently can identify blooms in estuaries where the reflectance is between 0.01 and 0.07 and, with some calibration, may provide estimates of chlorophyll for concentrations greater than 5 micrograms per liter. A simple uniform atmospheric correction to AVHRR (Advanced High Resolution Radiometer) and CZCS (Coastal Zone Color Scanner) satellite data showed the location of blooms in the Chesapeake Bay in the springs of 1981 and 1982.

64. Stumpf, R.P. and Pennock, J.R. 1989. Calibration of a general optical equation for remote sensing of suspended sediments in a moderately turbid estuary. Journal of Geophysical Research 94 (C10): 14363-14371.

65. Summers, J.K., Polgar, T.T., Tarr, J.A., Rose, K.A., Heimbuch, D.G., McCurley, J., Cummins, R.A., et al. 1985. Reconstruction of long-term time series for

commercial fisheries abundance and estuarine pollution loadings. In: Long-Term Estuarine and Coastal Data Sets. Seventh Biennial Conference of the Estuarine Research Foundation, Virginia Beach, VA, 22-26 Oct. 1983. Holland, A.F. and Kjerfve, B. (ed.). Estuaries 8 (2A): 114-124.

> Time series for 100 years (1880-1980) for the commercial landings of 35 species and associated fishing effort were reconstructed for five river basins, the Hudson-Raritan Estuary, Potomac River, Delaware River, Connecticut River and Narragansett Bay. Time series for the same period were developed for indices representing pollutant loadings, developmental activities, and habitat alterations for the five river basins. These indices included representations of demography, sewage and industrial loadings, habitat factors, and nutrient, carbon, and sediment inputs.

66. Sweeney, B.W. 1992. Streamside Forests and the physical, chemical, and trophic characteristics of piedmont streams in eastern North America. Water Science and Technology 26 (12): 2653-2673.

> The quality of streamside forests may be the most important factor altered by humans that affects the ultimate water quality of the streams providing water to the coastal embayments. Comparative data from forested and deforested reaches of streams in a small Piedmont watershed (White Clay Creek in southeastern Pennsylvania) illustrate the actual and/or potential effects of streamside forests on availability of habitat, nutrient chemistry of the water, and nature of organic detritus and algae, the primary food base of higher trophic levels in streams. By greatly increasing the amount and complexity of benthic habitat available to stream organisms, streamside forests may partially mitigate the flux of sediment and nutrients into aquatic ecosystems.

67. Thorhaug, A., Man, E. and Ruvin, H. 1990. Biscayne Bay: A decade of restoration progress. In: Environmental Restoration. Science and strategies for restoring the earth. Conference on Ecological Restoration, Berkeley, CA, Jan. 1988. Berger, J.J. (ed.). Pp. 192-195.

> In 1976, the Biscayne Bay Committee of the University of Miami organized a symposium to review how the bay originally functioned, what impacts had occurred, and what remediation or mitigation was feasible. Since then, state and federal regulatory agencies have cooperated in viewing regulatory permits as a portion of the restoration effort, and two Dade County Departments, Environmental Regulation and Planning have begun a series of enhancement activities. Conflict between environmental interests and developers remains intense in this estuary but water-resource use has improved in quality and quantity.

68. Tippie, V.K. 1984. An environmental characterization of Chesapeake Bay and a framework for action. In: The Estuary as a Filter. Seventh Biennial Conference of the Estuarine Research Federation, Virginia Beach, VA, 23 Oct. 1983. Kennedy, V.S. (ed.). Pp. 467-487.

The scientific findings and management implications of the Environmental Protection Agency's Chesapeake Bay Program suggest that the Chesapeake Bay has changed dramatically in the last century and the change has accelerated since 1980. Many valued living resources of the Bay, such as the submerged aquatic vegetation, shad, striped bass, and oysters have declined, whereas nutrients and toxic compounds have increased. The Bay appears to serve as a filter for trapping and recycling pollutants. The review suggests that, to restore the Bay's ecological integrity, pollutant discharge to the Bay must be reduced.

69. Townsend, D.W. and Larsen, P.F. 1992. The Gulf of Maine: NOAA Proceedings of a Seminar Held May 22, 1989, Washington, DC. NOAA Coastal Ocean Program Regional Synthesis Series No. 1, 135 pp.

The proceedings are intended to provide an overview of the status of the Gulf of Maine and to convey a sense of the rapid natural and anthropogenic changes that the Gulf is experiencing. The following topics are considered: oceanography and biological productivity, sea-level change and coastal erosion, overall environmental quality, ecological consequences of fishing, fisheries management, economic growth trends, economic contributions of marine industries, and cooperative environmental management via the Gulf of Maine Initiative.

70. Treat, S.F., Simon, J.L., Lewis, R.R., III and Whitman, R.L., Jr. (ed.). 1985. In: Proceedings: Tampa Bay Area Scientific Information Symposium. 3-6 May 1982. Florida Sea Grant Program Report FSGR-65, 663 pp.

Existing physical, chemical, geological, meteorological, biological, anthropological and economic information on the Tampa Bay area is summarized and discussed.

71. Tripp, B.W. 1985. Buzzards Bay Bibliography: A Reference Collection of Scientific and Technical Reports Published on Buzzards Bay. Woods Hole Oceanographic Institute Technical Report WHOI-85-27. 103 pp.

This publication is a compilation of scientific and technical information on Buzzards Bay. Buzzards Bay is a segment of the Massachusetts coast that is heavily used for industrial, commercial and recreational activities. Despite

heavy use, few systematic scientific studies have been done in this area. This bibliography is a first step in assessing the available information so that future research can be planned more rationally, and the best use can be made of finite resources.

72. Walker, R. and Rex-Lopatto, K. 1987. Evaluation of costs associated with regional environmental impact in Chesapeake Bay, USA. Journal of Environmental Systems 17 (1): 15-32.

Pollution impact in Chesapeake Bay was examined, particularly in relation to the health and maintenance of striped bass populations. A dynamic simulation model was developed using optimal control theory to calculate accumulating opportunity costs of fish population decline caused by pollution in the Bay. The model was then applied to the actual situation using data on striped bass populations and rates of habitat loss resulting from decreased submerged aquatic vegetation.

73. West, N. and Robadue, D.D. 1987. An effort to model the relationship between estuarine quality, management, perception and use: The Narragansett Bay. In: Proceedings of the Tenth National Conference, Estuarine and Coastal Management, Tools of the Trade. New-orleans, LA, 12-15 Oct. 1986. Lynch, M.P. and McDonald, K.L. (ed.). Vol. 1, p. 271.

Data from groups of Narragansett Bay users were obtained from personally conducted and mail surveys during the summer of 1985. The user groups included beach visitors, boat people, quahoggers, tourists, and residents. The preliminary survey results suggest that perceptions of environmental quality and usage are less affected by traditional socio-economic variables than by the manner in which the Bay resources are being used.

74. Wetzel, R.L., Hopkinson, C.S., Diaz, R.J., Schaffner, L.C. and Dillaha, T.A. 1990. Perspectives on the Chesapeake Bay, 1990: Advances in Estuarine Sciences. Environmental Protection Agency, Annapolis, MD, Chesapeake Bay Program Report CBP/TRS-41/90, 104 pp.

The report reviews four technical topics relevant to activities of the Chesapeake Bay Program: (1) Coastal ecosystem models and the Chesapeake Bay Program; (2) Functional role of estuarine benthos; (3) Role of management practices in restoring the health of the Bay; and (4) Development of an ecological risk assessment strategy for the Bay.

75. Whalen, K.J., Lombardo, P.S., Wile, D.B. and Neel, T.H. 1989. Constructed wetlands: Design, construction and costs. In: Constructed Wetlands for Wastewater

Treatment: Municipal, Industrial and Agricultural. Lewis Publishers, Chelsea, MI, pp. 590-596.

Constructed wetlands which have successfully treated settled domestic wastewater have been pilot or small-scale projects. This article is based on a constructed bulrush (*Scirpus olneyi*) wetland that is the principal component of the 1770 m^3/day Mayo Water Reclamation Subdistrict Large Communal Water Reclamation Facility. Septic tank effluent collected from 2000 homes is treated before discharge into the Chesapeake Bay. The development of community-scale wetland treatment facilities for nitrogen removal should include consideration of the following engineering issues: (1) process-conceptual aspects, such as target removal, carbon source, and carbon-nitrogen ratio; (2) basin characteristics, including liner, baffles, length/width ratio, media, vegetation, and storm impact; and (3) process control aspects, such as adjustment of carbon-nitrogen ratios, variable loadings, adjustable hydraulic loadings, and odor control. Construction of wetlands should be modular to match treatment capacity to flow and to facilitate recovery of capital cost of expanding the treatment facilities. Wetlands startup should consider hydraulic balance to ensure that a critical water level is maintained in the wetland to maintain vegetation.

76. Wolfe, D.A., Monahan, R., Stacey, P.E., Farrow, D.R.G. and Robertson, A. 1991. Environmental quality of Long Island Sound: Assessment and management issues. Estuaries 14 (3): 224-236.

77. Wright, E.L. 1985. Decision Making and the Chesapeake Bay (Curriculum Unit). University of Maryland Sea Grant Program Publication UM-SG-ES-85-01, 220 pp.

This curriculum unit focuses on the Chesapeake Bay as both political and ecological watershed. Aimed primarily at high school science or social studies classes, the text involves students in a simulated decision-making process. The unit contains a teachers guide with seven specific activities; appendices with eleven suggested activities, including scripts for optional slide/tape show and video program; student materials; and a Chesapeake Bay Data Bank, which lists facts and figures pertinent to an understanding of the Bay.

1B. WEST COAST AND ALASKA ECOSYSTEMS

78. Barnhart, R.A., Boyd, M.J., and Pequegnat, J.E. 1992. The ecology of Humboldt Bay, California: An estuarine profile. Biological Reports, U.S. Fish and Wildlife Service No. 1, 121 pp.

Humboldt Bay, the second largest California estuary, is important ecologically, as habitat for invertebrates, fishes, birds, and mammals, and economically, for recreational use and industry. This report synthesizes scientific data on the ecological relationships and functions of the estuary, including information on geological, climatological, hydrologic and physical-chemical aspects; describes the biotic communities and their relationships; compares other west coast estuaries to Humboldt Bay; provides management considerations in terms of procedures, socioeconomic factors, and environmental concerns; and identifies research and management information gaps. Portions of the bay are managed as a national wildlife refuge. Management issues for this ecosystem include loss of habitat and degradation of the environment by additional industrial development and nonpoint source pollution.

79. Burns, K.A. 1993. Evidence for the importance of including hydrocarbon oxidation products in environmental assessment studies. Marine Pollution Bulletin 26 (2): 77-85.

To emphasize the importance of including hydrocarbon oxidation products in environmental assessment studies, ten samples of bivalve tissue were collected from Prince William Sound, extracted, and separated into fractions based on polarity. Each fraction was analysed by ultraviolet fluorescence spectroscopy (UVF) and examined for evidence of the presence of oxidation products of aromatic hydrocarbons (O-PAHs). Fluorescence in the wavelengths characteristic of O-PAHs was present in the bivalve extracts and intensity correlated with the amount of petroleum hydrocarbons as determined by gas chromatography (GC). The percentage of UVF intensity in polar fractions corresponded with the degree of weathering the oil residues had undergone as determined by their GC patterns. These results support the contention that photo and bacterial degradation processes create a complex assemblage of intermediate oxidation products of hydrocarbons that are bioaccumulated in marine organisms.

80. Calambokidis, J., Buchanan, J.B., Steiger, G.H. and Evenson, J.R. 1991. Toxic Contaminants in Puget Sound Wildlife: Literature Review and Recommendations for Research and Monitoring. Environmental Protection Agency, Seattle, WA, Region X Report EPA/910/9-91/023, 109 pp.

The report summarizes current knowledge of toxic contaminants in Puget Sound wildlife and recommends future research and monitoring.

81. Chapman, P.M., Dexter, R.N. and Goldstein, L. 1987. Development of monitoring programs to assess the long-term health of aquatic ecosystems. A model from Puget Sound, USA. Marine Pollution Bulletin 18 (10): 521-527.

This paper describes an holistic approach to environmental monitoring developed for Puget Sound which, in development, purpose, and application, is broadly applicable to all nearshore marine environments.

82. Cloern, J.E. and Nichols, F.H. 1985. Time scales and mechanisms of estuarine variability: A synthesis from studies of San Francisco Bay, California, USA. Hydrobiologia 129 (1): 229-237.

Temporal variability in San Francisco Bay can be characterized by four time scales (hours, days-weeks, months, years) and associated with at least four mechanisms (variations in freshwater inflow, tides, wind, and exchange with coastal waters). The best understood component of temporal variability is the annual cycle, which is influenced by seasonal variations in freshwater inflow. The winter season of high river discharge is characterized by large-scale redistribution of the salinity field; enhanced density stratification and gravitational circulation with shortened residence times in the bay; decreased tissue concentrations of some contaminants (e.g., copper) in resident bivalves; increased estuarine inputs of river-borne materials such as dissolved inorganic nutrients, suspended sediments, and humic materials; redistributions of pelagic organisms such as copepods and fish; low phytoplankton biomass and primary productivity in the upper estuary; and elimination of freshwater-intolerant species of macroalgae and benthic infauna from the upper estuary. Wind speed, seasonal variations in the coastal ocean, and annual temperature cycles modulate this river-driven annual cycle. The interannual variability in the Bay is also correlated with freshwater inflow. Mechanisms of short-term variability, episodic events, and long-term trends directly attributable to human activities are not as well understood.

83. Coomes, C.A., Rosenthal, G.S., Ebbesmeyer, C.C. and Kurrus, K.A. 1989. Puget Sound Environmental Atlas: View of an estuary. In: Oceans '89. The Global Ocean. Vol. 1. Fisheries, Global Ocean Studies, Marine Policy and Education, Oceanographic Studies. Oceans '89, Seattle, WA, 18-21 Sep. 1989. Marine Technology Society, Washington, DC. Institute of Electrical and Electronics Engineers, New York, NY Report IEEE-89CH2780-5, pp. 196-201.

The Puget Sound Environmental Atlas includes physical environment, natural resources, human use patterns, and pollution data and sources. Decision making for regulatory codes and siting feasibility has been streamlined by overlaying Atlas maps. This type of product in computerized form could aid decision makers in other areas of the country.

84. Crecelius, E.A., Woodruff, D.L. and Myers, M.S. 1989. Survey of sediment quality, contaminants in fish tissue, and incidence of fish disease in four non-urban bays of Puget Sound. In: Oceans '89. The Global Ocean. Vol. 2. Ocean Pollution. Oceans '89 Conference, Seattle, WA, 18-21 Sep. 1989. Marine Technology Society and Institute of Electrical and Electronics Engineers, New York, NY, Report (no report number), pp. 676-679.

Four non-urban bays of Puget Sound (Dyes Inlet, Gig Harbor, Port Angeles, and Oak Harbor) were surveyed to characterize contamination problems. Sediment samples were analyzed for contaminants and amphipod bioassays were conducted. Flatfish were analyzed for contaminants, and livers of sole were examined for diseases or disorders. Some sediments contained elevated levels of arsenic, cadmium, copper, lead, mercury, silver, zinc, PAH, PCB, and tributyltin, but only a few sediments exceeded the Puget Sound Apparent Effect Threshold (AET) sediment quality values for mercury, silver, and PAH. None of the sediments tested by the amphipod bioassay indicated a toxic response. Some fish muscle and liver tissue contained elevated levels of PCBs with the highest concentration found in muscle tissue in English sole (Parophrys vetulus) from Gig Harbor. Concentrations of PAH metabolites in bile indicated low to moderate exposure to petroleum and combustion hydrocarbons.

85. Dickert, T.G. and Tuttle, A.E. 1985. Cumulative impact assessment in environmental planning. A coastal wetland watershed example. Environmental Impact Assessment Review 5: 37-64. California University Report CUIMR-R-85-031.

Watershed development on coastal wetlands offers an ideal context for evaluating the land disturbance target approach to cumulative problems. A model land use planning system that involved a time series approach was developed for Elkhorn Slough in California. The approach included evaluation of erosion susceptibility, measurement of land disturbance, establishment of a land disturbance target, and comparison of existing and target land disturbance values.

86. Evans, D. 1991. Commencement Bay Cumulative Impact Study: Historic Review of Special Aquatic Sites. Evans and Associates, Inc., Bellevue, WA, Report, 91 pp.

The Commencement Bay Nearshore-Tideflats area has been designated as a Superfund site by the EPA. Activities such as development, dredging, diking, filling, and channelizing have resulted in loss of wetland habitat and degradation of water quality. Resource agency and tribal recommendations were used to produce the Cumulative Impact Study, which was designed to provide a complete historic record of the area from the mid-1800's through 1941.

87. Grenell, P. 1991. Non-regulatory approaches to management of coastal resources and development in San Francisco Bay. Environmental Management and Appropriate Use of Enclosed Coastal Seas - EMECS '90. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas '90 held in Kobe, Hyogo Prefecture (Japan), 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 503-507.

San Francisco Bay, California's largest coastal water body, faces problems which may be faced by other large, enclosed bodies of water. Management of the bay's coastal resources, particularly the California State Coastal Conservancy's experience as a non-regulatory problem-solving agency, may be pertinent to situations which either have similar complex regulatory systems as the Bay Area, or which face problems not amenable to regulatory solution.

88. Hayes, M.O., Hoff, R., Michel, J., Scholz, D and Shigenaka, G. 1992. Introduction to Coastal Habitats and Biological Resources for Oil Spill Response. NOAA, Seattle, WA, Coastal Monitoring and Bioeffects Assessment Division Report HMRAD-92-4, 382 pp.

Possible physical, geological, and biological effects of oil spill behavior are examined as a contribution to an effective oil spill response and cleanup in coastal waters.

89. Leschine, T.M. 1990. Setting the agenda for estuarine water quality management: Lessons from Puget Sound. Ocean and Shoreline Management 13 (3-4): 295-313. Special issue: Responses to marine resource change/social sciences perspective.

The Puget Sound Water Quality Authority has had agenda building as its primary mission. The Authority has become increasingly proactive, however, as it has moved from consolidating gains made in other state and federal water quality programs on behalf of Puget Sound to developing new initiatives aimed at long-standing water quality problems. This paper details the interplay between synoptic planning and strategic policy-making during the development of the water quality management program developed through the 1980s.

90. Long, E.R. 1985. Status and trends in sediment toxicity in Puget Sound. In: Oceans '85. Ocean Engineering and the Environment. Vol. 2. Oceans '85 Conference, San Diego, CA, 12-14 Nov. 1985. Institute of Electrical and Electronics Engineers, New York, NY, Report (no report number), pp. 919-925.

Multiple sediment bioassay methods were applied to over 600 sediment samples to determine the toxicity of surficial sediments in Puget Sound. The toxic spots were often associated with past dumping, nearby landfills, storm drains, sewer overflows, or industrial discharges. Significantly toxic sites, those from which the majority of the samples were toxic for over half of the types of test, encompassed about four square miles of the bottom of the Sound and represented about 0.2% of the U.S. portion of the Sound.

91. Long, E.R. and Buchman, M.F. 1990. Comparative evaluation of selected measures of biological effects of exposure of marine organisms to toxic chemicals. In: Biomarkers of Environmental Contamination. Pp. 355-394. Lewis Publishers, Chelsea, MI.

Samples collected at field sites in the San Francisco Bay area and presumed to represent a range in chemical contamination were analyzed for five types of sediment toxicity tests: macrobenthos community composition; sediment profiling photography; induction of hepatic aryl hydrocarbon hydroxylase; induction of hepatic cytochrome P-450 enzymes; plasma steroid hormone concentration; reproductive success; and incidence of micronuclei in erythrocytes of fish. The least and the most contaminated sites differed by approximately an order of magnitude in the concentration of many analytes in sediments. Larval development of *Mytilus edulis* was the most sensitive test. The *Rhepoxynius abronius* test of survival had very high sensitivity. The suite of total cytochrome measures in the fish livers were relatively sensitive.

92. Long, E.R. and Markel, R. 1992. Evaluation of the Extent and Magnitude of Biological Effects Associated with Chemical Contaminants in San Francisco Bay, California. National Ocean Service, Seattle, WA, Office of Ocean Resources Conservation and Assessment Report NOAA-TM-NOS-ORCA-64, 111 pp.

In this report, data from several studies were assembled to provide an estimate of the extent and severity of effects of chemical contaminants potentially toxic to marine and estuarine organisms in sediments and biota of San Francisco Bay. Data from the studies indicated that toxicant-related effects occur among some of the resident biota of the estuary, but the data precluded an identification of the spatial patterns.

93. Lung, W.S., Martin, J.L. and McCutcheon, S.C. 1993. Eutrophication analysis of embayments in Prince William Sound, Alaska. Journal of Environmental Engineering 119 (5): 811-824.

Fertilizers were used in the summer of 1989 to accelerate bacterial growth in a bioremediation effort following the Exxon Valdez oil spill in Prince William Sound. Mathematical models were used to quantify the eutrophication potential in two selected embayments, Passage Cove and Snug Harbor. Mass transport was determined, and eutrophication models were developed to simulate the seasonal algal concentrations prior to fertilizer application. Nutrient-loading scenarios based on different fertilizer application rates were developed to investigate the impact. Model results and the data available indicated that no increased algal growth would be expected following fertilizer application.

94. MacDonald, D.A. 1989. A summary of status and trends in concentrations of selected chemical contaminants and measures of biological stress in San Francisco Bay. In: Oceans '89. The Global Ocean. Vol. 2. Ocean Pollution. Oceans '89 Conference, Seattle, WA, 18-21 Sep. 1989. Marine Technology Society and Institute of Electrical and Electronics Engineers, New York, NY, Report, pp. 647-651.

Concentrations of selected chemical contaminants (Hg, Cd, Cu, Pb, Cr, Ag, PAH, DDT, and PCB) and biological stress were measured in San Francisco Bay as part of the NOAA National Status and Trends Program. Higher concentrations of toxicants were found in peripheral harbors and waterways than in the basins of the Bay. Available data for most measures of contamination or effects did not indicate any long-term trends, but they suggested possible recent decreases in Cd, DDT and PCB concentrations. Only the sediment bioassay data showed a clear relationship between contaminant concentrations and bio-effects. Overall, the recent NOAA-generated data were similar to the historical data.

95. Malek, J. and Phillips, K. 1989. Managing uncertainty in the aquatic environment. In: Oceans '89: The Global Ocean. Vol. 2. Ocean Pollution. Oceans '89, Seattle, WA, 18-21 Sep. 1989. Marine Technology Society, Washington, DC. Institute of Electrical and Electronics Engineers, New York, NY Report IEEE-89CH2780-5, pp. 457-460.

Uncertainties inherent in regulatory decisions for dredged material disposal are identified. The paper describes an integrated approach to addressing uncertainties in aquatic disposal of dredged material in Puget Sound. This approach stresses programmatic rather than case-by-case decisions and recognizes the need for multi-agency cooperation and consensus in addressing complex issues.

96. Malins, D.C., McCain, B.B., Landahl, J.T., Myers, M.S., Krahn, M.M., Brown, D.W., Chan, S.L. and Roubal, W.T. 1988. Neoplastic and other diseases in fish in relation to toxic chemicals: An overview. Aquatic Toxicology 11 (1-2): 43-67.

> Correlations between prevalences of hepatic neoplasms in bottom-dwelling marine fish, such as English sole (*Parophrys vetulus*), and concentrations of toxic chemicals in sediments and bottom fish were investigated in Puget Sound over a five-year period. Statistically significant correlations were found between hepatic neoplasms and sediment concentrations of aromatic hydrocarbons, and concentrations of metabolites of aromatic compounds in the bile. Laboratory studies also showed that high molecular weight aromatic hydrocarbons play a significant role in the etiology of hepatic tumors in bottom-dwelling fish. Associations between chemical exposures and diseases in other marine species from southern California and Boston Harbor are discussed, and similar relationships between liver and skin neoplasms in selected bottom feeding fresh water species and sediment-associated chemicals are presented.

97. McCreary, S., Twiss, R., Warren, B., White, C., Huse, S., Gardels, K. and Roques, D. 1992. Land use change and impacts on the San Francisco estuary. Coastal Management 20 (3): 219-253.

> This article reports on the methods, findings, and policy implications of a major study entitled "The Effects of Land Use Change and Intensification on the San Francisco Estuary." The impacts of future growth on wetlands, streams, and water quality were estimated on a region-wide basis by means of a geographic information system. Only 18 of 111 jurisdictions within the estuary study region have specific ordinances to protect streams and wetlands. The results of the study suggest that improvements are needed in the goals, management strategies, and institutional arrangements for the San Francisco estuary. The study recommends that a specific focus on estuarine resource protection be incorporated in any new growth management legislation enacted in California.

98. Mearns, A.J., Matta, M., Shigenaka, G., MacDonald, D.A., Buchman, M., Harris, H., Golas, J. and Lauenstein, G. 1991. Contaminant Trends in the Southern California Bight: Inventory and Assessment. NOAA Technical Memorandum NOS ORCA 62, 389 pp. + Appendices.

99. Miller, B.S., Moulton, L.L. and Stadler, J.H. 1991. Long-Term Trends in Puget Sound Marine Fishes: Selected Data Sets. Washington University, Seattle, WA, Fisheries Research Institute Report FRI-UW-9105, 50 pp. Environmental Protection Agency, Seattle, WA, Region X Report EPA/910/9-91/010, 50 pp.

The report presents the results of an analysis of long-term trends in marine fishes of Puget Sound based on three existing data sets: geographical distribution data, research beach seine data, and research trawl data. The authors suggest that more non-economically important fish species should be monitored in order to separate trends due to fishery pressures from those that are environmentally driven.

100. Mongeau, J. 1985. Population policies in California's coastal zone. In: 1984-1985 Trainee Report. University of Southern California Sea Grant Report SCU-T-85-001, pp. 17-18.

101. Monroe, M. 1991. Environmental activism in the San Francisco Bay Estuary. Environmental Management and Appropriate Use of Enclosed Coastal Seas - EMECS '90. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas '90 held in Kobe, Hyogo Prefecture (Japan), 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 607-611.

This paper briefly describes the San Francisco Bay Estuary and its modifications, problems associated with habitat loss and degradation, pollutants, freshwater diversion, and dredging. Several examples are given of activities of environmental groups addressing these problems.

102. Myers, M.S., Landahl, J.T., Krahn, M.M. and McCain, B.B. 1991. Relationships between hepatic neoplasms and related lesions and exposure to toxic chemicals in marine fish from the U.S. West Coast. Presented at Symposium on Chemically Contaminated Aquatic Food Resources and Human Cancer Risk, Research Triangle Park, NC, 29-30 Sep. 1988. Environmental Health Perspectives 90: 7-15.

English sole (*Parophrys vetulus*) that inhabit polluted waterways and embayments of Puget Sound are affected with hepatic lesions and neoplasms. In wild English sole, exposure to certain hepatotoxic and hepatocarcinogenic xenobiotic compounds in the marine environment has shown significant and consistent statistical associations between levels of aromatic hydrocarbons in sediment and prevalences of these liver lesions. Hepatic lesions have also been seen in white croaker (*Genyonemus lineatus*) from contaminated marine sites near Los Angeles, California.

103. Pastorak, R. and Ginn, T. 1987. Action-assessment strategy for toxic contamination problems in urban embayments of Puget Sound. In: Proceedings of the Tenth National Conference, Estuarine and Coastal Management Tools of the Trade. New Orleans, LA, 12-15 Oct. 1986. Lynch, M.P. and McDonald, K.L. (ed.). Vol. 1, p. 348.

Examples of an action-assessment method for identifying and ranking problem areas in Elliott Bay, Commencement Bay, and Everett Harbor are presented. The approach relies on identification of toxic hot spots using a weight-of-evidence concept and data on sediment contamination, bioaccumulation (body burdens in marine organisms), sediment toxicity to the amphipod *Rhepoxynius abronius*, abundance of benthic macroinvertebrate taxa, and prevalence of liver lesions in English sole. Once problem areas have been identified, they are ranked, and sources of problem chemicals are evaluated. Potential remedial alternatives are developed through workshop sessions with regulatory and resource-management agencies.

104. Pritchard, P.H. 1991. Bioremediation as a technology: Experiences with the Exxon Valdez oil spill. Journal of Hazardous Materials 28: 115-130.

In Prince William Sound, the addition of fertilizers increased the natural rate of biodegradation of oil from the Exxon Valdez.

105. PTI Environmental Services, Bellevue, WA. 1991. Pollutants of Concern in Puget Sound. Environmental Protection Agency, Seattle, WA, Region X Report EPA/910/9-91/003, 127 pp.

The report, which replaces and updates the 1986 User's Manual for the Pollutant of Concern Matrix, includes regulatory status, analytical considerations, criteria, guidelines, regulatory action levels, sources, and concentrations of 64 pollutants in Puget Sound. Each pollutant is described in a narrative which contains information on exposure routes and risks, and sources and fate in the environment. The report is useful for permit writers and reviewers, environmental impact statement writers and reviewers, and resource managers.

106. Rensel Associates, Seattle, WA. 1991. Nutrients and Phytoplankton in Puget Sound. Environmental Protection Agency, Seattle, WA, Region X Report EPA/910/9-91/002, 156 pp.

The report summarizes the current knowledge concerning nutrient-phytoplankton relationships in Puget Sound and discusses water-quality problems associated with increased nutrients and phytoplankton blooms. Some of the results include increased paralytic shellfish poisoning and fish kills in mariculture facilities.

107. Rote, J.W. 1985. Science and the management of San Francisco Bay. In: Proceedings of the Tampa Bay Area Scientific Information Symposium. Tampa Bay,

FL, 3-6 May 1982. Treat, S.F., Simon, J.L., Lewis, R.R., III and Whitman, R.L. (ed.). Florida Sea Grant Program Report FSGR-65, pp. 1-6.

108. Salazar, M.H. and Salazar, S.M. 1990. Mussels as bioindicators: A case study of tributyltin effects in San Diego Bay. Proceedings of the 17th Annual Aquatic Toxicology Workshop, pp. 47-75.

As part of a Navy research program, the effects of tributyltin (TBT) antifouling coatings were investigated on mussels. Seasonal mussel transplants and chemical sampling showed temporal and spatial variability in TBT, and the effects of TBT on growth, bioaccumulation, and survival were reported.

109. Stein, J.E., Collier, T.K., Reichert, W.L., Casillas, E., Hom, T. and Varanasi, U. 1993. Bioindicators of contaminant exposure and sublethal effects in benthic fish from Puget Sound, WA, USA. Marine and Environmental Research 35: 95-100.

110. Varanasi, U., Chan, S.L., McCain, B.B., Schiewe, M.H. and Clark, R.C. 1988. National Benthic Surveillance Project: Pacific Coast. Part I: Summary and Overview of the Results for Cycles I to III (1984-86). NOAA Technical Memorandum NMFS F/NEC-156, 64 pp.

The distribution of chemical contaminants sampled during 1984-1986 has been incorporated into a database. These contaminants include selected aromatic hydrocarbons, PCBs, organochlorine insecticides and metals in surficial sediments and in liver tissue, bile, and stomach contents of selected bottom-feeding fish. This technical memorandum, the first part of a two-part report which summarizes the results of the first three years of the West Coast portion of the National Benthic Surveillance Project, is an overview of findings. The highest concentrations of most sediment-associated contaminants were present in the highly urbanized areas and contaminants were bioavailable to indigenous marine species.

111. Varanasi, U., Chan, S.L., McCain, B.B., Schiewe, M.H. and Clark, R.C. 1989. National Benthic Surveillance Project: Pacific Coast. Part II: Technical Presentation of the Results for Cycles I to III (1984-86). NOAA Technical Memorandum NMFS F/NEC-170, 248 pp. Available from the National Technical Information Service, Springfield, VA.

This technical memorandum, second part of a two-part report, summarizes the results of the first three years of the West Coast portion of the National Benthic Surveillance Project. Detailed descriptions of sampling strategies, analytical methods, and data are presented. The highest concentrations of most sediment-associated contaminants were present in the highly urbanized areas

and contaminants were bioavailable to indigenous marine species. No correlation was found between concentrations of most of the measured metals in sediment and in liver tissue of the target fish species. Of all the sites sampled, the most contaminated sites were located in Commencement Bay (Tacoma), San Diego Bay, Elliott Bay (Seattle), and San Pedro Bay (Los Angeles/Long Beach).

112. Varanasi, U., McClain, B.B., Stein, J.E. and Chan, S.L. 1993. Effects of coastal pollution on living marine resources. In: Transactions of the Fifty-Eighth North American Wildlife and Natural Resources Conference. Washington, DC, 19-24 Mar. 1993, pp. 271-286.

113. Williams, P.B. 1989. Managing freshwater inflow to the San Francisco bay estuary, California, USA. Regulated Rivers Research and Management 4 (3): 285-298.

The watershed of California's Central Valley drains into San Francisco Bay. The water resources of the Valley have been intensively exploited, particularly in the last 50 years, with the construction of dams and large-scale irrigation systems. These water diversions are having adverse effects on the estuarine ecosystem, including declines in the economically significant anadromous fishery. Growing recognition of the problem has led the California state agency that governs water allocation to consider applying operating conditions on the upstream reservoirs in order to provide sufficient freshwater inflows in the estuary to maintain the estuarine ecosystem. Freshwater flow and salinity standards have been proposed and are described in this paper. These flow requirements are based on extensive research on the role of freshwater inflow on estuarine hydrodynamics and on the estuarine ecosystem.

1C. GULF COAST ECOSYSTEMS

114. Brooks, J.M., Wade, T.L., Dennicutt, M.C., Weisenburg, D.A. and Wilkinson, D. 1992. Toxic Contaminant Characterization of Aquatic Organisms in Galveston Bay: a Pilot Study. Galveston Bay National Estuary Program Report GBNEP-20, 352 pp.

Trace contaminants were analyzed in five species of edible fish and shellfish from four sites in Galveston Bay. The trace contaminants included heavy metals, polynuclear aromatic hydrocarbons, pesticides, and PCBs. The analyses showed that oyster and crab tissues contained more trace contaminants than did fish tissues.

115. Cairns, S. 1992. Distribution of Selected Fish Species in Tampa Bay. Environmental Protection Agency, St. Petersburg, FL, Tampa Bay National Estuary Program Report TBNEP-05-92, 62 pp.

Ten fish species were selected for distribution analysis in Tampa Bay. Extensive spring and fall samplings were conducted, and an index of relative abundance was developed that described zero, low-to-medium, and high catch-per-unit-effort in one-degree grids of latitude and longitude. Analyses showed that several species concentrated in tributaries during one or more seasons.

116. Dowgiallo, M.J. (ed.). 1994. Coastal Oceanographic Effects of Summer 1993 Mississippi Flooding. Special NOAA Report, 76 pp. NOAA Coastal Ocean Office/National Weather Service, Silver Spring, MD.

The Great Flood of 1993 inundated over 15 million acres in nine states and had adverse effects on the population, on the economy of the region, and on the natural environment. The flood event was exceptional due to the combination of the preceding persistent wet meteorological pattern, severity, off-season occurrence (floods generally occur in spring), duration, and damage. The flood sent large volumes of fresh water down the Mississippi during a time of year normally characterized by lower flows. Higher stream-flow in the lower Mississippi River caused higher surface water temperatures and lower salinities offshore. As a result of the increased stream flow, overall loading of nutrients and agricultural herbicides was greatly increased. Increased nutrient loading was followed by increased phytoplankton biomass in the coastal waters adjacent to the Mississippi and Atchafalaya River outflows. Death and decomposition of the phytoplankton caused hypoxic bottom waters of the Louisiana coast in July 1993 that were approximately twice as large as the average hypoxic area mapped since 1985.

117. Environmental Protection Agency. 1990. The Environmental and Economic Status of the Gulf of Mexico. Proceedings of the Symposium. New Orleans, LA, 2-5 Dec. 1990, 186 pp. Environmental Protection Agency, Gulf of Mexico Program Office, Stennis, MS.

118. Fay, R.R., Sweet, S. and Wilson, R.J. 1991. Shoreline Survey for Unpermitted Discharges to Galveston Bay. Galveston Bay National Estuary Program Report GBNEP-12, 50 pp.

> Low altitude aerial surveys and shallow draft small boat surveys were used in a pilot study to determine the extent of unpermitted discharges along 159 miles of shoreline. Nine shoreline types were surveyed. The locations of both permitted and unpermitted discharges were documented.

119. Foldman, L., Hosking, W., Lowery, T. and Skupien, L.A. 1987. Mobile Bay: An Update. Executive Summary of the Symposium on the Natural Resources of the Mobile Estuary. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS Report MASGP-87-032, 28 pp.

> The report describes Mobile Bay and summarizes water quality, wetlands losses, waste discharges, biological diversity, land acquisition, education, recreation and tourism, navigation and industry, residential and commercial development, transportation, zoning, and coastal programs.

120. Haddad, K.D., McGarry, G.A, Matheson, R.E., Rydene, D.A. and Peters, K.M. 1990. Marine Resources Geographic Information System and Fishery Resources. National Oceanic and Atmospheric Administration, Washington, DC, Office of Ocean and Coastal Resource Management, and Florida State Department of Environmental Regulation, Tallahassee, Office of Coastal Management, Final Report, 263 pp.

> The report summarizes the activities associated with the implementation of the Marine Resources Geographic Information System for the Little Manatee River watershed in the Tampa Bay area. The GIS includes a SPOT base map, 1988 land use and land cover, FEMA flood maps, soils, future land-use plan,elevation, habitat cover, transportation, and hydrology. Results indicate that the Little Manatee River responds to salinity change, and alterations in water flow caused by drought can impact fish distribution.

121. Hochberg, R.J., Weisberg, S.B. and Frithsen, J.B. 1992. Design of a Basin-wide Monitoring Program for the Tampa Bay Estuary. Environmental Protection Agency, St. Petersburg, FL, Tampa Bay National Estuary Program Report TBNEP-09-92, 92 pp.

A Comprehensive Conservation and Management Plan (CCMP) is being developed by the Tampa Bay National Estuary Program to recommend management actions for protecting the estuary. The report defines the objectives of a monitoring program, including indicators and a sampling design, and identifies how existing monitoring programs can be incorporated and/or modified.

122. Johnson, A.F., Muller, J.W. and Bettinger, K.A. 1991. Assessment of Florida's Remaining Coastal Upland Natural Communities: Panhandle. Final report. Florida Natural Areas Inventory Report, 145 pp. Sponsored by National Oceanic and Atmospheric Administration, Washington, DC, Office of Ocean and Coastal Resource Management, and Florida Department of Natural Resources, Tallahassee.

Existing data on 20-acre or larger occurrences of certain coastal upland natural communities were identified and entered into the Florida Natural Areas Inventory (FNAI). Field surveys were conducted on 34 sites in panhandle Florida, and data were collected on plant species, community structure, presence or absence of uninterrupted transitions between communities, degree of invasion by exotic species, and physical disturbance. Sites were then compared and ranked. All 19 sites in public ownership were ranked as good and eight were ranked excellent; of the 15 sites in private ownership, seven were ranked excellent and seven as good. The major coastal upland community not well represented on public lands was oak scrub, which occurred on five of the seven sites in private ownership that were ranked as excellent. Five rare plant species were found in this sector of the coast.

123. Johnson, A.F. and Muller, J.W. 1992. Assessment of Florida's Remaining Coastal Upland Natural Communities: Southwest Florida. (March 1992). Final report. Florida Natural Areas Inventory Report, 161 pp. Sponsored by National Oceanic and Atmospheric Administration, Washington, DC. Office of Ocean and Coastal Resource Management, and Florida Department of Natural Resources, Tallahassee.

Existing data on 20-acre or larger occurrences of certain coastal upland natural communities were identified and entered into the Florida Natural Areas Inventory (FNAI). Field surveys were conducted on 52 sites in southwest Florida, and data were collected on plant species, community structure, presence or absence of uninterrupted transitions between communities, degree of invasion by exotic species, and physical disturbance. Sites were then compared and ranked. Fifteen sites in public ownership were ranked as good and 16 were ranked excellent; of the 22 sites in private ownership, six were ranked excellent and eight were ranked as good.

124. Killam, K.A., Hochberg, R.J. and Rzemien, E.C. 1992. Synthesis of Basic Life Histories of Tampa Bay Species. Environmental Protection Agency, St. Petersburg, FL, Tampa Bay National Estuary Program Report TBNEP-10-92, 255 pp.

The purpose of the Tampa Bay National Estuary Program is to characterize habitat types favorable to the endemic fish and wildlife species. The information will be used to determine strategies for habitat restoration and protection. Two general life history patterns have emerged from the species summaries; some species remain in the estuary during their entire life cycle, while others spawn outside the estuary and the eggs, larvae, or juveniles are swept back into the estuary by the tides or currents. In both situations, the estuary serves as a nursery and development area.

125. Lewis, R.R. and Estevez, E.D. 1988. Ecology of Tampa Bay, Florida: An estuarine profile. Mangrove Systems, Inc., Tampa, FL. Biological Report 85(7.18), 132 pp. Available from the National Technical Information Service, Springfield, VA. 22161, as PB89-130488.

Tampa Bay is Florida's largest open-water estuary and one of the most highly urbanized. This report synthesizes many years of scientific investigation into Tampa Bay's geology, hydrology and hydrography, water chemistry, and biotic components. The estuary is a phytoplankton-based system, with mangroves being the second most important primary producer. Benthic organisms are abundant and diverse, although in parts of the bay the benthos consists of relatively few opportunistic and pollution-tolerant species. The estuary provides habitat for the juveniles and adults of many commercial and recreational fishery species. As a result of urbanization and industrialization, significant declines have occurred in intertidal wetlands and seagrass meadows, circulation and flushing have changed, and water quality has declined.

126. Long, E.R., MacDonald, D. and Cairncross, C. 1991. Status and Trends in Toxicants and the Potential for Their Biological Effects in Tampa Bay, Florida. National Ocean Service, Seattle, WA, Office of Ocean Resources, Conservation, and Assessment Report NOAA-TM-NOS-OMA-58, 85 pp.

The report provides a synthesis and evaluation of information from many surveys and programs concerning the concentrations of selected toxicants in sediments and biota, and estimations of the biological effects that may result or have resulted from exposure of biota to these toxicants.

127. Lowery, T.A. 1987. Symposium on the Natural Resources of the Mobile Bay Estuary. Mississippi-Alabama Sea Grant Consortium, Ocean Springs MS Report MASGP-87-007, 218 pp.

The report includes fisheries research and management; benthic and wetland resources; habitat preservation, restoration, and mitigation; educational efforts; hydrography; circulation; water quality; and pollutants of Mobile Bay estuary.

128. NOAA AOML Ocean Chemistry Division. 1993. The Proceedings of a Workshop on Future Research, Monitoring and Modeling of Coastal Interactions in the Northern Gulf of Mexico. Miami, FL, 2-3 Feb. 1993, 54 pp.

This document presents the consensus of a workshop to asses the results of the Nutrient Enhanced Coastal Ocean Productivity (NECOP) program in the northern Gulf of Mexico in terms of NOAA's management responsibilities. The environmental perturbations and their consequences were described as three linked levels: exposure/inputs; primary ecosystem responses, and impacts/integrative outputs. Based on workshop discussions and Working Group reports, a new program entitled the Mississippi-Atchafalaya Coastal Interaction Initiative (MACII) was proposed. In the new program, research efforts would identify ecosystem response parameters and define appropriate space and time scales; monitoring efforts would assemble date sets of varied spatial scales and short and long-term time series measurements; and modeling efforts would refine the NECOP model.

129. NOAA Coastal Ocean Program Office. 1992. Nutrient Enhanced Coastal Ocean Productivity: NECOP Workshop Proceedings. Louisiana Universities Marine Consortium, Oct. 1991. Texas A&M University Sea Grant Publication TAMU-SG-92-109, 153 pp.

In 1989, NOAA initiated NECOP as the first field effort of the Coastal Ocean Program. The long-term goal of NECOP is to conduct generic studies of nutrient loading to ecosystems of the coastal U.S. Field work began in summer 1990 in the shelf waters of Louisiana and Texas influenced by the Mississippi and Atchafalaya River (MAR) system. This report summarizes the observations and preliminary interpretations presented at the October 1991 workshop. NECOP includes monitoring and process studies, as well as a modeling effort.

130. Osborn, M., Chai, P., Green, A., Lin, J. and Loeffler, C. 1992. Status and Trends of Selected Living Resources in the Galveston Bay System. Environmental Protection Agency, Austin, TX, Galveston Bay National Estuary Program Report GBNEP-19, 472 pp.

The report attempts to assess the relative health of the Galveston Estuary ecosystem by evaluating the increases and declines of selected endemic species. The species were selected based on their ecological use in the system or on their economic importance.

131. Ramsay, M., Boynton, W. and Clark, P. 1992. Framework for Characterization (Revised Final Report March 1992). Environmental Protection Agency, St. Petersburg, FL, Tampa Bay National Estuary Program Report TBNEP-01-92, 64 pp.

Prior to the development of the Comprehensive Conservation and Management Plan for the Tampa Bay National Estuary Program, the problems of the bay must be identified and linked to causes. This process is called characterization. Characterization workshops held in June and July 1991 focused on living resources and water quality deterioration.

132. Reynolds, J.E. and Patton, G.W. 1985. Marine mammals, reptiles and amphibians of Tampa Bay and adjacent coastal waters of the Gulf of Mexico. In: Proceedings of the Tampa Bay Area Scientific Information Symposium. May 1982. Florida Sea Grant College Report 65, pp. 448-459.

133. Wade, D.L. and Janicki, A.J. 1992. Compendium of Current Monitoring Programs in Tampa Bay and its Watershed. Environmental Protection Agency, St. Petersburg, FL, Tampa Bay National Estuary Program Report TBNEP-02-92, 96 pp.

Ongoing, recently suspended, and proposed monitoring programs for Tampa Bay and its watershed were identified and summarized. The status, objectives, approach, sample selection method, and level of sampling effort were described for each program.

134. Williams, S.J. and Sallenger, A.H. 1990. Loss of coastal wetlands in Louisiana: Cooperative research to assess the critical processes. In: Federal Coastal Wetland Mapping Programs. A report by the National Ocean Pollution Policy Board's Habitat Loss and Modification Working Group. Fish and Wildlife Service Biological Report 90 (18): 139-144.

The coastal plain of Louisiana contains 40% of the tidal wetlands in the contiguous 48 states. The barrier islands that provide a natural buffer for Louisiana's deltaic plain environments are eroding at a rate of 20 m/yr, while wetlands losses are about 100 km^2/yr. In response to these problems and the lack of understanding of the processes causing erosion and land loss, the U.S. Geological Survey has, since 1986, conducted field investigations in Louisiana. Research elements included in the studies of Louisiana's coastal barriers and wetlands are: (1) the shallow geologic framework; (2) documentation by maps and aerial photographs of the physical changes that have occurred during the past 135 yrs; (3) measurements of several critical processes in the coastal zone and in a typical sediment-starved or sediment-rich basin; and (4) transfer of the results and findings to coastal resource managers.

135. Woodward-Clyde Consultants. 1985. Southwest Florida Shelf Ecosystems Study. Year 2. Volume 1. Executive summary. OCS Report, Minerals Management Service MMS/GM-85/0060, 96 pp.

Benthic communities and habitats off southwest Florida from Florida Bay northward to Charlotte Harbor, in depths from 20 to 200 meters, were studied. Both "live" and soft bottom regions were sampled using conventional trawls, dredges, and grabs. Habitats were described along six transects using underwater television cameras, still cameras, side-scan-sonar, and shallow subbottom profilers. Sediments were analysed for total organic carbon, carbonate, grain size, hydrocarbons, and trace metals. Water column descriptions included dissolved oxygen, salinity, and temperature; photometer and transmissivity profiles; and analyses of nutrients, chlorophyll, and yellow substance.

1D. GREAT LAKES COASTS ECOSYSTEMS

136. Allan, R.J. and Ball, A.J. 1990. Overview of toxic contaminants in water and sediments of the Great Lakes. Water Pollution Research Journal of Canada 25 (2): 1-309.

This review of selected toxic chemical concentrations in the water and sediments of the Great Lakes and their connecting channels includes sources, pathways, and fate of the chemicals, and a history of contamination. Lead, mercury, cadmium, arsenic, DDT and metabolites, dieldrin, lindane, mirex, toxaphene, dioxins, furans, and PCBs are discussed.

137. Allee, D.J. and Dworsky, L.B. 1990. Breaking the incrementalist trap: achieving unified management of the Great Lakes ecosystem. In: International and Transboundary Water Resources Issues. American Water Resources Association, Bethesda, MD, pp. 213-227.

In normal times only small changes in policy can find agreement, but policy change windows occur when the sense of crisis is great and it can be expected that there will be support to act and to ignore at least some objections that would become road blocks in normal times. A definition of the Great Lakes as an ecosystem and the application of that definition suggests the basis for the development of policy windows as well as the current need for issue resolution. Two efforts currently provide new opportunities to manage the Great Lakes as an integrated ecosystem: the wide ranging effort of the International Joint Commission (IJC), and the carrying out of its responsibilities of the Great Lakes Water Levels Reference; and the creation of an Ecosystem Study Board to gain a Great Lakes ecosystem perspective that is not tied to a specific issue.

138. Amacher, G.S., Brazee, R.J., Bulkley, J.W. and Moll, R.A. 1988. Interdisciplinary Approach to Valuation of Michigan Coastal Wetlands. Michigan Institute of Water Research, E. Lansing, Technical Report 88-G1429-02, 101 pp.

Because of the continuing loss of wetlands, there is a need to apply proper economic methods to value them. This study establishes three requirements to produce accurate values for coastal wetlands: incorporation of ecology and economics; applicability to different regions and sites, and capability of addressing multiple sites simultaneously. In the article, attempts are made to apply six market and non-market valuation techniques for the purpose of valuing the biological and economic functions of Michigan's coastal wetlands. These methods are the environmental quality as input, implicit price hedonics, energy analysis, contingent valuation, travel cost, and property hedonics.

139. Amacher, G.S., Brazee, R.J., Bulkley, J.W. and Moll, R.A. 1989. Application of Wetland Valuation Techniques: Examples from Great Lakes Coastal Wetlands. Michigan Institute of Water Research, East Lansing, Technical Report 88-G1569-02, 48 pp.

Because previous valuation studies of Michigan's coastal wetlands failed to value individual wetland ecological functions and used improper techniques to derive wetland values, Michigan wetlands have been undervalued. This report used existing Michigan wetland data and proper economic methods to value recreational fishing, commercial fishing, and real estate benefits for Lake St. Clair and Saginaw Bay wetlands. Wetland values calculated in this report are better than in previous work, but additional data are required to develop more accurate values. Required modifications of existing market and non-market valuation procedures are discussed.

140. Bicknell, D.J. 1992. Ranking Great Lakes persistent toxics. Water Environment and Technology 4 (7): 50-55.

The International Joint Commission-Great Lakes Water Quality Board has recommended the virtual elimination of persistent toxics (PTs) to the Great Lakes Basin ecosystem. As one step toward fulfilling the final objectives, the pollution prevention plan requires the determination of those PTs that are of greatest risk to the quality of the Great Lakes system. General Motors has developed a system that uses toxicity, persistence, and fate factors to rank PTs. After specific factors and fate-group weight values have been selected, a PT can be ranked. PT ranking indicates that halogenated polycyclic hydrocarbons, such as many pesticides, are the greatest concern to Great Lakes water quality. These PTs have three common features: medium to high toxicity, long half-lives, and high bioaccumulation values.

141. Caldwell, L.K. 1987. Implementing an ecological approach to basin-wide management. In: Abstracts of Papers, 153rd National Meeting AAAS. Chicago, IL, 14-18 Feb. 1987, p. 31.

Article I(g) of the Great Lakes Water Quality agreement of 1978 between Canada and the United States defined the Great Lakes ecosystem and declared that "...restoration and enhancement of the boundary waters cannot be achieved independently of other parts of the Great Lakes Basin ecosystem with which these waters interact." The implementation of the Agreement, however, has been delayed because management of the Lakes is inherently social and political, and not strictly technical or scientific. Nevertheless, Canada and the United States are formally committed to the Basin-wide ecosystem approach to management policy for the Lakes.

142. Carter, D.S. and Hites, R.A. 1992. Fate and transport of Detroit River derived pollutants throughout Lake Erie. Environmental Science and Technology 26 (7): 1333-1341.

The fate and transport of Detroit River derived sediment-bound pollutants in Lake Erie were investigated by the analysis of 2,4-di-tert-pentylphenol (24DP), an unusual sediment-bound pollutant originating from a single point source on the Trenton Channel of the Detroit River. When 24DP depositional histories were determined in 25 dated sediment cores taken throughout Lake Erie in 1988-9, 24DP was found in sediments throughout the lake from the mid-1930s on. Maximum deposition occurred in 1966-1970 in all three basins of the lake. Mass balance was applied in a three-compartment model to determine pollutant accumulation rates in each basin and inter-basin transport rates. About 73% of Detroit River derived, sediment-bound pollutants accumulated in the western basin of Lake Erie (especially within 20-30 km of the mouth of the river); about 20% accumulated in the central basin, and approximately 5% accumulated in the deep eastern basin.

143. Depinto, J.V. 1991. State of the Lake Ontario ecosystem. Introduction to an ecosystem. Perspective on a vital resource. Canadian Journal of Fisheries and Aquatic Sciences 48 (8): 1500-1502.

This paper provides an overview of the physical, toxic, resources, management, economic, and aesthetic aspects of Lake Ontario. It also serves as an introduction to a compendium of ten papers which form the basis of a new ecosystem perspective for Lake Ontario.

144. Donahue, M.J. 1986. Institutional Arrangements for Great Lakes Management: Past Practices and Future Alternatives. Michigan Univ., Ann Arbor. Ph.D. Dissertation, 551 pp. Available from University Microfilms International, Ann Arbor, MI 48106, Order No. 8702720.

Institutional arrangements for regional resource management in the Great Lakes Basin were analyzed in light of five objectives: provision of a historical perspective in the United States and Canada; identification of organizational characteristics and management strategies; exploration of the linkages between the components of the Great Lakes institutional ecosystem and identification of means for strengthening them; development of essential guidelines and organizational criteria for a viable institution or set of institutions; and design of alternative institutional arrangements to encourage the orderly and informed evolution of the Great Lakes institutional ecosystem. Theoretical and applied literature, personal interviews, a questionnaire survey, and observation and analysis of relevant institutions served as the information sources.

145. Donahue, M.J. 1987. The "institutional ecosystem" for Great Lakes management: Elements and interrelationships. In: Abstracts of Papers, 153rd National Meeting AAAS. Chicago, IL, 14-18 Feb. 1987, p. 30.

The Great Lakes system is a shared, multipurpose resource used and managed at every level from local to international. Two federal governments, eight states and two provinces share the basin and hundreds of governmental entities are charged with some aspect of the resource management task. The institutional ecosystem is explored in this paper, focussed on the elements and inter-relationships; the rationale for institutional complexity; the importance of institutional considerations in shaping the region's resource and economic profile; the strengths and weaknesses of present arrangements; and proposals and prospects for institutional revision.

146. Environment Canada, Ottawa. 1991. Toxic Chemicals in the Great Lakes and Associated Effects. Vol. 1. Contaminant Levels and Trends. Department of Fisheries and Oceans, Ottawa, and Health and Welfare Canada, Ottawa, Report SSC-EN37-95/1990-1E, 498 pp.

The concentrations of lead, mercury, cadmium, arsenic, DDT and metabolites, dieldrin, alpha-BHC, lindane, mirex, toxaphene, benzo(a)pyrene, dioxins and furans, HCB, HCBD, and PCBs are summarized in Great Lakes water, sediments, invertebrates, fish, wildlife, and humans. The history of contamination and the sources, pathways, and fate of the chemicals are described.

147. Environment Canada, Ottawa. 1991. Toxic Chemicals in the Great Lakes and Associated Effects. Vol. 2. Effects. Department of Fisheries and Oceans, Ottawa, and Health and Welfare Canada, Ottawa, Report SSC-EN37-95/1990-1E, 273 pp.

The effects of persistent toxic chemicals are reviewed in fish, wildlife, and humans, and a synthesis is presented of the data in the two volumes.

148. Evans, D.O., Warren, G.J. and Cairns, V.W. 1990. Assessment and management of fish community health in the Great Lakes: Synthesis and recommendations. Journal of Great Lakes Research 16 (4): 639-669.

Fish community health is being studied as a conceptual framework for assessing the effects of toxic chemicals and other anthropogenic influences on fish communities in the Great Lakes. The methods employed reflect the diversity of stressors operating on the fish communities, but they have been applied within relatively narrow disciplinary perspectives. There is a need for broader perspectives and interdisciplinary investigation of the effects of

stressors. A field-oriented epidemiological approach is recommended for monitoring and assessing fish community health, supported by trans-disciplinary investigative teams for resolving ecosystem problems. The Areas of Concern under Annex 2 of the 1978 Great Lakes Water Quality Agreement are suggested as sites for experiments involving deliberate manipulation of ecosystem processes, not only to rehabilitate these areas, but also to improve understanding of the structural and functional properties of these systems, and to provide feedback for adjustment of the selected management options.

149. Fetterolf, C.M., Jr. 1985. Ecosystem Management and Institutions: Great Lakes. In: Programs and Abstracts, 28th Conference on Great Lakes Research. Milwaukee, WI, 3-5 Jun. 1985, p. 38.

The Great Lakes basin includes approximately 300,000 mi^2 and covers parts of two countries, one province, and eight states. Despite the fractionated responsibility for management, the Great Lakes are more ecologically stable than in the recent past. Managers and regulators are addressing such inter-jurisdictional and interdisciplinary issues as atmospheric contamination; leaking landfills containing toxic wastes; flow regimes below Lake Superior; residues of persistent contaminants in fish, birds, and humans; phosphorus control; Indian treaty fishing rights; water diversions; and allocation of resources among jurisdictions and user groups. There is an increasing awareness, both by the public and governments, of the need for management based on an environmental ethic and the ecosystem approach rather than the partitioned methods currently in use.

150. Flint, R.W. 1985. Biological control as a management strategy in the Great Lakes. Journal of the Washington Academy of Sciences 75 (4): 85-90.

This paper discusses alternatives to present chemical or other unnatural management strategies and focuses on the use of natural biological systems in the Great Lakes to mitigate or eliminate nuisances such as aquatic weeds and sea lamprey. The control of aquatic weed growth through enhanced grazing by crayfish is discussed, and predation by lake sturgeon is emphasized for the control of sea lamprey parasites on game fish.

151. Foy, J. 1988. Air toxics and the Great Lakes. Environmental Education and Information 7 (4): 192-194.

Air toxicants that pollute the Great Lakes and recent programs designed to address this pollution problem are reviewed. The atmosphere is believed to contribute 39-97% of the lead and 6-90% of the polychlorinated biphenyls (PCBs) that enter the lakes' waters. Efforts to control the introduction of toxic

substances into the Lakes and their tributaries included the Great Lakes Toxics Control policy resolution adopted by Great Lakes Governors. The policy's task force drafted the Great Lakes Toxic Substances Control Agreement to establish a framework for coordinating regional action in controlling toxic pollutants. In September 1986, the Environmental Administrators of the Great Lakes States agreed that each state in the region will seek to gain the authority to address the problem of air toxic emissions and their effects on the Lakes.

152. Francis, G.R. 1986. Evolving governance and management arrangements. In: IAGLR Program, 29th Conference of the International Association for Great Lakes Research. Scarborough, Ont. (Canada), 26-29 May 1986, p. 34.

Incongruous institutional arrangements and practices are found among Great Lakes issues. Inherent complexity and uncertainty in socio-ecosystems are reviewed and discussed with reference to three domains in the Great Lakes: areas of concern in need of rehabilitation, areas having sensitive ecological values in need of protection, and toxics control.

153. Gannon, J.E., Edwards, C.J., Reynoldson, T.B. and Hartig, J.H. 1986. Indicator approaches used in the Great Lakes International Surveillance program. In: Oceans '86 Science, Engineering, Adventure: National Symposium on Monitoring Strategies. Washington, DC, 23-25 Sep. 1986. Conference Record, Vol. 3. Marine Technology Society, and IEEE Report IEEE-86CH2363, pp. 894-900.

The traditional emphasis on water chemistry (conventional pollutants and algal nutrients) in the joint U.S. and Canadian Great Lakes International Surveillance Plan (GLISP) has recently been expanded to include toxic substances and a basin-wide approach. Toxic substances problems in the Great Lakes have prompted a new integrated approach to monitoring, one which uses pollutant fate and distribution in water and sediment and in biota.

154. Glass, G.E., Sorensen, J.A, Schmidt, K.W., Rapp, G.R., Jr., Yap, D. and Fraser, D. 1991. Mercury deposition and sources for the upper Great Lakes region. Water Air and Soil Pollution 56: 235-250.

Mercury (Hg) concentrations in precipitation were measured in northeastern Minnesota to investigate depositional trends, relationships with major cations and anions, and possible source emission regions. During 1987-1990, environmentally significant amounts of Hg were found in precipitation and air and were subsequently deposited to remote lake watersheds. Volume-weighted concentrations of total Hg in precipitation averaged about 18 ng Hg/L with calculated annual depositions near 15 $\mu g\ Hg/m^2$. Mercury concentrations in precipitation were positively correlated with major ions, conductivity, and pH,

and were negatively correlated with precipitation volume. From measurements of Hg in rain concentrations as a function of time within events, scavenging ratios for "washable" Hg were calculated to be 140 ± 80 (mass based at a 1 mm/hr precipitation rate). Up to about 10% of the total Hg in air is subject to washout by precipitation for a given event. Air parcel back-trajectories indicated that possible source regions within 72-hr travel time were located mostly to the south, southeast, and southwest, up to 2500 km distance away but local sources may also be important.

155. Gobas, F.A.P.C. 1993. A model for predicting the bioaccumulation of hydrophobic organic chemicals in aquatic food-webs. Application to Lake Ontario. Ecological Modelling 69 (1-2), 1-17.

A model is presented for estimating water and sediment concentrations of hydrophobic organic substances in organisms of aquatic food webs. The model, when applied to the Lake Ontario food web, was in satisfactory agreement with field data. Since the model only requires basic data to characterize the organisms of the food web, chemical properties and environmental conditions, the model is a practical tool for the management of organic contaminants on an ecosystem level.

156. Hallett, D.J. 1986. Decontamination of the Great Lakes ecosystem. In: IAGLR Program, 29th Conference of the International Association for Great Lakes Research. Scarborough, Ont. (Canada), 26-29 May 1986, p. 35.

The Great Lakes ecosystem has been adulterated with anthropogenic toxic chemicals since the advent of its industrialization. In sequence, human health concerns have arisen over drinking water, the sale of commercial fish, and the consumption of sport fish. In the 1980's, toxic chemicals were linked to surface interaction of the lakes with the atmosphere, and humans were found to be contaminated with Great Lakes contaminants. In order to prevent exposure of future generations, the ecosystem must be decontaminated. The hypothetical assessment of impact must be replaced with the estimation of loading potential, the cost to reduce loading sources, the extent of control possible, and the allocation of loading reductions.

157. Harris, H.J., Sager, P.E., Richman, S., Harris, V.A. and Yarbrough, C.J. 1987. Coupling ecosystem science with management: A Great Lakes perspective from Green Bay, Lake Michigan, USA. Environmental Management 11 (5): 619-626.

Continued resource degradation in several Great Lakes areas has led to doubts of the adequacy of conventional science and management approaches. The need for an ecosystem approach appears to be widely accepted. One problem

of implementing an ecosystem approach is forging the link between ecosystem-based research and management. For Green Bay, Wisconsin, structural and functional qualities of the ecosystem have been used to define operational guides, to formulate management objectives, and to develop a remedial action plan.

158. Harris, H.J., Harris, V.A., Regier, H.A. and Rapport, D.J. 1988. Importance of the nearshore area for sustainable redevelopment in the Great Lakes with observations on the Baltic Sea. Ambio 17 (2): 112-120.

The ecological systems of the nearshore waters and wetlands are similar in the Baltic and Great Lakes Basins. *Fucus spp* (bladderwrack) dominates the more saline parts of the Baltic, whereas the attached algal community in the Great Lakes that is broadly comparable is relatively less important. Nearshore waters and wetlands modulate sharp influences such as nutrient pulses and floods, and provide locales and resources for critical reproductive and feeding periods of large organisms (fish, shellfish, mammals, birds) that dominate and regulate other species in the area. The nearshore waters of the Baltic and Great Lakes have all been degraded in part, but especially near industrialized urban centers. Rehabilitation and preservation efforts are under way, if only slowly.

159. Hartig, J.H. 1988. Remedial Action Plans: A Great Lakes program whose time has come. In: The Great Lakes: Living with North America's Inland Waters. Proceedings of a Symposium. American Water Resources Association, Bethesda, MD, pp. 45-51.

Forty-two Areas of Concern have been identified in the Great Lakes Ecosystem where general or specific objectives of the Great Lakes Water Quality Agreement are not met and such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life. The major problem is contamination by toxic substances (e.g., in 41 of the 42 Areas of Concern). In 1985, the eight Great Lakes states and the province of Ontario committed themselves to developing a remedial action plan (RAP) to restore beneficial uses in each Area of Concern within their political boundaries. Three primary reasons why this RAP program is different from previous initiatives are: public participation, strategic planning, and evaluation and tracking adequacy.

160. Hartig, J.H. and Vallentyne, J.R. 1989. Use of an ecosystem approach to restore degraded areas of the Great Lakes. Ambio 18 (8): 423-428.

Two mutually supportive initiatives have arisen under the auspices of the Canada/United States International Joint Commission as part of the evolution of Great Lakes Water Quality Agreements: an ecosystem approach to resolving

problems, and the development of comprehensive remedial action plans to restore 42 degraded areas (i.e., Great Lakes Areas of Concern). The ecosystem approach considers the interrelationships among water, land, air, and all living things, including people, and involves all user groups in management. The remedial action plan program sets up the institutional arrangements necessary to implement locally designed ecosystem approaches to cleaning up Great Lakes Areas of Concern.

161. Hartig, J.H., Lovett-Doust, L. and Seidl, P. 1990. Successes and challenges in developing and implementing remedial action plans to restore degraded areas of the Great Lakes. In: International and Transboundary Water Resources Issues. American Water Resources Association, Bethesda, MD, pp. 269-278.

Based on the Great Lakes Water Quality Agreement, 42 Areas of Concern have been identified in the Great Lakes Basin Ecosystem. The eight Great Lakes States and the Province of Ontario have committed to developing and implementing a Remedial Action Plan (RAP) to restore beneficial uses in each Area of Concern within their political boundaries. RAPs identify when specific remedial actions are to be taken, and who is responsible for implementing them. The International Joint Commission believes that successful remediation of Areas of Concern depends on the effective involvement of all stakeholders. Successes include enhanced cooperation, greater emphasis on contaminant control at the source, and assessment and remediation of contaminated sediments.

162. Hartig, J.H., Kitchell, J.F., Scavia, D. and Brandt, S.B. 1991. Rehabilitation of Lake Ontario: The role of nutrient reduction and food web dynamics. Canadian Journal of Fisheries and Aquatic Sciences 48 (8): 1574-1580.

The Great Lakes have a complex history of changes due to eutrophication, exotic species, and phosphorus management practices. Remedial actions have reduced nutrient loadings and enhanced the role of food web interactions in improving water quality. Workshops sponsored through the United States-Canada International Joint Commission have addressed the relative importance of nutrient abatement and/or food web manipulation in affecting water quality trends. Both controls have combined to enhance water clarity in Lake Michigan. Lake Ontario has already exhibited the effects of nutrient controls and may soon manifest food web controls.

163. Johnson, M.G. 1984. Great Lakes fisheries and environmental issues. In: Contaminant Effects on Fisheries. Cairns, V.W., Hodson, P.V. and Nriagu, J.O. (ed.). Advances in Environmental Science and Technology 16: 1-8.

Anthropogenic stresses on aquatic communities include toxic metals and organic compounds, excessive nutrient enrichment, acid rain, mortalities at water intakes by impingement and entrainment, losses of natural littoral habitat, degradation of streams and bays, pressures from exotic species, and over-exploitation. These stresses, coupled with natural variability, make it extremely difficult to attain tolerable fluctuations in quantity and quality of fish yields. Instability does not favor public and private investment in the resource, and, furthermore, funds available for management of the stocks and fisheries may be diverted to other programs. It is important for fisheries agencies to deal with these issues: how this is done is a central concern of the book.

164. Joshi, S.R. 1991. Radioactivity in the Great Lakes. Science of the Total Environment 100: 61-104.

Studies of radioactivity were reviewed to evaluate the impact of radionuclide dissemination in the Great Lakes. Significant amounts of radioactivity are stored in the basin, which has numerous nuclear reactors as well as uranium mine waste areas. The prevailing low levels of artificially-produced radionuclides provide very little radiation dose to the area residents who consume lake water. The inter-lake transport of radionuclides is adequately described by existing models, although refinements of the source term are needed. Revised estimates of fallout over each lake are given, but no data are available to estimate drainage basin contributions. Limited information is available on the dispersal of radioactive pollutants. The influence of chemical parameters on radionuclide cycling has been investigated in Lake Michigan and in Lake Ontario. Very few data have been collected thus far on biological and dosimetric aspects in fish.

165. Leshkevich, G.A., Schwab, D.J. and Muhr, G.C. 1993. Satellite environmental monitoring of the Great Lakes - A Review of NOAA's Great Lakes CoastWatch Program. Photogrammetric Engineering and Remote Sensing 59 (3): 371-379.

Within NOAA's Coastal Ocean Program, CoastWatch is a program designed to provide a rapid supply of up-to-date, coordinated, environmental information, including remotely sensed data, to support Federal and state decision makers and researchers who are responsible for managing the Nation's living marine resources and ecosystems. This paper describes the NOAA CoastWatch program for the Great Lakes. The initial products of the program, surface water temperature images, are routinely derived from NOAA Advanced Very High Resolution Radiometer (AVHRR) satellite data and made available within hours of acquisition. Preliminary analysis has shown excellent correlation of satellite-derived temperatures with in situ water temperature measurements from mid-lake weather buoys. Other products including turbidity, ocean color,

and ice mapping are planned. Components of the Coast Watch system are described, such as a wide area communications system, on-line product data bases, an electronically-accessible product archive, and PC software for display and analysis of the satellite imagery.

166. MacKenzie, S.H. 1990. Challenge of implementing ecosystem management plans in the Great Lakes basin. In: International and Transboundary Water Resources Issues. American Water Resources Association, Bethesda, MD, pp. 69-77.

In order to maintain and enhance the integrity of the Great Lakes, an ecosystem approach to water resource planning and management should be adopted. Six preconditions exist for the implementation of the ecosystem approach: intergovernmental coordination, interdisciplinary cooperation, political support, public participation, funding, and conflict resolution. Intergovernmental and interdisciplinary cooperation are essential; by achieving these two preconditions, the administrative and programmatic capacity of governments to implement the ecosystem approach may be attained. In a dynamic and uncertain political arena, where disparate values and interests clash in an effort to dominate public policy, ecosystem planning and management is trying to find its niche. There is cause for optimism concerning implementation of the ecosystem approach in the Great Lakes based on the Remedial Action Plan (RAP) initiative under the International Joint Commission (IJC). Since 1973, the IJC Water Quality Board has identified 42 Areas of Concern in the Great Lakes Basin where the quality of a Great Lake or its tributaries has been severely compromised, and extraordinary measures are needed for remediation. The jurisdictions responsible for devising the RAP have considerable latitude, but they are all expected to incorporate ecosystem concerns into their planning process. As such, they provide an exceptional means for studying the challenges of implementing the ecosystem approach.

167. MacKenzie, S.H. 1993. Ecosystem management in the Great Lakes: Some observations from three RAP sites. Journal of Great Lakes Research 19 (1): 136-144.

The development of Remedial Action Plans (RAPs) represents a first step in the application of the ecosystem approach to Great Lakes water management. Several preconditions to ecosystem management are proposed: intergovernmental and interdisciplinary participation; creation of a mutually agreed upon decision making process; political and public support; and funding. The level of attainment of these preconditions was studied in three RAP sites (Green Bay, Lake Michigan, Wisconsin; Saginaw Bay, Lake Huron, Michigan; and Hamilton Harbor, Lake Ontario, Ontario) through on-site in-depth interviews of 35 RAP participants. Two RAPs, Green Bay and Hamilton Harbor, achieved part of the preconditions. To date, the Saginaw Bay RAP has not achieved the

preconditions outlined in this study. Overall, the participation of key individuals, a movement toward consensual decision making, and adequate funding appear to be very important factors in the development and implementation of RAP plans using the ecosystem approach.

168. Makarewicz, J.C. and Bertram, P. 1991. Evidence for the restoration of the Lake Erie ecosystem. Bioscience 41 (4): 216-223.

The implementation of a phosphorus reduction program in Lake Erie has not only resulted in the reduction of concentrations of total phosphorus, chlorophyll a, phytoplankton abundance and biomass, nuisance species abundance and biomass, and crustacean biomass, but the recovery of the walleye fishery and the introduction of a new salmonine fishery have had a cascading effect on trophic structure. As top-level predators increased in abundance, forage fish abundance decreased. Grazing pressure from calanoid copepods and *Daphnia* species appears to have caused a decrease in algal abundance, an increase in filamentous algae during the summer, and a decrease in mean size of non-filamentous algae. There are also indications that the persistent anoxic conditions in the bottom waters of the central basin have improved.

169. Manny, B.A., Edsall, T.A. and Jaworski, E. 1988. Detroit River, Michigan: An ecological profile. Fish and Wildlife Service Biological Report 85 (7.17), 86 pp.

A part of the connecting channel system between Lake Huron and Lake Erie, the Detroit River forms an integral link between the two lakes for both humans and biological resources such as fish, nutrients, and plant detritus. This article summarizes scientific information on the ecological structure and function of this ecosystem, including the geological history of the region, climatic influences, river hydrology, lower trophic-level biotic components, native and introduced fishes, waterfowl use, ecological inter-relationships, commercial and recreational uses of the river, and current management issues. Management issues include sewer overflows; maintenance dredging for navigation and port activities; industrial discharges of potentially hazardous materials; and wetland, fishery, and waterfowl protection and enhancement.

170. Meadows, L.A. (ed.). 1987. Great Lakes Coastal Erosion Research Needs: Workshop Summary. Ann Arbor, MI, 8-9 July 1987. Michigan Sea Grant College Program MICHU-SG-88-900, 59 pp.

Record-setting Great Lakes high water levels with resultant damage and the threat of rising sea level have emphasized the need for increased understanding of coastal processes and improved coastal management. Researchers and administrators who attended the workshop identified research

needs and the roles that each organization can play in meeting those needs. Field experiments and data collection, analysis of existing data, and numerical modelling were recommended.

171. Mills, E.L., Leach, J.H., Carlton, J.T. and Secor, C.L. 1993. Exotic species in the Great Lakes: A history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19 (1): 1-54.

In documenting the introductions of non-indigenous aquatic flora and fauna into the Great Lakes basin since the early 1800s, the focus was placed on the origin, probable mechanism(s) of introduction, and the date and locality of the first discovery of Great Lakes exotic species. Thirteen non-indigenous species (9%) were identified that have substantially influenced the Great Lakes ecosystem, both economically and ecologically. The apparent lack of effects of 91% of the exotic species in the Great Lakes does not mean that they have had little or no ecological impact. Alterations in community structure may predate modern investigations by decades or centuries, and the effects of many species have simply not been studied.

172. Minns, C.K., Kelso, J.R.M. and Johnson, M.G. 1986. Large-scale risk assessment of acid rain impacts on fisheries: Models and lessons. Canadian Journal of Fisheries and Aquatic Sciences 43 (4): 900-921.

Lakes, streams, and their watersheds in many parts of the world have little ability to neutralize acid precipitation. Resource management agencies are concerned with the extent of these impacts, including possible loss or hazard to key fish species. Two models are presented in the paper; the models were designed to provide a large-scale risk assessment. The strengths and weaknesses are identified. Since models draw together the best of theories, experimental, and survey data, these models are compared with existing knowledge, theories, and data.

173. Muir, T. and Sudar, A. 1986. On the economic and social causes and consequences of toxic substances in the Great Lakes Basin ecosystem. In: IAGLR Program. 29th Conference of the International Association for Great Lakes Research. Scarborough, Ontario (Canada), 26-29 May 1986, p. 44.

This paper provides a concise overview of the history, status, and effects of toxic contaminants in the Great Lakes basin ecosystem. Synchronous states of health and contaminant patterns in all life forms (including humans), effects, unifying factors, and causal concepts are discussed. Economic causes are explained, and the costs of toxics in the ecosystem are estimated. Social causes and consequences of toxics are also discussed.

174. Munawar, M., Munawar, I.F., Mayfield, C.I. and McCarthy, L.H. 1989. Probing ecosystem health: A multi-disciplinary and multi-trophic assay strategy. Hydrobiologia 188/89: 93-116.

The ecosystem health of stressed environments in the Great Lakes was evaluated by a multi-trophic and multi-disciplinary battery of structural and functional tests using a field-to-laboratory approach. At organism level, the test focused on water-borne and sediment-bound toxicities. Functional tests were also selectively chosen across trophic levels and included size-fractionated primary productivity, and *Colpidium, Daphnia, Hyalella*, and *Pontoporeia* assays. Some of the emerging techniques evaluated included in situ plankton cages and microcomputer-based chlorophyll fluorescence.

175. Munawar, M., Munawar, I.F., Ross, P. and Dermott, R. 1992. Exploring aquatic ecosystem health: A multi-trophic and an ecosystemic approach. I. Rationale and application. Journal of Aquatic Ecosystem Health 1 (4): 237-252.

The restoration and recovery of habitats is extremely complex and requires a clear understanding of desirable and maximum/minimum conditions which are acceptable, achievable, and cost-effective for implementation. A multidisciplinary, multi-trophic, and ecosystemic approach was initiated and applied in the Great Lakes during the past several years. This strategy, consisting of structural and functional indicators and endpoints, was implemented in the Great Lakes Areas of Concern.

176. Nalepa, T.F. 1991. Status and trends of the Lake Ontario macrobenthos. Canadian Journal of Fisheries and Aquatic Sciences 48 (8): 1558-1567.

The benthic macroinvertebrate community of Lake Ontario was examined and compared to communities found in other Great Lakes and also related to trends over time. Benthic organisms are exposed to elevated levels of many persistent chemicals from the high contaminant loads into Lake Ontario. In nearshore areas, populations are influenced by municipal and industrial inputs. Contaminant levels in the depositional basins of Lake Ontario are higher than levels in the depositional basins of the other Great Lakes. Oligochaete abundances in nearshore area are higher than in any of the other Great Lakes (excluding shallow Lake Erie), communities have been altered even to relatively deep depths near the major river mouths, and the pollution-sensitive *Pontoporeia hoyi* is scarce along the southern shoreline east of the Niagara River mouth. Deep-water benthic composition is similar to that found in the other Great Lakes, but biomass is less than might be expected from the amount of organic material settling to the bottom. Benthic standing stocks in this region have declined nearly threefold since the 1960s.

177. Nater, E.A. and Grigal, D.F. 1992. Regional trends in mercury distribution across the Great Lakes states, north central USA. Nature 358 (6382): 139-141.

Increasing levels of mercury in aquatic environments and fish populations from human activities such as fossil-fuel burning and incineration of municipal wastes are becoming a public-health problem. Enhanced mercury concentrations in lake sediments relative to pre-industrial values have also been attributed to anthropogenic pollution. It is generally assumed that atmospheric mercury deposition is dominated by global-scale processes, and consequently is regionally uniform. To the contrary, we found a significant gradient in concentrations and total amounts of mercury in organic litter and surface mineral soil along a transect of forested sites across the north central United States from northwestern Minnesota to eastern Michigan. This gradient was accompanied by parallel changes in wet sulphate deposition and human activity along the transect, suggesting that the regional variation in mercury content is due to deposition of anthropogenic mercury, most probably in particulate form.

178. Niimi, A.J. 1990. Review of biochemical methods and other indicators to assess fish health in aquatic ecosystems containing toxic chemicals. Journal of Great Lakes Research 16 (4): 529-541.

Whole-animal, cellular, biochemical, and genetic studies were reviewed to identify methods that could be used to assess the health of fish in the field. The survey indicated that most techniques would not be suitable for field use because threshold response levels were substantially higher than most environmental chemical concentrations, and several indicators would be required because the causes are likely to be of multiple origin. Advances in assessment techniques can be made at the cellular and genetic levels because these indices appear to be the most sensitive to chemical exposure. Chemical impacts on fish population health would probably occur during reproduction, as this process appears vulnerable to chemical exposure.

179. Passino, D.R.M. 1986. Predictive models in hazard assessment of Great Lakes contaminants for fish. In: Proceedings of Technology Transfer Conference. Part B: Water Quality Research. Toronto, Ontario (Canada), 8-9 Dec. 1986, pp. 1-26.

A hazard assessment scheme was developed and applied to predict potential harm to aquatic biota of nearly 500 organic compounds detected in Great Lakes fish. The frequency of occurrence and estimated concentrations of compounds found in lake trout and walleyes were compared with available manufacturing and discharge information. Bioconcentration potential of the compounds was estimated from available data or from quantitative structure-activity relationship (QSAR) calculations. Acute toxicity to *Daphnia pulex* of 35 representative

compounds was measured and compared to the results with acute toxicity values generated by QSAR. The QSAR-derived toxicities for several chemicals underestimated the actual acute toxicity by one or more orders of magnitude.

180. Potash, M. and Henson, E.B. 1983. The limnology of Lake Champlain: An historical overview. In: Proceedings of the 26th Conference on Great Lakes Research, Oswego, NY, 23-27 May 1983, p. 26.

The first recorded study of Lake Champlain in 1905 reported on a pollution survey of river mouths. The New York Conservation Department carried out a biological survey in 1930, which concentrated on fish. Beginning in 1965, the authors carried out a 10-year study to establish base-line data and to evaluate the watershed to determine the influence of inflowing streams and rivers on the lake ecosystem. Temperature profiles, transparency, pH, specific conductance, total alkalinity, dissolved oxygen, potassium, sodium, calcium, and magnesium were measured. Five major water masses were found within the overall basin. Chemical concentrations were greatest in the southern basin and decreased significantly in the northern major lake basin. Water flowing westerly from the eastern regions of the lake appeared to produce a dilution effect. The main lake exhibited a linear decrease in most chemical parameters, from the south of the entrances of westerly flowing waters. Increasing nutrient concentration and decreasing dissolved oxygen were seen during the ten-year study.

181. Prince, H.H. and D'Itri, F.M. 1985. Coastal wetlands [Great Lakes]. In: First Great Lakes Coastal Wetlands Colloquium, Proceedings. East Lansing, MI, 5-7 Nov. 1984. Lewis Publishers, Inc. Michigan University Sea Grant Program Report MICHU-SG-85-601.

The sixteen papers included in the report resulted from a joint U.S.-Canada colloquium. The topics included the effect of water level fluctuations on marshes, fish, and fowl; marsh nutrient fluxes and cycles; wetland valuation; and the impact of human interference with water level.

182. Quinn, F.H. 1988. Great Lakes water levels, past, present, and future. In: The Great Lakes: Living with North America's Inland Waters. Proceedings of a Symposium. American Water Resources Association, Bethesda, MD, pp. 83-92.

The Great Lakes contain 95% of the nation's and 20% of the world's fresh surface water. At the present time, all the Great Lakes except Lake Ontario are receding from record high lake levels for this century. Storms superimposed on the high lake levels have resulted in extensive flooding, houses destroyed, extreme erosion and bluff damage, marina problems, and a loss of wildlife habitat. Historic fluctuations began with the retreat of the glaciers around

11,000 years ago, and essentially stabilized about 3,000 years ago. The recorded lake levels include the effects of event-related fluctuations (storm surge, wind setup, and pressure jumps), as well as diversions, lake regulation, modifications to connecting channels, and consumptive use. Higher lake level sequences could be expected in the future. Policy analysts should concentrate on a wide range in water levels rather than only on the high lake levels of the past two decades or on the recent drought conditions.

183. Rabe, B.G. and Zimmerman, J.B. 1992. Cross-media environmental integration in the Great Lakes Basin. Environmental Law 22 (1): 253-279.

The Great Lakes Basin, which holds nearly 20% of all the fresh water on the earth's surface, is beleaguered by environmental problems, many of which stem from cross-media pollution. Mass balance analysis has been used to document numerous cases of contamination of surface waters by air deposition. The Great Lakes Basin affords special opportunities because it encompasses such a diverse array of interests and falls under the jurisdiction of a broad spectrum of political institutions. Recently pollution prevention has emerged as a major vehicle for attempting to reduce overall pollution releases and cross-media transfers. One of the greatest impediments to integrated environmental management is the lack of concrete proposals for considering cross-media transfer in devising regulatory policy. Many of the analyses are at a very high level of abstraction. These include proposals to eliminate releases of select toxics under a zero release program, a mass balance modeling framework to better understand sources, and joint permitting programs to track major projects requiring multiple permits.

184. Ragotzkie, R.A. 1988. Great Lakes ecosystem experiment. Internationale Vereinigung fuer Theoretische und Angewandte Limnologie Verhandlungen 23 (1): 359-365.

During the last century, the Great Lakes have been subjected to two major sets of perturbations: increased nutrient loadings followed by reductions in recent years, and the introduction of non-native species of parasitic, planktivorous, and predatory fish. Examination of the hydrologic and morphometric characteristics of the lakes suggests that the different responses from lake to lake are due in part to their varying volumes and flushing rates. Recent above-normal precipitation in the basin and the consequent increased water flow through the lakes has probably accentuated these differences.

185. Richards, R.P. and Baker, D.B. 1993. Pesticide concentration patterns in agricultural drainage networks in the Lake Erie basin. Environmental Toxicology and Chemistry 12 (1): 13-26.

This paper presents information on pesticide concentrations in Lake Erie tributaries draining agricultural watersheds, information distilled from data sets spanning nearly a decade and including up to 750 samples per tributary. Pesticide concentrations were strongly skewed and approximately log-normal. Average concentrations of pesticides in tributaries were correlated with the amount applied in the basin, but with important secondary effects from chemical properties and modes of application. During runoff of storm events following application, concentrations rose rapidly, peaked about the time of peak discharge, and declined slowly. These patterns did not match those for nutrients, major ions, or sediment, indicating a different pathway from the fields for pesticides. On an annual basis, elevated monthly average concentrations were usually observed from May to August. Smaller tributaries had more strongly skewed distributions and much greater temporal variability in concentrations than did larger rivers.

186. Ross, P.E., Burton, G.A., Jr., Crecelius, E.A., Filkins, J.C., Giesy, J.P., Jr., Ingersoll, C.G., Landrum, P.F., Mac, M.J., Murphy, T.J., et al. 1992. Assessment of sediment contamination at Great Lakes Areas of Concern: The ARCS Program Toxicity- Chemistry Work Group strategy. Journal of Aquatic Ecosystems Health 1 (3): 193-200.

The Work Group's general objectives are to develop survey methods and to map the degree of contamination and toxicity in bottom sediments at three study areas, Saginaw Bay (MI), Grand Calumet River (IN), and Buffalo River (NY). These areas will serve as guidance for future surveys at other locations. A related objective is to use the data base that will be generated to calculate sediment quality concentrations by several methods. Samples will be collected for physical characterization, toxicity testing, mutagenicity testing, chemical analyses, and fish bioaccumulation assays. Fish populations will be assessed for tumors and external abnormalities, and benthic community structure will be analyzed. Low-cost indicator parameters will be studied at many stations, and the results will be extrapolated by correlation from traditional chemical and biological studies at a smaller number of locations.

187. Rowan,D.J. and Rasmussen, J.B. 1992. Why don't Great Lakes fish reflect environmental concentrations of organic contaminants? An analysis of between-lake variability in the ecological partitioning of PCBs and DDT. Journal of Great Lakes Research 18 (4): 724-741.

The literature on PCBs and DDT in the Great Lakes ecosystem was reviewed in an attempt to explain between-basin and between-species variation in fish contamination. Empirical models were developed, using log-linear multiple regressions, to link tissue contaminant concentrations to environmental levels

(water and sediments) as well as basin-specific ecological attributes. The factors that appear to determine the ecological partitioning of persistent organic contaminants are fish lipid content, trophic level of the fish in question, and the trophic structure of the food chain. Multiple regressions of these variables explain 59% (DDT) to 72% (PCBs) of the variation in contaminant concentrations of 25 species of Great Lakes fish.

188. Schwab, D.J., Leshkevich, G.A. and Muhr, G.C. 1992. Satellite measurements of surface water temperature in the Great Lakes: Great Lakes CoastWatch. Journal of Great Lakes Research 8 (2): 247-258.

189. Scieszka, M. 1990. Digital wetlands data base for the U.S. Great Lakes shoreline. In: Federal Coastal Wetland Mapping Programs. A Report by the National Ocean Pollution Policy Board's Habitat Loss and Modification Working Group. Fish and Wildlife Service Biological Report 90 (18): pp. 159-163.

Based on the Michigan Resource Inventory Act of 1979, the Michigan Department of Natural Resources (DNR) conducted a state-wide land cover and land use inventory which mapped seven main categories: urban land, agricultural land, open land, forest land, water, wetlands, and barrens. The data were mapped and digitized in the detailed land cover and land use inventory, and processed into various theme maps, including wetland maps. The wetlands maps are used to implement inventory and public information requirements of the State's wetland protection act. The data collection methodology and digital processing environment are being used by the International Joint Commission to map the remainder of the United States' shoreline. An overview of the Michigan Resources Inventory Program is presented along with how the data were collected, and how to access the data.

190. Serafin, R. and Zaleski, J. 1988. Baltic Europe, Great Lakes America and ecosystem redevelopment. Ambio 17 (2): 99-105.

Effective redevelopment strategies for Great Lakes and Baltic ecosystems are likely to be those that provide for long-term change of cultural processes. Four perspectives are outlined for redevelopment of the Great Lakes and Baltic region ecosystems. 1) The focus of research should be on causes of area degradation, not its symptoms. 2) A synoptic perspective of the past and future population, agriculture, energy and trade patterns should provide the basis for economic decision-making in the area. 3) A cultural space is highlighted in which economic and land-use planning, industrial development, political representation, and fiscal budgets take place within geographically defined jurisdictions. 4) A broad-scale long-term development process (50 to 100 years) is stressed.

191. Slaats, M.J. and Kreutzwiser, R.D. 1993. Shoreline development regulations: Do they work? Journal of Soil and Water Conservation 48 (3): 158-165.

Flooding and erosion cause problems in the Great Lakes, particularly when lake levels are high. In response to a disastrous storm in December 1985, the Ontario government established the Shoreline Management Review Committee to develop a shoreline management program. As part of this program, Ontario Conservation Authorities (CAs) were given new responsibilities for shoreline management. Shoreline development regulations instituted by two Ontario CAs were evaluated, those of the Essex Region CA, with jurisdiction along southern Lake St. Clair, the Detroit River, and western Lake Erie; and the Metropolitan Toronto and Region CA, with jurisdiction along the Greater Toronto waterfront of Lake Ontario. Three areas are regulated by CAs: dumping or removal of fill, construction of buildings, and alterations to waterways which change or interfere with existing shorelines. Four process criteria and four outcome criteria were used in the evaluation. The regulations were clear, limited in comprehensiveness, and moderately stringent. Regulations and enforcement were moderately effective to effective while penalty provision and sanctions were ineffective for both CAs.

192. Smith, P.G.R., Glooschenko, V. and Hagen, D.A. 1991. Coastal wetlands of three Canadian Great Lakes: Inventory, current conservation initiatives, and patterns of variations. Canadian Journal of Fisheries and Aquatic Sciences 48 (8): 1581-1594.

The decline of wetlands, including those in the Great Lakes coastal zone, prompted the Government of Ontario to initiate a wetlands management policy in 1981. Wetland inventory and evaluation in southern Ontario began in 1983. To date, 1982 wetlands have been evaluated, of which 160 are coastal wetlands. Current wetland conservation initiatives are outlined in the document, including the Wetlands Planning Policy Statement and Conservation Lands Act. Ecological variation was shown in wetland and site types, soils, dissolved solids, vegetation complexity, and rare flora and fauna which differed in wetlands along Lakes Ontario, Huron, Erie, St. Clair, and connecting channels. Wetlands of Lake Huron reflected a more northern species composition, less organic soil, and more swamp and fen habitat. Along Lakes Erie, Ontario, and St. Clair, the predominant marshes have smaller swamp components, organic soils, and considerable dissolved solids.

193. Sonzoni, W.C. 1987. Large lake models uses, abuses, and future model task force (USA). Journal of Great Lakes Research 13 (3): 387-396.

Mathematical modeling of the Great Lakes is entering a phase of relative maturity in which expectations are more realistic than in the past. The major

thrust in the past has been water quality (eutrophication) modelling, but there has been a recent shift toward developing toxic substances models. Modelers and model users have been limited by a lack of knowledge of Great Lakes processes, limited data availability, and incomplete or improper validation. The Great Lakes modeling activities likely to have the greatest payoff in the near future are: the development and refinement of toxic substances models, post-auditing and improvement of eutrophication models, and the adaptation of models for use on personal computers to allow greater model utilization.

194. Stoermer, E.F. 1988. Algae and the environment: The Great Lakes case. In: Algae and Human Affairs. Cambridge University Press, New York, pp. 57-83.

Algae have played an important role in some of the highly visible problems in the Great Lakes. Due to the large surface area of the lakes and a large portion of the drainage area from bedrock types that are resistant to leaching, the dissolved constituents in the lakes are largely from rainfall. As a result, the lakes are naturally deficient in phosphorus and silicon but relatively rich in nitrogen. Research carried out since the 1970's indicated that phosphorus controlled the growth rate and standing crop of phytoplankton, and also the availability of other nutrients. Shifts in the type of algae present occur based on their specific nutrient requirements. Although phosphorus loadings to the lakes are decreasing, it is unlikely that the algal flora will return to previous patterns. The original nutrient balance cannot be restored rapidly, if at all, and new additions, planned and unplanned, of species not native to the lakes and synthetic compounds are likely to affect the biota.

195. Strachan, W.M.J. 1988. Research needs in support of the assessment process. In: Toxic Contamination in Large Lakes. Vol. I: Chronic Effects of Toxic Contaminants in Large Lakes. Lewis Publishers, Chelsea, MI, pp. 343-359.

Assessments which provide protection for all uses and deal with the system as a whole are needed for the nearly 1000 chemicals which have been detected in the Great Lakes. An acceptable sequence of decisions leading to control of a chemical is described, including identification, preliminary assessment, several in-depth assessments, and control if required. A minimum number of data elements must be considered at the preliminary assessment stage. These elements include: mammalian acute LD50, preferably oral dosing of the rat; aquatic acute LC50 with a sensitive fish species; mutagenicity for two cell lines, including one mammalian; and octanol-water partition coefficient. Other elements which are important but not likely to be available nor readily developed at this stage include production and release to the environment and environmental concentrations.

196. Todd, M.J. and Kangas, J.W. 1988. Great Lakes water resources management. In: The Great Lakes: Living with North America's Inland Waters. Proceedings of a Symposium. American Water Resources Association, Bethesda, MD, pp. 93-102.

> Excessive precipitation in the Great Lakes basin in 1985-87, which resulted in record high levels for all months for all lakes, except Lake Ontario, caused flooding and erosion damage along the Great Lakes shoreline. The U.S. shore damages in 1972-76 were estimated to be about $200 million and the estimates for 1985-87 are expected to be higher, about $285 million. Limited outflow capacities of Great Lakes outlet channels cannot accommodate the high water supplies recently experienced. Complete regulation of the Great Lakes has been found to be engineeringly feasible but economically unjustified. Such measures are currently being reevaluated on a comprehensive basis by the International Joint Commission under a new Great Lakes Levels Reference Study. Improvements of the U.S. Army Corps of Engineers' computer and mapping facilities, the real-time hydrometeorological data collection network system, and forecasting techniques are some of the measures being considered. Many of these measures will use state-of-the-art models and data systems. Additionally, computer simulation models will be explored and implemented to better determine the hydrologic and hydrodynamic behavior of the lakes and the connecting channels and to better manage this resource.

197. Vallentyne, J.R. 1983. From water quality to ecosystem management in the Great Lakes Basin. In: Lake Restoration, Protection, and Management. Second Annual Conference of the North American Lake Management Society, Vancouver, B.C. (Canada), 26-29 Oct. 1982. Taggart, J. and Moore, L. (ed.). Environmental Protection Agency, Washington, DC, Office of Water Registration Standards Report EPA 440-5-83-001, pp. 1-3.

> By the mid-1960's, recognizing that human influences had changed the chemistry and biology of the lower Great Lakes, the governments of the United States and Canada directed the International Joint Commission to investigate and report on the nature and extent of the problems, causes, and remedial measures. To control eutrophication, the Boards recommended reducing the concentrations of phosphate in detergents and removing phosphate by chemical treatment at sewage treatment plants. The focus on phosphorus for control was based on experimental and observational evidence showing that the supply of phosphorus could be made to limit plant growth in the lower Great Lakes.

198. Vallentyne, J.R. and Beeton, A.M. 1988. 'Ecosystem' approach to managing human uses and abuses of natural resources in the Great Lakes basin. Environmental Conservation 15 (1): 58-62.

An approach to planning, research, and management that relates people to ecosystems of which they are part is described and related to the Canada-United States Great Lakes Water Quality agreements of 1972, 1978, and 1987. Factors favoring the development of an ecosystem approach in the Great Lakes Basin include: a shared, highly valued resource; the long residence times of conservative pollutants in the Lakes; use of the lakes for drinking-water supplies by about 23 million people; threats to the integrity of the Lakes by pollution and water diversion; advances in ecosystem theory; the rise of voluntary membership associations with interests in the resource; institutional arrangements for managing nationally shared resources; and common economic ties and cultural heritages. The principal obstacle to implementation of an ecosystem approach in the Great Lakes basin is the lack of policies for comparable approaches in the political jurisdictions surrounding the Great Lakes.

199. Von Moltke, K. 1988. Introducing scientific analysis to public policy: An international perspective. In: Toxic Contamination in Large Lakes. Vol. IV: Prevention of Toxic Contamination in Large Lakes. Managing a Large Ecosystem for Sustainable Development. Lewis Publishers, Chelsea, MI, 1988. p 179-188.

Policy in relation to natural resources is unique in its focus on goods which have no voice of their own. Policy, however, is made through the articulation of goals and social means. To develop environmental policy it is essential to articulate the changes which occur in nature. It is extremely difficult to obtain assessments of research with respect to a trans-jurisdictional ecosystem, such as in large lakes, because of the differences which may be obtained in the various jurisdictions. The major difficulty in obtaining assessments of research with respect to a trans-jurisdictional ecosystem lies neither in the absence of relevant research nor in language problems, but in the fact that the policy-making institutions for large lakes are either indeterminate or poorly known. Without a functioning policy-making context, it is also impossible to develop effective institutions for policy-relevant research assessments. One example of a cooperative venture by academies, the assessment of the Great Lakes Water Quality Agreement by the National Academy of Sciences and the Canadian Royal Society is probably an example of the kind of assessments which it will be necessary to undertake in advancing complex policy issues in trans-jurisdictional situations.

200. Williams, D.J. 1992. Great Lakes water quality - a case study. ACS Symposium Series 483: 207-223.

Pollution of the Great Lakes exemplifies the problems associated with the impact of human activities on a major aquatic ecosystem. Problems have

included bacteriological contamination, eutrophication, and contamination by anthropogenic, potentially toxic substances. Management of the Great Lakes is divided between Canada and the United States and involves eleven governments at federal, state and provincial levels. The Great Lakes have responded dramatically to remediation initiatives. Human impacts on the lakes associated with development of the Great Lakes Basin are discussed in the context of the unique binational arrangements agreed to by the two countries to restore and protect this shared ecosystem.

1E. MULTIPLE COASTS ECOSYSTEMS

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201. Allan, R.J. 1990. Estuarine and coastal water contamination, an issue for the 1990s. Science of the Total Environment 97/98: 1-5.

Near-shore areas of the world are becoming increasingly impacted by toxic chemicals. An international symposium devoted exclusively to the issue of toxic chemical contamination of large rivers and their estuaries and bays was convened in Quebec City, Canada, in October 1988. The conference focused on contamination of estuaries rather than on estuarine processes. In North America, the sites most studied are along the east coast from the St. Lawrence River/estuary to the Hudson River, Chesapeake Bay and the rivers which drain into it, the Mississippi River and the Gulf of Mexico, San Francisco Bay and its major tributaries, and the Fraser River. Strategies to solve contamination problems in estuaries and near-shore zones of regional seas and oceans require identification of toxic chemical sources and loads, both to the bodies of water directly and to rivers draining to them. Estuaries are complex interfaces between fresh and saline water, between the land and the oceans, and models of toxic chemical fate will necessarily be complex. Management plans for estuaries, bays and near-shore areas must be open to a range of strategies to reduce toxic contamination.

202. Baird, D., McGlade, J.M. and Ulanowicz, R.E. 1991. Comparative ecology of six marine ecosystems. Philosophical Transactions of the Royal Society of London. Series B. Biological Sciences 333 (1266): 15-29.

Six marine ecosystems worldwide, including the Chesapeake Bay, were compared using a network analysis of carbon flows. Contrary to current views on ecosystems, the aggregate amount of cycling of materials, such as carbon, appears to indicate stress rather than system maturity. The reason that higher stressed systems are associated with a higher throughput could be because perturbations frequently impact higher-level species to a greater extent than the lower trophic components. Any release of standing biomass from these higher levels could therefore be taken up through increased recycling via short intense loops.

203. Becker, P. 1983. Out of and into the 80's: The American shellfish industry 1890-1983. In: Oceans '83. Effective Use of the Sea: An Update. Vol. 2. Technical Papers, Mineral Resources and Energy, Non-Mineral Resources, Transportation. Oceans '83 Conference, San Francisco, CA, 29 Aug.-1 Sep. 1983. Institute of Electrical and Electronics Engineers, New York, NY Report IEEE-83CH1972-9, pp. 857-859.

Some segments of the American shellfish industry, such as the small sport and commercial shrimp fishery in Hood Canal, WA, and the large commercial shrimp fishery of Kodiak Island, AK, have been managed to a state of near revival. Other oyster fisheries collapsed long ago, such as the Olympia oyster fishery, or relatively recently, such as the Delaware Bay oyster fishery. Many causes have been attributed to the collapse: human and industrial pollution of the water, domestic and imported predators and disease, destruction of marshland habitat, and over-harvest. Most of the public are ignorant of the many problems which have historically beset the commercial shellfish industry.

204. Cantillo, A.Y., Calder, J.A., Long, E.R. and Peter, G. 1984. A new emphasis on coastal and estuarine environmental quality assessment. In: Oceans '84 Conference Record. Industry, Government, Education. Designs for the Future. Vol. 1. Oceans '84 Conference, Washington, DC, 10-12 Sep. 1984. Institute of Electrical and Electronics Engineers, New York, NY Report, pp. 302-308.

NOAA has initiated the Status and Trends (S&T) Program, in order to quantify the current status and long-term, temporal, and spatial trends of concentrations of key contaminants, water quality parameters, and biological indications of adverse effects in the nation's coastal and estuarine environments. The S&T Program has four major components: benthic surveillance, mussel watch, water quality, and compilation of a data base from relevant existing programs.

205. Chapman, P.M., Power, E.A. and Burton, G.A. 1992. Integrative assessments in aquatic ecosystems. In: Sediment Toxicity Assessment. Lewis Publishers, Boca Raton, FL. Pp. 313-340.

Integrative assessments are conducted to assess sediment quality as a measure of ecosystem health. Healthy ecosystems have a high level of biodiversity, productivity, and habitability. The triad concept comprises an effects-based approach to sediment quality and typically incorporates measures of sediment chemistry, sediment toxicity, and benthic infaunal community structure. Tiered testing is a cost effective method used to determine when integrative assessment is needed. To date, only two comprehensive five-component integrative assessments of sediment quality have been completed, the Superfund investigations in Puget Sound, WA, and the ARCS program studies in the Great Lakes.

206. Chasis, S. 1985. Coastal Zone Management Act: A protective mandate. Natural Resources Journal 25 (1): 21-30.

The rationale of the Coastal Zone Management Act (CZMA), its provisions, its problems of statutory structure and implementation, and the continued

importance of its purpose are reviewed. At the time the Act was passed, Congress recognized the deteriorating condition of coastal resources and the inability of state and local governments alone to remedy the situation. Thirty states, including those bordering the Great Lakes, and five territories are eligible for federal funds under the CZMA. Responsibility for administering the Act is assigned to the Secretary of Commerce, who designated NOAA as the agency to manage the program. Within NOAA, the responsibility resides in the Office of Ocean and Coastal Resources Management. The statute is very broad, and participation is voluntary.

207. Cote, R., VanderZwaag, D. and Townsend Gault, I. 1988. Social, economic, institutional and legal considerations in the management of land-based sources of marine pollution. In: Canadian Conference on Marine Environmental Quality, Proceedings. Halifax, Nova Scotia (Canada), 29 Feb.-3 Mar. 1988. The International Institute for Transportation and Ocean Policy Studies, Halifax, Nova Scotia, Canada, pp. 59-74.

In Canada, social, economic, institutional and legal considerations must be emphasized if governments expect to make significant gains in the protection of coastal waters. The awareness of the public must be raised while involving them in the decision-making processes. Management must understand and quantify the true costs of current disposal practices but also provide appropriate incentives for reducing waste. Legislation must foster the collaboration among agencies and between levels of government. This paper explores issues associated with new institutional mechanisms and agencies which will have to be established, such as intergovernmental management bodies now in place in the Fraser River Estuary, Puget Sound, and Chesapeake Bay.

208. Cote, R.P. 1992. Marine Environmental Management: Status and Prospects. Marine Pollution Bulletin 25 (1-4): 18-22.

A comprehensive global marine environmental management framework does not yet exist. Comprehensiveness involves consideration of all relevant stresses on the quality of the marine environment, a recognition of the interlocking nature of the geographic or spatial dimensions, and the application of managerial elements from goal-setting to monitoring and enforcement. The most comprehensive management plans on the individual, local, national, regional and global levels have focused on the problems of ocean dumping. A number of water-body management programs are being pursued on a regional level in Chesapeake Bay, Puget Sound, Boston Harbor and San Francisco Bay.

209. Council on Environmental Quality, Washington, DC. 1993. Building Alliances to Restore Coastal Environments: A Coastal America Progress Report, 31 pp.

The unique purpose of Coastal America is to join the forces of federal agencies with state, local, and private alliances to collaboratively address environmental problems along U.S. shorelines. Coastal America focuses on three wide-spread problems that are the result of rising populations in coastal areas and associated increases in demands on coastal resources: loss and degradation of habitat; pollution from nonpoint sources; and contaminated sediments. The challenge is to integrate capabilities and existing resources with state, local, and nongovernmental efforts to address specific local problems by sharing information, pooling field expertise, and combining management skills and resources. Coastal America partners come to the table with a broad, problem-solving orientation to produce demonstrable environmental results.

210. Culliton, T.J., McDonough,J.J., Remer, D.G. and Lott, D.M. 1992. Building along America's Coasts. Twenty years of Building Permits, 1970-1989. National Ocean Service, Rockville, MD. Strategic Environmental Assessments Division Coastal Trends Series, 53 pp.

Between 1970 and 1989, about half of the construction in the U.S. occurred in coastal areas. Land and water resources of the coastal areas, considered to be resilient to the stresses of growth, are being diminished in both quality and quantity. The report includes information on 30 coastal states (including the Great Lakes), which include 451 coastal counties and 1,569 non-coastal counties in these states.

211. Duda, A.M., Lyke, W.L. and Hoban, T.J. (ed.). 1988. Restructuring national water quality management policy to protect coastal resources. In: Proceedings of the Symposium on Coastal Water Resources. Wilmington, NC. American Water Resources Association, Technical Publication Series, pp. 811-820.

Despite hundreds of billions of dollars spent on point source control measures, many lakes/reservoirs and coastal waters have become further degraded over the last two decades. This paper examines the U.S. situation, identifies institutional barriers to effective water quality management in coastal areas, and discusses opportunities for restructuring national policy to achieve water quality goals. Examples of near-field (coastal North Carolina) and far-field (Tennessee Valley, Gulf of Mexico) sources of pollution are used to describe the dilemma.

212. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water. 1991. Portraits of our Coastal Waters. Supplement to the National Water Quality Inventory. Report from the EPA Regions. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water Report EPA/503/2-91/004, 35 pp.

The document includes reports of water quality problems from New Hampshire, the Middle Atlantic Bight, the Gulf of Mexico, San Diego Bay, Washington, and Wisconsin.

213. Farrow, D., Arenstam, S., De Souza, A., Kineon, F. and Lowe, J. 1992. Coastal Zone Boundary Review: National Summary, State Characterization Reports. National Ocean Service, Seattle, WA, Office of Ocean Resources Conservation and Assessment Report, 115 pp.

The report provides the capability to estimate the distribution of nonpoint source pollution across watersheds in four areas: the coastal zone, the coastal watershed, inland of the state watershed to the state border, and outside the state. Nineteen reference maps show the major watersheds, the coastal zone boundary, and the boundary of the coastal watershed for each coastal state.

214. Ford, K.E., Glatzel, K.A. and Piro, R.E. 1990. Watershed planning and restoration: Achieving holism through inter-jurisdictional solutions. In: Environmental Restoration. Science and Strategies for Restoring the Earth. Conference on Ecological Restoration, Berkeley, CA, Jan. 1988. Berger, J.J. (ed.). Pp. 312-320.

This paper examines watershed planning and management in an inter-jurisdictional context. Two regional approaches to watershed planning are examined and evaluated as applied by: (1) the Marine Resource Council of East Florida for the Indian River Lagoon, and (2) the Puget Sound Water Quality Authority in Washington State. Inter-jurisdictional solutions are a prime mechanism for implementing watershed planning and restoration efforts.

215. Hennessey, T. and Robadue, D.D. 1987. A comparison of the governance of Narragansett and San Francisco bays: The role of adaptive implementation. In: Proceedings of the Tenth National Conference, Estuarine and Coastal Management, Tools of the Trade. New Orleans, LA, 12-15 Oct. 1986. Lynch, M.P. and McDonald, K.L. (ed.). Vol. 1, pp. 73-86.

The authors are engaged in a three-year systematic, comparative study of the governance process in four estuaries funded by Sea Grant: Narragansett, San Francisco, Delaware, and Galveston bays. Implementation structures, processes and outcomes of governance systems are being analyzed and specific criteria for success and failure are being developed and tested. The study reported in this paper focuses on the performance of two estuary governance agencies, the Rhode Island Coastal Resources Management Council, and the San Francisco Bay Conservation and Development Commission.

216. Imperial, M.T., Robadue, D. and Hennessey, T.M. 1992. Evolutionary Perspective on the Development and Assessment of the National Estuary Program. Coastal Management 20 (4): 311-341.

The progress that has been achieved in managing coastal environmental quality is reviewed, with the factors that have affected the design of coastal and estuarine management programs. Five experiences in environmental management that have influenced the development of the National Estuary Program are examined: the Delaware River Basin Commission, the federal river basin commissions, the Section 208 area-wide waste treatment planning, the federal Coastal Zone Management Program, and the Chesapeake Bay Program. These programs offer strengths and weaknesses as models for managing estuarine environmental quality. Based on the strategy, structure, and process of coastal environmental programs, evaluation criteria are proposed which can be used to evaluate the structure and management process of coastal environmental programs such as the National Estuary Program, as well as to assess their contributions to coastal environmental management.

217. Landin, M.C. and Newling, C.J. 1987. Long-term monitoring of CE habitat development on dredged material sites, 1974-84. In: Third United States - The Netherlands Meeting on Dredging and Related Technology. 10-14 Sep. 1984, Charleston, SC. Final Report, pp. 102-105.

During the past 11 years, seven dredged material sites located in U.S. waterways have been planned, constructed, planted, and monitored by the U.S. Army Engineer Waterways Experiment Station (WES): Windmill Point in the James River, VA; Buttermilk Sound in the Altamaha River, GA; Drake Wilson Island in Apalachicola Bay, FL; Bolivar Peninsula in Galveston Bay, TX; Salt Pond 3 in south San Francisco Bay, CA; and Miller Sands Island in the Columbia River, OR; and upland sites located at Nott Island in the Connecticut River, CT; Bolivar Peninsula, TX; and Miller Sands Island, OR. In addition, four dredged material sites are being monitored: Southwest Pass at the mouth of the Mississippi River, LA, and Lake of the Woods at Warroad, MN, are wetland sites only; Gaillard Island in lower Mobile Bay, AL, and Pointe Mouillee in western Lake Erie, MI, are both wetland and upland sites. Research and development of these eleven sites have shown that habitat development is feasible and that habitats can be successfully developed on dredged material under a variety of site-specific conditions. Each site has represented habitat types found in U.S. waterways, and each has shown that it can be developed into a beneficial use usually in less than 3 years. The wetland sites have exceeded early expectations, while the upland sites have been less successful.

218. Lesnick, J. 1990. Low wave energy stabilization of shorelines. In: Beneficial Uses of Dredged Material. Proceedings of the Gulf Coast Regional Workshop. 26-28 Apr. 1988, Galveston, TX. Technical Report D-90-3, pp. 93-100.

The U.S. Army Corps of Engineers undertook a five-year program to develop, demonstrate, and transfer knowledge about low-cost methods for shore protection. The study addressed six sites in Delaware Bay, Roanoke Island on the North Carolina coast, Jentzen/Stuart Beach causeways, Basin Bayou in the Florida Panhandle, Fontainbleau State Park on Lake Pontchartrain, Alameda in the San Francisco Bay, Oak Harbor in Puget Sound, Port Wing on Lake Superior, Geneva State Park on Lake Erie, and two sites in Alaska. Structures were completed by 1978 and monitoring was continued through 1980. The demonstration sites were visited in 1986; many of them had failed in the intervening years. Four structures that were still functioning were examined. The results are reviewed in the paper.

219. Lindstrom, K. 1993. Wastewater Treatment: Gallons of Success. Environmental Protection 4 (3): 12-15.

Since the enactment of the Clean Water Act, an extensive effort has been made to meet the goals of fishable/swimmable waters nationwide. Industry and local governments have spent billions to upgrade sewer and wastewater management systems in order to abate and/or prevent water pollution problems. Several geographically diverse examples are reviewed: Potomac River, Cuyahoga River, and an area of Southern California where large volumes of wastewater are disposed of through deep ocean outfalls. What is important to note about the examples cited is the regional nature of the changes, which is indicative of the overall program efforts in a given area. Specific improvements based upon reduced loadings reductions from these regional publicly owned treatment works are reviewed in the report.

220. LMER Coordinating Committee. 1992. Understanding changes in coastal environments: The LMER Program. EOS, Transactions, American Geophysical Union 73 (45): 484-485.

After the state of knowledge of the land-margin ecosystem was reviewed at a workshop in May 1987 and the need for basic research was identified, the first call for proposals was issued under the Land-Margin Ecosystems Research (LMER) initiative in 1988. Four geographically widely distributed LMER sites which represent different types of land-margin environments have been established: Chesapeake Bay, the Columbia River, Tomales Bay, and Waquoit Bay. Research at each LMER site is conducted by groups of investigators who represent multiple disciplines. Models synthesize information within each LMER

site. The intensive and experimental studies within LMER sites are complemented by the opportunity that the LMER sites provide for extensive comparisons within LMER and with other coastal systems that represent a wide range of estuarine characteristics.

221. Long, E.R. 1992. Ranges in chemical concentrations in sediments associated with adverse biological effects. Marine Pollution Bulletin 24: 38-45.

222. Ludwig, D.F., Womack, C.J., Jordan, S.J. and Bell, W. 1985. Petroleum in coastal environments: What do we know?. In: The Fate and Effects of Pollutants: A Symposium. College Park, MD, 26-27 Apr. 1985. University of Maryland Sea Grant Program Technical Report UM-SG-TS-85-02, p. 62.

As part of an ongoing review of literature concerning potential environmental effects of offshore petroleum rights leasing, 1196 key references have been assembled from a variety of sources, including map series, government documents, refereed journals, review volumes, and symposia papers. The data base is assumed to be reasonably representative of available information, and an analysis of the catalogue has suggested regional topics that require additional study, or have been sufficiently reported. Preliminary analysis of the data base indicates that the Atlantic, Pacific, and parts of the southern Alaskan coasts have been thoroughly investigated, but the Gulf of Mexico coast, despite its developed drilling industry, is deficient in ecological study.

223. Mann, K.H. 1993. Physical oceanography, food chains, and fish stocks: A review. ICES Journal of Marine Science 50 (2), 105-119.

Many examples of correlations between changes in physical phenomena and changes in fish stocks have held for only several years. This does not necessarily mean that the correlation was invalid, but it is necessary to understand the mechanism of interaction before we can understand correlations that change with time. In this review, biological production processes are examined as links between the physical phenomena and the fish stocks. Two food chains exist in the plankton, one based on diatoms and the other based on bacteria and flagellates. Diatoms are consumed by mesozooplankton or by benthos, and they form the food of most commercially important fish stocks. Bacteria and flagellates are consumed by microzooplankton and enter a complex food web that is inefficient in supporting fish production. The pattern of events in the water column favors diatom production; it consists of vertical mixing followed by stratification. Stocks have varied synchronously in spite of widely different management patterns, and it may be that physical factors, operating through marine food webs, are the dominant forces for change in the fish stocks.

224. National Research Council, Washington, DC. Committee on a Systems Assessment of Marine Environmental Monitoring. 1990. Managing Troubled Waters: The Role of Marine Environmental Monitoring. National Academy Press, Washington DC. 125 pp.

Despite spending over $133 million on marine environmental monitoring annually in the United States, decision-makers still lack sufficient accurate information to make timely decisions about protecting coastal waters. This book evaluates the current monitoring system; examines the benefits and limitations of monitoring, with case studies of successful programs; evaluates the role of monitoring in environmental management; and describes the need for greater coordination among monitoring programs, with case studies of programs in the Chesapeake Bay and the Southern California Bight.

225. NOAA Coastal Ocean Program. 1992. Nutrient Enhanced Coastal Ocean Productivity, NECOP Workshop Proceedings. Oct. 1991. 154 pp.

The Nutrient Enhanced Coastal Ocean Productivity (NECOP) program seeks to determine the degree to which coastal primary productivity has been enhanced in areas that receive terrestrial nutrient inputs, determine the impact of the enhanced productivity on water quality, and determine the fate of fixed carbon in coastal areas as well as its impact on living resources within the affected coastal ecosystems. Field work in NECOP began during the summer of 1990. This report summarizes the observations and preliminary interpretations that were presented at the October 1991 workshop.

226. O'Connor, T.P., Price, J.E. and Parker, C.A. 1989. Results from NOAA's National Status and Trends Program on distributions, effects, and trends of chemical contamination in the coastal and estuarine United States. In: Oceans '89. The Global Ocean. Vol. 2. Ocean Pollution. Oceans '89 Conference, Seattle, WA, 18-21 Sep. 1989. Marine Technology Society and Institute of Electrical and Electronics Engineers, New York, NY Report, pp. 569-572.

Data from NOAA's National Status and Trends (NS&T) Program were examined for correspondences in contaminant concentrations among bivalve mollusks and sediments. Sediment data were compared with estimates of sediment toxicity, and possible temporal trends in contamination were indicated. Data on contaminant levels in sediments provide a better measure of relative contamination among all sites than do data from analyses of mussels or oysters. Liver tumors in fish, an extreme response to contamination, have been found infrequently. Hints of trends in contamination of bivalves were found in a few instances.

227. Orth, R.J., Ferguson, R.L. and Haddad, K.D. 1991. Monitoring seagrass distribution and abundance patterns. In: Coastal Zone '91 Conference. Wetlands Mapping - National Programs. Coastlines of the World. Magoon, O.T., Converse, H., Tippie, V., Tobin, L.T. and Clark, D. (ed.). Long Beach, CA, July 1991, pp. 281-300. American Society of Civil Engineers, New York.

228. Paul, J.F., Holland, A.F., Scott, K.J., Flemer, D.A. and Meier, E.P. 1989. An ecological status and trends program: EPA's approach to monitoring condition of the nation's ecosystems. In: Oceans '89: The Global Ocean. Vol. 2: Ocean Pollution. Oceans '89 Conference, Seattle, WA, 18-21 Sep. 1989. Marine Technology Society, Washington, DC and Institute of Electrical and Electronics Engineers, New York, NY., pp. 579-582.

> The U.S. Environmental Protection Agency is initiating an Environmental Monitoring and Assessment Program (EMAP) to monitor the status and trends of the nation's near coastal waters, forests, freshwater wetlands, surface waters, and agroecosystems. This program will also evaluate the effectiveness of Agency policies to protect ecological resources within these systems. Monitoring data for all ecosystems will be collected and integrated. The near coastal component of EMAP consists of four ecosystem categories: estuaries, wetlands, coastal waters, and Great Lakes. Near coastal ecosystems will be regionalized and classified, an integrated sampling strategy will be designed, and quality assurance/quality control procedures and data base management procedures will be implemented.

229. Pyke, T.N. 1989. CoastWatch: New mission for NOAA weather satellites. Sea Technology 30 (4): 27-28, 30, 32.

230. Seaman, W., Jr. 1987. Translating science for coastal decision-making. In: Coastal Zone '87. Vol. 1. Proceedings of the Fifth Symposium on Coastal and Ocean Management. Seattle, WA, 26-29 May 1987, pp. 222-236.

> This paper describes the uniform process of technical information assembly, application, and transfer used in six Florida estuarine systems. Since 1976, consolidation and interpretation of scientific data and transfer of information have fostered cooperative actions among public and private interests for Apalachicola, Biscayne, Choctawhatchee, and Tampa bays, the St. Johns River and vicinity, and Indian River Lagoon. Habitat restoration, revised management, and increased public awareness have resulted from legislative and civic initiatives.

231. Sherman, K. 1986. Measurement strategies for monitoring and forecasting variability in large marine ecosystems. In: Variability and Management of Large

Marine Ecosystems. Sherman, K. and Alexander, L.M. (ed.). AAAS Selected Symposium Series No. 99, pp. 203-235.

> Significant effort is underway to provide a scientific basis for the management and conservation of living resources within seven large marine ecosystems (LMEs): the Insular Pacific, Eastern Bering Sea, Gulf of Alaska, California Current, Gulf of Mexico, Southeast Atlantic Shelf, and Northeast Atlantic Shelf. In each LME, three resource assessment strategies have been implemented to monitor variability and forecast abundance of resource populations: utilization of yield statistics to estimate population trends, yield-independent surveys of adult and early-life stages on mesoscale spatial (20-100 km) and temporal (weeks-months) sampling frequencies, and process-oriented studies of ecosystem structure and function leading to improved resource forecasts.

232. Stumpf, R.P. and Tyler, M.A. 1988. Satellite detection of bloom and pigment distributions in estuaries. Remote Sensing of Environment 14: 385-404.

233. Thomas, J.P. and Ferguson, R.L. 1990. National Oceanic and Atmospheric Administration's Habitat Mapping under the Coastal Ocean Program. In: Federal Coastal Wetland Mapping Programs. A Report by the National Ocean Pollution Policy Board's Habitat Loss and Modification Working Group. Fish and Wildlife Service Biological Report 90 (18): 27-37.

> Timely documentation of the location, abundance, and change in coastal wetlands is critical to their conservation and to effective management of marine fisheries. The rapid changes occurring in these valuable wetlands require monitoring on a 1- to 5-year cycle. Therefore, NOAA's Coastal Ocean Program is initiating a cooperative interagency and State and Federal effort to map coastal wetlands and adjacent upland cover and change in the coastal region of the United States every 2-5 years, and to monitor annually areas of significant change. In fiscal year 1990, the program concentrated on protocol development and prototype studies in Chesapeake Bay and coastal North Carolina. In out-years, coastal wetlands and adjacent upland cover and change maps will be generated for coastal regions of the United States, beginning in the Gulf of Mexico. Extant land use and habitat mapping databases in other Federal and State agencies will be used, where appropriate, to minimize data acquisition cost, provide supplemental ground truth, and assist in verification.

234. Thomas, J.P., Ferguson, R.L., Dobson, J.E. and Cross, F.A. 1991. NOAA's CoastWatch: Change Analysis Program. In: Coastal Zone '91 Conference. Wetlands Mapping - National Programs. Coastlines of the World. Magoon, O.T., Converse, H., Tippie, V., Tobin, L.T., and Clark, D. (ed.). Long Beach, CA, July 1991. American Society of Civil Engineers, New York. Pp. 259-267.

235. Wolfe, D.A. 1992. Selection of bioindicators of pollution for marine monitoring programs. Chemistry and Ecology 6: 149-167.

236. Wolfe, D.A., Long, E.R. and Robertson, A. 1993. The NS&T Bioeffects Surveys: Design strategies and preliminary results. In: Coastal Zone '93. Vol. 1. Proceedings of the Eighth Symposium on Coastal and Ocean Management. Magoon, O.T., Wilson, W.S., Converse, H., and Tobin, L.T. (ed.). American Society of Civil Engineers, New York. Pp 298-312.

237. Wright, D.A. and Phillips, D.J.H. 1988. Chesapeake and San Francisco Bays: A study in contrasts and parallels. Marine Pollution Bulletin 19 (9): 405-413.

> Estuarine areas have generally become the most heavily developed of all coastal regions, and estuarine waters are possibly those most at risk from pollution and the inappropriate use of natural resources. The comparison of Chesapeake Bay and San Francisco Bay, among the largest extended estuarine systems in the country, provides an interesting study in contrasts and parallels. This paper reviews the main features of each estuary as a background to the more detailed studies presented later in the volume.

238. Zarba, C. 1989. National perspective on sediment quality. In: Contaminated Marine Sediments: Assessment and Remediation. National Academy Press, Washington, DC. Pp. 38-46.

> To meet the growing need for a regulatory tool that could be used in assessing and making decisions concerning contaminated sediments, a sediment criteria development effort was undertaken by the Environmental Protection Agency's Criteria and Standards Division. Seven chemical categories were identified: polynuclear aromatic hydrocarbons (PAHs), pesticides, chlorinated hydrocarbons, mononuclear aromatic hydrocarbons, phthalate esters, metals, and miscellaneous. In general, coastal areas were the most affected regions. The principal sites that contained chemicals of interest at high concentrations included Puget Sound waterways, Corpus Christi Harbor, New York Harbor, Baltimore Harbor, Boston Harbor, New Bedford Harbor, Blackrock Harbor, the California sewage outfalls at Palos Verdes, and parts of San Francisco Bay. Toxic metals, PAHs, polychlorinated biphenyls, and DDT exceeded the provisional sediment threshold values at several coastal locations.

COASTAL WATER BODY CONDITIONS

2A. WETLANDS AND UPLANDS

239. Adamus, P. 1991. Choices in Monitoring Wetlands. Environmental Protection Agency, Corvallis Environmental Research Lab., Corvallis, OR, Report EPA/600/D-91/129, 26 pp.

Proper characterization of the wetlands requires that large numbers of samples be collected due to the spatial and temporal variability of wetlands. Because of access problems, the ability to sample wetlands easily is sometimes severely limited although the combination of normally great productivity and potential for exposure to unnatural stresses suggests the need for extensive monitoring. This document contains numerous considerations for wetland monitoring programs.

240. Batiuk, R.A., Orth, R.J., Moore, K.A., Dennison, W.C. and Stevenson, J.C. 1992. Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis. Environmental Protection Agency, Annapolis, MD, Chesapeake Bay Program Report CBP/TRS-83/92, 258 pp.

The historical abundance of submerged aquatic vegetation (SAV) has been a major factor in the high productivity of Chesapeake Bay. SAV consists of approximately 20 species of rooted, flowering plants that provide food and habitat for finfish and shellfish, and affect nutrient cycling, sediment stability, and water turbidity. The primary objective of the SAV Technical Synthesis is to determine the relevant water quality parameters necessary to continue to support the SAV.

241. Brown, M.T. 1991. Evaluating Created Wetlands through Comparisons with Natural Wetlands. Environmental Protection Agency, Corvallis Environmental Research Lab., Corvallis, OR, Report EPA/600/3-91/058, 47 pp.

Methodology and field protocols for wetlands sampling were modified to reflect conditions and difficulties encountered in sampling herbaceous wetlands in urban areas of Florida. Emphasis was placed on the appropriateness of the measured variable for determining successful wetland re-creation. Biological and physical parameters were measured and compared in nine created and nine natural wetlands. Evaluations of temporal change in hydrology and plant successional trends appeared to be the most important parameters in determining wetlands success.

242. Cairns, J., Jr. and Buikema, A.L., Jr. (ed.). 1984. Restoration of Habitats Impacted by Oil Spills. Butterworth, Boston. 182 pp.

This book presents reports of a workshop held at the Virginia Polytechnic Institute and State University on November 9-11, 1981. Scientists from various backgrounds reviewed the problem of oil spills and determined courses of action for possible restoration of impacted habitats. Seven chapters discuss recovery and restoration of rocky shores, sandy beaches, tidal flats, and shallow subtidal bottoms; the effects of oil on seagrass ecosystems; the recovery and restoration of salt marshes and mangroves; measurements of damage, recovery, and rehabilitation of coral reefs; damage and recovery in tundra and taiga; fisheries resource impacts; and a workshop summary.

243. Dahl, T.E. and Johnson, C.E. 1991. Wetlands Status and Trends in the Conterminous United States, Mid-1970's to Mid-1980's. First Update of the National Wetlands Status Report, 1991. Fish and Wildlife Service Report ISBN-0-16-035916-3, 33 pp.

The Emergency Wetlands Resources Act of 1986 requires an updated report on the status and trends of wetlands and deep-water habitats in the contiguous U.S. on a ten-year cycle. The report, an update of the 1982 report on the 1950's to 1970's, provides the gains and losses of wetland for 14 categories of wetland and deep-water habitats.

244. Denbow, T.J. and Davis, W.S. 1989. Aquatic Sediments. Journal of Water Pollution Control Federation 61 (6): 1054-1068.

This document reviews ten subjects of recent research on aquatic sediments: (1) A general overview of method and policy-related documents on mitigation of sediment contamination, metal-sediment interactions, and ecological effects of sediment contamination; (2) Methods for detecting volatile fatty acids, rotenone, hexachlorophene, dioxin, organics, PCBs, PAHs, chlorine, viruses, pesticides, and performing algal assays; (3) Biological activity and toxicity in plants and animals; (4) Nutrients; (5) Benthic oxygen flux; (6) Metals; (7) Radionuclides; (8) Organics; (9) Dredging effects; and (10) Modeling and paleolimnology to determine resuspension, deposition, and transport of fine-grained sediments; chrysophyte and diatom distributions; past human disturbance; and mechanical reworking of sediments.

245. Durako, M.J., Carlson, P.R., Barber, T.R., Yarbro, L.A. and Kuss, K. 1992. Catastrophic mortality of the seagrass *Thalassia testudinum* in Florida Bay, January 1992. Note, Final Report, 1 Oct. 1990-31 Dec. 1991. Florida Marine Research

Institute, St. Petersburg, FL, 37 pp. Published in 1991 Marine Ecology Progress Series 71: 297-299.

The study was conducted to quantify the successional dynamics of seagrass beds experiencing active die-back, and to determine the capacity of healthy and diseased *Thalassia* to avoid hypoxic stress and sulfide toxicity. Basin level observation of frequency of occurrence, abundance, and density revealed that recovery of *Thalassia* in the most severely affected basin (Rankin Lake) was being outstripped by rapid recolonization of the pioneering species, *Halodule wrightii*. In an attempt to assess the susceptibility of *Thalassia* to sediment sulfide toxicity, a series of transplant studies were conducted using both seedlings and apical rhizome segments with at least three short shoots. Overall poor survival of transplant material indicated that *Thalassia* does not have the vigor of a pioneer species like *Halodule*. Rather, as a climax species, it is much more easily disrupted.

246. Eastern Research Group, Inc., Arlington, VA. 1991. Seminar Publication: Non-point Source Watershed Workshop. New Orleans, LA, 29-31 Jan. 1991. Environmental Protection Agency, Cincinnati, OH, Center for Environmental Research Information Report EPA/625/4-91/027, 210 pp.

The seminar concentrated on the management of nonpoint source pollution problems on a watershed basis.

247. Eleuterius, L.N. 1987. Seagrass: A neglected coastal resource. In: Proceedings of the Tenth National Conference. Estuarine and Coastal Management: Tools of the Trade. New Orleans, LA 12-15 Oct. 1986. Lynch, M.P. and McDonald, K.L. (ed.). Vol. 2, pp. 719-724.

The primary species found in this region are: *Syringodium filiforme*, *Halodule wrightii* and *Halophila engelmannii*. *Ruppia maritima* is estuarine in Louisiana, Mississippi and Alabama, and in those regions, it does not grow intermixed with the three; however, *R. maritima* occurs associated with true seagrass in Texas and South Florida. This paper reviews the main causes for the lack of research on seagrasses.

248. Ferguson, R.L., Wood, L.L. and Graham, D.B. 1992. Detection of change in submerged coastal habitat. In: ASPRS/ACSM/RT 92 Technical Papers. Vol. 1. Global Change and Education, pp. 70-79. American Society for Photogrammetry and Remote Sensing and American Congress on Surveying and Mapping, Bethesda, MD.

249. Ferguson, R.L., Wood, L.L. and Graham, D.B. 1993. Monitoring spatial change in seagrass habitat with aerial photography. Photogrammetric Engineering and Remote Sensing 59 (6): 1033-1038.

250. Fonseca, M.S., Thayer, G.W. and Kenworthy, W.J. 1985. The use of ecological data in the implementation and management of seagrass restorations. Eighth Biennial International Estuarine Research Conference, Durham, NH 28 Jul. 1985. Estuaries 8 (2B): 125A.

> Effective restoration of seagrass systems is based on the incorporation of basic ecological data, including careful selection of a site to be transplanted, site monitoring under strict performance standards, and environmental factors such as light, temperature, salinity, tidal range, and sediment stability. The utilization of population growth models of seagrasses is also essential in the planning process.

251. Fonseca, M.S., Kenworthy, W.J. and Thayer, G.W. 1987. Environmental Impact Research Program. Transplanting of the Seagrasses *Halodule wrightii, Syringodium filiforme,* and *Thalassia testudinum* for Sediment Stabilization and Habitat Development in the Southeast Region of the United States. Technical Report (Final). Army Engineer Waterways Experiment Station, Vicksburg, MS Environmental Laboratory, Report No. WES/TR/EL-87-8, 60 pp.

> Seagrass transplants were conducted at sites across a broad geographic area in order to assess seagrass shoot generation and coverage rates under different environmental conditions. The environmental factors considered were temperature; salinity; light attenuation; water depth; hydraulic regime; sediment type, fluctuation, and depth; and biotic disturbance of these factors. Temperature, sediment fluctuation, sediment depth, and biotic disturbance were the most influential factors in transplant survival and coverage.

252. Fonseca, M.S. 1990. Regional analysis of the creation and restoration of seagrass systems. In: Wetland Creation and Restoration: The Status of the Science. Kusler, J.A. and Kentula, M.E. (ed.). Island Press, Washington, D.C. Pp. 171-194.

253. Gadbois, L.E. 1989. Measuring the Effectiveness of Non-point Source Control Techniques for Aquatic Protection. Naval Ocean Systems Center, San Diego, CA, Report NOSC/TD-1682, 15 pp.

> The report describes a method for selecting and evaluating the effectiveness of a nonpoint source pollution control technique.

254. Haddad, K. 1990. Marine Wetland Mapping and Monitoring in Florida. In: Federal Coastal Wetland Mapping Programs. A Report by the National Ocean Pollution Policy Board's Habitat Loss and Modification Working Group. Fish and Wildlife Service Biological Report 90 (18), 145-150.

Landsat Thematic Mapper (TM) satellite data have been used as the base for the Florida Department of Natural Resources program of mapping and monitoring of Florida's coastal marine wetland habitat. The TM data are processed to distinguish the marine and estuarine emergent vegetation. Aerial photography is used for seagrass mapping. Although the protocol and techniques for the mapping effort have begun and an initial mapping effort has been completed, a fully established monitoring effort is still being developed. The success of this program depends on the flexibility of using multiple sources of data with a resultant digital product.

255. Kemp, W.M., Twilley, R.R., Stevenson, J.C., Boynton, W.R. and Means, J.C. 1983. The decline of submerged vascular plants in upper Chesapeake Bay: Summary of results concerning possible causes. Special issue - Seagrass ecology. Marine Technology Society Journal 17(2): 78-89.

This paper summarizes and synthesizes the results of research concerning possible causes of the decline in abundance of submerged aquatic vegetation (SAV) in upper Chesapeake Bay beginning in the late 1960s. Three factors were emphasized: runoff of agricultural herbicides, erosional inputs of fine-grain sediments, and nutrient enrichment and associated algal growth. Although widespread use of herbicides occurred in the estuarine watershed contemporaneous with the SAV loss, extensive sampling of estuarine water and sediments during 1980-81 revealed that typical bay concentrations of herbicides rarely exceeded 2 ppb. The results of the experiments were synthesized into an ecosystem simulation model which demonstrated the relative potential contributions of three factors to SAV declines, in order of declining contribution: nutrients, sediments, and herbicides.

256. Kenworthy, W.J. and Haunert, D.E. (ed.). 1991. The Light Requirements of Seagrasses: Proceedings of a Workshop to Examine the Capability of Water Quality Criteria, Standards, and Monitoring Programs to Protect Seagrasses. NOAA Technical Memorandum NMFS-SEFC-287, 181 pp.

257. Liebowitz, N.C., Squires, L. and Baker, J.P. 1991. Environmental Monitoring and Assessment Program: Research Plan for Monitoring Wetland Ecosystems. Environmental Protection Agency, Corvallis Environmental Research Lab., Corvallis, OR, Report EPA/600/3-91/010, 191 pp.

The goal of Environmental Monitoring and Assessment Program (EMAP) is to provide a quantitative assessment of the status and long-term trends in wetlands both regionally and nationally. The objectives of EMAP-Wetlands include the quantification of the regional status of wetlands, monitoring of changes in hydrology, pollution exposure, and other factors that could stress wetlands, and identification of plausible causes for wetlands changes.

258. Minello, T.J. and Webb, J.W., Jr. 1993. The development of fishery habitat value in created salt marshes. In: Coastal Zone '93. Vol. 2. Proceedings of the Eighth Symposium on Coastal and Ocean Management. Magoon, O.T. (ed.). New Orleans, LA, 19-23 July 1993, pp. 1864-1865. American Society of Civil Engineers, New York.

259. Montague, C.L., Zale, A.V. and Percival, H.F. 1987. Ecological effects of coastal marsh impoundments: A review. Environmental Management 11 (6): 743-756.

The effects of diking and flooding marshes (impounding) for mosquito control and waterfowl management are reviewed. Major changes include increased water level, decreased salinity, and decreased exchange of marsh water with estuarine water. Dramatic changes in species composition occur, which vary from place to place. For example, emergent vegetation may change to submerged vegetation, cattails proliferate due to decreased salinity and other favorable conditions, black mangrove marshes change to red and white mangroves, nutrients decrease from reduced water circulation or increase from wastes of newly attracted wildlife, primary production increases due to a reduction in salinity or decreases due to salt concentration by evaporation. Changes in overall production and transport phenomena may not be as great as commonly believed. An important concern is occasional barring of free access to open water when conditions become unfavorable in an impounded marsh. For example, high summer temperatures and depleted oxygen can cause fish kills in an impounded marsh because no access to better conditions is readily available as in a natural marsh.

260. Moy, L.D. and Levin, L.A. 1991. Are *Spartina* marshes a replaceable resource? A functional approach to evaluation of marsh creation efforts. Estuaries 14: 1-16.

261. Murray, L., Dennison, W.C. and Kemp, W.M. 1992. Nitrogen versus phosphorus limitation for growth of an estuarine population of eelgrass (*Zostera marina L.*). Aquatic Botany 44 (1), 83-100.

The relative importance of nitrogen (N) and phosphorus (P) limitation for growth and biomass accumulation in eelgrass was examined by in-situ additions of

nitrogen (N), phosphorus (P), and nitrogen plus phosphorus (N+P) to sediments at low and high loading rates. Nitrogen treatments resulted in no significant increases in leaf-tissue N levels and only a small increase in the N content of root-plus-rhizome tissues. Addition of P and N+P resulted in significantly higher phosphorus concentrations in both leaf and root-plus-rhizome tissues. Comparison with other sediment-fertilization experiments for both fresh-water and marine plant species revealed a clear relationship between relative plant growth rates and tissue nutrient concentrations for both N and P enrichment. This relationship suggests a uniformity of submersed plant nutrition, wherein responses to changes in nutrient availability are regulated by alterations in both growth rates and tissue nutrient content.

262. Olson, R.K. and Marshall, K. 1991. Workshop Proceedings: The Role of Created and Natural Wetlands in Controlling Non-point Source Pollution. Arlington, VA, 10-11 Jun. 1991. Environmental Protection Agency, Corvallis Environmental Research Lab., Corvallis, OR, Report EPA/600/9-91/042, 276 pp.

Effective use of wetlands in the control of nonpoint source pollution requires an integrated landscape approach that includes scientific knowledge and a consideration of social, economic, and government policy issues.

263. Orth, R.J. and Moore, K.A. 1984. Distribution and abundance of submerged aquatic vegetation in Chesapeake Bay: An historical perspective. Estuaries 7 (4B): 531-540.

The historical distribution and abundance of submerged aquatic vegetation (SAV) in Chesapeake Bay are summarized in this report. SAV has been common throughout the bay over the last several hundred years, with several fluctuations in abundance. The decline of *Zostera marina* (eelgrass) in the late 1930's and the rapid expansion of *Myriophyllum spicatum* (water milfoil) in the late 1950's and early 1960's were significant events that each involved a single species. Between 1965 and 1970, declines of SAV were observed in the Patuxent, Potomac and sections of other rivers in the Maryland portion of the Bay. From 1970 to 1975, dramatic reductions were observed over the entire length of the bay. The greatest losses of vegetation occurred in the years following Tropical Storm Agnes in 1972. Since 1975, little regrowth has been observed in the Chesapeake Bay. Other areas along the Atlantic Coast of the U.S. during the same period have experienced no similar widespread decline.

264. Orth, R.J. 1985. Submerged aquatic vegetation in the Chesapeake Bay: Value, trends and management. In: Wetlands of the Chesapeake. Proceedings of the Conference Held April 9-11, 1985, Easton, Maryland. 1985. p 84-95.

Although there is a history of oscillations of submerged aquatic vegetation (SAV) in the Chesapeake Bay, the recent decline of SAV has affected all native species in all sections of the Bay and is a local phenomenon. Nutrient enrichment and increased turbidity are the major factors responsible for this decline, and the adverse impacts on water quality and secondary production may be considerable. If SAV is to be part of the Bay's future, short-term efforts must be concentrated on dredge and fill operations, and long-term efforts must control sediment and nutrient inputs. Transplanting programs should be viewed with caution, and priority consideration should be given to conservation of existing beds (as opposed to mitigation plans to offset potential SAV losses).

265. Orth, R.J., Nowak, J.F., Frisch, A.A., Kiley, K.P. and Whiting, J.R. 1991. Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Tributaries and Chincoteague Bay - 1990. Virginia Institute of Marine Science, Gloucester Point, VA, Report, 280 pp.

Black-and-white aerial photography was used to map the distribution of submerged aquatic vegetation in the Chesapeake Bay, its tributaries, and Chincoteague Bay during May-October 1990. SAV (*R. maritima* and *Z. marina*) in Chincoteague Bay increased slightly from 1989. In 1990, the Chesapeake Bay had 24,296 hectares of SAV.

266. Orth, R.J., Nowak, J.F., Anderson, G.F., Kiley, K.P. and Whiting, J.R. 1992. Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Tributaries and Chincoteague Bay, 1991. Virginia Institute of Marine Science, Gloucester Point, VA, Report, 286 pp.

Black-and-white aerial photography was used to map the distribution of submerged aquatic vegetation in the Chesapeake Bay, its tributaries, and Chincoteague Bay during May-October 1991. In 1991, the Chesapeake Bay had 1,327 hectares more than in 1990 (24,296 hectares).

267. Race, M.S. 1985. Critique of present wetlands mitigation policies in the United States based on an analysis of past restoration projects in San Francisco Bay. Environmental Management 9 (1): 71-82.

A detailed evaluation of past wetland restoration projects in San Francisco Bay was undertaken to determine their present status and degree of success. On the basis of these findings, it is debatable whether any sites in San Francisco Bay can be described as completed, active, or successful restoration projects at present. Policies encouraging or allowing quid pro quo exchanges of natural wetlands with man-made replacements should proceed with caution.

268. Ramsay, M., Boynton, W. and Clark, P. 1992. Framework for Characterization. Revised Final Report March 1992. Tampa Bay Regional Planning Council, St. Petersburg, FL, Report No. TBNEP-01-92, 64 pp.

The Tampa Bay National Estuary Program (TBNEP) was established in 1990 to restore and protect the bay and its resources. The process of identifying the problems of the bay and linking problems to causes is known as characterization. Characterization workshops were held in June and July 1991 to guide the process toward areas of the greatest information needs; contribute to the development of a preliminary bay report; and depict bay ecosystem components and interrelationships. The workshops focused on living resources and water quality deterioration. Priority information needs were identified, including estuarine seagrasses, low-salinity habitats, benthic habitats, refinement of a nitrogen input budget, and establishment of cause-effect relationships among nutrient loading, dissolved oxygen concentrations, and the distribution of seagrass and benthic communities.

269. Schneller-McDonald, K., Ischinger, L.S. and Auble, G.T. 1990. Wetland Creation and Restoration: Description and Summary of the Literature. National Ecology Research Center, Fort Collins, CO Report BIOLOGICAL-90(3), 205 pp.

The report provides a hard copy of the 1,100 records in the Wetland Creation/Restoration Data Base. Information in the data base includes a description of all fields and keywords, a summary of findings in tables and graphs, and information on four cross-referenced indexes (Location, Plant Genus, Wetland Type, and Subject).

270. Short, F.T., Jones, S.H., Sale, P.F. and Wellenberger, P. 1992. Great Bay Estuary management issues. In: The Ecology of the Great Bay Estuary, New Hampshire and Maine: An Estuarine Profile and Bibliography. Chapter 10, pp. 145+. Short, F.T. (ed.). NOAA Coastal Ocean Program/New Hampshire Sea Grant College Program Publication.

A number of specific as well as interactive management issues are of concern when considering the health of the Great Bay Estuary, in NH and ME. The primary issues are the closure of shellfishing beds, the rapid rate of shoreline development, the loss of eelgrass habitat, decreased water clarity, and the fate of hazardous wastes and contaminants that enter estuarine waters. The issues are of both immediate and long-range concern, and they should be addressed in the early stages of monitoring and research activities of the Great Bay Estuarine Research Reserve System. This chapter also discusses wetlands loss, habitat restoration, and mitigation for replacing resources destroyed by development.

271. Short, F.T., Burdick, D.M., Wolf, J. and Jones, G.E. 1993. Declines of Eelgrass in Estuarine Research Reserves; Along the East Coast, USA: Problems of Pollution and Disease, and Management of Eelgrass Meadows in East Coast Research Reserves. NOAA Coastal Ocean Program Publication, 109 pp. NOAA Coastal Ocean Program Office, Silver Spring, MD.

272. Thom, R.M. and Hallum, L. 1991. Long-Term Changes in the Areal Extent of Tidal Marshes, Eelgrass Meadows and Kelp Forests of Puget Sound. Washington University, Seattle, WA, Fisheries Research Institute Report FRI-UW-9008, 116 pp. Environmental Protection Agency, Seattle, WA, Region X Report EPA/910/9-91/005, 116 pp.

Historical changes in the distribution of marshes, eelgrass meadows, and kelp forests are described. Tidal marshes have decreased 71 percent in area since the 1800s. Eelgrass loss was estimated at 15-30 percent in some areas but gain was estimated to be five-fold in Padilla Bay. Kelp has increased approximately 58 percent in Puget Sound in the Straits. Recommendations are made concerning monitoring, investigating causal factors, and incorporating only new habitat records into a Geographic Information System.

273. Thorhaug, A. 1985. Large-scale seagrass restoration in a damaged estuary. Marine Pollution Bulletin 16 (2): 55-62.

After several years of planning, a large-scale seagrass restoration project was initiated in a damaged estuary in Biscayne Bay, FL, in 1982. For the project, 13 test plots were selected, totalling 10.38 acres in area, which is the second largest test plot program implemented to date (an ongoing test plot program in Jamaica is 16.9 acres). Three seagrasses, *Thalassia testudinum*, *Halodule wrightii* and *Syringodium filiforme*, were transplanted at each test plot by two methods. After 9-18 months, test plots differed widely in the survival and growth of the three species. Nine of the 13 plots had one species/method successful enough for further planting. Mid-bay sites damaged by dredging had two species surviving 60% or more. High turbidity sites were the least successful.

274. Thorhaug, A. 1986. Review of seagrass restoration efforts. Ambio 15 (2), 110-117.

Seagrass beds, which provide food, habitat and erosion control, have been adversely affected by a number of man-made stresses such as pollution and over-exploitation. Seagrass restoration efforts have had varying degrees of success; this article documents the history of the efforts and suggests areas for improvement.

275. Thorhaug, A. 1989. Fish aggregation and fisheries nursery restoration by seagrass rehabilitation. Fourth International Conference on Artificial Habitats for Fisheries, Miami, FL 2-6 Nov. 1987. Bulletin of Marine Science 44 (2): 1070-1071.

The need to restore seagrasses decimated by development is critical to the maintenance of fish and shellfish populations. The placing of estuarine and nearshore artificial reefs is an opportunity for recreating nursery. In Biscayne Bay, a series of sublittoral areas which were adjacent to dredge and fill pits were planted. Two sites had artificial reefs placed next to them at a later date. Lobsters, crabs, snapper, groupers, spadefish, barracuda and several other species were found grazing through the seagrass beds adjacent to the reef. Egg cases and juveniles appeared, and, when threatened, individuals rapidly retreated to the artificial reef. It is suggested that artificial reefs be coupled with seagrass restoration in decimated estuaries.

276. Valiela, I., Foreman, K., LaMontagne, M., Hersh, D., Costa, J., Peckol, P., DeMeo-Anderson, B., D'Avanzo, C., Babione, M., Sham, C.H., Brawley, J. and Lajtha, K. 1992. Couplings of watersheds and coastal waters: Sources and consequences of nutrient enrichment in Waquoit Bay, Massachusetts. Estuaries 15 (4), 443-457.

A series of sub-watersheds of Waquoit Bay that differ in degree of urbanization and hence exposure to nutrient loading rates were used to investigate the coupling of land to marine systems. The sub-watersheds differ in the number of septic tanks and the acreage of forests. Groundwater is the major nutrient transport mechanism to coastal waters. Urbanized areas showed significant increases in groundwater nutrient content. Loading dependent alterations included increased nutrients in water, greater primary production by phytoplankton, and increased macroalgal biomass and growth. The increases in seaweeds, which have decreased the areas covered by eelgrass habitats, have changed the composition of the benthic fauna. The coupling of land to sea by groundwater-borne nutrient transport is mediated by a complex series of steps; the cascade of processes make it unlikely to find a one-to-one relation between land use and conditions in the aquatic ecosystem.

277. Zedler, J. and Langis, R. 1990. A Manual for Assessing Restored and Natural Coastal Wetlands, with Examples from Southern California. 105 pp. Pacific Estuarine Research Lab., San Diego State University, San Diego, CA.

Present restoration and mitigation policies allow natural wetlands to be degraded or destroyed if other wetlands are enhanced or constructed. But there is controversy over whether restoration efforts are successful in providing the habitat required for native species to thrive, and whether such projects are contributing to the overall objective of maintaining regional diversity of plant and

animal species. This manual recommends methods for assessing the structure and function of coastal wetlands, especially salt marshes and tidal creeks, toward the goal of standardizing assessment methods. A case study is included of the Sweetwater River Wetlands Complex, San Diego Bay, California.

278. Zedler, J.B. 1992. Restoring cordgrass marshes in southern California. In: Restoring the Nation's Marine Environment. Thayer, G.W. (ed.). Pp. 7-51. Maryland Sea Grant College Publication, College Park, MD.

279. Zedler, J.B. 1993. Restoring biodiversity to coastal salt marshes. In: Interface between Ecology and Land Development in California. Keeley, J.A. (ed.). Proceedings 1992 Southern California Academy of Sciences, pp. 253-258. Southern California Academy of Sciences, Los Angeles, CA.

280. Zedler, J.B. and Powell, A. 1993. Problems in managing coastal wetlands: Complexities, compromises, and concerns. Oceanus 36 (2): 19-28.

2B. RED TIDES AND OTHER ALGAE

281. Baird, D. and Ulanowicz, R.E. 1989. Seasonal dynamics of the Chesapeake Bay ecosystem. Ecological Monographs 59 (4), 329-364.

The full suite of carbon exchanges among the 36 most important components of the Chesapeake Bay mesohaline ecosystem was estimated to examine the seasonal trends in energy flow and the trophic dynamics of the ecosystem. Although the overall typology of the ecosystem did not change substantially from season to season, there was a dominant seasonal cycle in the activities of all subcommunities, which was greatest in the summer and least in the cold season. The complicated trophic network assessed by matrix operations was mapped into an eight-level trophic chain. Annual efficiencies of trophic levels decreased as the chain was ascended. Despite the existence of eight trophic levels, the average level at which each species feeds always remains below 5. One "pest" species (the coelenterate *Chrysaora quinquecirrha*) feeds high on the trophic pyramid and, as a result, it may exert an unappreciated level of control on the planktonic food chain. The collection of cycles present in the system is disjoint; there is no overlap among the cycles of the planktonic community and the circulations among the deposit feeders and nekton.

282. Carder, K.L. and Steward, R.G. 1985. A remote-sensing reflectance model of a red-tide dinoflagellate off West Florida. Limnology and Oceanography 30 (2): 286-298.

A mathematical model that simulates the spectral curves of remote-sensing reflectance of blooms of the red-tide dinoflagellate *Ptychodiscus brevis* has been developed. The model results have been compared to measurements obtained from a low-flying helicopter for *P. brevis* populations with chlorophyll-like pigment concentrations of 7-77 mg/m^3 found in case 2 waters along the west Florida shelf.

283. Conte, F.S. 1984. Economic impact of paralytic shellfish poison on the oyster industry in the Pacific United States. Aquaculture 39 (1-4): 331-343. Special issue: Innovations in Pacific mollusk culture.

The oyster industry on the west coast of the continental United States extends from Puget Sound to Morro Bay, CA. Periodic outbreaks of paralytic shellfish poison caused by the dinoflagellate *Gonyaulax* have resulted in symptoms and even death from consumption of contaminated shellfish. Although no deaths and only two reported outbreaks have affected commercial oysters, the fear of paralytic shellfish poison causes seasonal depressions in oyster markets, even

without outbreaks. This study reviews the economic impact of paralytic shellfish poisoning, the factors that increase the impact beyond the normal response, and requirements to lessen the impact on the oyster industry.

284. DePinto, J.V. 1990. Application of toxics exposure models to large lakes: From Green Bay to Lake Champlain. In: Proceedings of a Symposium on Lake Champlain. Vermont Water Resources Research Center, VT, pp. 70-80.

In an effort to develop a functional methodology for application of the Toxics Mass Balance Modeling Approach to large lakes and to determine the feasibility of using modeling for determining priorities and strategies for regulatory and remedial actions, the Environmental Protection Agency has implemented an integrated toxics modeling study of Green Bay, Lake Michigan. The Integrated Exposure Model will include the following submodels: hydraulic transport, integrated particle fate and transport, physical and chemical toxics, and food chain bioaccumulation. The following lessons from the Green Bay project are relevant to similar undertakings on Lake Champlain: (1) The first step should be a detailed specification of the problem and management expectations; (2) Up-front screening model calculations and analysis of historical data are useful for optimizing project design and implementation; (3) Large-scale interdisciplinary projects require a well-conceived project management structure; (4) Individual research efforts should have significant system-level implications; and (5) Toxics system-level studies can be very expensive.

285. Flynn, M.C. and Martin, D.F. 1988. Inhibition of growth of a red tide organism, *Ptychodiscus brevis*, by a green alga, *Nannochloris oculata*. Microbios Letters 39 (153): 13-18.

The inhibition of growth of the dinoflagellate *Ptychodiscus brevis* was a function of the number of the green alga *Nannochloris oculata* initially present in the mixed culture. The inhibition was an example of allelopathy. This was indicated by removing *N. oculata* cells, adding different amounts of cell-free culture to *P. brevis* culture, and noting that inhibition of growth still occurred.

286. Fowler, P.K. and Tester, P.A. 1989. Impacts of the 1987-88 North Carolina red tide. 1990 Annual Meeting of the National Shellfisheries Association, Williamsburg, VA, 1-5 Apr. 1990. Journal of Shellfisheries Research 8 (2), 440.

The first recorded occurrence of *Ptychodiscus brevis* along the North Carolina coast caused approximately 365,000 acres of approved shellfish harvesting waters to be closed and impacted approximately 50% of the oyster and 90% of the clam harvesting areas in the State. After *Ptychodiscus brevis* was identified from North Carolina coastal waters on November 2, 1987, harvesting of clams

was delayed until waters reopened between 19 February and 6 May 1988. There were 48 confirmed illnesses from consumption of shellfish contaminated by brevetoxins during this red tide event.

287. Gilgan, M.W., Burns, B.G. and Landry, G.J. 1990. Distribution and magnitude of domoic acid contamination of shellfish in Atlantic Canada during 1988. In: Toxic Marine Phytoplankton. Fourth International Conference on Toxic Marine Phytoplankton, Lund (Sweden), 26-30 Jun. 1989. Graneli, E., Sundstroem, B., Edler, L. and Anderson, D.M. (ed.). Pp. 469-474. Elsevier, New York.

During the late fall of 1987, domoic acid contamination of shellfish was responsible for severe illness in many Canadians. The contamination of the shellfish has subsequently been attributed to the occurrence of a toxic variety of the diatom, *Nitzschia pungens*. The presence and abundance of domoic acid in shellfish throughout Atlantic Canada was monitored. Outbreaks of severely contaminated shellfish were characterized by long, low-level preliminary contamination followed by an abrupt rise to severe levels and an equally abrupt decline in the domoic acid content. The toxin was first detected in mussels (*Mytilus edulis*) and soft-shell clams (*Mya arenaria*) collected in the Bay of Fundy and vicinity during late July-early August.

288. Guidorzi, R., Beghelli, S., Soverini, U., Terragni, F. and Boni, L. 1992. Dynamical correlation techniques in eutrophication phenomena analysis. In: Marine Coastal Eutrophication. Symposium on Marine Coastal Eutrophication, Bologna (Italy), 21-24 Mar 1990. Vollenweider, R.A., Marchetti, R. and Viviani, R. (ed.). Suppl. pp. 935-944.

Before trying to model complex phenomena such as eutrophication, a model must be selected with a complexity that compares favorably with the number of samples in the sequences used for their determination. Most approaches described in the literature rely on assumptions which are made a priori or on the results of algebraic correlation analyses performed on the data. This paper describes the deduction of this information from the measured data by a process of dynamical correlation. The results obtained in the application of this approach to dinoflagellate and diatom bloom data show substantial differences in the optimal inputs to be selected to describe such phenomena and also the suitability of such inputs to identify models with reduced complexity and good performance.

289. Harding, L.W., Jr. and Itsweire, E.C. 1990. Synoptic measurements on the distribution of chlorophyll in the Chesapeake Bay using aircraft remote sensing. In: Proceedings of the Second Chesapeake Research Conference. Baltimore, MD, 4-6 Dec. 1990. [no pages]

290. Maranda, L. and Shimizu, Y. 1987. Diarrhetic shellfish poisoning in Narragansett Bay. Estuaries 10 (4): 298-302.

A two-year survey for diarrhetic shellfish poisoning (DSP) was conducted in Narragansett Bay. The suspected causative organisms, *Dinophysis spp.*, were monitored concurrently. Only one shellfish sample, in September 1984, yielded an unequivocal positive result at a time when the dinoflagellate population was dominated by *D. acuminata*. False positive results were suspected in May, when the mussels appeared sexually mature, and in the summer of 1985, at the time of a massive bloom. Evidence of toxin production by *D. acuminata* was obtained from an almost monospecific sample. Improvements for DSP detection are suggested.

291. Martin, B.B. and Martin, D.F. 1983. An investigation of the photodynamic activity of a red tide (*Ptychodiscus brevis*) cytolytic agent. Microbios Letters 93 (24): 15-17.

The yellow colored material of aponin, isolated from cell-free cultures of *Gomphosphaeria aponina* was equally cytolytic toward *Ptychodiscus brevis* in the dark and in the light. Although it has been demonstrated that *P. brevis* is readily cytolysed through photodynamic action by dyes, photodynamic action is not the mechanism for the cytolytic activity of aponin. The implications of this observation to management of a red tide bloom are considered.

292. Paerl, H.W. 1987. Nuisance phytoplankton blooms in coastal, estuarine and inland waters. In: Comparative Ecology of Coastal Waters, Proceedings of UNESCO - Sea Grant Symposium. Special Symposium, Nairobi, Kenya. Vol. 1, 55 pp.

Criteria for specific aquatic habitats are discussed which qualify such waters as having nuisance bloom characteristics. The paper also addresses those phytoplankton taxa specifically responsible for nuisances. Environmental conditions favoring nuisance bloom formation are related to the ecological and physiological characteristics, bloom strategies and trophic impacts of relevant organisms. It is hoped that recognition of key causative factors will aid management strategies aimed at moderating or controlling blooms.

293. Park, J.S. and Kim, H.G. (ed.). 1991. Recent approaches of red tides. Proceedings of 1990 Korean-French Seminar on Red Tides, held November 9-10, 1990, at National Fisheries Research and Development Agency, Republic of Korea. Kyongsangnam-do (Korea) NFRDA 1991. 159 pp.

For many years, toxic algal blooms and red tides have had severe economic impact on shellfish and finfish resources, public health, and the aquatic

environment throughout coastal regions of the world, but the magnitude, frequency and geographic extent of red tides have increased dramatically during the last two decades. The major topics of this seminar were: (1) mutual experiences of red tide occurrences; (2) national research strategies, including monitoring and prediction; (3) phytoplankton bloom development, including physical, chemical and biological factors that control bloom formation; (4) benthic cyst distribution; (5) toxicological studies, including toxic problems and effects of paralytic shellfish poisoning and diarrhetic shellfish poisoning; and (6) general techniques for toxic assessment, and prevention of blooms, and extermination of red tide organisms.

294. Pierce, R.H. 1986. Red tide (*Ptychodiscus brevis*) toxin aerosols: A review. Toxicon 24 (10): 955-965.

This review summarizes current knowledge of the characterization, effect, and production of red tide toxin aerosols, with emphasis on the Florida red tide organism, *Ptychodiscus brevis*. Insight into the chemical characterization and toxic effects of aerosolized toxins is provided from investigations of toxins extracted from natural blooms and from laboratory cultures. The production of aerosolized toxins is examined through studies of jet drop aerosol formation from bursting bubbles. Available information suggests that aerosolized red tide toxins may be the same chemicals as those extracted from laboratory cultures, with one of the toxins having a greater respiratory effect than others.

295. Shimizu, Y. 1989. Toxicology and pharmacology of red tides: An overview. In: Red Tides: Biology, Environmental Science, and Toxicology. First International Symposium on Red Tides, Takamatsu (Japan), 10-14 Nov. 1987. Okaichi, T., Anderson, D.M. and Nemoto, T. (ed.). Pp. 17-21. Elsevier Science Publishing Co., New York.

Recent pharmacological and biochemical studies of red tide organisms, *Gonyaulax* (= *Protogonyaulax*, *Alexandrium*) spp. and *Gymnodinium breve* (= *Ptychodiscus brevis*) are reviewed in this article. The toxicity of other deleterious red tide organisms which cause serious economic and environmental problems is discussed also.

296. Simon, M., Cho, B.C. and Azam, F. 1992. Significance of bacterial biomass in lakes and the ocean - Comparison to phytoplankton biomass and biogeochemical implications. Marine Ecology - Progress Series 86 (2): 103-110.

Marine and limnetic bacterial biomass carbon (BOC) and phytoplankton biomass carbon (PhytoC) data were synthesized to examine the relationships between these major biotic carbon pools. Based on six limnetic and six marine

studies, BOC and PhytoC were correlated in both systems although the slope was substantially lower than for similar correlations on the basis of bacterial abundance and chlorophyll a. Limnetic systems, however, supported more BOC relative to PhytoC than did marine systems. The food-web structure in oligotrophic systems was fundamentally different from that in eutrophic systems, e.g. that BOC/PhytoC dramatically increased with decreasing PhytoC concentrations. This has implications for the significance of planktonic bacteria in particle abundance and size-dependent properties of lakes and oceans such as trace metal and radionuclide adsorption, biogeochemical dynamics and in light scattering and remote sensing.

297. Stabell, O.B. and Cembella, A.D. 1990. Standardizing extraction and analysis techniques for marine phytoplankton toxins (workshop). In: Toxic Marine Phytoplankton. Fourth International Conference on Toxic Marine Phytoplankton, Lund (Sweden), 26-30 Jun. 1989. Graneli, E., Sundstroem, B., Edler, L. and Anderson, D.M. (ed.). Pp. 499-503. Elsevier, New York.

This workshop was convened in order to compare analytical techniques and extraction methods for the determination of marine phytotoxins. Most of the discussion was devoted to methods for diarrheic shellfish poisons (DSP), but the general approach was valid for the analysis of other phytotoxins, such as paralytic shellfish poisons (PSP), brevetoxins, ciguatera, and domoic acid. In general, the results of the collaborative study of the DSP method were discouraging. Quantitative toxicity values for the same sample often differed several-fold among various laboratories. Using this study as a model to illustrate the difficulties encountered in the standardization of techniques for the analysis of marine phytotoxins, the workshop participants identified several key areas which require further investigation.

298. Subba Rao, D.V., Quilliam, M.A. and Pocklington, R. 1988. Domoic acid - a neurotoxic amino acid produced by the marine diatom *Nitzschia pungens* in culture. Journal of Fisheries and Aquatic Sciences 45 (2): 2076-2079.

During late 1987, human fatalities resulted from the ingestion of cultivated blue mussels (*Mytilus edulis*) from a localized area in eastern Canada (Cardigan Bay, Prince Edward Island). Massive blooms of *Nitzschia pungens*, a widely distributed diatom not previously known to produce toxins, were in the area of mussel growth. In this article, the authors show that the causative agent, domoic acid, is produced by this diatom. No domoic acid was detected in culture medium prepared from Cardigan River water, but it was found in cultures of *Nitzschia pungens* grown in this medium 7-68 days after inoculation.

299. Taft, W.H. and Martin, D.F. 1986. The potential for managing a Florida red tide. Journal of Environmental Science and Health, Part A 21A (2), 107-127.

> The potential for management of a Florida red tide *(Ptychodiscus brevis)* outbreak is considered. Control agents that have been considered previously are reviewed, and most are rejected in favor of a natural product (Aponin from a marine green alga, *Nannochloris sp.*) or in favor of biocontrol (direct seeding with *Nannochloris sp.* or similar species). The cost of biocontrol is compared with the reported cost of a typical red tide on the west coast of Florida.

300. Tester, P.A., Fowler, P.K. and Turner, J.T. 1989. Gulf Stream transport of the toxic red tide dinoflagellate *Ptychodiscus brevis* from Florida to North Carolina. In: Coastal and Estuarine Studies, 35. Novel Phytoplankton Blooms. Pp. 349-358.

301. Tester, P.A. and Fowler, P.K. 1990. Brevetoxin contamination of *Mercenaria* and *Crassostrea virginica*: A management issue. Fourth International Conference on Toxic Marine Phytoplankton, Lund (Sweden), 26-30 Jun. 1989. In: Toxic Marine Phytoplankton. Graneli, E., Sundstroem, B., Edler, L., Anderson, D.M. (ed.). pp. 499-503.

> The first red tide (*Ptychodiscus brevis*) bloom ever recorded along the North Carolina coast was both massive and persistent. Between 2 Nov. 1987 and 21 Jan. 1988, 145,280 hectares of shellfish harvesting areas were closed. This caused severe economic loss to coastal communities and was especially devastating to the clam fishery. The authors examine factors affecting the toxicity of clams and oysters in the field and comment on existing guidelines which govern the reopening of the shellfish harvesting areas after a red tide bloom.

302. Tester, P.A., Stumpf, R.P., Vukovich, F.M., Fowler, P.K. and Turner, J.T. 1991. An expatriate red tide bloom: Transport, distribution, and persistence. Limnology and Oceanography 36: 1053-1061.

303. White, P.A., Kalff, J., Rasmussen, J.B. and Gasol, J.M. 1991. The effect of temperature and algal biomass on bacterial production and specific growth-rate in fresh-water and marine habitats. Microbial Ecology 21 (2): 99-118.

> Heterotrophic, pelagic bacterial production and specific growth rate data were analyzed from 57 studies conducted in fresh, marine and estuarine/coastal waters. Strong positive relationships were identified between (1) bacterial production and bacterial abundance and (2) bacterial production and algal biomass. The relationship between bacterial production and bacterial abundance was improved by also considering water temperature. The analysis

of covariance model revealed consistent differences between fresh, marine and estuarine/coastal waters, with production consistently high in estuarine/coastal environments. A strong relationship was identified between specific growth rate (SGR) and temperature. This relationship differed slightly across the three habitats. A substantial portion of the residual variation from this relationship was accounted for by algal biomass, including the difference between marine and estuarine/coastal habitats. Pronounced seasonality, fluctuations in nutrient quality, and variation of the grazing environment may contribute to the unexplained variation in specific growth.

304. Yentsch, C.S. 1989. Monitoring algal blooms, the use of satellites and other remote sensing devices. In: Red Tides: Biology, Environmental Science, and Toxicology. First International Symposium on Red Tides, Takamatsu (Japan), 10-14 Nov. 1987. Okaichi, T., Anderson, D.M. and Nemoto, T. (ed.). Pp. 181-184. Elsevier Science Publishing Co., New York.

Monitoring of blooms by remote sensing has been suggested because of the short time scales and large spatial dimensions of many blooms. By remote sensing, a quantitative assessment of the numbers of algae and the dimensions of the patch can be made without direct sampling of the water mass. Instruments for satellites and aircraft have been developed which utilize the light absorption and/or light emitted as fluorescence from algae. Being able to predict the size and movement of a patch allows the observer to understand, to a first approximation, the cause of the bloom and to take actions to prevent destruction of aquaculture products.

2C. TOXICS, NUTRIENTS, SALINITIES, PRODUCTIVITY, SEDIMENTS

305. Baker, D.B., Krieger, K.A., Richards, R.P. and Kramer, J.W. 1985. Gross erosion rates, sediment yields, and nutrient yields for Lake Erie tributaries: Implications for targeting. In: Perspectives on Nonpoint Source Pollution. Proceedings of a National Conference, Kansas City, MO, 19-22 May 1985. Environmental Protection Agency Report EPA 440-5-85-001, pp. 251-255.

Studies of agricultural nonpoint pollution in selected watersheds within the Lake Erie Basin have indicated that, under conventional management practices, average gross erosion rates for watersheds are not reliable indicators of the export of either soluble or sediment-associated pollutants, or sediment yields. Therefore, factors other than gross erosion need to be considered in watershed level targeting for agricultural pollution abatement programs.

306. Baker, D.B. 1987. Overview of rural nonpoint pollution in the Lake Erie basin. In: Effects of Conservation Tillage on Groundwater Quality: Nitrates and Pesticides. Lewis Publishers, Chelsea, MI, pp. 65-91.

Area rivers transport large loads of sediments, phosphorus and nitrate derived from agricultural sources, and pesticides from pesticide applications, to the Lake Erie Basin. Residue management in this region must be accompanied by improved fertilizer and pesticide management if agricultural nonpoint source pollution problems in the Great Lakes Region are to be addressed. The Lake Erie tributary monitoring programs illustrate six effects of reduced watershed size on the characteristics of agricultural pollution in stream and river systems: increased annual variability in material export; increased peak concentrations of sediment, nutrients and pesticides; decreased duration of intermediate concentrations of sediments, nutrients and pesticides; larger proportions of total material export accounted for by smaller proportions of time; need for the collection and analysis of additional samples for the accurate measurement of material export; and correspondence of the seasonal distribution of stream sediment transport to the seasonal distribution of erosion processes.

307. Baker, D.B. 1993. The Lake Erie agroecosystem program - water quality assessments. Agriculture Ecosystems and Environment 46 (1-4): 197-215.

In contrast with the watersheds draining into the other Great Lakes where forestry is the dominant land use, row crop agriculture is the dominant land use in Lake Erie 's watershed. Consequently, the tributaries draining into Lake Erie generally carry larger loads of sediments, nutrients, and pesticides than do the tributaries entering the other Great Lakes. To support the development,

operation, and assessment of agricultural non-point pollution control programs in the Lake Erie Basin, the major tributary watersheds were analyzed as large-scale agroecosystems, using mass balance approaches. Detailed tributary loading studies that were initiated in the mid-1970s have shown large day-to-day, season-to-season, and year-to-year variability in both pollutant concentrations and loads, which is characteristic of non-point pollution. The data also illustrate systematic shifts in pollutant concentration and loading patterns that occur in relation to watershed size. Although gross erosion rates in northwestern Ohio tributaries are relatively low, the phosphorus and nitrate export rates are high in comparison with other U.S. streams and rivers. Analyses of the water quality data reveal significant downward trends in time for total and soluble phosphorus and significant upward trends in nitrate. Reduced phosphorus export apparently reflects the effectiveness of agricultural pollution abatement programs that combine more careful fertilizer management with increasing use of conservation tillage. Increased nitrate concentrations may reflect a trade-off associated with the adoption of conservation tillage.

308. Baker, D.E. and Senft, J.P. 1992. Advances in agricultural nutrient runoff controls. Water Quality International '92, Washington, DC. 16th Biennial Conference of the International Association on Water Pollution Research and Control, Washington, DC, 24-30 May 1992. Suzuki, M., Ballay, D., Dahlberg, A.G., Gujer, W., Jenkins, D., Kroiss, H., DiPinto, A.C., Zotter, K., Milburn, A., Izod, E.J. and Nagle, P.T. (ed.). Water Science and Technology 26 (12): 2685-2694.

On farms where manure nitrogen and phosphorus are equal to or greater than the crop requirements, knowledge of the contributions of residual, available nitrogen to the crop to be grown are essential. For many soils, such as the well-drained limestone soils of southeastern Pennsylvania, the problem may not be excess manure nitrogen and phosphorus, but rather decreased rates of nitrogen immobilization and a leveling or decrease in yields due to decreased carbon:nitrogen ratio of manures. With experience, farmers will require a manure analysis and interpretations based on total nitrogen, ammonium nitrogen phosphorus, and potassium, amount and bioavailability of carbon, the carbon:nitrogen ratio, water-holding capacity, and residual, available nitrogen.

309. Bertram, P.E. 1993. Total phosphorus and dissolved oxygen trends in the central basin of Lake Erie, 1970-1991. Journal of Great Lakes Research 19 (2): 224-236.

Five yearly estimators of total phosphorus (TP) concentrations in the central basin of Lake Erie from 1970 to 1986 were calculated and compared to evaluate their utility in the assessment of long-term trends. The rate of decline in TP concentrations from the spring-only estimator was similar to that of the

time-weighted multiple survey estimator. Additional spring survey data from 1987 through 1991 confirmed that the negative trend continued. The stratified season and the autumn-only estimators exhibited no significant trends, but were biased low and high, respectively, relative to the spring and multiple survey estimators.

310. Borkman, D.G. and Turner, J.T. 1993. Plankton studies in Buzzards Bay, Massachusetts, USA. 2. Nutrients, chlorophyll-a and pheopigments, 1987 to 1990. Marine Ecology Progress Series 100 (1-2): 27-34.

As part of a study of Buzzards Bay, MA, levels of nutrients (ammonium, nitrate, nitrite, orthophosphate, silicate), chlorophyll a and phaeopigments were measured from October 1987 to September 1990. Ammonium comprised up to 99.79% of total dissolved inorganic nitrogen. Nitrate levels were maximal in winter, and orthophosphate levels were higher during the warmer months. Both variables exhibited interannual variation. Silicate exhibited sustained bay-wide summer increases, followed by precipitous declines in autumn. Inverse relationships between silicate and diatoms during 1987 to 1988 suggest that silicate fluctuations were biologically related. Chlorophyll a levels were comparatively high and relatively uniform throughout the bay except for higher concentrations near the sewage outfall, or within an enclosed harbor where a hurricane dike appears to increase residence times of phytoplankton blooms by reducing circulation. Buzzards Bay is a habitat favorable to high phytoplankton production because shallow depth and frequent mixing result in a water column that is holomictic and euphotic throughout most of the year.

311. Bricker, S.B., Wolfe, D.A., Scott, K.J., Thursby, G., Long, E.R. and Robertson, A. 1993. Sediment toxicity in Long Island Sound embayments. In: Proceedings, Long Island Sound Research Conference. New Haven, CT, 23-24 Oct. 1992. [no pages]

312. Brooks, A.D. 1991. Sustaining the Chesapeake Bay: Managing population growth and development. In: 34th Conference of the International Association for Great Lakes Research (IAGLR '91) Program. Ann Arbor, MI, 2-6 Jun. 1991, p. 115.

Siltation, overharvesting, and toxic chemicals are all causing the decline of the Chesapeake Bay, but nutrient enrichment is the major problem to be managed for revitalization of the Bay. The 1987 Chesapeake Bay Agreement committed its signatories to achieve a 40 percent reduction of nitrogen and phosphorus loadings by the year 2000. To meet this commitment, the states are improving their sewage treatment facilities, changing their forestry and agricultural practices, improving their erosion and stormwater management, and eliminating phosphates from detergents.

313. Bulen, L.K. 1985. Toxics: Today's Great Lakes challenge. EPA Journal 11 (2): 15-16.

Countless quantities of chemicals have been discharged into the Great Lakes. Eutrophication attracted considerable scientific and public concern and led to the Great Lakes Water Quality Agreement, signed by the U.S. and Canada in 1972. The two countries have spent billions of dollars to reduce phosphorus loadings from municipal and industrial discharges. A comprehensive strategy is needed now for toxic substances. Research is needed on rendering toxic materials harmless before their release into the environment. Pre-treatment technologies for industrial wastes sent to municipal waste-water treatment plants require expansion. Less toxic waste should be generated, and recycling and non-toxic substitutes should be promoted.

314. Burke, M.L. 1987. Puget Sound estuary program, toxics control strategy, urban bay approach. In: Tenth National Conference. Estuarine and Coastal Management: Tools of the Trade. Lynch, M.P. and McDonald, K.L. (ed.). New Orleans, LA, 12-15 Oct. 1986, pp. 613-620.

The urban bay approach, which uses existing data to identify problem areas and controls toxics-contributing sources early, appears to be an effective solution for chemical contamination problems in Puget Sound. Control actions include inspections, permit and order revisions, enforcement actions, and installation of the best management practices. The approach has a geographic, problem-oriented focus. Work plans are developed for urban bays where sources of toxic contamination are concentrated, and the critical problem areas within these bays are addressed first.

315. Burroughs, R.H. and Lee, V. 1988. Narragansett Bay pollution control: An evaluation of program outcome. Coastal Management 16 (4): 363-377.

In this paper, program evaluation is applied to estuarine management. Point source loadings of oxygen-demanding organic material and ambient conditions of bottom-water dissolved oxygen in the Narragansett estuary were examined over recent decades to determine the effects of a sewage treatment plant in reducing pollution. Two analyses are presented. The first analysis shows that sewage treatment plant upgrade produced a statistically significant increase in bottom-water dissolved oxygen. The second analysis demonstrates that these improvements in water quality exceed those attributable to improved background conditions caused by reduced loading from the major river.

316. Butt, A.J. 1992. Numerical models and nutrient reduction strategies in Virginia. Coastal Management 20 (1): 25-36.

Based on the results from a two-dimensional, steady-state model, a 40% reduction of nitrogen and phosphorus loadings is necessary to eliminate anoxic conditions in Chesapeake Bay. A comprehensive nutrient reduction strategy is being implemented in Virginia as part of an interstate plan to reduce nutrient loadings. Point source discharges of phosphorus were the first target. Included in Virginia's plan were a phosphate-based detergent ban, financial assistance programs to municipalities for nutrient removal, and point source nutrient discharge limitations. Preliminary studies have indicated that Virginia has achieved its initial goal of reducing nutrient loadings by 40%. Current modeling efforts are directed toward a re-evaluation of the nutrient reduction strategy and the establishment of work plans for future program development. A three-dimensional, time-variable water quality model has been developed which allows consideration of questions relating to the effects of high-flow spring runoff, the impact of past events on existing water quality, and the evaluation of the effects of winter/spring algal blooms on summer water quality conditions.

317. Campbell, S., Bartoshesky, J., Heimbuch, D., Janicki, J. and Petrimoulx. H. 1987. Relationships between Acid Deposition, Watershed Characteristics, and Stream Chemistry in Maryland's Coastal Plain. Final Report. Maryland Power Plant Research Program, Annapolis, MD Report PPRP/AD-87-8, 8 vol., 1949 pp.

Precipitation and water chemistry were measured in three streams in Maryland (Lyons Creek, Morgan Creek, and Granny Finchley Branch) during May 1984 through June 1985. Modeling results indicated that precipitation acidity can influence stream water acidity under some conditions.

318. Charlton, M.N. 1991. Lake Erie water quality in 1990: Restoration or resilience?. In: 34th Conference of the International Association for Great Lakes Research (IAGLR '91) Program. Ann Arbor, MI, 2-6 Jun. 1991, p. 121.

Electronic profiling apparatus was used to measure water quality in the basins of Lake Erie. Water clarity was exemplary in the central basin as it has been for 11 years. Anoxic conditions developed in the relatively warm and thin hypolimnion. Phosphorus was released from sediments. These data are consistent with a lag response of oxygen to phosphorus load. The apparent recalcitrancy of the oxygen depletion "problem" may be explained by resilience related to the scale of the lake and the locations of loadings.

319. Cohn-Lee, R.G. and Cameron, D.M. 1992. Urban stormwater runoff contamination of the Chesapeake Bay: Sources and mitigation. Environmental Professional 14 (1): 10-27.

A runoff modelling system incorporating urban land use, annual rainfall, and stormwater concentration data for selected heavy metals, nutrients, and organics was applied to four urban areas in the Chesapeake Bay region. When annual quantities of pollutants were compared to area and statewide point source discharges from sewage treatment plants and large factories, contamination from runoff was comparable to contamination from industrial and sewage sources. A comparison between nutrient contributions from urban and agricultural sectors in Montgomery and Prince George's counties showed that, for non-manured farmland, urban runoff either outweighs or is at least the same order of magnitude as agricultural runoff as a source of nutrients to the Bay.

320. Cooper, S.R. and Brush, G.S. 1991. Long-term history of Chesapeake Bay anoxia. Science (Wash.) 254 (5034): 992-996.

Stratigraphic records from four sediment cores collected along a transect across the Chesapeake Bay near the mouth of the Choptank River were used to reconstruct a 200-year history of anoxia and eutrophication in the Chesapeake Bay. Variations in pollen, diatoms, organic carbon, nitrogen, sulfur, acid-soluble iron, and an estimate of the degree of pyritization of iron indicate that sedimentation rates, anoxic conditions, and eutrophication have increased in the Chesapeake Bay since the arrival of Europeans in the 17th and 18th centuries. These alterations may be due to industrialization and urbanization, or the cumulative effect of increasing eutrophication and increased river discharge since deforestation began. These conditions can lead to greater oxygen depletion in the Bay and more production of toxic hydrogen sulfide in years of high spring precipitation when stratification of the water column is more intense.

321. Correll, D.L. 1987. Nutrients in Chesapeake Bay. In: Contaminant Problems and Management of Living Chesapeake Bay Resources. Majumdar, S.K., Hall, L.W., Jr. and Austin, H.M. (ed.). 152nd National Meeting AAAS: Chesapeake Bay Fisheries and Contaminant Problems. Philadelphia, PA, 26 May 1986, pp. 298-320.

Phosphorus, nitrogen, and silicon are the key nutrients for phytoplankton production in Chesapeake Bay. Control of this production at healthy levels can only be attained by management of these nutrients. Phytoplankton assimilates phosphorus only as dissolved orthophosphate, silicon only as dissolved orthosilicate, but nitrogen is assimilated as ammonium, simple organic fractions, or nitrate. Natural communities, however, recycle all three elements by mineralizing and hydrolyzing more complex nutrient fractions to these biologically available forms. Redfield ratios may change by one or two orders of magnitude if at least one nutrient is presently, or was recently limiting, or if light intensity is limiting.

322. Costa, J.E., Howes, B.L., Giblin, A.E. and Valiela, I. 1992. Monitoring nitrogen and indicators of nitrogen loading to support management action in Buzzards Bay. In: Ecological Indicators. International Symposium. Mckenzie, D.H., Hyatt, D.E. and McDonald, V.J. (ed.). Fort Lauderdale, FL, 16-19 Oct. 1990, pp. 499-531.

323. D'Elia, C.F. 1987. Nutrient enrichment of the Chesapeake Bay. Environment 29 (2): 6-11, 30-33.

> The ecological balance of the Chesapeake Bay is changing. Phytoplankton are growing faster than they can be consumed by other food chain organisms. Upon dying and settling to the bottom they become food for bacteria which then consume all available dissolved oxygen and produce hydrogen sulfide. Sessile bottom dwellers cannot survive, and mobile forms migrate. The nitrogen and phosphorus which fuel this eutrophication come from point and nonpoint sources. Management agencies differ regarding adequate control measures. Proponents of the upstream source hypothesis maintain that an effective nutrient control strategy would focus on controlling phytoplankton growth in upstream freshwater areas and reduce external sources of oxygen-demanding material. Proponents of a local production hypothesis maintain that an effective management strategy for the downstream zone must reduce inputs of the least available nutrient, i.e., the growth regulating nutrient, to that zone.

324. D'Elia, C.F., Harding, L.W., Leffler, M. and Mackiernan, G.B. 1992. The role and control of nutrients in Chesapeake Bay. Water Quality International '92. 16th Biennial Conference of the International Association on Water Pollution Research and Control. Suzuki, M., Ballay, D., Dahlberg, A.G., Gujer, W., Jenkins, D., Kroiss, H., DiPinto, A.C., Zotter, K., Milburn, A., Izod, E.J. and Nagle, P.T. (ed.). Washington, DC, 24-30 May 1992. Water Science and Technology 26 (12): 2635-2644.

> The results of a workshop conducted by scientists who participated in a six-year study of hypoxia on the Chesapeake Bay suggest that at least a 40% reduction in total inputs is needed to reduce hypoxia and restore a trophic structure that maximizes metazoan food chains and minimizes microbial processes. Effects of enrichment can be traced in the sedimentary record to colonial times, but they are not as easily discerned in water quality parameters from monitoring in the last 50 years. Initially, agricultural land-use practices that decreased forest coverage and increased erosion accounted for most nutrient inputs, but in this century, point and nonpoint sources have predominated.

325. DeWitt, T.H., Swartz, R.C. and Lanberson, J.O. 1989. Measuring the acute toxicity of estuarine sediments. Environmental Toxicology and Chemistry 8: 1035-1048.

Because of the great range of salinities that characterize estuaries, few infaunal organisms have both the sensitivity and physiological tolerance to chemical contaminants to serve in estuarine sediment toxicity tests. The report summarizes studies on the burrowing amphipod, *Eohaustorius estuarius*, which can survive a salinity range of 2-28% in 10 days. The organism was very sensitive to fluoranthene, a polycyclic aromatic hydrocarbon.

326. Environmental Protection Agency. 1992. Trends in Nitrogen in the Chesapeake Bay, 1984-1990. Environmental Protection Agency, Chesapeake Bay Program, Annapolis, MD, Report CBP/TRS-68/92, 61 pp.

The 1987 Chesapeake Bay Agreement attempted to reverse declines in the water quality and productivity of living resources by setting the goal of 40 percent reduction of nitrogen and phosphorus loads entering the Bay by the year 2000. Water quality monitoring data compiled since June 1984 were analyzed and are presented in the report. The amount of phosphorus entering the Bay has been substantially reduced, and the amount of nitrogen has been somewhat reduced.

327. Environmental Protection Agency. 1993. Role and Function of Forest Buffers in the Chesapeake Bay Basin for Non-point Source Management. Environmental Protection Agency, Annapolis, MD, Chesapeake Bay Program Report CBP/TRS-91/93, 16 pp.

The conversion of forests to other uses, in combination with other land uses, have had adverse effects on the water resources of the Chesapeake Bay. The value of the forest buffer in maintaining water quality is discussed.

328. Fink, L.E. and Wise, P.L. 1988. Mass balance approach to water quality management in the Great Lakes basin tributaries. In: Protection of River Basins, Lakes and Estuaries: Fifteen Years of Cooperation toward Solving Environmental Problems in the USSR and USA. Environmental Protection Agency, Chicago, IL. Region V Report EPA/600/9-88/023, pp. 37-57.

The 1978 Great Lakes Water Quality Agreement between the United States and Canada states that the total loadings of the most persistent and bioaccumulative of the toxic pollutants to the Great Lakes be reduced to the maximum extent possible within the shortest time. One approach to this task is by mass balance, an accounting scheme that allows for the identification, quantification, and control, where possible, of all significant sources of a toxicant to a receiving water. Its application requires a broader view of what sources that need to be addressed, an understanding of the transport and fate of toxicants in lotic and lentic ecosystems, and an appropriate margin of safety

in the waste load allocation formula. The success of the mass balance effort for toxic chemicals relies on the ability to monitor these chemicals from diffuse sources at levels corresponding to loading rates of concern and in the ambient environment at concentrations at or near the Water Quality Standard.

329. Fisher, D.C. and Oppenheimer, M. 1991. Atmospheric nitrogen deposition and the Chesapeake Bay estuary. Ambio 20 (3-4): 102-108.

Anthropogenic sources of nitrogen to the Chesapeake Bay were examined to determine the relative contribution of atmospheric deposition. Two methods, based on different assumptions about ecosystem retention of nitrogen, were used to calculate loadings to the Bay. The base case estimate indicated that approximately 25% of the anthropogenic nitrogen loading to the Bay originated as atmospheric nitrate deposition from emissions of nitrogen oxides. A sensitivity analysis that was performed indicated that atmospheric nitrate contributed 20-30%. Atmospheric ammonium deposition contributed 14% of the total. Atmospheric sources of nitrogen should be considered in management strategies aimed at reducing nitrogen loading of coastal waters.

330. Fisher, T.R., Peele, E.R., Ammerman, J.W. and Harding, L.W., Jr. 1992. Nutrient limitation of phytoplankton in Chesapeake Bay. Marine Ecology Progress Series 82 (1): 51-63.

This paper presents evidence of a seasonal shift from phosphorus (P) to nitrogen (N) as the nutrient limiting the accumulation of algal biomass in Chesapeake Bay. Following the winter/spring maximum in freshwater runoff, the ratio of dissolved inorganic nitrogen to soluble reactive phosphorus was greater than the N/P ratio of algal biomass, alkaline phosphatase activity was high, phosphate turnover times were short, ammonium turnover times were long, and growth rates of phytoplankton were stimulated by additions of phosphate but not by additions of ammonium or silicate. During the period of low runoff in summer, all indicators reversed, and N limited algal growth rates. P and Si appear to limit the accumulation of algal biomass along the major axis of Chesapeake Bay in spring, but N limits algal accumulation in summer.

331. Fitzpatrick, J.J., Blumberg, A.F., O'Connor, D.J. and Mulligan, T.J. 1987. Development of a coupled hydrodynamic/water quality model for assessing eutrophication and anoxia within Chesapeake Bay. In: Proceedings of the Tenth National Conference, Estuarine and Coastal Management, Tools of the Trade. Vol. 1. Lynch, M.P. and McDonald, K.L. (ed.). New Orleans, LA, 12-15 Oct. 1986, pp. 99-110.

In recent years, the health of Chesapeake Bay has been stressed by the activities of the region's growing population. Management strategies to address the questions of nutrient enrichment must consider the seasonal patterns of nutrient loadings, the degree to which each contributing source may be controlled, the relative cost to implement this control, and the resulting improvement in water quality.

332. Flemer, D.A., Boynton, W.R., D'Elia, C.F., Kemp, W.M., Nichols, M., Orth, R.S., Smullen, J.T., et al. 1985. The Chesapeake Bay Program: A summary of scientific research to address management needs for Chesapeake Bay. In: Proceedings of the International Symposium on Utilization of Coastal Ecosystems: Planning, Pollution, and Productivity. Vol. 1. Labish-Chao, N., et al. (ed.). Rio Grande, RS (Brazil), 21 Nov. 1982, pp. 399-438.

Nutrient enrichment, toxic substances, and decline of Chesapeake Bay grasses were studied and the management implications of the results are described. In excess, nutrients can contribute to hypoxic conditions in the deeper stratified waters. Effective management control must accommodate the environmental processes that result in undesirable effects. Control of metal discharges should consider their solubilities, bioavailability, and adsorption properties.

333. Fontaine, T.D. and Lesht, B.M. 1987. Improving the effectiveness of environmental management decisions with optimization and uncertainty analysis techniques. In: Systems Analysis in Water Quality Management. Pp. 31-41. Pergamon Press, New York.

The stochastic nature of environmental processes and forcing functions diminishes the credibility of management decisions based on models employing "average" conditions. The environmental decision-making process must quantitatively account for uncertainties. In doing so, management strategies based on acceptable levels of risk to the environment can be formulated. This uncertainty analysis approach can be extended to demonstrate that acceptable risk scenarios can also be cost-effective. This is demonstrated for the Great Lakes by showing that present and proposed phosphorus management plans have neither the probability of success nor the cost-effectiveness of a management plan based on a combined uncertainty-optimization analysis.

334. Forstner, U. 1989. Contaminated Sediments: Lectures on Environmental Aspects of Particle-Associated Chemicals in Aquatic Systems. 157 pp. Springer-Verlag, New York, New York.

Sediments, recognized as a carrier and a possible source of contaminants in aquatic systems, may also affect groundwater quality and agricultural products

when disposed of on land. In these lecture notes, the description of priority pollutants related to sedimentary phases is followed by a discussion of four aspects which reflect the development of knowledge in particle-associated pollutants during the past 25 years: the identification, surveillance, monitoring and control of sources and distribution of pollutants; the evaluation of solid/solution relations of contaminants in surface waters; the study of in-situ processes and mechanisms in pollutant transfer in various compartments of the aquatic ecosystems; and the assessment of the environmental impact of particle-bound contaminants, i.e. the development of sediment quality criteria. The last chapter focuses on dredged materials. Cases studied include Lake Ontario pollution, solid speciation of metals in river sediments, Puget Sound, and the mobilization of cadmium from tidal river sediments.

335. Fourqurean, J.W., Zieman, J.C. and Powell, G.V.N. 1992. Relationships between porewater nutrients and seagrasses in a subtropical carbonate environment. Marine Biology 114 (1): 57-65.

Porewater nutrient concentrations were measured in 18 seagrass beds across Florida Bay, a shallow, seagrass-dominated subtropical embayment, during the summers of 1987 and 1988. Concentrations of nutrients in porewater varied widely. Soluble reactive phosphorus (SRP) and NH4+ concentrations were positively correlated. No apparent trends were seen with sediment depth (down to 40 cm) in the porewater nutrient concentrations. The SRP concentration of the porewater was highest in areas supporting *Halodule wrightii*, intermediate in areas of *Thalassia testudinum*, and lowest in sediments without seagrasses. There was no similar relationship with NH4+. Porewater SRP, but not NH4+, was significantly correlated with total seagrass standing crop. Elemental content (both N and P) of green leaves of *T. testudinum* was a function of the concentration of the nutrients in the porewater. Standing crop of *T. testudinum* was correlated with phosphorus content, but not with N content, of the seagrass leaves. The results support the hypothesis that sediment porewaters are the most important source of nutrients for seagrass growth.

336. Fourqurean, J.W., Zieman, J.C. and Powell, G.V.N. 1992. Phosphorus limitation of primary production in Florida Bay: Evidence from C:N:P ratios of the dominant seagrass *Thalassia testudinum*. Limnology and Oceanography 37 (1): 162-171.

Florida Bay is a shallow, seagrass-dominated embayment on the southern tip of Florida. Variation of C, N, and P content of leaves of *Thalassia testudinum* was measured on two spatial scales: locally (10-100 m) in relation to a point source of nutrients associated with a bird colony in eastern Florida Bay, and regionally (10-100 km) across the entire bay. Locally, the P content of leaves decreased

with distance from the nutrient source; the C and N content was independent of distance from the nutrient source. P content varied locally, and C:P and N:P also varied. Regionally, P content varied greatly, but C and N showed less variation. Variation in C:P and N:P across the bay was very large, but C:N showed little variation. Local variation around the nutrient point source indicated that C:P and N:P were indicators of P availability, and trend analysis of the regional spatial variation of the P ratios showed that P availability was greatest in northwest, and least in eastern, Florida Bay. This pattern mirrored abundance of seagrasses and productivity in the bay.

337. Fourqurean, J.W, Jones, R.D. and Zieman, J.C. 1993. Processes influencing water column nutrient characteristics and phosphorus limitation of phytoplankton biomass in Florida Bay, FL, USA: Inferences from spatial distributions. Estuarine Coastal and Shelf Science 36 (3): 295-314.

The concentrations of nutrients, dissolved and particulate organic matter, salinity and chlorophyll a in the water column were measured from June 1989 to August 1990 at 26 sampling locations across Florida Bay. The Bay was hypersaline during this time period. Dissolved organic phosphorus was the dominant form of P in the water column, and soluble reactive P was less than 5 percent of the total P. Organic nitrogen forms dominated the N pool, and NH4+ was the dominant form of dissolved inorganic nitrogen. Many measured parameters were correlated. Principal Components Analysis (PCA) extracted three composite variables that described 90.3% of the variation in the original data set. The spatial distribution of factor scores from PCA indicate that three processes are acting independently to control the composition of the water column: the evaporation-driven concentration of dissolved material in the Bay; the delivery of P to the Bay through water exchange with the Gulf of Mexico; and the delivery of fresh water with excess N with respect to P to Florida Bay. The phytoplankton biomass in the water column of Florida Bay is P-limited.

338. Gibson, G.R., Jr., Lyke, W.L. and Habon, T.J. (ed.). 1988. A cost effective and education approach to watershed investigation and management. In: Proceedings of the Symposium on Coastal Water Resources. Wilmington, NC. American Water Resources Association, Technical Publication Series, pp. 393-402.

Eutrophic symptoms in the waters of the West and Rhode Rivers which converge near Annapolis, Maryland and discharge into the Chesapeake Bay have caused concern in local citizens. The mixed agricultural and residential watershed was mapped for sub-basins and land use. The phosphorus concentration of each stream system, as the limiting factor, was sampled, combined with runoff estimates for each sub-basin, and was used to estimate a total phosphorus load to the rivers. The potential impact of this load on the

steady state concentration in the receiving water of the rivers was assessed and management options were proposed.

339. Grassle, J.P. and Grassle, J.F. 1984. The utility of studying the effects of pollutants on single species populations in benthos of mesocosms and coastal ecosystems. In: Concepts in Marine Pollution Measurements. White, H.H. (ed.). Maryland University Sea Grant Publication MDU-W-84-001, pp. 621-642.

340. Groman, H.A., Henderson, T.R., Meyers, E.J., Burke, D.M. and Kusler, J.A. (ed.). 1985. Wetlands of the Chesapeake. Proceedings of the Conference Held April 9-11, 1985, Easton, MD. 389 pp.

This conference originated from informal discussions among staff members of the Association of State Wetland Managers, the Environmental Law Institute, and Maryland Department of Natural Resources at the December 1983 signing of the Chesapeake Bay Agreement. The chapters present points of science, management, and future directions and needs, including (1) water quality functions of the wetlands; (2) habitat functions; (3) flood loss reduction and hydrological values; (4) toxics; (5) urbanization and watercourse modifications; (6) protection strategies; and (7) tax incentives and disincentives.

341. Hager, S.W. and Schemel, L.E. 1992. Sources of nitrogen and phosphorus to northern San Francisco Bay. Estuaries 15 (1): 40-52.

Nutrient sources to the Sacramento River and Suisun Bay in the northern San Francisco Bay were studied along with their influence on the distribution of dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP). Agricultural return flow drains and a municipal waste-water treatment plant were the largest sources of nutrients to the river during low river flow. The Sacramento Regional Waste-water Treatment Plant discharged DIN and DRP at rates that were roughly 70% of total DIN and DRP transport by the river at that time. Concentrations at Rio Vista on the tidal river below the Sacramento plant and at the head of the estuary were related to the reciprocals of the river flows, indicating the importance of dilution of the Sacramento waste by river flows.

342. Hager, S.W. 1993. Dissolved Nutrient and Suspended Particulate Matter Data for the San Francisco Bay Estuary, October 1988 through September 1991. U.S. Geological Survey Open-File Report 98-57, 52 pp.

The U.S. Geological Survey conducted hydrologic investigations in San Francisco Bay during Water Years 1988-1991. Dissolved inorganic plant nutrients, nitrate, nitrite, ammonium, silica, and reactive phosphorus were measured, as well as salinity, turbidity, and concentrations of suspended

particulate matter. In addition, in Water Year 1991, concentrations of dissolved organic nitrogen and phosphorus were measured. The sampling and analytical methods, and the data for these studies are presented in this report.

343. Hall, L.W., Jr., Fischer, S.A. and Sullivan, J.A. 1991. A synthesis of water quality and contaminants data for the Atlantic menhaden *Brevoortia tyrannus*: Implications for Chesapeake Bay. Journal of Environmental Science and Health, Part A, Environmental Science and Engineering 26 (8): 1513-1544.

This article synthesizes the limited data available on the effects of water quality and contaminant conditions on Atlantic menhaden, and the more voluminous data measuring the effects of temperature, salinity, temperature-salinity interactions and dissolved oxygen for various life stages. Although populations of Atlantic menhaden have remained stable in Chesapeake Bay in recent years, information on adverse water quality and contaminant effects may be very important for managing the species or establishing protective water quality or contaminant regulations or standards.

344. Harned, D.A. and Davenport, M.S. 1990. Water-Quality Trends and Basin Activities and Characteristics for the Albemarle-Pamlico Estuarine System, North Carolina and Virginia. U.S. Geological Survey, Water Resources Division Open-File Report 90-398, 177 pp.

The Albemarle-Pamlico estuarine system has a total basin area of nearly 31,000 square miles and includes six rivers and five sounds. Albemarle Sound receives the greatest freshwater inflow of all the sounds in the estuarine system, about 13,500 cu ft/sec. From 1945 to 1988, dissolved oxygen (DO) concentrations increased throughout the estuarine system, except in the Chowan River where decreases occurred. pH increased in streams throughout the area except in the Pamlico River. Suspended solids concentrations decreased throughout the area, probably as a result of a general decrease in suspended inorganic material. Increasing trends of salinity concentrations were detected in Albemarle Sound. Increases of DO could reflect increased plant biomass in the estuary, probably as a result of agricultural activities. Decreases in suspended solids in the estuarine system probably reflect decreases in corn and tobacco production or improved agricultural soil management. In the Pamlico River, decreases in ammonia nitrogen were correlated with decreases in tobacco acreage and fertilizer use, and increases in total ammonia plus organic nitrogen were correlated with increases in crops and livestock.

345. Heath, R.T. 1992. Nutrient dynamics in Great Lakes coastal wetlands: Future directions. Journal of Great Lakes Research 18 (4): 590-602.

Comprehensive investigations of nitrogen (N) and phosphorus (P) dynamics in Great Lakes coastal wetlands were done at Old Woman Creek National Estuarine Reserve (OWC). This wetland stores P in sediments (at least temporarily) and releases N by dissimilatory denitrification. Also, its biotic community transforms dissolved inorganic N and P inputs into organic dissolved and particulate outputs, thereby altering nutrient availability to Lake Erie communities. A conceptual model specific for coastal wetlands for OWC accounts for the wide range of redox potentials encountered over the short vertical span of the shallow OWC wetland system.

346. Hendrey, G.B. 1987. Acidification and anadromous fish of Atlantic estuaries. Water, Air, and Soil Pollution 35 (1/2): 1-6.

The Hudson River Foundation convened a conference to evaluate evidence pertaining to the roles played by acid deposition and stream acidification in the decline of anadromous fish populations along the Atlantic coastal plain. The stimuli for the conference included severe decline of some populations of Atlantic salmon, American shad, hickory shad, alewives, blueback herring, and striped bass as well as a few species resident in coastal streams (yellow perch and white perch) along portions of the east coast of North America; the simultaneous decline of several species since 1970; and severe episodic pH depressions in some streams of the Chesapeake Bay system. For example, the pH of Lyons Creek decreased from 7.0 to 5.9 in one hour during a rain event, and returned to 7.0 a day later. The conferees agreed that a combination of factors, including stream and river acidification, toxic metals, organic compounds, eutrophication, and overfishing may be contributing to the reduction in fish stocks. The essential point resulting from the conference is that the acid deposition hypothesis for stream acidification and declines of anadromous fish populations is viable for these coastal areas.

347. Heral, M., Rothschild, B.J. and Goulletquer, P. 1990. Decline of Oyster Production in the Maryland Portion of the Chesapeake Bay: Causes and Perspectives. International Council for the Exploration of the Sea, Copenhagen (Denmark). Fish Capture Committee Meeting, 4-12 Oct. 1990. ICES Council Meeting 1990 Collected Papers Report ICES-CM-1990/K:20 (ICESCM1990K20), 37 pp.

The historical landings of the oyster *Crassostrea virginica* are described for the Maryland part of the Chesapeake Bay. The trends are analyzed concurrently with the main events and prevalent management strategies. Three periods are identified in the report: 1840-1890: time of the greatest fishery, with overfishing and the destruction of the oyster habitat by the oyster gears (the landings of oysters reached 600,000 tons in total weight); 1900-1980: decrease and stable landings due to the failure of the reseeding plan resulting from the heavy

sedimentation and the anoxic summer conditions (landings of up to 80,000 tons); and 1981-1988: large decrease of production due to high mortalities related to diseases (MSX and *Perkinsus marinus*), predation, and management practices (landings less than 15,000 tons since 1986).

348. Jaworski, N.A. and Linker, L.C. 1990. Uncertainties in Nitrogen Mass Loadings in Coastal Watersheds. Environmental Protection Agency, Environmental Research Laboratory, Narragansett, RI, Report EPA/600/D-91/232, 15 pp.

This report presents reviews of the nitrogen mass balance of the Chesapeake Bay and of the Upper Potomac Basin.

349. Johengen, T.H. and Beeton, A.M. 1988. Monitoring the Effectiveness of Best Management Practices to Reduce Agricultural Nonpoint Source Pollution. 8th Annual International Symposium on Lake and Watershed Management. St. Louis, MO, 15-18 Nov. 1988, p. 44.

The Saline Valley Rural Clean Water Project is one of 21 national projects sponsored by the U.S. Department of Agriculture to provide solutions to agricultural nonpoint source pollution. The project's main goal is to reduce loads of phosphorus and sediments to Lake Erie. Water quality monitoring, consisting of weekly grab samples and flow measurements in eight sub-basins, has been carried out since 1981. Time-trend data analyses have been used to examine the effectiveness of best management practices implemented throughout the watersheds. Trends in both discharge-normalized loading and flow-weighted concentrations suggest that BMPs can reduce the input of these pollutants to surface waters.

350. Kadlec, R.H. and Hammer, D.E. 1988. Modeling nutrient behavior in wetlands. Ecological Modelling 40 (1): 37-66.

A simple mathematical model was developed which permits dynamic simulation of wetland hydrology and nutrient-driven interactions between waste water and the wetland ecosystem. Spatial variations due to surface water flow are described, and material balance calculations are carried out for phosphorus, nitrogen, and chloride. Ecosystem phenomena are represented, using a one-dimensional spatially distributed compartmental model, with compartments representing active parts of the ecosystem (soil, surface water, interstitial soil water, and several types of live biomass, standing dead, and litter). When computer simulations were compared with operating data from the Porter Ranch waste-water treatment facility at Houghton Lake, Michigan, they accurately predicted solute concentrations in surface water, biomass growth patterns, changes in the litter pool, and soil accretion rates.

351. Kadlec, R.H. and Alvord, H. 1989. Mechanisms of water quality improvement in wetland treatment systems. In: Wetlands: Concerns and Successes. Proceedings of a Symposium held September 17-22, 1989, Tampa, Florida. American Water Resources Association, Bethesda, Maryland. Pp. 489-498.

Over the last 11-year period, the Houghton Lake, Michigan, wetland treatment system has removed an average of 96% for P and 97% for ammonium. Sulfur was also reduced to natural wetland levels. Species composition shifted to cattail (*Typha latifolia*) and duck weed (*Lemna minor*), and above ground biomass increased by a factor of four. Sediment deposition in the duckweed zone buried a significant portion of the nutrients. Gasification of nitrogen and sulfur compounds accounted for another important fraction. The remainder of the added N, S, and P was utilized to construct the new expanding biomass. Root biomass decreased in the presence of greater nutrient availability, partially counteracting the above-ground increase. Denitrification entirely removed nitrate from the wetland waters. The accumulation of microdetritus and macrophyte litter were comparable. Sufficient accumulation occurred after ten years to affect water levels by several centimeters.

352. Kashmanian, R., Downing, D., Jaksch, J. and Podar, M. 1986. Managing point/nonpoint-source loading: A cost-effective approach to nutrient reduction in the Chesapeake Bay. In: The Economics of Chesapeake Bay Management. Jacoby, M.E. (ed.). Conference on Economics of Chesapeake Bay Management. Durham, NH, July 1985, pp. 28-32.

The authors have focused on the total flow of pollutants and their overall reductions. The conceptual construct of the water bubble is recommended; think of all the potential sources of a pollutant affecting the same water body as residing within a single bubble. That bubble contains pollutants discharged from point and nonpoint sources. The goal is to reduce the pollutant loadings from the bubble to a target level equivalent to the total loadings under the conventional practice of individual controls. Less concern is placed on the specific loadings from individual sources as long as the same or better water quality is produced and existing controls required by current regulations are maintained as the treatment floor.

353. Kemp, W.M., Sampou, P.A., Garber, J., Tuttle, J. and Boynton, W.R. 1992. Seasonal depletion of oxygen from bottom waters of Chesapeake Bay: Roles of benthic and planktonic respiration and physical exchange processes. Marine Ecology Progress Series 85 (1-2): 137-152.

Seasonal oxygen budgets were developed for the mesohaline region of Chesapeake Bay, which experiences bottom water oxygen depletion in summer.

Rates of oxygen production and consumption by the planktonic community and oxygen consumption by the benthos were measured at one- to four-week intervals from March to October at two stations. Rates of sulfide diffusion from sediments were also measured, and observations were made of water column temperature, salinity and oxygen. Based on this study, for stratified estuaries with bottom layers thicker than 5 m, seasonal oxygen depletion is driven primarily by planktonic respiration rather than benthic consumption of accumulated organic pools. A comparison of mean monthly rates for bottom respiration (plankton plus benthos) and net physical oxygen replenishment revealed that the two processes were highly correlated between March and October. This strong correlation underscores a fundamental interdependence of biological oxygen consumption and net physical transport. Consequently, relatively large reductions in respiratory oxygen consumption (e.g., with decreased organic inputs) would lead to substantially smaller decreases in the extent of bottom water oxygen depletion because of an inherent adjustment between the coupled biological and physical processes.

354. Kjerfve, B. and Magill, K.E. 1990. Salinity changes in Charleston Harbor, 1922-1987. Journal of Waterway, Port, Coastal and Ocean Engineering (ASCE) 116 (2): 153-168.

Charleston Harbor, South Carolina, underwent pronounced changes in salinity regimes after the diversion of the Santee River into the Cooper River in 1942 and rediversion of the Cooper into the Santee in 1985. The mean monthly harbor surface salinity decreased from 30.1 ppt to 16.8 ppt as a result of the diversion, and has increased to 22.0 ppt since rediversion. Based on regression models for salinity variability, discharge explains 78% of the salinity variance during the post-diversion period, but it accounts for only 1% of the salinity variance after rediversion because of the nearly constant discharge.

355. Krupnick, A.J. 1986. Managing the Chesapeake Bay cleanup: A modeling approach. In: The Economics of Chesapeake Bay Management. Jacoby, M.E. (ed.). Conference on Economics of Chesapeake Bay Management. Durham, NH, Jul. 1985, pp. 21-23.

The seven-year study of the Chesapeake Bay by EPA documented the decline of water quality and blamed excessive nutrients, toxic effluents, and sedimentation. The author contends that, in response to these findings, local governments have instituted a patchwork quilt of policies to effect a cleanup. This response reflects a belief that the Bay's recovery can best be accomplished by government through the use of subsidies and redirection of administrative priorities. The author, however, argues that there are two major deficiencies in this approach: the policies were constructed with minimal

quantitative information on their likely effect on the Bay, and the policies ignore economic incentives by focusing on direct government spending and regulation. An economic-ecologic water quality management model is needed which is capable of modeling the effects of economic incentive policies and ranking policies by their cost effectiveness.

356. Kuo, A.Y. and Neilson, B.J. 1987. Hypoxia and salinity in Virginia USA estuaries. Estuaries 10 (4): 277-283.

Hypoxia was observed not only in the main Chesapeake Bay but also in the deeper waters of the Virginia estuaries that are tributaries to the Bay. When water temperature exceeded 20° C, minimum oxygen concentrations were less than 50% of saturation concentrations in 75%, 50% and 2% of the surveys in the estuaries of the Rappahannock, York and James rivers, respectively. Hypoxia rarely occurred in the James River; this was surprising, considering that it receives the greatest amount of waste water. Analysis of the oxygen budgets in these estuaries indicates that the variations in the frequency, duration, and severity of hypoxia were related to the net movement of bottom waters. This relationship has significant implications for the management of water quality and marine fisheries.

357. Lapointe, B.E. and Clark, M.W. 1992. Nutrient inputs from the watershed and coastal eutrophication in the Florida Keys. Estuaries 15 (4): 465-476.

Widespread use of septic tanks in the Florida Keys increases the nutrient concentrations of limestone groundwaters that discharge into shallow nearshore waters, resulting in coastal eutrophication. Watershed nutrient inputs, transformations, and effects were characterized along a land-sea gradient stratified into four ecosystems that occur with increasing distance from land: man-made canal systems, seagrass meadows, patch reefs, and offshore bank reefs. Soluble reactive phosphorus (SRP) was significantly elevated in canal systems, while dissolved inorganic nitrogen (as DIN, NH4, or NO3), a secondary limiting nutrient, was elevated both in canal systems and seagrass meadows. SRP and NH4 decreased to low concentrations within approximately 1 and 3 km from land, respectively. DIN and SRP contributed the greatest quantity of total N and P pools in canals, compared to dissolved organic N (DON) and dissolved organic P (DOP) that dominated the total N and P pools at the offshore bank reefs. Particulate N and P fractions were elevated in canals and nearshore seagrass meadows. Chlorophyll a (chl a) and turbidity were elevated in canal systems and seagrass meadows; chl a was maximal during summer and was correlated with maximum watershed nutrient input; turbidity was maximal during winter due to seasonally maximum wind conditions and sediment resuspension. Dissolved oxygen was negatively correlated with

NH4 and SRP; hypoxia frequently occurred in nutrient-enriched canal systems and seagrass meadows during the warm summer months.

358. Lee, C.R. 1985. Minimizing adverse impacts on wetlands of water quality associated with forest and agricultural practices. In: Wetlands of the Chesapeake. Proceedings of the Conference Held April 9-11, 1985, Easton, MD, pp. 225-230.

Several control techniques exist for reducing suspended solids, nutrients and pesticides associated with runoff from forest and agricultural operations that enters the Chesapeake Bay. These techniques include vegetated sedimentation ponds, check dams, and filtering structures which can reduce suspended solids in surface runoff; nitrogen absorption by plants; and denitrification by surface soil mechanisms.

359. Long, E.R., Wolfe, D.A., Robertson, A. and Bricker, S.B. 1992. Sediment toxicity surveys as pollution assessment tools. In: MTS '92. Proceedings. Vol. 1, pp. 240-249. Marine Technology Society, Washington, DC.

360. Lyon, W.A. 1988. History of point source control of nutrients in Pennsylvania and other Chesapeake Bay states: Part I. Water Pollution Control Association of Pennsylvania Magazine 21 (4): 34-37.

The sources of nutrients reaching the Chesapeake Bay are discussed. The need for control of nutrients derives from the process of eutrophication, which is a natural process that is accelerated by human activities, agricultural runoff, animal wastes, septage, and some industrial wastes. In 1983, the EPA's report, "Chesapeake Bay Framework for Action," described the adverse effects of nutrients on this body of water. Publicly owned treatment works are the major sources of N and P to the Bay. Municipal loadings also enter the Bay in the discharge from the Susquehanna River basin (2.9 million pounds of P during an average rainfall year). Nonpoint sources of phosphorus are mainly farm animal wastes, dead vegetation, fertilizers applied to fields, and effluents from storm sewers and combined municipal sewers. A significant share of the nonpoint inputs results from natural processes, such as sediment input from Hurricane Agnes in 1972, which created 60 acres of islands in the Bay.

361. Lyon, W.A. 1988. History of point source control of nutrients in Pennsylvania and other Chesapeake Bay States: Part II. Water Pollution Control Association of Pennsylvania Magazine 21 (5): 7-14.

Studies of the impact of nutrients on the Chesapeake Bay, emergence of public policy to deal with the problem, implementation, municipal performance, and future prospects are discussed. The approach used to control pollution of the

Chesapeake Bay is compared with that employed in the Lower Great Lakes Basin. Nutrient enrichment has been considered a major factor affecting both phytoplankton and epiphyte growth in the Chesapeake Bay. Increased turbidity from sediment loads and reduction in dissolved oxygen due to impoundments are additional problems. The efforts on the Lower Lakes were expedited by a concise management plan tied to specific load targets. This approach was not applied on the Chesapeake Bay. There also is less certainty about the relative importance of nutrients versus other pollutants. There is limited scientific evidence to support the relationship between nutrients and the decline of submerged aquatic vegetation and nutrients and deoxygenation. Nonpoint source programs need more management analysis to address priorities and to recognize the difference between man-made and natural events and sources.

362. Macknis, J. 1985. Chesapeake Bay nonpoint source pollution. In: Perspectives on Nonpoint Source Pollution. Proceedings of a National Conference, Kansas City, MO, 19-22 May 1985. Environmental Protection Agency Report No. 440-5-85-001, pp. 165-171.

In 1976, Congress directed the EPA to conduct an in-depth study "to protect and preserve the quality of the Chesapeake Bay by effectively managing its uses and resources." As part of the study, the EPA Chesapeake Bay Program developed a watershed model to estimate point and nonpoint source loadings to the Bay and to evaluate management strategies in reducing nutrient loadings. Model production runs indicated that nonpoint sources contribute 31-64% of the phosphorus load and 62-81% of the nitrogen loads to the Bay system depending upon annual rainfall conditions. In response to the findings of the Chesapeake Bay Program, Maryland, Pennsylvania, and Virginia initiated nonpoint source control programs.

363. Magnien, R.E., Summers, R.M. and Sellner, K.G. 1992. External nutrient sources, internal nutrient pools, and phytoplankton production in Chesapeake Bay. Estuaries 15 (4): 497-516.

External nutrient loadings, internal nutrient pools and phytoplankton production were examined during 1985-1989 for three major subsystems of the Chesapeake Bay Estuary: the upper Mainstem (MS), and the Patuxent (PA) and Potomac (PO) estuaries. Approximately 7-16 percent of the N load and 48-69 percent of the P entered as particulate matter. Water column TN:TP ratios in the tidal fresh, oligohaline, and mesohaline salinity zones of each estuary ranged was 56-82 in the MS, 27-48 in the PA, and 72-126 in the PO. A major storm event in the Potomac watershed accounted for 11 percent of the N and 31 percent of the P delivered to the estuary by the PO. Within the MS estuary, salinity dilution plots revealed strong sources of NH4 and PO4 in the

oligohaline to upper mesohaline region, sites of considerable internal recycling of nutrients to surface waters. In the PA and PO, the TN:TP ratios of external loads were 2-4 times higher than those observed over the previous two decades, changes attributed to point source P controls and the likelihood that N-rich nonpoint sources have increased.

364. Martin, M. 1985. State Mussel Watch: Toxics surveillance in California. Marine Pollution Bulletin 16 (4): 140-146.

The California State Mussel Watch Program is described. Results of coastal monitoring of trace toxic substances are reported, along with biological effects measurements in synoptic studies of San Francisco Bay, chemical and biological monitoring at a major waste-water discharge in southern California, and the use of mussel watch data in regulation of toxics discharge to California marine and estuarine waters. Chromium, copper, zinc, and lead concentrations were elevated in mussels in the southern California area. At the state level, California uses the Water Quality Control Plan for Ocean Waters of California to regulate waste discharge to ocean waters.

365. Martin Marietta Environmental Systems, Columbia, MD. 1987. Chesapeake Bay Mainstem Monitoring Program Statistical and Analytical Support Contract: Final Report. Vol. I. Available from the National Technical Information Service, Springfield, VA 22161, as PB89-156640.

A statistical analysis framework was developed for detection of trends in Chesapeake Bay water quality attributable to pollution control management actions. The analysis selection procedure, based on the characteristics of the data being analyzed, is applicable to both historical and Chesapeake Bay Program (CBP) water quality monitoring data. Based on the proposed analysis framework and graphical and tabular analyses of the CBP monitoring data, a preliminary evaluation of the sampling design of the monitoring program is provided. The quality assurance/ quality control (QA/QC) procedures applied to CBP monitoring data prior to analyses are described. Specific recommendations are made on collection and analysis of Chesapeake Bay water quality monitoring program data.

366. McCoy, S.E. 1986. Monitoring the estuary. In: Proceedings, MDS '86: Marine Data Systems International Symposium. New Orleans, LA, 30 Apr.-2 May 1986, pp. 27-30.

The importance of estuaries cannot be overstressed. Most shellfish and finfish are harvested from estuaries, and several of the world's largest shipping ports are located within estuaries. Many estuaries originated as river valleys drowned

by rising sea level and are geologically ephemeral features, destined eventually to fill with sediments. Nutrients, heavy metals, and organic chemicals are often associated with the sediments trapped in estuaries. Part of the trapped nutrients may be recycled to the water column, promoting undesirable algal growth. The metals and organics may be concentrated in the food web, further upsetting the ecology and threatening fisheries.

367. McKay, N. 1991. Environmental management of the Puget Sound. Environmental Management and Appropriate Use of Enclosed Coastal Seas - EMECS '90. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas '90 held in Kobe, Hyogo Prefecture (Japan), 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 509-512.

Historically, water quality management in the United States has been carried out by several levels of government through a series of separate, often overlapping, programs. Water quality has continued to decline, even though some programs regulate pollution from certain sources very strictly. Recently, emphasis has shifted from a case-by-case approach to the implementation of overall water quality management plans for estuarine bodies of water. This paper describes one such management plan currently in operation.

368. Minello, T.J., Zimmerman, R.J. and Klima, E.F. 1987. Creation of fishery habitat in estuaries. In: Beneficial Uses of Dredged Material. Proceedings of the First Interagency Workshop, 7-9 Oct. 1986, Pensacola, FL. Technical Report No. D-81-1, Final Report, pp. 106-120.

The importance of estuaries for U.S. commercial and recreational fisheries and the accelerating habitat loss in the estuaries require action by managing agencies in order to avert major declines in fishery stocks. Studies on abundance patterns of organisms in estuaries are useful in determining the importance of habitats under the assumption that organisms can and will select habitats that are optimal for growth and survival. Comparisons of paired samples show that juveniles of brown shrimp, blue crabs, and spotted sea trout select intertidal *Spartina alterniflora* habitat over adjacent non-vegetated bottom. The presence of higher nutrient levels in transplanted marshes may cause eutrophic conditions unattractive to fisheries organisms. Transplanted marshes also displayed areas of die-back and low abundances of macrofauna. Research in Galveston Bay, Texas, is being designed to test the hypothesis that the construction of access channels will increase the density of fishery organisms. A second experimental project is being conducted in coastal North Carolina to test the importance of accessibility to salt marshes by fishery organisms.

369. Monahan, R., Beede, S., Costa, J. and Rosinoff, B. 1992. Controlling nitrogen in coastal waters. Civil Engineering 62 (3): 56-59.

In New England, three towns have changed zoning ordinances to limit nonpoint sources of nitrogen into Buzzards Bay; research in Long Island has focused on limiting point sources of nitrogen; and a plant in Stamford, CT, has successfully incorporated biological nitrogen removal. To limit the nonpoint sources of nitrogen in Buzzards Bay, the area that contributes ground water and surface water to the embayment was delineated, existing and potential levels of development within the contributing area were determined, nitrogen loading from all anthropogenic sources within the contributing area were evaluated, and local zoning bylaws and regulations to control nitrogen loading to coastal embayments were developed. In Long Island, a water quality model simulated pastoral and existing conditions, and secondary treatment conditions. Predictions of existing conditions were compared with available water quality data from the Sound, and were used to evaluate the relative importance of these nitrogen sources to hypoxia. Management options in Long Island Sound now include new sewage treatment plant construction, and modifications of discharge permits for existing plants.

370. Mountford, K. and Mackiernan, G. 1987. Multidecade trend-monitoring program for Chesapeake Bay, a temperate east coast estuary. In: New Approaches to Monitoring Aquatic Ecosystems. Pp. 91-106. American Society for Testing and Materials, Philadelphia, PA.

In the past two decades, Chesapeake Bay has experienced increasing periods of deep water anoxia, poor spawning success by anadromous fish species, and unprecedented declines in submerged aquatic vegetation. These changes coincide with increased loading of nutrients and toxic materials from the drainage basin, which is experiencing significant changes in land use and population density. Concern by basin governments and citizens led to the establishment in 1984 of a 167-station monitoring network reporting to a common data bank. This program is designed to define trends in Bay water and sediment quality. Collections link with studies of sediment organics, toxics, benthos, phyto- and zooplankton, and commercially harvested species. Data for 1984 indicate that large riverine inflows produced intense water column stratification and widespread anoxia in the Bay main stem, but mixing events and wind forcing may temporarily have reduced severity and promoted reaeration. Early data sets indicate pulses of nutrient input into the estuary, nutrient regeneration in subpycnoclinal water, phytoplankton response to nutrients, and instances of potential nutrient limitation.

371. National Research Council, Washington, DC. Water Science and Technology Board. 1993. Managing Wastewater in Coastal Urban Areas. Sponsored by National Science Foundation, Washington, DC., Environmental Protection Agency, Washington, DC., National Oceanic and Atmospheric Administration, Rockville, MD., and National Academy of Engineering, Washington, DC. 494 pp.

This book provides a clear approach to integrated management of the large quantity of wastewater and stormwater discharged into coastal waters. Principles and methods are described for management, from setting goals through performance monitoring. Examples are given from the Chesapeake Bay and Santa Monica Bay.

372. Neilson, M.A. 1991. Nutrient Trends in Lake Ontario. 34th Conference of the International Association for Great Lakes Research (IAGLR '91) Program. Ann Arbor, MI, 2-6 Jun. 1991, p. 58.

The water quality of Lake Ontario has been monitored on a continuous basis since 1968. Total phosphorus concentrations have declined, in response to phosphorus control measures, to achieve the acceptable in-lake concentration of 10 µgP/L, as recommended by the Phosphorus Management Strategies Task Force (1980). Chlorophyll a concentrations have responded to the reduced P levels.

373. Nixon, S.W., Oviatt, C.A., Frithsen, J. and Sullivan, B. 1986. Nutrients and the productivity of estuarine and coastal marine ecosystems. Journal of the Limnological Society of Southern Africa 12 (1/2): 43-71.

The existence of a direct relationship between the input of nutrients and the productivity of higher trophic levels has long been a principle of marine ecology. It is difficult, however, to find quantitative evidence showing that estuaries, lagoons, or other coastal waters respond to eutrophication by producing a larger biomass of animals. Available results indicate that there is a modest enhancement of primary production with nutrient addition, but that most of the extra organic matter is rapidly consumed. In other words, the rate of nutrient recycling rises with the rate of nutrient input, and only a fraction of the added nutrients appears as an increment in the production of higher trophic levels.

374. Officer, C.B., Biggs, R.B., Taft, J.L., Cronin, L.E., Tyler, M.A. and Boynton, W.R. 1984. Chesapeake Bay anoxia: Origin, development, and significance. Science (Washington, DC) 223 (4631): 22-26.

Anoxia, which now occurs annually in deeper waters of the central portion of the Chesapeake Bay, extends from Baltimore to the mouth of the Potomac

estuary and lasts from May to September. This condition, which encompasses some 5 billion cubic meters of water, is the result of increased stratification of the water column in early spring, with consequent curtailment of reoxygenation of the bottom waters across the halocline, and benthic decay of organic detritus accumulated from plankton blooms of the previous year. The Chesapeake Bay anoxia appears to have had significant ecological effects on many marine species, including several of economic importance.

375. Oviatt, C.A. 1989. The health of Narragansett Bay: An overview of recent studies. Maritimes 33 (4): 1-4.

Thanks to the efforts of the agencies that are working on studies of pollution and its effects on the resources of Narragansett Bay, the picture of inputs of pollution into the Bay is well focused. The sources and fates of many materials are well understood. Nutrients enter the Bay from rivers and sewage treatment plants. Metals derived from various industries are passed through sewage treatment plants. The sources of hydrocarbons in the Bay are sewage treatment plants, rivers, runoff, spills, and atmospheric deposition.

376. Parker, C.A. and O'Reilly, J.E. 1991. Oxygen depletion in Long Island Sound: A historical perspective. Estuaries 14 (3): 248-264.

This paper presents the results of a retrospective analysis of available data was conducted to determine the spatial distribution and temporal trends of dissolved oxygen in Long Island Sound during the past 40 years.

377. Paulson, A.J., Curl, H.C., Feely, R.A., Massoth, G.J. and Krogslund, K.A. 1991. Trace Metal and Ancillary Data in the Watersheds and Urban Embayments of Puget Sound. NOAA Data Report ERL PMEL-30, 72 pp.

This report encompasses trace metal and ancillary data obtained by the Pacific Marine Environmental Laboratory (PMEL) in Puget Sound, Washington, between 1979 and 1986. This report includes the complete data set from two urban embayments (Elliott and Commencement Bays) and the watersheds discharging into Puget Sound. In 1979, scientists at PMEL began an investigation of the sources, transformation, transport and fate of pollutants in Puget Sound and its watershed. The process studies were undertaken to understand the role of flocculation in trace metal transport. Subsequently, the research centered on the role of suspended sediments in transporting and redistributing trace metals and organics in the main basin of the Sound. Twenty-eight cruises were undertaken between 1979 and 1986. In addition to the water column data, sediment trap, sediment column solid phase and sediment column interstitial phase (pore water) data are presented.

378. Paulson, A.J., Curl, H.C., Feely, R.A., Geiselman, T. and Krogslund, K.A. 1991. Trace Metal and Ancillary Data in the Open Waters of Puget Sound: 1980-1985. NOAA Data Report ERL PMEL-31, 56 pp.

In this report, the complete data set between 1980 and 1985 for the open waters of Puget Sound is presented. The water column data are divided geographically into Strait of Juan de Fuca, North Puget Sound, Admiralty Inlet, Central Main Basin, Alki mixing zone, East Passage, Colvos Passage, South Puget Sound, Whidbey Basin and Hood Canal. Besides the dissolved and particulate trace metals data, salinity, temperature data and concentrations of dissolved oxygen, methane, nutrients, particulate organic carbon and particulate organic nitrogen were sometimes obtained.

379. Price, K.S., Flemer, D.A., Taft, J.L., Mackiernan, G.B. and Nehlsen, W. 1985. Nutrient enrichment of Chesapeake Bay and its impact on the habitat of striped bass: a speculative hypothesis. Transactions of the American Fisheries Society 114 (1): 97-106.

Stocks of striped bass have declined in the Chesapeake Bay over the last decade. Evidence is presented for the hypothesis that the decline has resulted in part from loss of deep-water habitat for adults, caused by limiting concentrations of dissolved oxygen that are related, in turn, to nutrient enrichment and greater planktonic production. A related hypothesis is that changes in the near-shore habitat for juvenile striped bass also have contributed to the decline. Nutrients (nitrogen and phosphorus) and chlorophyll a have increased in many areas of the bay and tributaries over the past 20-30 years. These trends are correlated with greater deoxygenation of the deep channel in the mid and upper bay. The volume of Chesapeake Bay bottom waters containing 0.5 ml O_2/liter or less was about 15 times greater in July 1980 than in July 1950. The combination of the expanding hypoxic pool and summer temperatures above preferred levels for adult striped bass may contribute to an oxygen-temperature squeeze that forces adults onto shoal areas of the bay or out of the upper bay. Many of these shoal areas now lack suitable cover for juvenile striped bass and their prey.

380. Quinn, H., Tolson, J.P., Klein, C.J., Orlando, S.P. and Alexander, C. 1989. Susceptibility of East Coast Estuaries to Nutrient Discharges: Albemarle/Pamlico Sound to Biscayne Bay. National Ocean Service, Rockville, MD, Strategic Assessment Branch Summary Report, Sponsored by the Environmental Protection Agency, Washington, DC, 38 pp.

This is the first report in a series being developed to help the EPA develop its Near Coastal Waters and National Estuary Programs. The report summarizes

estimates of the relative susceptibility to nutrient-related pollution and status of 17 estuaries on the East Coast from North Carolina to Florida. Each estuary is described in a one-page summary which includes significant physical and hydrologic features, nutrient-loading estimates, pollution susceptibility, and nutrient concentrations.

381. Quinn, H., Tolson, J.P., Klein, C.J., Orlando, S.P. and Alexander, C. 1989. Susceptibility and Status of Gulf of Mexico Estuaries to Nutrient Discharges: Strategic Assessment of Near Coastal Waters. NOAA, Rockville, MD, Ocean Assessments Division, and Environmental Protection Agency, Washington, DC, 89 pp.

This report summarizes the status of 23 estuaries in the Gulf of Mexico with respect to estimated relative susceptibility to nutrient-related pollution. This report, second in a series, is being developed to assist in the implementation of the Environmental Protection Agency 's Near Coastal Waters Program and National Estuary Program.

382. Quinn, H., Tolson, J.P., Klein, C.J., Orlando, S.P. and Alexander, C. 1989. Susceptibility of East Coast Estuaries to Nutrient Discharges: Passamaquoddy Bay to Chesapeake Bay. National Ocean Service, Rockville, MD, Strategic Assessment Branch Summary Report, Sponsored by the Environmental Protection Agency, Washington, DC, 44 pp.

This is the third report in a series being developed to help the EPA develop its Near Coastal Waters and National Estuary Programs. The report summarizes estimates of the relative susceptibility to nutrient-related pollution and status of 17 estuaries on the Northeast Coast. Each estuary is described in a one-page summary which includes significant physical and hydrologic features, nutrient-loading estimates, pollution susceptibility, and nutrient concentrations.

383. Richards, R.P. and Baker, D.B. 1993. Trends in nutrient and suspended sediment concentrations in Lake Erie tributaries 1975-1990. Journal of Great Lakes Research 19 (2): 200-211.

During the last twenty years, intensive efforts have been aimed at reducing the eutrophication of Lake Erie. Point source inputs have been greatly reduced, but models have indicated that nonpoint source inputs would need to be reduced also in order to meet phosphorus management goals. Since nonpoint inputs enter the lake via tributary inflow, it is important to examine tributary records for evidence of trends in nutrient concentrations. Data series for the Maumee, Sandusky, and Cuyahoga Rivers, and for Honey Creek, spanning 9 to 16 years, were examined for trends in nutrients and suspended solids. Flow and suspended sediment generally showed statistically non-significant minor trends.

Total and soluble phosphorus both showed downward trends. Nitrate+nitrite showed statistically significant increase per year, except for the Cuyahoga data, which showed a statistically significant downward trend per year. These results are important because they reflect important progress in the remediation of Lake Erie, and because they demonstrate the possibility of detecting trends in tributaries, given sufficient data and appropriate statistical approaches.

384. Richardson, W.L. and Paul, J.F. 1988. Historical synopsis of great lakes water quality research and management and future directions. In: Protection of River Basins, Lakes and Estuaries: Fifteen Years of Cooperation toward Solving Environmental Problems in the USSR and USA. Report No. EPA/600/9-88/023, pp. 150-175.

In 1972, when the U.S. EPA became involved with protecting and cleaning the Great Lakes, severe water quality issues were confronting the United States and Canada - most notably, eutrophication and the impacts on drinking water, fisheries, and recreation. The understanding of cause-effect relationships and managing water quality in the Great Lakes increased in the following 16 years. Most notable was the establishment of target loadings for phosphorus. With phosphorus target loadings established, control programs in place, and eutrophication declining, effects of toxic substances became the major environmental issue in the 1980s. Initial monitoring and research has indicated that rational management of toxics is a difficult problem. The progress made in managing eutrophication in the Great Lakes is reviewed and research results are summarized, with a discussion of the approach being taken in planning a major field and modeling (mass balance) study of Green Bay.

385. Rosa, F. and Burns, N.M. 1987. Lake Erie (USA/Canada) central basin oxygen depletion changes from 1929-1980. Journal of Great Lakes Research 13 (4): 684-696.

The hypolimnetic oxygen depletion rates of the Lake Erie central basin have been reassessed using a new approach. The new approach reduces the effect of spatial variability on the calculation of the interval oxygen depletion rates and hence permits the identification of a time-trend with more precision, particularly when the data are corrected for the effects of vertical mixing, temperature effects on metabolic rates. A linear regression analysis of the final corrected depletion rates with time shows a significant increase in the yearly average hypolimnetic oxygen depletion rate between 1929 and 1980. This increase in the rate accounts for a loss of 4 to 5 g/m^3 of oxygen from the central basin hypolimnion since the earliest oxygen records in 1929.

386. Sanders, J.G. and Reidel, G.F. 1992. Sources, cycling and fate of contaminants in Chesapeake Bay. Water Science and Technology 26 (12): 2645-2652.

In order to predict and control the impacts of contaminants to the Chesapeake Bay, the geochemical, physical, and biological factors that control contaminant transport, transformation, uptake, and fate must be understood. There are numerous sources of contaminants to the Chesapeake Bay (e.g., from major tributaries, industry, municipal waste water, urban runoff, shore erosion, and atmospheric deposition). Some processes exert control over broad groups of contaminants, whereas the importance of others varies with specific contaminants. Many of these processes are well known and are amenable to predictive modeling, while others are less well understood and require further attention and research. Some of the factors controlling the fate and transport of contaminants include partitioning and sedimentation, phases, and flocculation and sedimentation), deposition and flux of sediments, and biological processes.

387. Schroeder, W.W., Dinnel, S.P. and Wiseman, W.J., Jr. 1990. Salinity stratification in a river-dominated estuary. Estuaries 13 (2): 145-154.

Analysis of salinity data from Mobile Bay, AL, indicates that stratification-destratification events within this broad, shallow estuary are not uncommon. These events are related to the strength of the winds, through their influence on wave generation and subsequent bottom drag coefficient increases, and to the strength of river discharge. They do not appear to be due to the strength of tidal currents, as has been observed elsewhere. Furthermore, river flow appears to be the dominant control, the winds being important only in the absence of large freshwater discharges. The annual spring freshet can flush most of the salt from the bay. During other times of the year the relative strengths of river discharge and wind stress change the bay from highly stratified to nearly homogeneous and back on a variety of time scales ranging from daily to seasonal.

388. Seliger, H. H., Boggs, J.A. and Biggley, W.H. 1985. Catastrophic anoxia in the Chesapeake Bay in 1984. Science 228 (4695): 70-73.

In 1984, four climatic sequences combined to produce a major anoxic catastrophe in the northern Chesapeake Bay. These sequences are: the highest late-winter stream-flow on record from the Susquehanna River watershed; stream-flows from the Susquehanna River for the months of June-August that were higher by two standard deviations than the respective monthly mean values measured over the last 34 years; a stationary high in August off the Atlantic Coast; and the absence of strong storm events in summer. An

empirical equation is proposed for the prediction of the monthly trend of dissolved oxygen decrease. As of 23 August 1984, the summer pycnocline of the northern bay had eroded upward from its historically recorded depth below 10 meters to a very shallow five meters, with higher stratification than in earlier years. Dissolved oxygen concentrations directly below the pycnocline decreased to zero during June, two months earlier than for previous wet years. Oxygen-deficient waters containing significant concentrations of hydrogen sulfide penetrated into Eastern Bay and the Choptank and Potomac rivers.

389. Sheng, Y.P., Lee, H.K. and Wang, K.H. 1990. Numerical strategies of estuaries and coastal modeling. In: Estuarine and Coastal Modeling. American Society of Civil Engineers, New York, pp. 291-301.

Various strategies for numerical simulation of estuarine and coastal circulation and transport in Chesapeake Bay have been developed. The results of the modeling effort were significantly improved when the following strategy was implemented: (1) reduction of the skewness of the grid near the Mid-Bay station, (2) use of Leonard's algorithm in the longitudinal direction, (3) use of a second order advective algorithm in the transverse direction, and (4) evaluation of baroclinic gradients along the z-plane.

390. Sherwood, C.R., Jay, D.A., Harvey, R.B., Hamilton, P. and Simenstad, C.A. 1990. Historical changes in the Columbia River Estuary. Progress in Oceanography 25 (1-4): 299-352.

Historical changes in the hydrology, sedimentology, and physical oceanography of the Columbia River Estuary have been evaluated with a combination of statistical, cartographic, and numerical-modelling techniques based on data digitized from U.S. Coast and Geodetic Survey bathymetric surveys conducted in during 1867-75, 1926-37, and 1949-58. Large changes in the morphology of the estuary have been caused by navigational improvements, such as jetties, dredged channels, and pile dikes, and by the diking and filling of the wetland area, and lesser changes are attributable to natural shoaling and erosion. The overall effects of human intervention in the physical processes of the Columbia River Estuary (i.e. decrease in freshwater inflow, tidal prism, and mixing; increase in flushing time and fine sediment deposition, and net accumulation of sediment) are qualitatively similar to those observed in less energetic and more obviously altered estuarine systems.

391. Shirmohammadi, A., Shoemaker, L.L. and Magette, W.L. 1992. Model simulation and regional pollution reduction strategies. Journal of Environmental Science and Health, Part A - Environmental Science and Engineering A27 (8): 2319-2336.

The Chemical, Runoff, Erosion from Agricultural Management Systems (CREAMS) model was used to simulate the long-term effects of different agricultural best management practices (BMP's) on nitrogen losses to surface and groundwater systems. Soils, geology, climate, and cultural practices of watersheds representing coastal plain, Piedmont, and Appalachian physiographic regions in the Chesapeake Bay basin simulated. Different tillage practices and erosion control structures, with and without a nutrient management plan (NMP) and a winter cover were selected for this study. The results showed that a NMP plays a major role in reducing surface and groundwater loadings of nitrogen. No-till (NT) with a NMP was the optimum BMP studied in both the Piedmont and Appalachian regions. Winter cover also resulted in significant reductions in nitrogen losses to surface and groundwater systems in the coastal plain physiographic region.

392. Smith, K. 1992. Report on the Usage of Computer Models of Estuaries by Eastern Coastal States. North Carolina Water Resources Research Inst., Raleigh, Special Report Series SRS-10, 80 pp.

As part of a program of whole basin planning, the NC Division of Environmental Management investigated how estuary models are used by other East Coast states, the adequacy of existing models, and potential alternatives. They noted that state agency modelers have different concerns than do federal, private, or academic modelers. The project began in the spring of 1992 with a written survey. Nineteen responses were received. The report presents the results of these information gathering activities.

393. Stanley, D.W. and Nixon, S.W. 1992. Stratification and bottom-water hypoxia in the Pamlico River estuary. Estuaries 15 (3): 270-281.

Relationships among bottom-water dissolved oxygen (DO), vertical stratification, and the factors responsible for stratification-destratification in the Pamlico River estuary were studied using a 15-year set of biweekly measurements. Hypoxia developed when there was both vertical water column stratification and water temperature greater than 15° C. In July, 75 percent of the DO readings were less than 5 mg/L, and one-third were less than 1 mg/L. Severe hypoxia occurred more frequently in the upper half of the estuary than near the mouth. Both the time series data and correlation analysis results indicated that stratification events and DO levels are tightly coupled with variations in freshwater discharge and wind stress. There has been no trend toward lower bottom water DO in the Pamlico River Estuary over the past 15 years.

394. Stanley, D.W. 1993. Long-term trends in Pamlico River estuary nutrients, chlorophyll, dissolved-oxygen, and watershed nutrient production. Water Resources Research 29 (8): 2651-2662.

In order to determine whether or not the estuary was becoming more eutrophic, trends in Pamlico River estuary ammonia nitrogen, nitrate nitrogen, phosphate phosphorus, chlorophyll a, and dissolved oxygen during the past 20-24 years were analyzed, and estimates of annual N and P production in the watershed over the past century were computed. The weight of the evidence indicates that the Pamlico has not become more eutrophic during the past two decades. Watershed nutrient production is estimated to have increased between 1880 and 1970, but appears to have stabilized after 1970.

395. Swartz, P.O. 1987. Nutrients: The missing link. In: Proceedings of the 10th National Conference on Estuarine and Coastal Management, Tools of the Trade. Vol. 1. Lynch, M.P. and McDonald, K.L. (ed.). New Orleans, LA, 12-15 Oct. 1986, pp. 323-331.

In three years, nutrients have virtually revolutionized soil conservation programs in Pennsylvania. With the Chesapeake Bay as its impetus, Pennsylvania has initiated a nutrient management program designed to complement the traditional soil conservation program. The program's purpose is to apply nutrients to agricultural land in accordance with the nutrient requirements of crops. Based on the analyses of the nutrient levels in soils and animal wastes on a farm, field-by field recommendations are made to farmers concerning the proper amounts of manure and commercial fertilizer to grow a particular crop. These recommendations, based on a program developed at Penn State University, constitute the heart of nutrient management plans developed by various agencies.

396. Tippie, V.K. 1984. Environmental characterization of Chesapeake Bay and a framework for action. In: The Estuary as a Filter. Pp. 467-487. Academic Press, Orlando, FL.

Data compiled and analyzed during the EPA's Chesapeake Bay Program show how the filtering action responsible for the estuary's high productivity also traps pollutants. The bay's ecology has changed gradually. Blue-green algal blooms have increased in frequency; submerged aquatic vegetation has declined dramatically; freshwater-spawning fish have declined while marine-spawning fish have increased; and oyster spat set has decreased as blue crab harvests have increased. Nutrient levels are high in the upper bay and tributaries, moderate in the eastern shore area, and normal in the lower bay. The amount of water in the main part of the bay which has low or no dissolved oxygen

increased 15-fold between 1950 and 1980. High concentrations of toxic organic compounds are in bottom sediments of the main bay near industrial facilities, near river mouths, and in areas of maximum turbidity. Metal concentrations are significantly higher than background levels in many areas. To reverse the decline of this ecosystem, inputs of nutrients and toxic materials must be controlled. Nutrient loadings can be reduced by controlling agricultural runoff, urban runoff, and industrial and waste-water treatment plant discharges.

397. Turner, R.E., Kaswadji, R., Rabalais, N.N. and Boesch, D.F. 1987. Long-term changes in the Mississippi River water quality and its relationship to hypoxic continental shelf waters. In: Proceedings of the 10th National Conference on Estuarine and Coastal Management, Tools of the Trade. New Orleans, LA, 12-15 Oct. 1986. Lynch, M.P. and McDonald, K.L. (ed.). Vol. 1, pp. 261-266.

Oxygen deficient bottom waters of the northern Gulf of Mexico continental shelf are an extensive, intensive, and seasonal phenomenon. Hypoxic water masses (less than 2.0 mg per liter) typically form during the spring, expand in the summer (up to 8,000 km^2 in July 1985, and 9,500 km^2 in July 1986) and dissipate in the fall. Based on ongoing field research, hypotheses concerning hypoxic zones were formulated. The authors concentrated on the implications of historical water quality changes in the Mississippi River drainage basin.

398. Tuttle, J.H., Jonas, R.B. and Malone, T.C. 1987. Origin, development and significance of Chesapeake Bay anoxia. In: Contaminant Problems and Management of Living Chesapeake Bay Resources. Majumdar, S.K., Hall, L.W., Jr. and Austin, H.M. (ed.). 152nd National Meeting AAAS: Chesapeake Bay Fisheries and Contaminant Problems, Philadelphia, PA, 26 May 1986, pp. 442-472.

Summer anoxia in deep waters of the mesohaline portion of Chesapeake Bay has been an annual event throughout the historical record, but there is recent evidence that the areal extent and duration are increasing. The increase has been attributed to increasing nutrient loading and the consequent increase in phytoplankton production. Phytoplankton carbon fuels oxygen consumption, a significant portion of which is due to aerobic, heterotrophic bacterial metabolism and microbial sulfur cycling by at least two processes: sulfate reduction catalyzed by obligately anaerobic bacteria in Bay sediments, and sulfide oxidation in surficial sediments or in subpycnoclinal waters. Anoxia results when rates of oxygen consumption exceed reaeration to the deep waters.

399. Tyler, M. 1988. Contribution of Atmospheric Nitrate Deposition to Nitrate Loading in the Chesapeake Bay. Versar, Inc., Columbia, MD. Maryland Department of Natural Resources Contract PR86-043-01(88). Report No. AD-88-7, December 1988. 29 pp.

Recent studies have suggested that nitrate introduced into the Chesapeake Bay via atmospheric deposition may be a significant source of excess nutrients. In order to determine if concerns about atmospheric deposition are justified, modeled estimates of wetfall nitrate deposition over the Chesapeake Bay basin, based on monitoring data collected in 1984, were used to estimate basin-wide nitrate loading over the land area of the basin. Conservative assumptions were made in developing the figures. The model results suggest that the actual percentage contribution of atmospheric nitrate deposition may be lower than the estimated value.

400. Tyler, M.A. and Stumpf, R.P. 1989. Feasibility of using satellites for detection of kinetics of small phytoplankton blooms in estuaries: Tidal and migrational effects. Remote Sensing of the Environment 27 (3): 233-250.

Reliable and accurate measurements of fine-scale pigment distribution in a turbid estuarine environment are feasible and desirable using satellite imagery to determine algal migration, bloom origins, dissipation, tidal spatial reconfiguration, and population dynamics. The Chesapeake Bay was used to illustrate the feasibility of this approach during the spring 1982 season. AVHRR and CZCS images processed with the algorithms for turbid systems confirmed the kinetics of a 100 km^2 bloom of the dinoflagellate *Heterocapsa triquetra*, including abundance changes due to diurnal migration, and axial and cross stream spatial reconfiguration due to tidal excursion.

401. Valente, R.M., Rhoads, D.C., Germano, J.D. and Cabelli, V.J. 1992. Mapping of benthic enrichment patterns in Narragansett Bay, Rhode Island. Estuaries 15 (1): 1-17.

A synoptic reconnaissance survey was performed over a five-day period in August 1988 to assess benthic habitat quality in Narragansett Bay, using REMOTS sediment-profile photography and analysis in combination with counts of *Clostridium perfringens* spores (a fecal indicator) in sediments. Three main areas of degraded benthic habitat quality related to either excessive organic enrichment or physical disturbance were identified: the Providence River Reach, Greenwich Bay and its associated coves and harbors, and an area located along the southwest side of Prudence Island. The highest spore counts occurred at the head of the bay, where waste-water treatment discharges and associated combined sewer overflows are numerous. Using data from the REMOTS analysis and the sediment inventory of *C. perfringens* spores, organic enrichment of the bottom from sewage was distinguished from non-sewage enrichment or physical disturbance. The combination of techniques employed in this investigation could be used to design more efficient monitoring programs to assess eutrophication effects in estuaries.

402. Valiela, I. and Costa, J.E. 1988. Eutrophication of Buttermilk Bay, a Cape Cod coastal embayment: Concentrations of nutrients and watershed nutrient budgets. Environmental Management 12 (4): 539-553.

To evaluate the sources of nutrients into Buttermilk Bay, inputs of nutrients by each major source in the watershed were estimated. Most nutrients that entered the watershed failed to reach the bay; uptake by forests, soils, denitrification, and adsorption intercepted two-thirds of the nitrogen and nine-tenths of the phosphorus. The nutrients that did reach the bay probably originated from subsoil injections into groundwater by septic tanks, or leaching of fertilizers. Buttermilk Bay water has relatively low nutrient concentrations. Annual budgets of nutrients that entered the watershed showed a low nitrogen-to-phosphorus (N/P) ratio of 6, but passage of nutrients through the watershed raised N/P to 23. The N/P ratio of water that leaves the watershed and presumably enters the bay is probably high enough to maintain active growth of nitrogen-limited coastal producers. N/P exceeded the 16:1 Redfield ratio during midwinter; N/P fell below 16:1 during the remainder of the year. This suggests that annual budgets do not provide sufficiently detailed data with which to interpret nutrient-limitation of producers.

403. Valiela, I., Costa, J., Foreman, K., Teal, J.M., and Howes, B. 1990. Transport of groundwater-borne nutrients from watersheds and their effects on coastal waters. Biogeochemistry 10 (3): 177-197.

The flow of groundwater and concentrations of nitrate, nitrite, ammonium and phosphate into Great Sippewissett Marsh, on the West coast of Cape Cod facing Buzzards Bay, were studied. Concentrations varied widely, but the upper ranges of dissolved organic nitrogen and phosphate were two to three orders of magnitude higher than those of the receiving seawater. Anthropogenic activities on coastal watersheds increase nutrient concentrations of groundwater. As groundwater travels downslope it transports these nutrients toward the adjoining coastal water. Groundwater- borne nutrients are subject to active biogeochemical transformations in the bottom sediment where conditions favor anaerobic processes such as denitrification, and other mechanisms that either sequester or release nutrients. The relative importance of advective vs. regenerative pathways of nutrient supply may result in widely different rates of release of nutrients from sediments. The relative activity of denitrifiers also may alter the ratio of nitrogen to phosphorus released to overlying waters. The consequences of nutrient loading include increased nutrient concentrations in the water column leading to increased growth of macroalgae and phytoplankton, and reduced seagrass beds and associated fauna.

404. Warsh, C., Tolson, J.P., Klein, C.J., Orlando, S.P. and Alexander, C. 1988. Susceptibility and concentration status of northeast estuaries to nutrient discharges. In: Strategic Assessment of Near Coastal Waters: Northeast Case Study. Chapter 3. Environmental Protection Agency and National Oceanic and Atmospheric Administration Team on Near Coastal Waters, Rockville, MD. Report EPA/503/6-88/000, 56 pp.

The report presents background information on the problems of nutrient overenrichment in 17 northeast estuaries, an analysis of the susceptibility and status of estuaries to nutrient discharges, nutrient sources, discharge estimation methods, and an overview of the region based on comparisons of discharge estimates across estuaries in the region. One-page summaries provided for each estuary include information on significant physical and hydrologic features, susceptibility and pollutant status, nutrient discharge estimates, and a narrative to assist the reader interpret the data. Changes in nitrogen and phosphorus inputs that would significantly alter the pollutant status of each estuary are summarized. Detailed descriptions are given of nutrient discharges by season and by source, an evaluation of the quality of the discharge estimates, and the method for determining an estuary's nutrient concentration status and susceptibility to nutrient-related pollution problems.

405. Williams, D.J. 1992. Great Lakes water quality - a case-study. ACS Symposium Series 483: 207-223.

Pollution of the Great Lakes exemplifies the serious problems associated with the impact of human activities on a major aquatic ecosystem. Problems have included bacteriological contamination, eutrophication, and contamination by hundreds of anthropogenic, potentially toxic substances. Management of the Great Lakes is divided between Canada and the United States and involves eleven governments at federal, state and provincial levels. Despite this environmental and institutional complexity, the Great Lakes have responded dramatically to remediation initiatives. Human impacts on the lakes associated with development of the Great Lakes Basin are discussed in the context of the unique binational arrangements agreed to by the two countries to restore and protect this shared, unique ecosystem.

406. Wiltse, W. and Connor, M.S. 1985. Environmental management concerns in three New England estuaries. In: Eighth Biennial International Estuarine Research Conference. Durham, NH (USA), 28 Jul. 1985. Estuaries 8 (2B): 48A.

Long Island Sound, Narragansett Bay, and Buzzards Bay have witnessed large losses of shellfish resources due to closures associated with coliform contamination. Each region has specific problems associated with the nature of

local discharges: eutrophication in western Long Island Sound, PCB contamination of finfish and lobsters in Buzzards Bay, and metal contamination of shellfish in Narragansett Bay.

407. Wolff, G.B. 1985. Nonpoint source pollution: Managing nutrients--a key to control. In: Perspectives on Nonpoint Source Pollution, Proceedings of a National Conference. Kansas City, MO, 19-22 May 1985, p. 244.

The problem of nonpoint source pollution, which came to light with the report from the Chesapeake Bay Study Committee, was confirmed by the Lake Erie Waste Water Management Study and by the Lake Wallenpaupack Study. The major problem found was excess nitrogen and phosphorus. A conservation program has to be matched with an equally efficient nutrient management program. However, little is known about nutrient management. Investigations have indicated that fast and accurate soil tests are needed for every field; fast and accurate tests are needed for the manure stored in waste management facilities; ways must be developed to transport manure from those farms with a surplus to agricultural lands that need the nutrients; and new uses must be developed for excess nutrients, including application to forest land, resource recovery operations, and methane digestion.

408. Wolff, G.B. 1992. Agriculture and water quality management goals. Water Quality International '92. 16th Biennial Conference of the International Association on Water Pollution Research and Control. Suzuki, M., Ballay, D., Dahlberg, A.G., Gujer, W., Jenkins, D., Kroiss, H., DiPinto, A.C., Zotter, K., Milburn, A., Izod, E.J. and Nagle, P.T. (ed.). Washington, DC, 24-30 May 1992. Water Science and Technology 26 (12): 2727-2730.

Despite many who believed that the overuse of herbicides and pesticides was killing the submerged aquatic vegetation in the Chesapeake Bay, a study showed that excess nitrogen and phosphorus were stimulating algal growth such that the bottom of the Bay was shaded to the point where sunlight could not penetrate enough to sustain vegetation growth. When the nitrogen and phosphorus attributable to Pennsylvania's agriculture was analyzed, it became apparent that the problem was the excess and injudicious application of animal wastes, not excess application of commercial fertilizer as had been suspected.

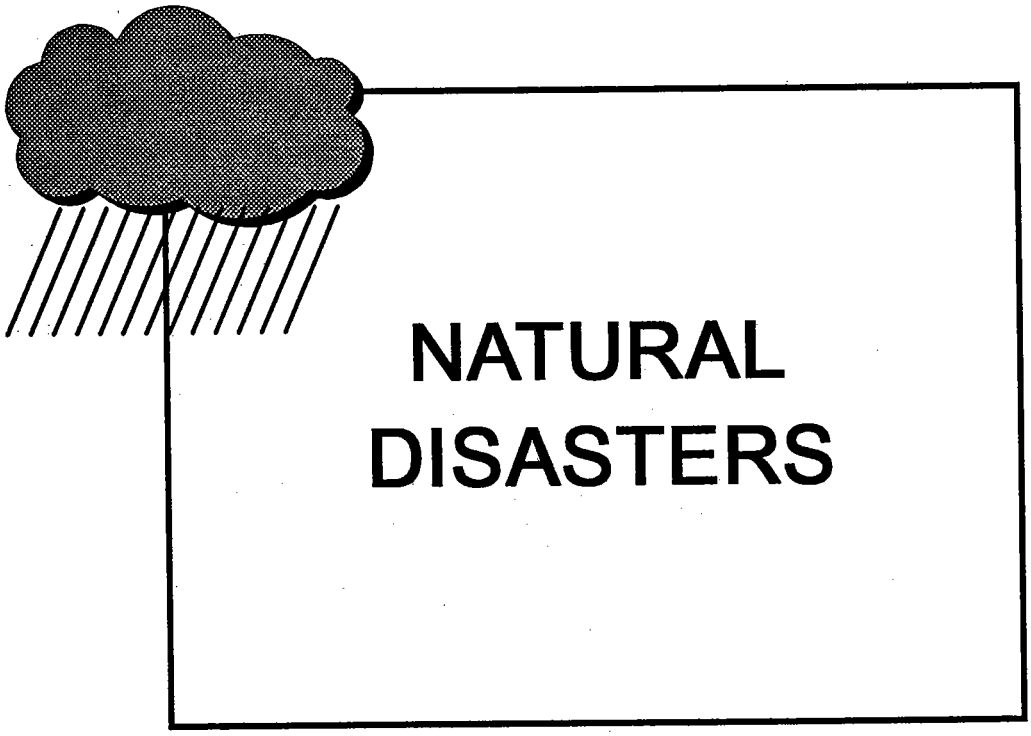
409. Wright, D.A. 1991. Chesapeake Bay toxics issue revisited. Marine Pollution Bulletin 22 (10): 487-491.

Over the last twenty years, Chesapeake Bay fisheries of oysters and striped bass have declined. This decline has prompted concern over deteriorating water quality as a result of the input of toxic chemicals. The goal of the 1988

Toxics Reduction Strategy is to reduce levels of toxic substances from all controllable sources to the Chesapeake Bay. The overall goal is the development of risk assessment strategy which will provide an estimate of the ecological cost of toxic chemical pollution in the Bay ecosystem. A Toxics Reduction Strategy should contain both source-driven and effects-driven components, but opinions differ as to the relative degree of emphasis. Management decisions can be made to protect the Chesapeake Bay environment using a variety of scientific data of which very few can be classified as direct cause-and-effect. Scientists, however, have yet to fill the management need for more sensitive tests for toxic stress in marginally polluted areas.

410. Zimmerman, R.C., Reguzzoni, J.L., Wyllieecheverria, S., Josselyn, M. and Alberte, R.S. 1991. Assessment of environmental suitability for growth of *Zostera marina L.* (eelgrass) in San Francisco bay. Aquatic Botany 39 (3-4): 353-366.

The relationship between turbidity and light availability, and its subsequent effect on the depth distribution of *Zostera marina L.* (eelgrass) in San Francisco Bay was explored. The average daily period of irradiance-saturated photosynthesis (H(sat)) required for the maintenance of whole plant carbon balance and growth, based on measured rates of photosynthesis and respiration as well as data from the literature, were estimated to be 3-5 hours. Estimates of average H(sat) availability in the field were determined from laboratory measurements of the photosynthesis vs. irradiance (P vs. I) response and from field observations of light attenuation measured at five sites in San Francisco Bay. Although plants were found to be low-light adapted with regard to their P vs. I response, they were limited to depths shallower than - 2 m mean lower low water at all sites. The - 2 m depth limit corresponded to predicted H(sat) requirements at two sites where turbidity was relatively low and constant; but depth limits of eelgrass were less than 1.5 m at three sites subjected to extremely turbid and variable light environments, much shallower than predicted from calculations of mean daily carbon requirements and H(sat) availability. Thus, in addition to the mean light environment, periods of extreme light attenuation that last from days to weeks may be important in controlling eelgrass growth and productivity in highly turbid and dynamic estuaries such as San Francisco Bay.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412. Conner, W.H., Day, J.W., Jr., Baumann, R.H. and Randall, J.M. 1989. Influence of hurricanes on coastal ecosystems along the northern Gulf of Mexico. Wetlands Ecology and Management 1 (1): 45-56.

This paper describes the impact of hurricanes on the natural environment and synthesizes existing information on the impact of hurricanes on natural systems in the northern Gulf of Mexico. In assessing hurricane effects as beneficial or detrimental to natural resources, increases in habitat diversity, productivity, fisheries, etc. are regarded as positive and decreases as negative. The analysis is seldom simple, however, as trade-offs usually occur.

413. Hall, S.L., Wilder, W. R. and Fisher, F.M. 1986. An analysis of shoreline erosion along the northern coast of east Galveston Bay, Texas USA. Journal of Coastal Research 2 (2): 173-179.

Shoreline erosion was measured along a portion of East Galveston Bay, Texas, over a period of five years. These short-term measurements were consistent with erosion estimates obtained from aerial photographs spanning almost 40 years. The erosion caused by Alicia, a major hurricane, was not as severe as expected. Many natural and anthropogenic factors appear to be responsible for the current erosion trend in this area. It is unlikely that this trend will be reversed due to the effects of subsidence and rising sea level.

414. Inman, D.L. 1985. Dynamics of migrating inlets. Eighth Biennial International Estuarine Research Conference, Durham, NH, 28 Jul. 1985. Estuaries 8 (2B): 114A.

Most beach erosion on the east coast of the United States can be correlated with human intervention with the natural migration pattern of barrier island inlets. The channels migrate in the direction of the littoral transport under the influence of longshore transport of sand, and onshore under the influence of sea level rise. As aids to navigation, humans attempt to stabilize the entrance position by building long jetties, and to increase navigable depths by dredging straight channels through the crescentic ebb-tide bar offshore of the entrance.

415. Louisiana Geological Survey, Baton Rouge, LA. 1989. Barrier Island Erosion and Land Loss Study Publication. Preprints. Number 1, 153 pp.

This series includes the following studies of Louisiana: Rapid dune changes on the deltaic coast; Sea level rise; Delta plain development and sea level history in the Terrebonne coastal region; Barrier island erosion study; Evolution of Cat

Island Pass; Barrier island erosion and the performance of coastal protection projects during the 1985 hurricane impacts; Inner-shelf shoal sedimentary facies and sequences: and Hurricane impact and coastal protection.

416. Meeder, J.F. and Meeder, L.B. 1989. Hurricanes in Florida Bay: A dominant physical process. Symposium on Florida Bay, a Subtropical Lagoon, Everglades National Park and Miami, FL (USA), 1-5 Jun. 1987. Bulletin of Marine Science 44 (1): 518.

The effects of hurricanes on the Bay ecosystem are described and their role on coastal and shallow bay communities is depicted. Many perturbations produced by hurricanes are uncontrollable, and their impact on the Florida Bay ecosystem has, therefore, remained unaltered by human activities. The alteration of hurricane runoff quantity and timing, quality of runoff water, and tidal exchange rates are major exceptions. Intense periods of rapid runoff appear to be very significant in maintaining the Florida Bay ecosystem. Storms that affect the Bay bottom and coastline occur at predictable intervals of once every 3-5 years and storms which produce extreme freshwater runoff occur once every 6-7 years. The significance of tropical storms becomes apparent when these frequencies are understood.

417. Nelson, W.G. 1992. Beach restoration in the southeastern U.S.: Environmental effects and biological monitoring. Ocean and Coastal Management 19 (2): 157-162.

In the coastal region of the southeastern U.S., beach restoration has become the method of choice for alleviating threats to property arising from erosion, but this method is controversial due to economic and environmental concerns. Many existing studies of biological impacts of beach restoration have deficiencies of sampling design that make clear interpretation of results difficult. This paper offers guidelines for sampling and analytical methods that will improve the study of beach restoration impacts. An overview of the biological composition of sandy beaches of the southeastern U.S., in the context of beach restoration, is provided first, followed by specific recommendations for the design, execution and analysis of beach restoration monitoring programs to receive the maximum return for effort invested.

418. Penland, S., Westphal, K.A., Debusschere, K., McBride, R.A. and Reimer, P.D. 1989. Hurricane impacts on Louisiana's barrier islands (1985): Geomorphic changes in the Isles Dernieres, 1984-85. Louisiana Geological Survey, Baton Rouge, LA. 143 pp.

The impacts of 1985 Hurricanes Danny, Elena, and Juan on the geomorphology of the Isles Dernieres barrier island arc (off the Louisiana coast) were assessed

by means of aerial videotape mapping. A coastal geomorphic classification system was developed to map the differences between pre-storm and post-storm conditions. The rate of shoreline change and sediment supply control landform development on these islands. A barrier island restoration project at one site reduced erosion and prevented breaching, indicating the importance of vegetation in reducing the effects of hurricanes. The lower-relief landforms are more sensitive to storm impacts.

419. Ritchie, W. and Penland, S. 1989. Bayou Lafourche Barrier Shoreline Changes 1978-1985: Assessment of Hurricane Impacts and Cold Front Impacts. Louisiana Geological Survey, Baton Rouge, LA. 85 pp.

In 1985, photographs, aerial surveys, and ground surveys were taken of areas that had been documented in 1978. It thus was possible to measure the amount and spatial pattern of recent coastline retreat and overwash penetration. In general, the central parts of the barriers retreated more rapidly than the flanks, and the hurricane erosion and overwash patterns reinforced and exacerbated these trends. Two areas with artificial measures intended to offer shoreline protection, a seawall and human-built dunes, were exceptions to this rule.

420. Skaggs, L.L. and McDonald, F.L. 1991. National Economic Development Procedures Manual. Coastal Storm Damage and Erosion. Final Report. Army Engineer Inst. for Water Resources, Fort Belvoir, VA. Report IWR-91-R-6, 285 pp.

This manual describes coastal storm damage erosion prevention benefit evaluation procedures based on the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Selected, specific procedures for the entire process of benefit estimation are described and are intended for use in project feasibility planning and evaluation. The manual is intended to serve as a reference guide to questions posed by an economic analyst in conducting a coastal storm damage and erosion prevention benefit evaluation.

RESOURCE MANAGEMENT

4A. GENERAL MANAGEMENT

421. Adamus, P.R. and Leibowitz, S. 1992. Process for Regional Assessment of Wetland Risk. Environmental Protection Agency, Corvallis Environmental Research Lab., Corvallis, OR; Report EPA/600/R-92/249, 180 pp.

This report describes a process for prioritizing risks of wetland loss in areas where technical data and/or resources are limited. In instances where best professional judgement (BPJ) is required, the report provides a means of formalizing BPJ in terms of ecological risk assessment. The process uses available literature and a panel of experts. The probability of loss of valued functions is determined as a function of wetland loss. The Prairie Pothole Region is assessed in the report.

422. Conner, W.H. and Day, J.W., Jr. 1989. Response of coastal wetland forests to human and natural changes in the environment with emphasis on hydrology. In: The Forested Wetlands of the Southern United States. Symposium Proceedings. Orlando, FL, 12-14 July 1988. Pp. 34-43.

Forested wetlands are important ecosystems because they provide habitat for fish and wildlife, improve water quality, attenuate flood peaks, produce timber products, and provide recreational sites. Anthropogenic impacts include impoundments and drainage, dam construction, thermal water additions, and nutrient introduction. Natural impacts include sea level rise, salinity intrusion, and tropical storms. Unfortunately, the overall impact of these changes on the functioning of these systems is not fully understood. Studies from the southern U.S. are reviewed to describe how these factors are impacting forested wetlands.

423. Cowie, G.M. and Cooley, J.L. 1989. Guidelines for Development of Watershed Protection Programs in Georgia. Georgia Institute of Technology, Atlanta. Environmental Resources Center, Technical Completion Report, 111 pp.

In Georgia in recent years, increased emphasis has been placed on watershed protection as a critical component of water supply planning. The planning process started with the evaluation of thirteen proposed water supply watersheds in Northeast Georgia, and it was refined through detailed analysis of three of these watersheds. Results for the study watersheds are presented with specific discussion of the seven components in watershed protection planning.

424. Environmental Protection Agency, Washington, DC, Office of Water. 1988. America's Wetlands: Our Vital Link Between Land and Water. Report OPA-87-016, 10 pp.

The Environmental Protection Agency established an Office of Wetlands Protection in 1986. This booklet describes the importance of wetlands, how they are threatened, and conservation measures that should be taken.

425. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water. 1989. Saving Bays and Estuaries: A Primer for Establishing and Managing Estuary Projects. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water Report EPA/503/8-89/001, 173 pp.

The report contains chapters on planning, building a management framework, defining the problem, and devising a comprehensive conservation and management plan.

426. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water. 1990. Water Quality Standards for Wetlands: National Guidance. Environmental Protection Agency, Washington, DC Report EPA/440/5-90/011, 61 pp.

The document provides guidance to states on the effective application of water quality standards to wetlands. The level of achievement to be reached by the states by the end of FY 1993 is stated.

427. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water. 1991. Watershed Protection Approach: an Overview. Environmental Protection Agency, Washington, DC Report EPA/503/9-92/002, 12 pp.

The document describes the EPA's efforts to coordinate water pollution control programs. The term Watershed Protection Approach is being used to encompass a basin-wide approach that considers dynamic relationships to sustain natural resources.

428. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water. 1992. National Estuary Program After Four Years: A Report to Congress. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water Report EPA/503/9-92/007, 101 pp.

This status report on the National Estuary Program considers the understanding and management of estuaries, the assessment of what has been learned from the program to date, trends, and a view to the future.

429. Environmental Protection Agency, Washington, DC, Office of Wetlands, Oceans and Watersheds. 1992. Protecting the Nation's Wetlands, Oceans and Watersheds: An Overview of Programs and Activities. Environmental Protection Agency, Report EPA/840/S-92/001, 24 pp.

The health of the wetlands and oceans is linked to the quality of the water in the watershed. The EPA's Office of Wetlands, Oceans,and Watersheds was created in 1991 to provide an integrated, cooperative approach to the management of watersheds, coastal and marine waters, and wetlands. The booklet discusses related topics, including the abatement of non-point source pollution, restoring and protecting water environments, and water quality assessment.

430. Etheridge, B.J. and Olson, R.K. 1992. Research and information needs related to non-point source pollution and wetlands in the watershed. An EPA perspective. Ecological Engineering 1: 149-156.

The use of created and natural wetlands to treat non-point source pollution is discussed. Increased research is recommended on construction methods and siting of created wetlands. Model watershed demonstrations are also recommended as a means of integrating research results of the research and conservation communities.

431. Fawcett, J.A. and Marcus, H.S. 1991. Are port growth and coastal management compatible? Coastal Management 19: 275-295.

Changes in the technology of marine transportation, such as concentration of cargo-handling activities in ports with heavy infrastructure investments in the ports and adjacent wetlands, have stressed coastlines in the developed world. U.S. ports generally provide support services for the marine transportation industry, but this style of management creates tensions between the transportation industry and coastal planning agencies. This article seeks to build a bridge between these port and coastal managers, in an attempt to provide regional port planning.

432. Good, J.W. and Ridlington, S.S. (ed.). 1992. Coastal Natural Hazards: Science, Engineering, and Public Policy. Oregon State University Sea Grant Report ORESU-B-92-001, 162 pp.

This book describes for lay readers the risks of building on the sifting sands and eroding sea cliffs that typify the U.S. Pacific coast. It also looks at some of the ways that have been tried to stop the changing coastline from changing. The book, which grew out of an October 1990 conference of coastal geologists,

oceanographers, engineers, planners, and resource managers, discusses the effects of El Nino on beach and shore erosion and recent research into sea cliff erosion and subduction zone earthquakes. Planning and engineering approaches to hazard mitigation on the west coast and the successes and shortcomings of public policies designed to deal with development in hazardous areas are addressed.

433. Grifman, P.M. and Fawcett, J.A. 1993. International perspectives on coastal ocean space utilization. In: Proceedings from the Second International Symposium on Coastal Ocean Space Utilization. Long Beach, CA, 2-4 Apr. 1991. University of Southern California, Los Angeles, Sea Grant Program Report USCSG-TR-01-93, 790 pp.

The development of techniques for the wise use of ocean resources is discussed, including policy, technology, and development. National efforts to protect the coast; reclamation and development of artificial islands; extraction of sea-bed minerals; increased fishery resources; utilization of the energy potential of ocean waves, thermal gradients, and winds; and shipping safety are discussed.

434. Hamann, R. 1987. Selected Annotated Bibliography: Coastal Resource Management. Florida Sea Grant College Report 89, 82 pp.

This bibliography of selected references to coastal resource management, 1967-1985, is intended for use by local government officials, regional planners, state agency personnel, and private citizens who are developing comprehensive plans, considering development, or drafting local or other ordinances.

435. Hershman, M.J. 1985. The coastal decision-making framework as a model for ocean management. In: Proceedings National Conference on the States and an Extended Territorial Sea. 9-11 Dec. 1985. Pp. 92-100.

An issue that will arise with increasing frequency is the long-term commitment of ocean space to a particular use: oil and gas production, mineral extraction, sanctuaries, research stations, mariculture, recreation, waste disposal, etc. Each use requires that a site be selected and alternative uses be limited. Deciding on a site requires a balance of development opportunities and preservation values, and fairness in the decision-making process. The coastal decision model can be a useful tool. This paper characterizes the structure and norms of the coastal decision framework and uses these characterizations as criteria for determining the adequacy of the current ocean management regime.

436. Hopkinson, C.S., Jr., Wetzel, R.L. and Day, J.W., Jr. 1988. Simulation models of coastal wetland and estuarine systems: Realization of goals. In: Wetland Modelling. Mitsch, W.J., Straskraba, M. and Jorgensen, S.E. (ed.). Pp. 67-97.

The most successful models of marsh/estuarine systems are useful tools for formulating new hypotheses, for guiding ecosystem-level research programs, and for guiding the management of coastal habitats. Six simulation models of coastal marsh/estuarine systems that are representative of management- and research-directed efforts are reviewed in this report.

437. Industrial Economics, Inc., Cambridge, MA. 1992. Protecting Coastal and Wetlands Resources: A Guide for Local Governments. Environmental Protection Agency, Washington, DC, Office of the Assistant Administrator for Water Report EPA/842/R-92/002, 197 pp.

The reports includes discussions of growth management, local plans, regulatory measures, acquisition of property, economic tools, and protection techniques.

438. Kentula, M.E., Brooks, R.P., Gwin, S.E., Holland, C.C. and Sherman, A.D. 1992. Wetlands: An Approach to Improving Decision Making in Wetland Restoration and Creation. Report ISBN-1-55963-221-6, 183 pp. Available from Island Press, Center for Resource Economics, Washington, DC.

Populations of natural and created wetlands were compared during five years to determine whether restored wetlands can successfully replace natural wetlands. The topics discussed include site selection, assessment of the level of attainable function of restored wetlands, and evaluation procedures.

439. Kentula, M.E. 1993. Establishing Quantitative Performance Criteria for Wetland Restoration. Environmental Protection Agency, Corvallis Environmental Research Lab., OR, Report EPA/600/A-93/232, 5 pp.

Five years of research is synthesized in the report for the Wetland Restoration Program. In wetland restoration, existing information can be used to guide decision-making, and projects can be evaluated relative to natural wetlands. The report describes techniques used to provide a method for setting performance criteria for evaluation.

440. Kusler, J.A. and Kentula, M.E. 1990. Wetland Creation and Restoration: The Status of the Science. Technology Services Corporation, Corvallis, OR, Report ISBN-1-55963-045-0, 620 pp. Available from Island Press, Covelo, CA.

This document synthesizes current knowledge on wetland creation and restoration. Diverse points of view are expressed.

441. Malysa, L.L. 1993. A comparative assessment of state planning and management capacity: tidal wetlands protection in Virginia and Maryland. The University of Oklahoma Ph.D. Dissertation, 277 pp. Dissertation Abstracts International 54/04-A: 1526.

During the 1970's and 1980's, the states assumed major planning, management, and coordinating roles in attempting to solve problems in domestic policy areas. This study assessed the levels of state capacity in Maryland and Virginia to plan, manage, and protect their vast tidal wetland resources.

442. Nyhart, J.D. (ed.). 1985. Coastal Zone and Continental Shelf Conflict Resolution: Improving Ocean Use and Resource Dispute Management. Proceedings of a Conference, Cambridge, MA, 13-15 Nov. 1984. Massachusetts Institute of Technology Sea Grant College Program Report MITSG 85-28, 167 pp.

The 19 papers in this report apply the mechanisms of dispute resolution to decision making in ocean affairs. The papers have been written by experienced mediators, third party facilitators, stake-holders, governmental policy makers, and academics. Conflicts over ocean uses, the opportunities for improving their management, the mechanisms available, and some of the problems to be overcome in arriving at broader usage of those processes are discussed. Specific cases in coastal zones and in continental shelf projects are analyzed, with emphasis on why negotiations succeeded or not, and what lessons might be drawn. In most of the analyses, mediators are paired as co-authors with one or more stake-holders in order to gain wider perspective.

443. Office of Technology Assessment, Washington, DC. 1984. Wetlands: Their Use and Regulation. Office of Technology Assessment Report OTA-0-206, 212 pp.

The report describes the results of OTA's study of wetland use. Recent trends have changed the perception of wetlands from wastelands to areas of high productivity as well as aesthetic beauty.

444. Paul, J.F., Scott, K.J., Holland, A.F., Weisberg, S.B. and Summers, J.K. 1992. Estuarine Component of the U.S. EPA's Environmental Monitoring and Assessment Program. Environmental Protection Agency, Narragansett, RI, Report EPA/600/J-93/136, 26 pp. National Oceanic and Atmospheric Administration, Environmental Research Lab., Narragansett, RI Report ERLN-1374, 26 pp. Chemistry and Ecology 7: 93-116.

The report describes efforts to monitor the status and trends of the nation's near-coastal waters, wetlands, agro-ecosystems, surface waters, deserts, and rangelands. EPA and NOAA have agreed to coordinate and integrate the near coastal component of Environmental Monitoring and Assessment Program (EMAP) and the NOAA National Status and Trends Program. A demonstration project was conducted in estuaries of the mid-Atlantic region in 1990 and in the mid-Atlantic and Gulf Coast estuaries in 1991.

445. Reed, S.C. and Brown, D.S. 1992. Constructed Wetland Design: The First Generation. Environmental Protection Agency, Cincinnati, OH, Risk Reduction Engineering Lab. Report EPA/600/J-92/394, 8 pp. Also in: Journal of Water Environmental Research 64 (6): 776-781.

The EPA has documented over 150 constructed wetlands systems in the U.S. for the treatment of municipal waste waters. The report summarizes some of the results from the inventory, including location, type, vegetation, design flow, loading rates, and costs.

446. Robadue, D.D., Jr. 1985. The role of scientific information in the restoration and protection of polluted estuaries. In: Engineering and the Environment. Proceedings Oceans '85, San Diego, CA, 12-14 Nov. 1985. Marine Technology Society, Washington, DC and IEEE Ocean Engineering Society, NY. Vol. 2, pp. 895-901.

The 1970s decision to separate water pollution control from coastal zone management essentially thwarted the efforts of the marine scientific community to assist in solving the problems of estuarine water pollution. Rhode Island's efforts to control pollution in Narragansett Bay and the state's coastal lagoons illustrate the weaknesses of the current case-by-case approach to regulation and point to the potential value of using special area planning to develop integrated pollution control plans which have a chance of being implemented at the state and local level.

447. Ross, D.A. 1985. Outer Continental Shelf conflicts: Georges Bank and Gulf of Maine. Introduction. In: Coastal Zone and Continental Shelf Conflict Resolution: Improving Ocean Use and Resource Dispute Management. MIT, Cambridge, MA, 13-15 Nov. 1984. Nyhart, J.D. (ed.). MIT Sea Grant Program Report MITSG 85-28, p. 113.

The papers in this section discuss problems and opportunities in Georges Bank and the Gulf of Maine/Bay of Fundy region. They also provide insight into how major ocean-related conflicts can be resolved.

448. Swanson, F.J., Neilson, R.P. and Grant, G.E. 1992. Some Emerging Issues in Watershed Management - Landscape Patterns, Species Conservation, and Climate Change. Environmental Protection Agency, Pacific Northwest Forest and Range Experiment Station, Corvallis, OR, Forestry Sciences Lab. Report EPA/600/A-92/256, 37 pp. Also in: New Perspectives for Watershed Management: Balancing Long-Term Sustainability with Cumulative Environmental Change. Seattle, WA, 27-29 Nov. 1990.

The activities utilized in watershed management need to be considered in terms of time scales of greater than 100 years and on spatial scales beyond watershed boundaries.

449. Watzin, M.C. and Gosselink, J.G. 1992. Coastal wetlands of the continental United States: The fragile fringe. Louisiana State University Sea Grant Program Report, 15 pp.

To ecologists, wetlands are ecotones, or transitional areas between permanently flooded deep-water environments and well-drained uplands. Ecotones are usually richer than either adjacent habitat because they have attributes of both. They often contain more plants and animals, and may produce more organic material than either adjacent habitat. They remove wastes from both natural and human sources, and they form natural reservoirs, storing flood waters and minimizing the damage from severe storms. They provide a home for a wide variety of plants and animals, and they produce and export food for a number of commercially important species. Time will tell whether America's love affair with the coast will spell the demise or salvation of the wetlands.

450. World Wildlife Fund. 1992. Statewide Wetlands Strategies: A Guide to Protecting the Resource. Report ISBN-1-55963-206-2, 183 pp. Island Press, Covelo, CA.

Comprehensive state-wide wetlands strategies are offered in this book in an effort to arrive at no net loss of wetlands. Both private-sector and government efforts are identified.

4B. ECONOMICS AND SUSTAINABLE DEVELOPMENT

451. Barg, U.C. 1992. Guidelines for the promotion of environmental management of coastal aquaculture development. FAO Fisheries Technical Paper No. 328, I-V, pp. 1-122.

452. Barica, J. 1992. Sustainable management of urban lakes: A new environmental challenge. Water Pollution Research Journal of Canada 27 (2), 211-219.

> In view of the growth of human population in urban areas during the last century, more attention should be paid to large city ecosystems as specific ecological bioregions. The present biocentric-naturalist views prevailing in environmental circles need to include the human population as an integral part of the ecosystem in a stringent application of the principles of ecosystem approach and sustainable development. A new environmental realism is needed: boundaries and limits of ecological sustainability must be respected and necessary caps must be imposed through rational urban planning and settlement policies.

453. Bauereis, E.I. 1992. Chesapeake experience: NPS Chesapeake challenge for sustainable development. Water Science and Technology 26 (12): 2723-2725.

> It is impossible to design control strategies that are effective, measurable, and flexible without quantification of compliance concepts. Non-point source (NPS) loading could be a major source for some heavy metals, organics, and sediments to the Chesapeake Bay. These NPS loadings may become a major impediment to attaining designated uses of water bodies, and there is a need for focus on the loading quantification of NPS. There are three areas which will impact the Chesapeake NPS program positively: the Toxics Research Program, the Clean Air Act of 1990, and the implementation of a cultural change embracing a philosophy of total quality management. The need for cost-effective controls and innovative methods to accomplish NPS goals is obvious.

454. Beatley, T. 1991. Protecting biodiversity in coastal environments - introduction and overview. Coastal Management 19 (1): 1-19.

> In recent years, less attention has been paid to threats to coastal and marine biodiversity than to biodiversity in terrestrial habitats. The threats to coastal biodiversity are numerous and they include air and water pollution; over-exploitation and harvesting; the introduction of exotic species; the loss of habitat due to urbanization and other land use changes; and the potentially

serious effects of global climate change. These threats suggest the need for action at jurisdictional and governmental levels. Major components include the need for comprehensive management approaches, the expansion of parks and protected areas, restoration and mitigation, multinational and international initiatives, and efforts to promote sustainable development and sustainable lifestyles.

455. Boelens, R.G.V. 1992. From policies to science - strategies for marine environmental protection. Marine Pollution Bulletin 25 (1-4): 14-17.

Concern over the extent of marine pollution in many of the world's coastal environments has stimulated an international debate on how to improve strategies for marine pollution prevention. Much of the debate centers on the concepts of Sustainable Development and Precautionary Action and the reflections of these concepts in new strategies and measures for reducing emissions of substances and wastes. The degree to which scientific considerations should influence regulatory actions in limiting the types and amounts of substances emitted to the environment is also a matter of intensive discussion. However, some scientists now believe that a comprehensive strategy for protection and management of the total environment is a logical prerequisite to significant reductions in marine and other forms of pollution.

456. Bowen, G.E. and Gangaware, T.R. 1988. Institutional barriers to environmental protection programs: An assessment methodology. In: Proceedings of the Symposium on Coastal Water Resources, Wilmington, NC . Lyke, W.L. and Hoban, T.J. (ed.). American Water Resources Association, Technical Publication, pp. 587-598.

The paper focuses on six dimensions of institutional barriers, consisting of thirty propositions, which are hypothesized to represent the major problems and constraints to implementing environmental programs. An implementation probability matrix is developed which can be used to evaluate the probability of environmental legislations, plans, programs, and projects. The matrix is a hypothetical construct which will assist in evaluating the major impediments to implementing environmental programs.

457. Burrowes, T.R. 1988. How are you going to get them down to the farm? Legal obstacles to salmon farming in Maine. Territorial Sea: Legal Developments in the Management of Ocean and Coastal Resources 8 (3/4): 1-11.

458. Carpenter, R.A. and Dixon, J.A. 1985. Ecology meets economics: A guide to sustainable development. Environment (Washington, DC) 27 (5): 6-11.

Natural systems are being developed that may be environmentally and/or economically unsound. Efforts are under way to combine ecological and economic analyses into a form more convincing for policy makers.

459. Chakalall, B. 1992. Sustainable fisheries development in the Caribbean. Report and Proceedings of the Meeting on Fisheries Exploitation Within the Exclusive Economic Zones of English-Speaking Caribbean Countries, St. George's (Grenada), 12-14 Feb 1992. Chakalall, B. (ed.). FAO Fisheries Report No. 483, pp. 55-61. FAO, Rome (Italy).

Major policy issues which should be considered for the sustainable development of fisheries in the WECAF region are examined in this document. The issues related to resources management are emphasized; they are fundamental for the sustainable development of the open access fisheries of the region. Legal matters, regional cooperation, planning, policy, small-scale fisheries, subsidies, regulations and enforcement, community-based management, critical habitats and human resources are discussed.

460. Chase, S., Irving, E., Long, N. and Pinkelman, J. 1987. Managing Natural Resources for Sustainable Development. Agency for International Development, Washington, DC Report AID-PN-AAZ-253 (AIDPNAAZ253), 53 pp.

The report summarizes A.I.D. efforts in a wide range of environmental issues, including environmental training, research, and institutional development. The report details specific efforts to enlist host country support for environmental programs and highlights A.I.D. efforts in particular topics of environmental concern, critical ecological areas, and specific country programs. A brief history of the evolution of the Agency's environmental strategy since 1976 is included.

461. Childers, D.L. and Gosselink, J.G. 1990. Assessment of cumulative impacts to water-quality in a forested wetland landscape. Journal of Environmental Quality 19 (3): 455-464.

462. Clingan, T.A., Jr. 1992. The Law of the Sea Convention: International obligations and stewardship responsibilities of coastal nations. Ocean and Coastal Management 17 (3-4): 201-215.

This paper examines the values to be enhanced by the stewardship responsibilities placed upon coastal States by the 1982 United Nations Convention on the Law of the Sea. Using the term "value" in its broadest sense, the author asks whether these values are the proper ones for ocean management, whether they are sufficient in scope, and whether the terms of the treaty are adequate to protect such values. The following desirable

objectives are examined: (1) facilitation of international communication; (2) promotion of peaceful uses of the seas and the oceans; (3) equitable and efficient uses of ocean resources; and (4) study, protection, and preservation of the marine environment. The paper concludes with a brief discussion of the value of ocean management as a model for international enhancement of commonly shared values.

463. Cowan, J.H., Jr., Turner, R.E. and Cahoon, D.R. 1988. Marsh management plans in practice: Do they work in coastal Louisiana, USA? Environmental Management 12 (1): 37-53.

Although 20% of coastal Louisiana may be in marsh management plans (MMPs) by the year 2000, conflict resolution of public and private goals is compromised by too many opinions and too little data and experience. The authors suggest that the next phase of management should include scientific studies of actual impacts, utilization of post-construction monitoring data, inventory of existing MMPs, development of new techniques, and determination of cumulative impacts.

464. Cumberland, J.H. 1991. Improved policy instruments for management of enclosed coastal seas and estuaries: The Chesapeake Bay, USA. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas - EMECS '90. Kobe, Hyogo Prefecture, Japan, 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A. Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 773-777.

Detailed technical recommendations for policies utilizing economic incentives have come from the discipline of economics. The recommendations include pollution taxes and marketable permits. However, such economic incentive based environmental policy instruments have received limited acceptance in the U.S. This paper explores a broader based public choice approach to environmental management, under which policy instruments would meet acceptable standards for distributional equity, scientific validity (especially ecological sustainability), and acceptability by the major interest groups involved. The current policy instruments, their limitations, and suggestions for improvement are summarized in a matrix.

465. Dickert, T. G. and Tuttle, A. E. 1985. Cumulative impact assessment in environmental planning. A coastal wetland watershed example. In: Environmental Impact Assessment Review 5: 28 pp.

Watershed development on coastal wetlands offers an ideal context for evaluating the land disturbance target approach to cumulative impact

assessment. A model land use planning system involving a time series approach was developed for Elkhorn Slough in California. The approach included evaluation of erosion susceptibility, measurement of land disturbance, establishment of a land disturbance target, and comparison of existing and target land disturbance values.

466. Dixon, J.A. 1986. The role of economics in valuing environmental effects of development projects. In: Economic Valuation Techniques for the Environment. A Case Study Workbook. Dixon, J.A. and Hufschmidt, M.M. (ed.). pp. 3-10. Johns Hopkins University Press, Baltimore, MD.

Over the past two decades, there has been increased understanding of the interrelationship of the environment and the continuing production of goods and services that are extracted from our physical surroundings. The ideal of sustainable development has led to a search for ways in which development projects can be assessed in order that direct project outputs and environmental effects can be included in the valuation process.

467. Edwards, S.F. 1987. An Introduction to Coastal Zone Economics: Concepts, Methods, and Case Studies. Taylor and Francis, New York.

This book is intended to promote the optimal use of coastal resources through an improved understanding of economics. The underlying premise is that economic analysis, broadly construed, is a powerful tool for illuminating tradeoffs among conflicting allocations of scarce coastal resources. The book is written for non-economists and for students enrolled in marine resource management courses. The reader should expect to learn enough about economics to evaluate critically such arguments.

468. Evans, N., King, L.R. and Broussard, A. (comps.). 1987. The coastal zone management experience as a model for collaborative resource management. In: Proceedings: National Conference on the States and an Extended Territorial Sea. San Antonio, TX, 9-11 Dec. 1985. Reports of Texas A&M University Sea Grant Program, pp. 101-105.

Coastal zone management is a comprehensive, multiple-use, collaborative planning system for the management, beneficial use, protection and development of coastal zone resources. The development of the coastal zone management system in the 1970s is reviewed in this historical perspective.

469. Fenster, M.S. and Dolan, R. 1993. Historical shoreline trends along the Outer Banks, North Carolina - processes and responses. Journal of Coastal Research 9 (1): 172-188.

The shoreline rate-of-change statistic, which is calculated from sequential measurements of shoreline position, implicitly represents the cumulative impact of those processes which have influenced shoreline behavior. In this paper, the authors suggest that an understanding of the processes governing shoreline behavior will aid response-centered analyses, such as applications involving shoreline rate-of-change values, especially those which must determine the persistence of short-term deviations from the long-term shoreline trend. Unfortunately, process-response data from most coastlines are neither synoptic nor of high resolution. In addition, functional relationships between the processes and responses are difficult to quantify due to the synergistic nature of the shoreline processes. The typical problems associated with identifying the principal causes of shoreline movement in a highly dynamic environment are demonstrated for a 7.4 km reach along the Outer Banks, North Carolina.

470. Gosselink, J.G., Shaffer, G.P., Lee, L.C., Burdick, D.M., Childers, D.L., Leibowitz, N.C., Hamilton, S.C., Boumans, R., Cushman, D., Fields, S., Koch, M. and Visser, J.M. 1990. Landscape conservation in a forested wetland watershed; can we manage cumulative impacts? Bioscience 40 (8): 588-600.

471. Graefe, A.R. and Ditton, R.B. 1986. Bay and offshore fishing in the Galveston Bay Texas area: A comparative study of fishing patterns, fishermen characteristics and expenditures. North American Journal of Fisheries Management 6 (2): 192-199.

Saltwater boat fishing patterns, and fishermen characteristics and expenditures near Houston and Galveston, TX, were investigated through a 1979 mail survey of registered boat owners who fished the Galveston Bay area. Bay and offshore fishermen were similar (except in income) but their economic impact varied greatly. Offshore fishing parties spent nearly twice as much money per day as bay parties, but they contributed only about one-fifth as much to the regional economy because they were fewer in number and made fewer fishing trips. Offshore fishing parties were more likely than bay parties to buy snack foods and beverages, restaurant meals, tackle and equipment, and gas and oil for their boat in the coastal community. The approach and findings should be of use to fishery managers and local officials when they allocate resources based on economic impact perspectives.

472. Haimes, Y.Y. and Iwra, F. 1992. Sustainable development: A holistic approach to natural resource management. Water International 17 (4): 187+.

An environmental awakening is gathering force to save Planet Earth from irresponsible human actions that have resulted in overall degradation. Mismanagement and shortsightedness are by-products of a lack of understanding of the dire consequences of uncontrolled economic development;

we are being forced to face what happens when minimal or no effort is made to consider the effect of present policies and decisions on future generations.

473. Hayashi, S. 1991. Enclosed sea and its coastal area as a model of the global environment - three conditions for realizing "sustainable development" and environmental education. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas - EMECS '90 held in Kobe, Hyogo Prefecture, Japan, 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 513-517.

Soundness of the human future depends on whether or not the world system of sustainable development can be developed. The development of the enclosed sea and its coastal area seems to be a just model of that of the finite globe. Three indispensable conditions for establishing the sustainable development system are discussed: (1) establishment of a social system for assuring priority of the environmental plan, (2) democratization of the policy making process and establishment of a system for rightly functioning environmental assessment, and (3) generalization of setting environmental assimilating capacity and conception on regulation of total emission. Environmental education as an important strategy for establishing sustainable development is discussed.

474. Hirsch, A. 1985. Science and decision making in the coastal zone; fifteen years of NEPA. Eighth Biennial International Estuarine Research Conference, Durham, NH, 28 Jul. 1985. Estuaries 8 (2B): 13A.

The National Environmental Policy Act (NEPA), with its requirement for preparing Environmental Impact Statements (EISs) for major federal projects and programs, is now 15 years old. It has been influential in resolving controversial questions involving outer continental shelf oil and gas development, wetlands development, power plant siting, and coastal sewage discharges.

475. Levings, C. D. 1991. Strategies for restoring and developing fish habitats in the Strait of Georgia - Puget Sound Inland Sea, northeast Pacific Ocean. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas - EMECS '90 held in Kobe, Hyogo Prefecture, Japan, 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 417-422.

Rehabilitation and development of fish habitats are potential techniques for achieving sustainable development in coastal seas. To examine this possibility, recent projects in the Strait of Georgia and Puget Sound conducted trials or

experiments with 26 sites of sedge marshes (*Carex lyngbyei*) and 14 sites of eelgrass beds (*Zostera marina*). Some studies were appropriate for examining the potential compensation of wetland losses from industrial developments, but many were experimental and small scale. Larger scale projects and longer term monitoring are needed to confirm that the policy goals of no net loss or net gain in fish habitat can be met using these techniques.

476. Miller, M.L. 1993. The rise of coastal and marine tourism. Ocean and Coastal Management 20 (3): 181-199.

Marine tourism has surfaced as a controversial topic in the field of ocean and coastal management. Because demand for travel exhibits greater variation and magnitude than ever in history, the tourism industry has become the largest business on earth. Ecotourism, a recent phenomenon attuned to the ideal of sustainable development, is suggested to emerge through the social construction processes of restoration and enhancement. The papers in this theme volume add fuel to the proposition that the resolution of tourism problems in the coastal zone will require the scientific study of environmental and social conditions, policy analyses, planning, and public education.

477. NERAC, Inc., Tolland, CT. 1993. Wetlands Legislation and Management (Latest Citations from the Selected Water Resources Abstracts Database). National Technical Information Service Bibliography, 250 citations.

The bibliography contains 250 citations of federal and state coastal and fresh-water wetlands legislation. The topics include regional regulations, specific site management, the relationship of environmental considerations with economic pressures and landowners' rights, and wetlands restoration and conservation.

478. NERAC, Inc., Tolland CT. 1993. Watershed Management Modeling. (Latest Citations from the Selected Water Resources Abstracts Database). National Technical Information Service Bibliography, 250 citations.

The bibliography contains 250 citations concerning watershed management by means of mathematical models and simulation techniques. The topics include precipitation and runoff rates, salinity or pollutant transport, and land use on flood plains.

479. Nyhart, J.D. (ed.). 1985. An overview of coastal zone and continental shelf conflicts. Introduction. In: Coastal Zone and Continental Shelf Conflict Resolution: Improving Ocean Use and Resource Dispute Management. MIT, Cambridge, MA 13-15 Nov. 1984. Mass. Institute of Technology, Sea Grant College Program Report, p. 3.

In the last 30 years, new technologies have made it possible to make greater use of ocean resources. Frequently, however, development and management have been accompanied by conflicts among different interests, such as industry and recreational groups, environmentalists and state and local governments. Some of the alternatives for resolving ocean-related conflicts discussed in this volume are: mediation, negotiation, mini-trial, conflict anticipation, and the use of models and quantitative analysis. Papers in this first section review the nature of the conflicts over ocean uses, the opportunities for improving their management, the mechanisms available, and some of the problems to be overcome in arriving at broader usage of those processes.

480. O'Connor, J.S., Pugh, W.L., Wolfe, D.A. and Dewling, R.T. 1986. Protection of natural resources through environmental indices. Sea Technology 27 (9): 31-33.

While many available indicators are useful in pollution assessment, simple indices are often most advantageous. An important benefit of indices is that they include technical interpretation, unlike the direct measurements on which they are based. Indices, therefore, can be readily interpreted without reference to additional standards or reference values. Improved indices of pollutant degradation are needed as guides to design monitoring programs. It is evident that major collaborative efforts would be necessary to monitor effectively on a national basis for compliance with existing laws and regulations.

481. Olson, R.K. 1992. Evaluating the role of created and natural wetlands in controlling non-point source pollution. Ecological Engineering 1: 1-15.

Created, restored, and natural wetlands, which can contribute significantly to watershed quality, must be protected from non-point source pollution. In controlling non-point source pollution, social, economic, and government policy issues must be considered.

482. Pait, A.S., De Souza, A.E. and Farrow, D.R.G. 1992. Agricultural Pesticide Use in Coastal Areas: A National Summary. National Ocean Service, Rockville, MD, Strategic Environmental Assessments Division, Rockville, MD, Report ORNL/ER-139, 113 pp.

This summary of information can be used to identify target areas for additional monitoring, research assessment, and management efforts. The use estimates and seasonal application can help decision-makers to identify pesticides to be monitored, and the time of the year the pesticides are most likely to have an impact.

483. Pearce, D.W. and Warford, J.J. 1993. World without End: Economics, Environment, and Sustainable Development. Summary. International Bank for Reconstruction and Development, Washington, DC. Copy available from World Bank Publications, P.O. Box 7247-8619, Philadelphia, PA. 19170-8619. 49 pp.

The book's comprehensive coverage details theories of environmental economics, and it shows how these theories can be applied to developing countries, tropical forestry, agriculture, energy and industry, population and poverty, international trade, and the global commons.

484. Peet, J. 1992. Ecological economics for sustainable development. IEEE Technology Society Magazine 10 (4): 14-20.

Conventional techniques of economics, in both capitalist and socialist countries, fail to take account of the physics and ecology of the world in which we live. New decision-making principles are needed, in which societies accept that the physics and ecology of the environment dominate long-term development opportunities.

485. Pezzey, J. 1992. Sustainable Development Concepts: An Economic Analysis. International Bank for Reconstruction and Development, Washington, DC. Environment Paper 2, 87 pp. Copy available from World Bank Publications, Philadelphia, PA.

Sustainability concepts, such as sustainable growth, sustainable development, and sustainable resource use are analyzed in terms of the conventional neoclassical theory of economics. The reasons why free market forces may not achieve sustainability are analyzed, as well as how policy intervention may help or hinder sustainability. Several definitions of sustainability are reviewed. Most require that the "quality of life" should not decline during the long-term future. Many can be interpreted in terms of maintaining an economy's capital stock. However, a relevant definition of capital stock still has to be chosen, and this means judging how significant, essential, or substitutable are the various natural and man-made resource inputs to the economy's production processes.

486. Rivers, R. 1990. Socio-economic considerations in remedial action planning for the Great Lakes: A case study for sustainable development. In: International and Transboundary Water Resources Issues. American Water Resources Association, Bethesda, MD, pp. 279-287.

Early in the process of remedial action planning (RAPs), it was recognized that socio-economic considerations would be a necessary component of any completed plan involving public expenditures. A discussion document on

socio-economics in RAPs was produced and released to the 17 Canadian RAP coordinators to encourage them to include socio-economic studies as part of the planning process. To date, socio-economic studies have been conducted for two Areas of Concern, Hamilton and Bay of Quinte, and an economic overview of the entire RAP process in Canada-Ontario. The two studies completed so far have been resisted by stakeholders to the RAP process. Reasons for this resistance need to be understood and addressed for any new studies. Benefit cost analysis should not be used for the consideration of RAP socio-economic desirability. Instead, studies are needed that provide timely information to support the public involvement process leading to the preparation and implementation of the RAP.

487. Rogers, J.W. 1992. Sustainable development patterns: The Chesapeake Bay region. Water Science and Technology 26 (12): 2711-2721.

The desirability of the Chesapeake Bay region as a place to live is both a boon and a curse. It illustrates clearly the relationship between a desirable environment and a good economy; the regional economy depends to great degree on whether or not the Bay remains a natural amenity. Those who decide how land is developed need to understand the concept of "nodes and corridors" for human development patterns as well as for sustainable biological diversity and natural processes. Sustainable economic vitality requires sustainable environmental quality. By maintaining landscape patterns of large woodlands and wetlands (nodes) and wooded stream valleys and drainage-ways (corridors), significant natural functions are protected.

488. Rowan,D.J. and Rasmussen, J.B. 1992. Why don't Great Lakes fish reflect environmental concentrations of organic contaminants? An analysis of between-lake variability in the ecological partitioning of PCBs and DDT. Journal of Great Lakes Research 18 (4): 724-741.

The literature on PCBs and DDT in the Great Lakes ecosystem was reviewed in an attempt to explain between-basin and between-species variation in fish contamination. Empirical models were developed, using log-linear multiple regressions, to link tissue contaminant concentrations to environmental levels (water and sediments) as well as basin-specific ecological attributes. The factors that appear to determine the ecological partitioning of persistent organic contaminants are fish lipid content, trophic level of the fish in question, and the trophic structure of the food chain. Multiple regressions of these variables explain 59% (DDT) to 72% (PCBs) of the variation in contaminant concentrations of 25 species of Great Lakes fish.

489. Sanbongi, K. 1991. New legal viewpoints for development and conservation of enclosed coastal seas. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas - EMECS '90 held in Kobe, Hyogo Prefecture, Japan, 3-6 Aug. 1990. Goda, T., Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 563-566.

This article reviews Japanese institutions related with the sea or to enclosed coastal seas, the characteristics of their conservation, development and utilization problems, and the choice of institutional policies. Several new legal viewpoints with regards to comparative law, such as public access, public trust doctrine, method of zoning, and role players in planning, mitigation and environmental investment are discussed in order to contribute to basic studies for sustainable development and sustainable environment of enclosed coastal seas.

490. Schramm, G. and Warford, J.J. 1989. Environmental Management and Economic Development. International Bank for Reconstruction and Development, Washington, DC. 220 pp. Copy available from World Bank, Washington, DC.

The book includes chapters on environmental management and economic policy in developing countries; environmental and natural resource accounting; marginal opportunity cost as a planning concept in natural resource management; the environmental basis of sustainable development; economic incentives for sustainable production; economic aspects of afforestation and soil conservation projects; and watersheds in multilevel resource analysis and management.

491. Schultink, G. 1992. Evaluation of sustainable development alternatives: Relevant concepts, resource assessment approaches and comparative spatial indicators. International Journal of Environmental Studies 41 (3-4): 203-224.

In this paper, the application of selected ecological concepts and a "systems approach" to resource assessment are suggested to improve understanding of environmental constraints and impacts. This approach includes the analysis of socio-economic, technological, and cultural indicators in a spatial and temporal framework supported by geographic information systems and relevant performance or risk/impact assessment models.

492. Ten Brink, B.J.E., Hosper, S.H. and Colijn, F. 1991. A quantitative method for description and assessment of ecosystems: The AMOEBA-approach. Proceedings of International Conference on the Environmental Management of Enclosed Coastal Seas - EMECS '90 held in Kobe, Hyogo Prefecture, Japan, 3-6 Aug. 1990. Goda, T.,

Prandle, D., Okaichi, T., Watanabe, M., Healy, T., Shapiro, H.A., Bell, W.H. and Wakeman, N. (ed.). Marine Pollution Bulletin 23: 265-270.

This article describes the AMOEBA-approach, a conceptual model for the development of quantitative and verifiable ecological objectives for Dutch waters. The model is based on the concept of sustainable development. "AMOEBA" is the Dutch acronym for "a general method of ecosystem description and assessment."

493. Thornburn, G. 1990. Applying sustainable development to the Great Lakes: Experience and opportunities under the Boundary Waters Treaty. In: International and Transboundary Water Resources Issues. American Water Resources Association, Bethesda, MD, pp. 149-158.

A review of the practice and experience of the International Joint Commission under the Boundary Waters Treaty provides many examples as to how the concepts of sustainable development can be and have been applied. The reasons for an early interest in these concepts include the process by which the Commission ensured that all affected interests were taken into account in decision-making, an approach that inevitably leads to a tracing of a wide range of impacts both directly and indirectly through environmental linkages. Examples drawn from the 75-year history of the Commission include the approach to the redevelopment of hydro-power facilities at Sault Ste. Marie, the assessment of diversions, consumptive uses of Great Lakes water nonpoint pollution, and the Remedial Action Plans (RAPs) under the Great Lakes Water Quality Agreement. Opportunities for applying sustainable development principles can be found, especially in the RAPs that jurisdictions are required to submit under this agreement.

494. Underwood, A.J. 1990. Experiments in ecology and management - their logics, functions and interpretations. Australian Journal of Ecology 15 (4): 365-389.

495. Vancini, F.W. 1992. Select Issues in International Environmental Protection: The Quest for Sustainable Approaches to Economic Development and World Security. Final Report. Cornell University, Ithaca, NY. 13 pp.

The report attempts to shed light on critical issues relating to sustainability (the state of being in agreement with sustainable development). A critique of the broad concept of sustainable development is followed by three case studies which involve (1) international trade practices, (2) the debt-for-nature swap type of thinking required in formulating operational sustainability mechanisms, and (3) business and industry as essential and potent players in working toward sustainable economic growth.

496. Walker, D.A., Webber, P.J., Binnian, E.F., Everett, K.R., Lederer, N.D., Nordstrand, E.A. and Walker, M.D. 1987. Cumulative impacts of oil fields on northern Alaskan landscapes. Science (Washington, DC) 238 (4828): 757-761.

Proposed further developments on Alaska's Arctic Coastal Plain raise questions about cumulative effects of development of multiple large oil fields on arctic tundra ecosystems. Maps of historical changes to the Prudhoe Bay Oil Field show that indirect impacts can lag behind planned developments by many years and the total area eventually disturbed can greatly exceed the planned area of construction. For example, in the wettest parts of the oil field (flat thaw-lake plains), flooding and thermokarst covered more than twice the area directly affected by roads and other construction activities. Protecting critical wildlife habitat is the central issue for cumulative impact analysis in northern Alaska.

497. Whelan, J.M. and Thayer, G. 1992. National Program for Wetlands Restoration and Creation. Report of the Interagency Committee on Wetlands Restoration. Department of the Interior Report, 50 pp.

A comprehensive plan for wetlands restoration and creation on federal lands was issued by President Bush in August 1991. The plan has subsequently been expanded to include federally-assisted restoration activities on non-federal lands. This report includes the recommendations, criteria, and coordination mechanism to establish a National Program for Wetlands Restoration and Creation.

498. Williams, S.L. and Zedler, J.B. 1992. Restoring Sustainable Coastal Ecosystems on the Pacific Coast: Establishing a Research Agenda. Summary of a Workshop. San Francisco, CA, Nov. 1991. 19 pp.

Pacific coastal ecosystems are more diverse and unique than are coastal ecosystems on the Atlantic and Gulf of Mexico, but they have been studied less frequently. This workshop resulted in a listing of critical research needs for Pacific coastal ecosystems, particularly in estuaries. The research needs were ranked by workshop participants within each of four categories: hydrology, habitat function, organism habitat requirements, and population dynamics.

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