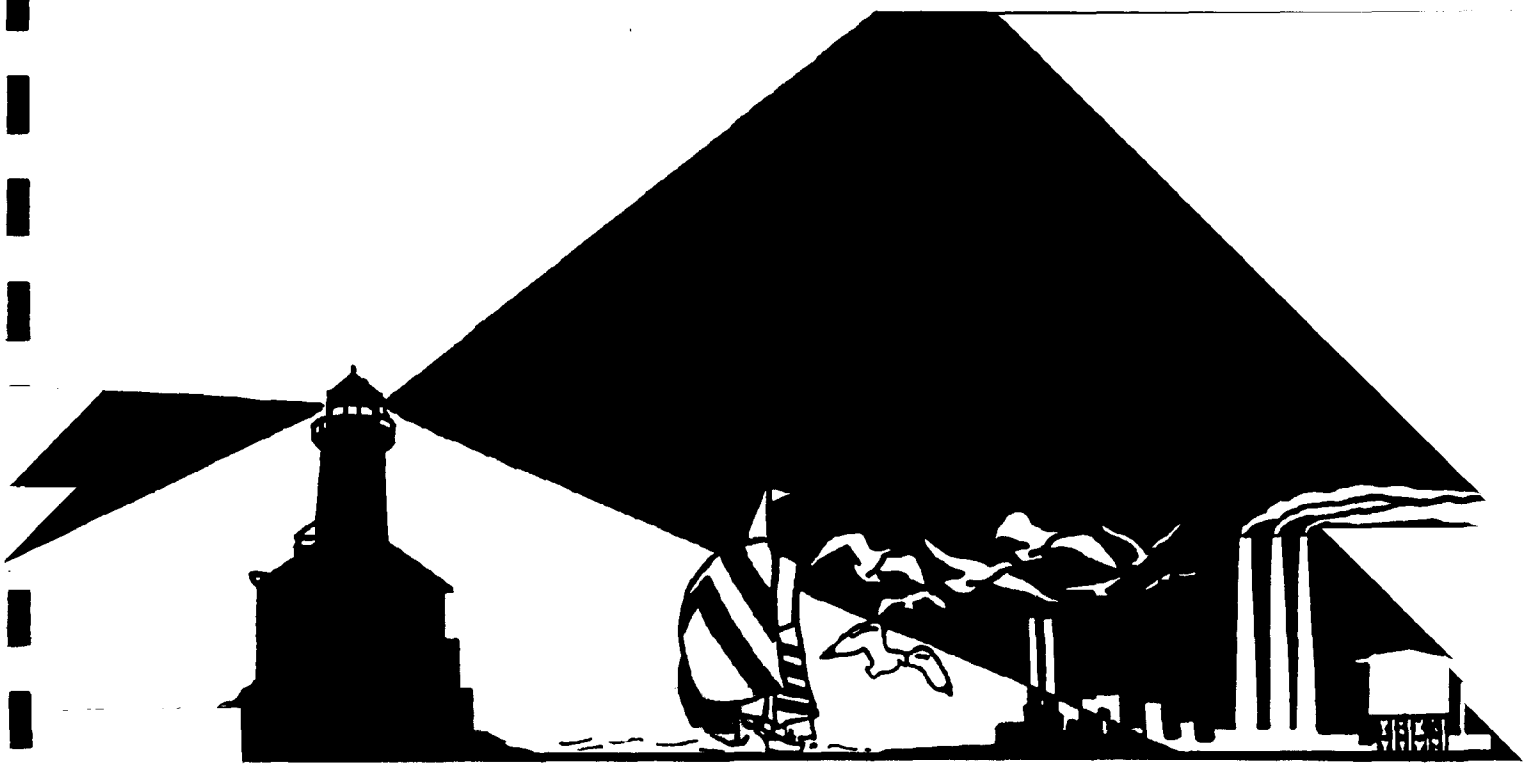
TOWARD A MANAGEMENT PLAN FOR INDIANA'S SHORELINE ON LAKE MICHIGAN



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THE INDIANA LAKE MICHIGAN SHORELINE: STATE OF KNOWLEDGE

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EXECUTIVE SUMMARY

This study was commissioned by the Northwestern Indiana Regional Planning Commission (NIRPC) as a means to survey and compile what currently is known about the Indiana portion of the Lake Michigan shoreline. The study was divided into four sections: environmental (including water quality), hydrological (including shoreline processes), recreational (including marina development), and socioeconomic (including municipal and industrial plans). Starting on page 4 there are eight annotated bibliographies containing 597 references. The first four bibliographies detail literature on the four principal sections (environment, hydrology, recreation, and socioeconomic) listed above as they relate to the Indiana portion of the Lake Michigan shoreline, including adjacent nearshore areas within the southern Lake Michigan basin. There is duplication among these four bibliographies; this was intentional. Many papers are cross-referenced in more than one bibliography due to their multidimensionality. For example, there is much duplication between the environmental and hydrological bibliographies as well as between the recreational and socioeconomic reference lists. The fifth through eighth bibliographies contain references which pertain to Lake Michigan or its surrounding environment but not directly to either Indiana or southern Lake Michigan. These are included as four appendices (beginning on page 91). A Table of Contents is provided immediately after this Executive Summary on page 3.

1. Environmental Concerns

Environmental concerns in the Lake Michigan basin include water quality, erosion and sedimentation, various organismal inventories, and preservation or conservation topics. Twenty-two papers involve aspects of water quality, lake levels, water flow, or sedimentation. An additional eleven papers deal with erosion, soil, or beach and shoreline processes. Fourteen papers deal with plants, vegetation, or succession, especially in dune areas. Seven papers are studies of benthos, zooplankton or phytoplankton; and another five are on fish or amphibians. Inventories of endangered plants and animals have taken place within the IDNLS (Breden, 1989). Offshore, numerous studies of fish populations and migration have been conducted (Brandt, et

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al. 1989). Studies of plant succession have been conducted, especially with dune ecosystems; some of these studies represent some of the pioneering research on plant ecology (Cowles, 1899). Additional studies have dealt with plant succession on man-made dunes and beach nourishment projects (Davis and Wood, 1979). Several projects have examined phytoplankton growth and changes in distribution.

Fifteen papers are concerned with preservation, conservation, restoration, community ecology or environmental effects on shoreline habitats and ecosystems. An additional thirteen papers deal with wetlands, resource inventories, past or present research, pollution (in general), and development feasibility. The impact of human population growth on the lake region environment also has been studied. Current state, federal, and corporate energy policies which may affect energy growth in the coastal zone have been reviewed. A scenario of growth in regional electricity need and state policy alternatives to meet future energy needs have been developed (Center for Urban and Regional Analysis, 1979). Both the development of additional marinas and the effects of the boats, themselves, have been addressed (Chmura and Ross, 1978; Mills, et al., 1991).

2. Hydrological Concerns

Twenty-two papers deal with the Lake Michigan shoreline or erosion. Twenty papers are concerned with monitoring or management of the shoreline, or environmental action plans. Sixteen papers deal with water quality or lake level fluctuations and effects. An additional twenty-three papers deal with topography or geology, development plans and effects, soil development, environmental impact, water resources, or harbor status.

3. Recreational Concerns

Twenty-nine papers deal with marina development and economic impacts, boating, and analysis of need. An additional eleven papers deal with recreation including sportfishing. Nine papers also deal with various topics such as harbor dredging, effects of water levels and shoreline conditions on recreation, wetlands protection, and development practices.

Boating and sportfishing are major pursuits of many people who use Lake Michigan for recreation. A comprehensive review of boating in Indiana has been compiled by Piechota, et al. (1989), and a detailed review of marinas and fishing along Lake Michigan has been conducted by Mills, et al. (1991). Bartholomew, et al. (1981) estimated the total impact of Michigan City marinas and boat launching facilities. Absher, et al. (1987) have developed profiles for various segments of southern Lake Michigan anglers. IDNR studied the feasibility of constructing fishing piers or

modifying existing breakwater facilities to accommodate shoreline fisherman.

4. Socioeconomic Concerns

Thirty-four papers deal with shoreline development or economic impacts and analysis. An additional twenty-three papers deal with coastal policy and management, research/projects, energy demand and facilities, demographics (social parameters), and coastal resources.

Comprehensive plans have been developed for several lakeshore communities. Most of these plans revolve around marina development and the economic impact thereof. NIRPC has developed an inventory of socioeconomic characteristics and conditions along Indiana's coastal zone, including population trends, population characteristics, personal and family finance, and employment (Tech. Rept. 102), as well as an inventory of plans, projects, and programs (Tech. Rept. 103).

In 1984, Thurow, et al, developed an analysis of the relationship between the availability of Great Lakes water and future economic growth.

ACKNOWLEDGEMENTS

The authors are grateful to E. Clark and G. Bolen for their valuable assistance in the collection of literature for this project. This is a report of the Indiana Agricultural Experiment Station.

ENVIRONMENT

1. Bowles, Marlin L.; DeMauro, Marcella M.; Pavlovic, Noel; Hiebert, Ronald D. Effects of Anthropogenic Disturbances on Endangered and Threatened Plants at the Indiana Dunes National Lakeshore. Natural Areas Journal; October 1990; 10(4): 187.

2. Bowles, Marlin L.; Hess, William J.; DeMauro, Marcella M.; Hiebert, Ronald D. Endangered Plant Inventory and Monitoring Strategies at Indiana Dunes National Lakeshore. Natural Areas Journal; January 1986; 6(1): 18.

3. Brannon, James M.; Gunnison, Douglas; Averett, Daniel E.; Martin, James L.; Chen, Rex L.; Athow, Robert F. Jr. Analysis of Impacts of Bottom Sediments from Grand Calumet River and Indiana Harbor Canal on Water Quality. U.S. Army Eng. Waterways Exp. Station, Vicksburg, Mississippi: U.S. Army Corps of Engineers; Feb. 1989; Dredging Operations Tech. Support Program. Misc. Paper EL-89-1. Final Report. Note: Mich. City.

4. Breden, F. Natural History and Ecology of Fowler's Toad, Bufo woodhousei fowleri (Amphibia: Bufonidae), in the Indiana Dunes National Lakeshore. Fieldiana Zoology; 1988; 49: 16 pp. Population size was estimated as 1814 adults, with only 150 egg masses laid in spring 1981 producing free swimming larvae. Relatively more dispersal from the natal areas occurred at the prereproductive juvenile stage than during the older age classes. While a strong male-biased sex ratio was observed in the breeding aggregations, the actual population sex ratio was not biased toward either sex. Females grew more quickly and attained a larger adult size than males, but became sexually mature at the same age, 2 yr after metamorphosis. Life table calculations showed a Type III survivorship curve, with <0.1% of all eggs surviving to age of first reproduction. Given the restriction of breeding areas of this species by specific habitat requirements and the intense utilization of the dunes area by humans, local extinctions of this species could be expected to be permanent events.

5. Chang, W.Y.B.; Rossmann, R. Changes in the Abundance of Blue-green Algae Related to Nutrient Loadings in the Nearshore of Lake Michigan. Hydrobiologia; Jan. 1988; 157(3): 271-278.
Nutrient loadings to the nearshore of southeastern Lake Michigan have undergone a remarkable reduction. This reduction can affect the nutrient supply and result in biological changes. Changes in phytoplankton community, particularly the blue-green algae, can be related to nutrient changes. After thermal stratification, sudden increases in the blue-green algae population were significantly correlated to soluble reactive phosphorus concentrations. Phosphorus-stimulated low dissolved silica and phosphorus limitations after stratification appear to be primary factors contributing to the success of these algae.

6. Cohen, D.A.; Shedlock, R.J. Shallow Ground-water Flow, Water Levels, and Quality of Water, 1980-84, Cowles unit, Indiana Dunes National Lakeshore; 1986; USGS Water-Resources Invest. Rept. 85-4340.
Note: Mich. City.
Water levels and water quality were monitored near settling ponds on adjacent industrial property. Since the settling ponds were sealed in 1980, the water table has been reduced, and concentration of boron has decreased.

7. Cole, K.L. Paleoecological Studies of Plant Succession and Settlement Impacts on Dune Forests at Indiana and Sleeping Bear Dunes. 32nd Conf. on Great Lakes Research; May 30-June 2, 1989; Madison, WI. Buffalo, NY: Int. Assoc. for Great Lakes Research; 1989; in 32nd Conference on Great Lakes Research: 38 (summary only).
The last several thousand years of vegetation and fire history of Great Lakes dune forests was studied using pollen and charcoal analysis of sediment cores from Sleeping Bear and Indiana Dunes National Lakeshores. Successional trends were evident for terrestrial plant taxa along dune chronosequences. However, the rates of vegetational change associated with settlement greatly exceeded natural rates in all areas studied. Some remote areas in Michigan seem to have recovered from lumbering to support presettlement type plant communities on the dunes. Dune communities in the more impacted areas of Indiana continue to diverge from presettlement conditions.

8. Cole, Kenneth L. Historical Impacts on Communities in Disequilibrium. Cole, Kenneth L.; Hiebert, Ronald D.; Wood, James D. First Indiana Dunes Research Conference Symposium on Plant Succession; May 1-3, 1986; Indiana University Northwest, Gary, Indiana. Scientific Publications Office
75 Spring Street, S.W.
Atlanta, Georgia 30303: U.S. Department of the Interior, National Park Service; 1987: 3-17.
Information from historical photos, presettlement land surveys, and fossil pollen demonstrates that large changes in vegetation have occurred along the southern shore of Lake Michigan since 1850 A.D. These changes were caused by: lumbering, land clearance, drainage of wetlands, changes in fire frequency, introduction of exotics, pollution, and changes in weather, but discrimination among these variables is difficult. The largest changes have occurred in communities (or species) that are near the limits of their spatial or temporal distribution, such as white pine forest and prairie. These communities now persist relictually in undisturbed sites and are in disequilibrium with modern conditions. Their survival is based upon the inertia of vegetation; they are supported only by the large number of propagules produced during infrequent favorable years and are incapapble of re-invasion of disturbed areas.

9. Cowles, H. C. The Ecological Relations of the Vegetation on the Sand Dunes of Lake Michigan. Bot. Gaz.; 1899; 27: 95-117, 167-202, 281-308, 361-391.

10. Crawford, C.G.; Wangsness, D.J. Streamflow and Water Quality of the Grand Calumet River, Lake County, Indiana, and Coole County, Illinois, October 1984. in: U.S. Geological Survey, Water-Resources Investigations Report. Indianapolis, IN; 1987; Rep. 86-4208.
Note: 137 pp.

11. Cushman, J.H.; Cockerill, S.E.; Purdue University. Water Resources Professionals in Indiana: A Directory; Feb. 1988; NTIS Order No.: PB88-195888/GAR: 78 pp.
Note: Water Resources Research Center: Grant DI-14-08-0001-G-1421: Sponsered by Geological Survey, Reston, VA.
The Indiana Water Resources Research Center has published the directory to identify and encourage communication among researchers and organizations involved with preserving, protecting, and improving Indiana's water resources. The directory may be of use to members of the water research community as well as to members of public agencies and private organizations in the water resources area.

12. Davenport, R.; Spacie, A. Acute Phototoxicity of Harbor and Tributary Sediments from Lower Lake Michigan. Journal of Great Lakes Research; 1991; 17(1): 51-56.

13. Davis, S. E.; Wood, W. L. Vegetative Establishment on an Artificial Beach. Proc. 2nd Conf. on Scientific Research in the National Parks; 1979: pp. 304-316.
Establishment of vegetation on the duned Lake Michigan coastline of Indiana Dunes National Lakeshore has not proceeded as expected, following placement of artificial beach nourishment. This nourishment was placed to mitigate severe erosion of the dunes and total denuding of the beach by a combination of recent high lake levels and storm events. The beach fill, composed of glacial till, had a positive influence in controlling coastal erosion, due to an unexpected cementation of the material, which made it highly resistant to wind and wave erosion. However, this induration adversely affected the expected vegetative establishment sequence. Lack of a loose surface material, needed by pioneer vegetation to successfully be introduced, prevented the immediate start of sand capturing grasses. Only wasteland plants, well adapted to hard soil environments, first invaded this artificially stabilized beach. These wasteland plants dominated the fill for several years, with almost no new dune forming activity. The eventual appearance of a few isolated pioneer grasses on the consolidated fill finally initiated embryonic dune growth. These dunes rapidly expanded horizontally, aided by vegetative stabilization, while continuing sand capture allowed vertical growth of the dunes. Presently these dune structures have matured beyond the pioneer plant stage, evidenced by the presence of secondary plants, adding to the diversity of species and consequently to the biological stability of the new dune system. The unnourished areas adjacent to the fill exhibited a totally different influence of this artificial beach on vegetative establishment.

14. De Cooke, B.G. Draft Report on United States Inundation and Erosion Stage Damage Relationships; 1991.
Note: Mich. City.
Reach 7006 (Gary, Ind. - South Haven, MI.) noted as having a high erosion level. Indicated erosion damage of $15,155,467 for 1985-87.

15. Dolske, Donald A.; Sievering, Herman. Trace Element Loading of Southern Lake Michigan by Dry Deposition of Atmospheric Aerosol. Water, Air, and Soil Pollution; 1979; 12: 485-502. Aerosol samples and meteorological data were collected at a mid-southern Lake Michigan site from May through September 1977. Hi-volume samplers with cellulose fiber filters and a digital meteorological data recording system were operated on board the U.S. EPA's R/V Roger R. Simons during four intensive sampling periods. Aerosol samples were analyzed by atomic absorption spectroscopy for seventeen trace elements. A diabatic drag coefficient method was used to determine aerosol deposition velocity overlake. By relating the observed trace element concentrations and deposition velocity to a long-term climatological record, annual dry deposition loadings to the southern basin for nine elements were estimated. For four elements, Fe, Mn, Pb, and Zn, dry deposition loadings to the southern basin alone of at least 500, 30, 250, and 100 (x's 10 to the third kg per year) were found. For Fe and Mn, these loadings represent about 15% of the total of all inputs to Lake Michigan. For Zn and Pb, about one-third to one-half of the annual loading from all sources is from dry deposition of atmospheric aerosol.

16. Eadie, B.J.; Chambers, R.L.; Gardner, W.S.; Bell, G.L. Sediment Trap Studies in Lake Michigan Resuspension and Chemical Fluxes in the Southern Basin. J. Great Lakes Res.; 1984; 10(3): 307-321; ISSN: 0380-1330.
The results of 4 years (1977-80) of sediment trap sample collection in the southeastern region of Lake Michigan are summarized and compared with water column and sediment characteristics. Mass flux data indicate strong seasonal patterns, with maximum fluxes recorded during the unstratified period. The large amount of winter resuspension is a mechanism which provides an intimate coupling of recent sediments and the water column. Also these trap study results indicate that there is a near-bottom (10-m-thick) benthic nepheloid layer whose chemical composition approaches that of deep water (fine grain) sediments. The amount of resuspended NaOH extractable phosphorus injected into the euphotic zone is estimated as approximately equal to the load of new phosphorus entering southern Lake Michigan. The role of resuspension in the cycling of organic carbon and contaminants associated with it appears to be important.

17. Edgington, David N.; Robbins, John A. Records of Lead Deposition in Lake Michigan Sediments Since 1800. Environmental Science and Technology; 1976; 10(1): 266.
The distribution of stable lead has been determined in several Lake Michigan cores that have been dated using the Pb technique. A mathematical model, based on records of national and regional fuel use, is developed that accounts for the effect of aquatic residence time, processes of sedimentation, compaction, postdepositional redistribution of sediment solids, and the effect of finite core sectioning. The model gives an excellent quantitative description of the data, indicating that the lead profiles reflect the history of lead input from the burning of coal and leaded gasoline since about 1830 and 1920, respectively. The model is applied to obtain the sedimentation and lead deposition rates from the stable lead distributions in undated sediment cores measured previously by others. The 1972 anthropogenic lead flux into the southern basin of the lake is determined to be 1.3 ug cm(-2) per year in comparison to the natural (precultural) flux of about 0.16 ug cm(-2) per year. The anthropogenic lead deposited in the southern basin in 1972 is estimated to be about 240 metric tons as compared with an estimate of about 230 metric tons from air pollution fallout originating in the Chicago-Gary urban-industrial area. The measurement of both lead and lead-210 fluxes in the same core may allow contributions of atmospheric lead to be distinguished from terrigenous pollution inputs.

18. Engel, J. R. Sacred Sands: The Struggle for Community in the Indiana Dunes. Middletown, Conn.: Wesleyan Univ. Press; 1983. Note: 268 pp.

19. Engel, J. Ronald. Social Democracy, the Roots of Ecology, and the Preservation of the Indiana Dunes. Journal of Forest History; January 1984; 28(1): 4.

20. Environmental Assessment (For City of Portage Port Authority). Environmental Assessment: Marina Development on the Burns Waterway System. Chicago, Illinois: Howard Tammen Needles & Bergendoff; Sept. 1991.
Note: reprint.
The Environmental Assessment considers the potential impacts of the projects on natural and cultural resources, and the socio-economic and physical environment. Special attention was focused on wetlands, water quality and impacts on the waterway system.

21. Erwin, Tanya Lee. Indiana Dunes: Another Border to Defend. National Parks and Conservation Magazine; October 1977; 51(10): 4.

22. Evans, M.S. The Morphology of Daphnia pulicaria, a Species Newly Dominating the Offshore Southeastern Lake Michigan Summer Daphnid Community. Trans. Am. Microsc. Soc.; July 1985; 104(3): 223-231.

23. Evans, M.S. Recent Major Declines in Zooplankton Populations in the Inshore Region of Lake Michigan: Probable Causes and Implications. Can. J. Fish. Aquat. Sci.; Jan. 1986; 43(1): 154-159; ISSN: 0706-652X.
Summer zooplankton communities in the inshore region of southeastern Lake Michigan were dominated by small species during the 1970s, suggesting that size-selective fish predation pressures were intense. Abundances of alewife (Alosa pseudoharengus), the dominant planktivore in the 1970s, declined in recent years, especially over 1982-94, suggesting that predatory pressures had intensified. Concurrent with the alewife population decrease was a major increase in yellow perch (Perca flavescens) abundances.

24. Evans, M.S.; Jude, D.J. Recent Shifts in Daphnia Community Structure in Southeastern Lake Michigan: A Comparison of the Inshore and Offshore Regions. Limnol. Oceanogr.; Jan. 1986; 31(1): 56-67.

25. Foland, Steve. A Lush Valley Assured. Soil Conservation; November 1979; 45(4): 20.

26. Franklin, Kay; Scaeffer, Norma. Industry, a Nuke, Even People Threaten the Indiana Dunes. Planning; April-May 1978; 44(4): 34.

27. Futyma, R. P. Paleobotanical Studies at Indiana Dunes National Lakeshore. Porter, Indiana: National Park Service; 1985.

28. Gardner, W.S.; Eadie, B.J.; Chandler, J.F.; Parrish, C.C; Malczyk, J.M. Mass Flux and "Nutritional Composition" of Settling Epilimnetic Particles in Lake Michigan. Can. J. Fish. Aquat. Sci; July 1989; 46(7): 1118-1124; ISSN: 0706-652X.
A series of sediment-trap samples, collected at a 30-m depth in southeastern Lake Michigan, was analyzed to evaluate the seasonal flux and nutritional value of settling epilimnetic particles as potential food for benthic organisms. Flux was highest in the spring (due in part to resuspension), lowest

in the summer during stratification, and intermediate during autumn months.

29. Gatz, Donald F. Pollutant Aerosol Deposition into Southern Lake Michigan. Water, Air, and Soil Pollution; 1975; 5(2): 239.
Current estimates of pollutant aerosol input to southern Lake Michigan are based on a single calculated emission inventory and various estimates of the fraction of emissions that enter the Lake. Alternative, but still crude, estimates of urban elemental emissions and their wet and dry deposition in the lake are made here. Observed elemental concentrations in urban air are used to calculate emissions and recently measured wet and dry deposition parameters are used to calculate deposition. All available treatments conclude that atmospheric inputs of at least Fe, Pb, Ti, and V are sizable fractions of total lake input of these metals. This study suggests tentatively that 1) wet and dry inputs from the atmosphere are about equal, 2) between 3 and 15% of elemental pollutant emissions from Chicago and NW Indiana enter the Lake, and 3) this fraction increases with particle size.

30. Gillies, Daniel C.; Lapham, Wayne W. Reassessment of the Effects of Construction Dewatering on Ground-water Level in the Cowles Unit, Indiana Dunes National Lakeshore, Indiana. Supplement to Geological Survey Water-Resources Investigations 78-138: U.S. Geological Survey; Open File Report 80-1105.
Note: Mich. City.
A revision for the dewatering plan for the construction of a nuclear power plant at the Northern Indiana Public Service Company's (NIPSCO) Bailly Generating Station. This reassessment of the effects of dewatering and construction gives light to evidence suggesting the presence of a lateral variation in the hydraulic characteristics of the confining unit separating the unconfined sand aquifer and the confined sand aquifer in and near Cowles Bog National Landmark.

31. Glatfelter, D.R.; Thompson, R.E.; Neil, G.E. (Geological surv., Indianapolis, IN. Water Resources Div.). Water Resources Data for Indiana, Water year 1986; Sep. 1986; NTIS Order No.: PB88-165808/GAR. USGS/WDR/IN-86/1.

32. Governor's Water Resources Study Commission. The Water Resources Situation in Planning Region 1A. In: Water Resources Planning in Indiana; November 1978.

33. Great Lakes United; Lake Michigan Federation. Cleaning up Lake Michigan. A Citizen's Agenda for Action. A Report from a Lake Michigan Regional Meeting.; April 16, 1988.
Note: Mich. City.
On April 16, 1988, approximately 70 leaders of conservation, labor, environmental and community interest groups met in Michigan City, Indiana. The purpose of the meeting was to develop an action plan for working together to clean up Lake Michigan in the coming years. Topics included air toxics, contaminated sediments, laws, action plans, pollution elimination, shoreline management, and recommendations.

34. Hardy, M.A. Chemical and Biological Quality of Streams at the Indiana Dunes National Lakeshore, Indiana, 1978-1980; 1984; USGS Water-Resources Investigation. 83-4208.
Note: Mich. City.
A variety of land uses affects the water quality of streams at Indiana Dunes National Lakeshore.

35. Harrison, W.; McCown, D.L.; Raphaelian, L.A.; Saunders, K.D., Energy and Environmental Systems Division, Great Lakes Project (For: Illinois Institute for Environmental Quality). Water Resources Research Program. Pollution of coastal waters off Chicago by sinking plumes from the Indiana Harbor Canal. Argonne, Illinois 60439: Argonne National Laboratory; December 1977; ANL/WR-77-2.
Note: CZM.
On March 2, 1977, during sinking-plume conditions, a portion of the water of the Indiana Harbor Canal (IHC) was injected with samarium and rhodamine-dye tags and a section of the IHC's surface was covered with simulated oily waste tagged with dysprosium. Water samples were taken downcurrent, over a 54-hr period, from a vessel and from the raw-water streams from the intakes at Chicago's South Water Filtration Plant (SWFP). Bottom currents and water temperatures were measured almost continuously at four Lake Michigan stations located between the IHC and the SWFP.

36. Henderson, Norman R. The Role of Fire in Succession in the Sand Dune Plant Communities of Lake Michigan. Cole, Kenneth L.; Hiebert, Ronald D.; Wood, James D. First Indiana Dunes Research Conference. Symposium on Plant Succession; May 1-3, 1986; Indiana University Northwest, Gary, Indiana. Scientific Publications Office, 75 Spring Street, S.W., Atlanta, Georgia 30303: U.S. Dept. of the Interior, National Park Service; 1987: 34.
Past research on plant succession on the sand dunes of Lake Michigan has been unable to adequately explain the apparent successional stagnation of the communities on the southern

dunes. Analysis of the contemporary and presettlement species composition within the southern and southeastern dunes (16 km apart) indicates that the plant communities were, and still are, vastly different. Those in the southern dunes are mostly early successional (mostly oaks) while those in the southeastern dunes are composed of later successional species (beech and maple). The climate and soil characterisitics, however, are similiar between the two areas. Fire is known to have been a potent ecological force in the midwest ecosystems. By including it as a major ecological force in the plant communities of the dunes, the vast differences in species composition and successional trends can be explained. With this force included, the original dune successional model, proposed by H. C. Cowles at the turn of the century, becomes useful.

37. Hiebert, Ronald D. An Ecological Restoration Model: Application to Razed Residential Sites. Natural Areas Journal; October 1990; 10(4): 181.

38. Hiebert, Ronald D.; Pavlovic, Noel B. Role of Past Land Use on Succession at the Indiana Dunes; Implications for Management. Cole, Kenneth L.; Hiebert, Ronald D.; Wood, James D. First Indiana Dunes Research Conference Symposium on Plant Succession; May 1-3, 1986; Indiana University Northwest, Gary, Indiana. Scientific Publications Office
75 Spring Street, S.W., Atlanta, Georgia 30303: U.S. Dept. of the Interior, National Park Service; 1987: 47.
Studies of plant succession in old residential sites have shown that this type of man-caused disturbance can significantly affect succession rates and potentially affect species composition of a site for at least a century. Past land use (drive, garden, building site, lawn) was mapped for thirty old residential sites, ranging from 3 yr - 11 yr old, using historical aerial photos and ground surveys. Vegetation and soils were sampled for each past land use at each site. Vegetation composition richness, and estimated biomass varied significantly among past land uses. Similarity in species composition was less in 9 yr old than in 3 yr old sites. Biomass was significantly different among past land uses for 3 yr old sites but not 9 yr old sites. These trends are most likely the result of substrate changes caused by the past land uses. Soil chemistry and compaction differed significantly among past land uses, although differences decreased with time. In spite of a convergence in substrate characteristics over time, the vegetation appears to be diverging. These results, along with the results of other studies and ecological theory are applied

towards formulation of management prescriptions to encourage succession towards the vegetation of the surrounding communities.

39. Hiebert, Ronald D.; Wilcox, Douglas A.; Pavlovic, Noel B. Vegetation Patterns In and Among Pannes (Calcareous Intradunal Ponds) at the Indiana Dunes National Lakeshore, Indiana. American Midland Naturalist; October 1986; 116(2): 276.
The relationships between plant species composition and dispersion, water chemistry and water depth/depth to water table were studied in five calcareous intradunal ponds (pannes) bordering the southern tip of Lake Michigan. The panne systems contained eight plant species threatened and endangered in Indiana. The aquatic zone was dominated by Chara, the pond edge by Rhynchospora capillacea, Juncus balticus and Utricularia cornuta, and the area surrounding the pond by Hypericum kalmianum. The water chemistry was typical of hardwater ponds in the area, probably affecting species composition but not species dispersion within the pannes. A significant correlation between the first axis scores from a reciprocal-averaging ordination and water depth/depth to water was demonstrated. Panne species are fitted to a model based on hydrology proposed by van der Laan for dune-slack vegetation in the Netherlands.

40. Hill, C. L, B. J. Ryan, B. A. McGregor, and M. Rust (U.S. Geological Survey / U.S. Department of the Interior / National Park Service). Our Changing Landscape: Indiana Dunes National Lakeshore. Free on application to the Books and Open-File Reports Section U.S. Geological Survey Federal Center, Box 25425 Denver, CO. 80225: United States Government Printing Office.; 1991; U.S. Geological Survey Circular 1085.
Note: reprint.
Earth-science information provides us with estimates of extent and rates of change. We need this information to transform the challenges presented here into opportunities for locating new or additional land, water, and mineral resources; for emphasizing prevention of contamination rather than cleanup; and for increasing our ability to live in harmony with nature.

41. Holm, Nancy Peterson. Inventory of Lake Michigan Research Projects: 1984-1987. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1987.
A review was conducted to assess the existing research programs of various agencies and universities working on Lake Michigan.

42. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography: 1860-1988 Geological and Physical Processes. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1988.
This bibliography covers research publications from 1860 to mid-1988 on geological and physical processes in Lake Michigan.

43. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 2: 1977-1986. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989b.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

44. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 1: 1960-1976. Champaign, IIlinois: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989a.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

45. Indiana Department of Natural Resources. Coastal Zone Management Program. Preliminary First Year Natural Resource Inventory. (Draft): Indianapolis; July 1976.
Note: CZM.
Compiles an inventory of significant natural and man-made coastal resources including an inventory of the existing data on the natural resources of the state's Lake Michigan coast, brief discussion papers on the problems and issues of the area, and an analysis of the collected data for its use in the Coastal Zone Management Program.

46. Indiana Dunes National Lakeshore / Indiana (U.S. Department of the Interior / National Park Service). General Management Plan Amendment/Development Concept Plan/Environmental Assessment.; Sept. 1990.
Note: Reprint.
The purpose of this General Management Plan Amendment/ Development Concept Plan/Environmental Assessment is to update the 1980 General Management Plan (GMP) considering the full range of issues that will affect the West Unit through the year 2000. These managment issues include access to West Beach, location of the West Unit transit center and parking area, use of shuttle bus systems, impacts of traffic on

adjacent communities, additional hiking and biking trails, boundary adjustments, and use of lands adjacent to the Portage/Burns Waterway and those lands between the Paul H. Douglas Environmental Education Center and Broadway in Gary.

47. Indiana Shoreline Erosion (U.S. Army Corps of Engineers). Indiana Shoreline Erosion: Final Feasibility Report and Environmental Impact Statement.; June 1982.
Note: reprint. Interim document under agency review subject to revision.
This study investigated the shoreland erosion problems between Michigan City Harbor, Indiana and the Illinois-Indiana State line. As a result of the study this report recommends shore erosion control measures for the reach of shore immediately west of Michigan City Harbor.

48. Indiana Dunes National Lakeshore (Indiana Dunes National Lakeshore). Land Protection Plan (Draft); 7-01-87.
Note: Covers National Lakeshore, Lake, Porter, Laporte counties.
Identification of land uses and land needs of IDNLS.

49. Indiana Department of Natural Resources. Natural Resources Inventory. Indianapolis, IN: DNR; September 1976; Technical Report No. 101.
Note: CZM.
The Indiana Coastal Zone Management Program will address the process of the future management of the natural resources in the "Coastal Zone". The purpose of the Natural Resources Inventory is to provide the natural resource data required for the CZM Program. The Natural Resources Inventory: identifies the natural resources; describes the natural processes; and identifies the existing and potential resource problems and issues in the CZM "study area". The emphasis of the inventory was placed on collating and interpreting existing information. However, where the basic information was inadequate, additional studies were initiated. Natural resource data in the form of maps and plates are included.

50. Indiana Dunes National Lakeshore Planning Newsletter (For National Park Service/Denver Service Center). NPS To Revise Three Lakeshore Reports.; Mar. 1991.
Note: reprint.
The public review and comment period for three draft national lakeshore reports closed on December 3, 1990. The National Park Service responded to many questions and received many comments at three public meetings. More than 600 written comments were received from the postage-paid comment forms; personal, agency, and organization letters; and interest

group form letters. This newsletter summarizes the comments made at the public meetings and in correspondence. Responses to each comment explain and clarify the NPS position. The National Park Service will correct errors and clarify ambiguous aspects of the draft documents.

51. Indiana Department of Natural Resources (For Indiana State Planning Services Agency). A Priority Rating of Selected Wetlands in the Indiana Coastal Zone: DNR; 4-30-79; Technical Report No. 303.
Note: CZM.
Until this time, a method for rating land on a priority basis for future acquisition as wetland conservation areas has been lacking. To devise a rating system, approximately 45 selected wetland areas within the coastal drainage area of Lake Michigan in Indiana were studied. The Lake Michigan watershed area covers approximately the northern halves of Porter and Lake counties and the northwest quarter of LaPorte County. The second purpose was to utilize this rating system to categorize these wetland areas by priority for possible future acquisition.

52. Indiana Department of Natural Resources; and Natural Land Institute (For: Indiana State Planning Services Agency). An Inventory of Natural Areas in the Indiana Coastal Zone Study Area. Indianapolis, IN: DNR; April 30, 1979; Technical Report No. 302.
Note: CZM.
As part of the current study of the Indiana Lake Michigan coastal zone, the Natural Land Institute and the Indiana Department of Natural Resources, Division of Nature Preserves, entered into a cooperative project to study natural areas and habitats of endangered and threatened plants and animals in the coastal zone. The Natural Land Institute, a private non-profit conservation and research organization with headquarters in Rockford, Illinois, was required to supply the following technical information to the Department: 1) an inventory and evaluation of natural areas, 2) a compilation of existing information, 3) locating and identifying populations of endangered and threatened plant species, and 4) locating and identifying endangered and threatened animal species. The findings of this inventory will provide local, State and Federal officials with the information they need to initiate programs to preserve the rapidly vanishing remnants of Indiana's natural heritage.

53. Indiana Department of Environmental Management; U.S. Environmental Protection Agency Region V. Northwest Indiana Environmental Action Plan.
Note: Mich. City.
The Northwest Indiana Environmental Action Plan is a comprehensive plan which encompasses all programmatic efforts into the full range of ongoing regulatory and investigative activities. The plan delineates resources and establishes agency priorities necessary to achieve realistic area-wide environmental results. The plan establishes basic goals for cleaning up known environmental problems and provides a comprehensive framework for identifying cumulative problems and implementing cross-program solutions.

54. Jackson, S. T. Plant Macrofossil Stratigraphy of Miller Woods Interdunal Pond 51, Indiana Dunes National Lakeshore. Porter, Indiana: National Park Service; 1985.

55. Jackson, S.T.; Futyma, R.P; Wilcox, D.A. A Paleoecological Test of a Classical Hydrosere in the Lake Michigan Dunes. Ecology; August 1988; 69(4): 928-936.
Aquatic vegetation varies along a chronosequence of dune ponds at Miller Woods, Indiana Dunes National Lakeshore. The oldest ponds are dominated by emergent plants, especially Typha angustifolia. The authors conducted paleoecological studies at a 3,000-yr old pond to test the hypothesis that the modern vegetational array along the pond chronosequence represents a hydrarch successional sequence. Pollen and macrofossil data indicate a major, rapid vegetational change at < 150 BP, evidently in response to local human disturbance. Pollen data reveal that the extensive Typha stands in the older ponds have developed recently, following post-settlement disturbance. Modern vegetational differences along the chronosequence reflect differential effects of disturbance rather than autogenic hydrarch succession.

56. Laird, G.A.; Scavia, D.; Fahnenstiel, G.L.; Strong, L.A.; Lang, G.A. Dynamics of Lake Michigan Phytoplankton: Relationship of Nitrogen and Silica Fluxes. Can. J. Fish. Aquat. Sci.; 1988; 45(8): 1459-1466; ISSN: 0706-652X.
The authors describe rates of nitrogen and silica concentration change during May-August 1983 and 1984 in southeastern Lake Michigan and compare those rates with measured plankton processes. Epilimnetic dissolved inorganic nitrogen depletion, compared with total phytoplankton demand, suggests that about 44% of the nitrogen demand is recycled.

57. Laird, G.A.; Scavia, D.; Fahnenstial, G.L.; Strong, L.A.; Malczyk, J.M. (NOAA Environmental Research Labs, Ann Arbor, MI). Southern Lake Michigan nutrients, temperature, chlorophyll, plankton, and water movement during 1983 and 1984. (Great Lakes Environmental Research Lab, Oct 1987 NOAA-TM-ERL-GLERL-67
NOAA TECH. MEMO; NTIS Order No. : PB88-148572/GAR).
Several biological, chemical and physical properties were determined in Lake Michigan for the region of the 100-m depth contour in the southeastern basin of Lake Michigan off Grand Haven, Michigan, in 1983 and 1984. The measurements are presented in tabular and graphical form, and a brief description is given of collection and preparation methods. The nutrient fluxes recorded for 1983 and 1984 are typical for oligo-mesotrophic, phosphorus-limited, temperate lakes, and the water movements recorded indicate that advection in Lake Michigan, on a lake-wide scale, is small.

58. Lake-Porter County Regional Transportation and Planning Commission. Water Resources Inventory: 1970.
Note: NRPC.
This is the first attempt in the region to systematically collect and record all water resource information.

59. Mac, M.J. Mortality of Lake Trout Swim-up Fry from Southeastern Lake Michigan: Documentation and Hepatic Structural Analysis. DISS. ABST. INT. PT. B-SCI. & ENG.; Jan 1987; 47(7): 82 pp.
Note: Diss. Ph. D.: Order No. FADDA8623098.
After the extinction of the lake trout (Salvelinus namaycush) in Lake Michigan in the mid-1950s, an attempt to bring back a self-sustaining population began in 1965 with extensive planting of hatchery-reared yearling fish. Despite the annual planting of nearly two-million fish, no natural reproduction by adult trout in the lake has been observed. A syndrome occured during early development when fry were switching from endogenous to exogenous feeding. Characteristic behavioral signs exhibited by afflicted fry included a loss of equilibrium, abnormal swimming, fish laying on their sides on the bottom of tanks, general lethargy, cessation of feeding and eventual death. The observed mortality and associated behavior were similar to that caused by DDT in the mid-1960s. To determine whether environmental contaminants were affecting the health of young lake trout, a structural examination of the liver, including quantitative histopathology and electron microscopy was conducted. The results of quantitative histopathology indicated that fry of lake origin had decreased glycogen,

increased vacuolation, and a decrease in mitotic activity when compared to healthy fry.

60. Madenjian, C.P.; Jude, D.J.; Tesar, F.J. Intervention Analysis of Power Plant Impact on Fish Populations. Can. J. Fish. Aquat. Sci.; April 1986; 43(4): 819-829; ISSN: 0706-652X.
Alewife and yellow perch abundances, estimated from monthly gillnet and trawl catches at two transects, were monitored before (1973-74) and during (1975-82) operation of the D.C. Cook Nuclear Power Plant, southeastern Lake Michigan. Intervention analysis, a technique which accounts for autocorrelated observations, and analysis of variance (ANOVA) were applied to the monitoring data to assess any plant impact beginning in 1975. Both analyses disclosed no significant power plant impacts except for gillnetted yellow perch adults. The ANOVA indicated a significant decrease in abundance at the plant-discharge transect relative to the reference transect as plant operation began, which established a plant effect; intervention analysis showed no change. When April and May catches (months of low abundance) were deleted, this plant effect was insignificant.

61. Marie, James R. (U.S. Geological Survey). Model Analysis of Effects on Water Levels at Indiana Dunes National Lakeshore Caused by Construction Dewatering: U.S. Dept. of the Interior; July 1976; Water-Resources Investigations 76-82. Note: Mich. City.
Two comprehensive models were developed to investigate possible hydrologic effects within the Indiana Dunes National Lakeshore caused by planned dewatering at the adjacent Bailly Nuclear Generator Construction Site. The results of this study have been used by the National Park Service to help evaluate the environmental impact of the dewatering, particularly the effects on the ecosystem of the lakeshore.

62. Mazer, Susan J. Ecological, Taxonomic, and Life History Correlates of Seed Mass Among Indiana Dune Angiosperms. Ecological Monographs; March 1989; 59(2): 153; ISSN: 0012-9615.
This study evaluated the ecological and taxonomic correlates of seed mass variation among 648 angiosperm species of the Indiana Dunes region (113 families, 507 genera in the original flora). The sample represented 50% of the species, 60% of the genera, and 67% of the families reported from the area. Species were chosen at random from the published flora. Each species was characterized by family membership, habitat, life history, phenological characters, and native vs. alien status, in order to determine the relationship

among species between these variables and mean seed mass. Unique to this study are measurements of the effects of phenology and taxonomic family on seed mass. The results of this study parallel previous comparative works that have demonstrated associations between seed mass and life form or habitat type. Seed mass does seggregate among species occupying distinct habitats, but this relationship is due largely to associations among taxonomic family, life form, and habitat.

63. McIntosh, Robert P. Community and Succession in the Indiana Dunes, Cole, Kenneth L.; Hiebert, Ronald D.; Wood, James D. First Indiana Dunes Research Conference. Symposium on Plant Succession; May 1-3, 1986; Indiana University Northwest, Gary, Indiana. Scientific Publications Office, 75 Spring Street, S.W., Atlanta, Georgia 30303: U.S. Department of Interior, National Park Service; 1987: p.1.
The Indiana Dunes are the cradle of succession in America and a symbol of the need for maintaining elements of the natural environment against increasing demands of a technological culture. Succession as a natural process of change underlies all planning and management of such sites.

64. McLeod, Kenneth W.; Murphy, Peter G. Establishment of Ptelea trifoliata on Lake Michigan Sand Dunes. American Midland Naturalist; 1977; 97(2): 350.
The microclimate to which a seed or small seedling on the sand dunes of Lake Michigan is subjected is characterized by high surface soil temperatures and low soil moisture during the summer. The survival of 1st-year seedlings of Ptelea trifoliata was very low (10.5%). Second-year seedlings had a 50% survival rate. The mortality was attributed to two environmental factors: insufficient soil moisture and illegal vehicular traffic. The slow elongation of the root makes the soil moisture a very critical factor. Shaded habitats within a Ptelea stand provide physical protection for the seedlings from vehicular traffic and have higher soil moisture; consequently, seedling survival is greater in shaded habitats than in open habitats. Because of the high mortality rate of young seedlings, seed production must be large to maintain the present population size.

65. Miller, W. P.; McFee, W. W. Distribution of Cadmium, Zinc, Copper, and Lead in Soils of Industrial Northwestern Indiana. Journal of Environmental Quality; 1983; 12(1): 29.
Note: Technical Reports section.
Five undisturbed locations of sandy Oakville and Plainfield soils under oak forest in the heavily industrialized region of northwestern Indiana were sampled at four depths, to assess the nature and extent of Cd, Zn, Cu, and Pb contamination. The litter layer and top 2.5 cm of soil at a site within 5 km of the center of the industrial complex were highly contaminated with Cd, Zn, Cu, and Pb. Levels of Cd and Zn decreased rapidly with distance to the south and east, while Cu and Pb decreased more erratically, with all metals reaching nearly background levels at 18 km. Samples taken deeper in the profiles (30 to 36 cm) did not show elevated metal levels compared with a rural site 67 km to the south. Sequential extraction methods applied to the top 2.5-cm soil samples showed large amounts of relatively labile metals associated with exchange sites (KNO_3-extractable: 23, 10, 1, and 8% of total Cd, Zn, Cu, and Pb, respectively), bound by soil organic matter, and associated with carbonates and/or noncrystalline Fe oxides (EDTA-extractable: 12, 8, 26, and 28% of the total Cd, Zn, Cu, and Pb). Minimal amounts of the metals were within the small amount of crystalline Fe and Mn oxides present in these soils. Nonextractable (residual) metals amounted to 26, 32, 23, and 4% of the total Cd, Zn, Cu, and Pb.

66. Mortimer, C.H. Discoveries and Testable Hypotheses Arising from Coastal Zone Color Scanner Imagery of Southern Lake Michigan. Limnol. Oceanogr.; Mar. 1988; 33(2): 203-226.
CZCS (Coastal Zone Color Scanner) images, confined mainly to the southern basin of Lake Michigan during the warm-up phases of 1979, 1980, and 1981, have furnished tools for synoptic reconnaissance of the wind-perturbed transition of the thermal regime in large basins from the winter to summer condition (including front formation and upwelling events), the coupling of phytoplankton growth with that transition, the intermittent mobilization and surface transport of sediment resuspended by storms, and the extensive temporary trapping of river-derived dissolved organic matter (gelbstoff) between the shoreline and the offshore-migrating thermal front. The observed pattern changes shed new light on the above processes and generate several testable conjectures. These relate to whole-basin sediment transport, coastal upwelling of near-bottom sediment suspensions, and frontal hydrodynamics and its coupling with phytoplankton distributions.

67. Nalepa, T.F. Long-term Changes in the Macrobenthos of Southern Lake Michigan. Can. J. Fish. Aquat. Sci.; 1987; 44(3): 515-524; ISSN: 0706-652X.
A benthic survey of 40 stations in southern Lake Michigan in 1980-81 was compared with results of studies conducted in the mid-1960s to evaluate long-term trends in populations. Although apparent improvements in the water quality of Lake Michigan since the mid-1970s were not yet reflected by benthic populations in 1980-81, continued monitoring of the benthos should provide a useful indicator of future trends.

68. Nalepa, T.F. Occurrence of a Resting Stage in Cyclopoid and Harpacticoid Copepods in Nearshore Lake Michigan. J. Great Lakes Res.; 1985; 11(1): 59-66; ISSN: 0380-1330.
Temporal and spatial differences in the abundance of dormant harpacticoid and cyclopoid copepods in a nearshore area of southeastern Lake Michigan are described.

69. Nalepa, T.F.; Quigley, M.A. Abundance and Biomass of the Meiobenthos in Nearshore Lake Michigan with Comparisons to the Macrobenthos. J. Great Lakes Res.; 1983; 9(4): 530-547; ISSN: 0380-1330.
The meiobenthos of nearshore southeastern Lake Michigan was quantified by taking cores from depths (11,17, and 23 m) at monthly intervals from May to November 1976-79.

70. Newsom-Brighton, Maryanne. The Indiana Dunes. Environment; May 1984; 26(5): 40.

71. Northwestern Indiana Regional Planning Commission. Remedial Action Plan for the Indiana Harbor and Canal, the Grand Calumet River, and the Nearshore Lake Michigan - Stage One. Highland, Indiana: NIRPC; 1991.
This report identifies environmental problems such as, groundwater contamination, oil slicks, and depressed fish populations. Sediment pollution is fingered as a most significant environmental concern.

72. Northwestern Indiana Regional Planning Commission. Water Quality Data for the Indiana Coastal Zone. Indianapolis, IN: NIRPC; August 1976; Technical Memorandum IV. (Draft).
Note: CZM.
Presents statistics describing the water quality of northwestern Indiana.

73. Olson, J. S. Rates of Succession and Soil Changes on Southern Lake Michigan Sand Dunes. Bot. Gaz.; 1958; 119: 125-170.

74. Osann, Edward R. Rounding out Indiana Dunes. National Parks and Conservation Magazine; August 1973; 47(8): 25.

75. Paulson, Gerald A. Wetlands and Water Quality: A Citizen's Handbook for Protecting Wetlands. Lake Michigan Federation, 59 East Van Buren, Suite 2215, Chicago, Illinois 60605. (302) 939-8038: The Lake Michigan Federation; 1990.
The true value placed by the public on protecting wetlands is reflected in the range of wetland protection laws that Congress has passed in recent years. Despite these laws, however, wetlands continue to be lost, throughout the country and particularly in the Great Lakes region - one of the most wetland-rich regions in the nation. This continued destruction sends a clear message that our regulatory agencies still do not have the capacity to safeguard these precious natural resources adequately. As a result, citizen action has emerged as one of the strongest defenses against continued wetland destruction. This book is designed to give you, the citizen, the basic, practical information you need to protect wetlands and to guide you through often confusing legal and regulatory processes. Understanding why wetlands are important (wetland values) is the first step. Knowing and building a defense against a given proposed project is the second step, followed by presenting your views in a factual manner. But most importantly, taking the offensive can help to ensure that you do not have to take these defensive steps. This handbook will direct you through these important steps toward building your own strategies. It concentrates in most detail on the leading wetland law, Section 404 of the Clean Water Act, but also refers to a number of other legal and regulatory tools you can use.

76. Perrone, M.; Schneeberger, P.J.; Jude, D.J. Distribution of Larval Yellow Perch (Perca flavescens) in Nearshore Waters of Southeastern Lake Michigan. J. Great Lakes Res.; 1983; 9(4): 517-522; ISSN: 0380-1330.
Spatial and temporal distribution of larval yellow perch (P. flavescens) in south-eastern Lake Michigan was described from samples collected during 1973-1981 with plankton nets and benthic slids in water 0.5 to 21 m deep.

77. Plato, Phillip A.; Jacobson, A. P. Cesium-137 in Lake Michigan Sediments: Areal Distribution and Correlation With Other Man-made Materials. Environmental Pollution; 1976; 10: 19.
Grab samples of sediment were collected at 530 locations in Lake Michigan, primarily in the southeastern quarter of the lake. Each sample was analysed in the field and in the laboratory for fallout cesium-137. Twenty-five of the samples, collected near the mouth of the St. Joseph River, were also analysed in the laboratory for 11 other man-made materials known to be discharged into the river. Two statistical methods were used to determine if cesium-137 can be used as an environmental tracer to predict the areal distributions of other man-made materials. The results show fallout cesium-137 to be a moderate to good tracer for locating areas of accumulation of plutonium-238, plutonium-239, zinc, copper, chromium, lead, dieldrin, DDT and PCB in sediment. Little or no correlation is found between fallout cesium-137 and strontium-90 or nickel.

78. Reshdin, M. Geology and Soils of the Indiana Dunes National Lakeshore, volume one.
Indiana Dunes Research Program Report 81-01; 1981; 81-01.

79. Reshkin, Mark. Indiana Dunes Natural Resource Management. Natural Areas Journal; October 1990; 10(4): 176.

80. School of Civil Engineering, Purdue University (Great Lakes Coastal Research Laboratory). Executive Summary; Shoreline Situation Indiana Dunes National Lakeshore. Purdue University; June, 1986 booklet.
The Indiana Dunes National Lakeshore (IDNLS) was established in 1966during a period of record rise in lake-level, but at a time when absolute lake-level was still below average. In 1974 after lengthy study, discussion, and compromise the first major "hard" coastal shore protection structure was constructed along IDNLS coastline (a 13,000 foot long rock revetment constructed to protect Lake Front Drive in Beverly Shores, IN). In that same year a major "soft" shore protection structure, in the form of a beach nourishment fill, was placed in front of Mt. Baldy west of Michigan City, IN. The Great Lakes Coastal Research Laboratory, Purdue University was selected as the monitoring agency in 1975 to determine the effectiveness and impact along the coast of these structures. The purpose of this Shoreline Situation Report is to present a complete data base on and rigorous assessment of the shoreline and adjacent nearshore area within the IDNLS. This report contains a thorough evaluation of coastal parameters and characteristics useful to

engineers, planners and managers of Indiana's coastal lands. Emphasis is placed on coastal processes as they relate to historic and contemporary erosion. Particular attention is given to position changes of the shoreline, bluff top, nearshore sand bars, and dune vegetation. Beach and nearshore sediments are analyzed with respect to their contemporary grain properties and compared to historic data to determine areas of change. An important aspect of this report deals with man-made structures on the coast and their impact on overall coastal stability. Recognizably, the proximity of owners homes to the receding shoreline of Indiana presents a special set of problems. However, poorly conceived coastal erosion control structures can ultimately be more damaging than helpful to overall coastal integrity. The basic philosophy guiding preparation of this report is that only through judicious planning can optimum benefit be derived from Indiana's coastal resources.

81. Spigarelli, S. A.; Goldstein, R. M.; Prepejchal, W.; Thommes, M. M. Fish Abundance and Distribution Near Three Heated Effluents to Lake Michigan. Canadian Journal of Fisheries and Aquatic Science; 1982; 39(2): 305.
A combined echo location-temperature mapping technique was used to determine the abundance and distribution of fish with depth and temperature in locally heated and unheated areas of Lake Michigan. Surveys were conducted between April and October at two adjacent power plants in the southern basin and at one plant in the northern basin of the lake. Fish densities in plume and reference areas differed seasonally. Densities typically differed by a factor of 2-4 although on one occasion plume area density was 90 times greater. Highest plume densities occurred during late spring when alewife (Alosa pseudoharengus) were spawning inshore. Consistently dense congregations of fish were found downstream of the interfaces between ambient shore-parallel currents and discharge flows. The general distribution of fish with depth was similar in all areas. Differences between plume and reference areas were related to the discharge type: at canal discharges fish tended to congregate inshore while at the offshore discharge they congregated in deeper zones. Fish also tended to occupy shallower depth strata in all plume areas. Positive correlation between fish density and increasing temperature was common at both plume and reference areas during all three seasons, but more frequent at plume areas. Temperatures selected by fish in plume areas were 1-3 degrees higher than maximum ambient temperatures.

82. Tarapchak, Stephen J.; Bigelow, Sylvia M.; Rubitshun, Cora. Over Estimation of Orthophosphorus Concentrations in Surface Waters of Southern Lake Michigan: Effects of Acid and Ammonium Molybdate. Canadian Journal of Fisheries and Aquatic Science; 1982; 39: 296-304.
Water from southern Lake Michigan was analyzed to determine if orthophosphorus (PO4-P) concentrations are overestimated by molybdenum blue methods and to assess the potential effects of ammonium molybdate on soluble reactive phosphorus (SRP) determinations. Time-course "hydrolysis" tests, based on the Chamberlain-Shapiro extraction method, showed that large amounts of orthophosphorus were released from bound sources into solution within seconds after acid molybdate was added, and that molybdate-reactive PO4-P could be retained by filters or released from particulate material into filtrates during filtration. PO4-P concentrations obtained by using the prescribed exposure of 30 s were overestimated minimally by up to 86%, and ammonium molybdate dramatically accelerated PO4-P release in filtered samples. Tests using up to a fourfold range in ammonium molybdate concentrations also showed that the extraction method and Harvey's method yielded SRP values that varied two- to three-fold or more, and that most of the PO4-P was released from "particles" in filtrates. Analytical methods, therefore, can yield substantially different SRP estimates because of differences in the length of time samples are exposed to acid molybdate and because of differences in molybdate concentrations.

83. Transeau, E. N. The Prairie Peninsula. Ecology; 1935; 16: 424-437.

84. U.S. Army Corps of Engineers. Burns Waterway Small Boat Harbor Monitoring Program. Portage County, Indiana. 2nd Annual Report.; 1990.
Note: NRPC.
Lower lake levels have had a significantly positive impact upon the shoreline. There is a consistent increase in beach width.

85. U.S. Army Corps of Engineers Chicago District. Burns Waterway Small Boat Harbor Monitoring Program Portage County, Indiana. 3rd Annual Report.; March 1991.
Note: Mich. City.
The conclusions drawn in this report will be used to evaluate the shoreline conditions and how they pertain to the construction of the Burns Small Boat Harbor, how successful the mitigative efforts have been, if additional mitigation or modifications to the existing monitoring procedure are

needed, and to identify monitoring needs for the following year.

86. U.S. Army Corps of Engineers. Indiana Shoreline Erosion. Final Feasibility Report and Environmental Impact Statement; 1982.
Note: NIRPC.
Shoreline erosion problems were investigated between Michigan City and the Illinois-Indiana state line. The shorelands within the National Lakeshore sustain the most serious shore erosion in the area. Harbor structures are responsible for about 60% of the erosion problem. This plan recommends mitigation of erosion damages caused by federal harbor structures in Michigan City and for restoration of shore processes at the Eastern end of the National Lakeshore.

87. U.S. Army Corps of Engineers. Indiana Harbor, Indiana. Confined Dredged Disposal Facility. Site Selection Study.; 1983.
Note: NIRPC.

88. U.S. Department of Interior; City of Gary, Indiana. Gary Marina. Draft Environmental Impact Statement; 1989.
Note: NIRPC.
Compliance instrument for executive order 11990. The protection of wetlands is discussed. 1,000+ slip marina is proposed to be located between USX breakwater and Marquette Park.

89. U.S. Park Service. Draft Land Protection Plan. Indiana Dunes National Lakeshore, Indiana; 1987.
Note: Mich. City.
Describes methods to protect approximately 4,500 acres of non-federal public or private land remaining within the lakeshore.

90. unknown. Interior Refuses to Step in on Behalf of Indiana Dunes. Conservation News; July 1977; 42(13): 2.

91. unknown. NPCA at Work. National Parks and Conservation Magazine; January 1980; 54(1): 20.

92. Watson, L.R.; Shedlock, R.J.; Banaszak, K.J.; Arihood, L.D.; Doss, P.K. Preliminary Analysis of the Shallow Ground-water System in the Vicinity of the Grand Calumet River/Indiana Harbor Canal, Northwestern Indiana; 1989; US Geological Survey Open-File Rept. 88-492.
Note: Mich. City.

93. Wells, J. R.; Thompson, P. W. Plant Communities of the Sand Dunes Region of Berrien County, Michigan. The Michigan Botanist; 1982; 21: 3-38.

94. Wilcox, D.A.; Apfelbaum, S.I.; Hiebert, R.D. Cattail Invasion of Sedge Meadows Following Hydrologic Disturbance in Cowles Bog Wetland Complex, Indiana Dunes National Lakeshore. Wetlands; 1984; 4: 115-128.

95. Wilcox, D.A.; Simonin, H.A. A Chronosequence of Aquatic Macrophyte Communities in Dune Ponds. Aquat. Bot.; Aug. 1987; 28(3-4): 227-242.
Note: Indiana Dunes Natl. Lakeshore, Porter, IN.
Differences in macrophyte community composition in a chronosequence of spatially separated dune ponds near the south shore of Lake Michigan were examined and related by environmental variables. Ordination of the vegetation data by detrended correspondence analysis revealed similarities in the plant communities of ponds in the same row and community differences between ponds in different rows.

96. Wilcox, Douglas A.; Simonin, Howard A. Aquatic Macrophyte Community Differences in Dune Ponds - Hydrarch Succession or Disturbance? First Indiana Dunes Research Conference Symposium on Plant Succession; May 1-3, 1986; Indiana University Northwest, Gary, Indiana. Scientific Publications Office, 75 Spring Street, S.W., Atlanta, Georgia 30303: U.S. Department of the Interior, National Park Service; 1987: 18.
Previous studies of plant succession at Indiana Dunes by Henry Cowles and Jerry Olson focused on the terrestrial vegetation of successively older dune ridges. Charles Shelford studied succession in the animal communities of the dune ponds that separate these ridges. In the Miller Woods area, adjacent to Gary, Indiana, a chronosequence of dune ponds in distinct linear rows remains despite local residential and industrial development. A study of the aquatic macrophyte communities of 25 ponds was undertaken to assess vegetational differences in relation to age differences between pond rows and water depths. The data suggest that a hydrarch successional sequence exists, with vegetation types changing from Chara/open water in the younger, deeper ponds to Myriophyllum/Nymphaea/Nuphar in the middle-age ponds to Typha in the older, shallower ponds. A closer examination of the data and comparisons with paleoecological data collected by Futyma and by Jackson suggest that the vegetational differences may have resulted from post-settlement disturbance. An assessment of these studies illustrates that the disturbance factor must be

examined closely before drawing conclusions about classical succession.

97. Winnell, M.H.; White, D.S. Trophic Status of Southeastern Lake Michigan Based on the Chironomidae (Diptera). J. Great Lakes Res.; 1985; 11(4): 540-548; ISSN: 0380-1330.

98. Wood, W. L. An Introduction to the Shoreline Problems of the Southern Lake Michigan Coast. Engineering Geology of the Greater Chicago Area and the South Shore of Lake Michigan; 1979: pp. 47-64.
Note: Association of Engineering Geologists.
Prior to the current period of high lake level, narrow bands of foredunes commonly occurred between the dune-bluff system and the lake. These foredunes and wide beaches provided protection for the dune-bluff system and supplied sand to active dune fields. During the recent period of high lake levels on Lake Michigan, the entire shoreline has been subjected to excessive erosion. In areas where high dunes and bluffs exist, erosion has been accentuated by undercutting and slumping of the foreslopes. The presence of erosion control structures, industrial jetties, and navigational breakwaters creates additional environmental pressure on the coastal region. Erosion control structures range from man-made construction alternatives, designed to "wall-off" the entire beach frontage from the lake, to the placement of natural sand nourishment on the beach with the intent of balancing ongoing rates of erosion. Industrial jetties are normally built across the coastal zone in order to transport effluents offshore or to protect coastal industrial sites. Navigational breakwaters are necessary for the commercial and recreational boat traffic; however, the presence of navigational breakwaters causes one of the major erosion problems in the coastal zone. The region upon which this field trip focuses is composed of high dunes and bluffs and is classified, therefore, as a critical erosion area. One aspect of today's field trip (Michigan City, Indiana Dunes National Lake Shore and Mt. Baldy with geologic history) is to observe some of the previously mentioned coastal structures and to discuss their impact on coastal sedimentation and stability.

99. Wood, William L.; Meadows, Guy; Cox, Jack, Dept. of Geosciences, Great Lakes Coastal Research Laboratory, Purdue Univ. (For: Department of Commerce, IN). Summary Report on The Feasibility of the Coastal Installations Proposed for the West Park and Marina Development at Michigan City, Indiana. Economic Feasibility Proposals of West Park and Marina Development. Michigan City, Indiana. T. "Ted" Pantazis ed. Indiana Department of Commerce. Indianapolis, IN: Indiana Dept. of Commerce.
Note: CZM.
The following brief summary report was prepared by the staff of the Great Lakes Coastal Research Laboratory to assist the Indiana Department of Commerce in assessing the feasibility of coastal installations proposed for the West Park and Marina Development at Michigan City, Indiana. The position supported herein is, that existing designs for breakwater and coastal defense systems will have deleterious effects on local and adjacent coastal provinces. It should be understood that this position is taken to be temporarily efficacious and does not imply that no solution is possible. Furthermore this position is designed to stress the concern for a total int grated coastal management concept in the assessment of the environmental impact of any coastal installations in the Michigan City or adjacent areas.

HYDROLOGY

100. Brannon; Gunnison; Averett; Martin; Chen (Waterways Experiment Station, Corps of Engineers). Analyses of Impacts of Bottom Sediments from Grand Calumet River Subtitle: Indiana Harbor Canal on Water Quality; 2-1-89; Miscellaneous Paper D-89-1, Final Report.
Note: Covers Grand Calumet River and Indiana Harbor Canal.

101. City of Gary; Planning and Development; IDNLS (U. S. Dept. of Interior, National Park Service, and City of Gary). Gary Marina; Draft Environmental Impact Statement 1987
Subtitle: City of Gary Marina; 1-1-87; Draft EIS; Draft Report.
Note: Covers Gary Indiana Shoreline, Marquette Park, U. S. Steel lakefill.
Alternative plans for shoreline development and access routes. Contains a history of the plans to develop the Gary shoreline.

102. Cockrell, Ron (IDNLS, National Park Service). Signature of Time and Eternity: Administrative History of IDNLS
Subtitle: Adm. History, IDNLS; 7-20-88.
Note: Covers development of IDNLS since 1966, Save the Dunes movement.
From James R. Whitehouse to Dale B. Engquist.

103. David, S. E.; Wood, W. L.; Weishar, L. L. Shoreline Situation Report, LaPorte County, Indiana; 1981; Special Report, State of Indiana, Coastal Zone Management Program. pp. 73.

104. Davis, R.A.; McGeary, D.F.R. Stability in the Nearshore Bottom Topography and Sediment Distribution, Southeastern Lake Michigan. Univ. of Michigan Great Lakes Res. Div.; 1965; Publ. No. 13: 222-231.

105. Davis, S. E.; Wood, W. L.; Markly, S. M. An Evaluation of Physical and Biological Controls on Coastal Erosion: National Park Service; 1976; Final Report. pp. 85.

106. Davis, S. E.; Wood, W. L. Historic Shoreline Loss in IDNLS Reach 3: National Park Service; 1985; Interim Report. pp. 33.

107. Davis, S. E.; Wood, W. L. A Perspective on Current and Future Condition of INDLS Coastline. Proc. Indiana Dunes Res. Conf.; 1986: pp. 84-96.

108. Davis, S. E.; Wood, W. L. Vegetative Establishment on an Artificial Beach. Proc. 2nd Conf. on Scientific Research in the National Parks; 1979: pp. 304-316.
Establishment of vegetation on the duned Lake Michigan coastline of Indiana Dunes National Lakeshore has not proceeded as expected, following placement of artificial beach nourishment. This nourishment was placed to mitigate severe erosion of the dunes and total denuding of the beach by a combination of recent high lake levels and storm events. The beach fill, composed of glacial till, had a positive influence in controlling coastal erosion, due to an unexpected cementation of the material, which made it highly resistant to wind and wave erosion. However, this induration adversely affected the expected vegetative establishment sequence. Lack of a loose surface material, needed by pioneer vegetation to successfully be introduced, prevented the immediate start of sand capturing grasses. Only wasteland plants, well adapted to hard soil environments, first invaded this artificially stabilized beach. These wasteland plants dominated the fill for several years, with almost no new dune forming activity. The eventual appearance of a few isolated pioneer grasses on the consolidated fill finally initiated embryonic dune growth. These dunes rapidly expanded horizontally, aided by vegetative stabilization, while continuing sand capture allowed vertical growth of the dunes. Presently these dune structures have matured beyond the pioneer plant stage, evidenced by the presence of secondary plants, adding to the diversity of species and consequently to the biological stability of the new dune system. The unnourished areas adjacent to the fill exhibited a totally different influence of this artificial beach on vegetative establishment.

109. Davis, Stephen E.; Wood, William L.; Markley, Susan M. (Great Lakes Coastal Research Laboratory). Evaluation of Physical and Biological Controls on Coastal Erosion in the Indiana Dunes National Lakeshore
Subtitle: Stability, Dunes; 3-1-76; Final Report, National Park Service PX 6000 5 0650.
Note: Covers Mt. Baldy area.

110. Davis, Stephen E.; Wood, William L.; Weishar, Lee L. (Great Lakes Coastal Research Laboratory, Purdue University). Shoreline Situation Report; LaPorte Co., CZM
Subtitle: CZM, Special Report to State Planning Services Agency, CZM Program; 1-1-81; CZ084-80-08.
Note: Covers East of Michigan City to Michigan state line.
The purpose of this shoreline situation report is to present a compilation and assessment of important coastal parameters and characteristics which will assist planners and managers of coastal lands in making decisions concerning these valuable resources. This report places special emphasis on historic and contemporary shore erosion.

111. Environmental Assessment (For City of Portage Port Authority). Environmental Assessment: Marina Development On The Burns Waterway System. 111 North Canal Street, Suite 880; Chicago, Illinois 60606: Howard Tammen Needles & Bergendoff; September 1991.
Note: reprint.
The Environmental Assessment considers the potential impacts of the projects on natural and cultural resources, and the socio-economic and physical environment. Special attention was focused on wetlands, water quality and impacts on the waterway system.

112. Environmental Planning and Engineering Inc. Indianapolis, Ind. (For the Indiana Department of Natural Resources). Regional Park Conceptual Development Plan
Subtitle: L. Calumet River in Northwestern Indiana; 1-1-76.
Note: Covers Lake and Porter Counties.
Detailed plans of the Little Calumet River corridor.

113. Franco, Jr., LTC Jess J. (U. S. Army Corps of Engineers, Chicago Dist. North Central Division). Coordination Meeting: State of Indiana/Corps of Engineers. Subtitle: Project Descriptions; 3-13-90.
Note: Covers Indiana; Little Calumet River, Duneland Beach, Dune Acres, Beverly Shores.

114. Great Lakes Coastal Research Laboratory, Purdue Univ. (Purdue University, for IDNLS). Shoreline Situation-Executive Summary. Subtitle: Indiana Dunes National Lakeshore; 6-1-86; Executive Summary.
Note: Covers IDNLS shoreline.
Summarized the Shoreline Situation Report on the Indiana Dunes National Lakeshore. Erosion rates. Coastal processes.

115. Hill, C. L., B. J. Ryan, B. A. McGregor, and M. Rust. Our Changing Landscape: Indiana Dunes National Lakeshore. United States Government Printing Office: free on application to the Books and Open-File Reports Section, U.S. Geological Survey Federal Center, Box 25425, Denver,CO. 80225.: U.S. Department of the Interior. U.S. Geological Survey.; 1991; U.S. Geological Survey Circular 1085.
Note: reprint.
Earth-science information provides us with estimates of extent and rate of change. We need this information to transform the challenges presented here into opportunities for locating new or additional land, water, and mineral resources; for emphasizing prevention of contamination rather than cleanup; and for increasing our ability to live in harmony with nature.

116. Holm, Nancy Peterson. Inventory of Lake Michigan Research Projects: 1984-1987. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1987.
A review was conducted to assess the existing research programs of various agencies and universities working on Lake Michigan.

117. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography: 1860-1988 Geological and Physical Processes. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1988.
This bibliography covers research publications from 1860 to mid-1988 on geological and physical processes in Lake Michigan.

118. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 1: 1960-1976. Champaign, Illinois: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989a.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

119. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 2: 1977-1986. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989b.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

120. IDEM - Indiana Dept. of Environmental Management and U.S. EPA Region V (IJC - Submitted to International Joint Commission). Northwest Indiana Environmental Action Plan
Subtitle: Area of Concern - Remedial Action Plan for Grand Calumet; 1-1-88; Environmental Action Plan.
Note: Covers Indiana Harbor.

121. IDEM - Indiana Dept. of Environmental Management (IJC - Submitted to International Joint Commission). Northwest Indiana Environmental Action Plan (Draft)
Subtitle: Area of Concern - Remedial Action Plan for Grand Calumet River/Indiana Harbor Canal; 1-1-88; Draft Remedial Action Plan.

122. Indiana Dunes National Lakeshore / Indiana (U.S. Department of the Interior / National Park Service). General Management Plan: Indiana Dunes National Lakeshore / Indiana. 63pp.; Feb. 1980.
Note: reprint.
The general management plan of the IDNLS. Two major trends affecting the natural environment of IDNLS has been the continual encroachment by residential, agricultural, and industrial development on the great Lake Michigan shoreline, and a growing awareness of the importance of creating national parks near urban area.

123. Indiana Dunes National Lakeshore / Indiana (U.S. Department of the Interior / National Park Service). General management plan amendment development concept plan/environmental assessment.; Sept. 1990.
Note: reprint.
The purpose of this General Management Plan Amendment/ Development Concept Plan/Environmental Assessment is to update the 1980 General Management Plan (GMP) considering the full range of issues that will affect the West Unit through the year 2000. These management issues include access to West Beach, location of the West Unit transit center and parking area, use of shuttle bus systems, impacts of traffic on adjacent communities, additional hiking and biking trail, boundary adjustments, and use of lands adjacent to the Portage/Burns Waterway and those lands between the Paul H. Douglas Environmental Education Center and Broadway in Gary.

124. Indiana Shoreline Erosion (U.S. Army Corps of Engineers). Indiana Shoreline Erosion: Final Feasibility Report and Environmental Impact Statement.; June 1982.
Note: reprint. Interim document under agency review subject to revision.
This study investigated the shoreland erosion problems between Michigan City Harbor, Indiana and the Illinois-Indiana State line. As a result of the study this report recommends shore erosion control measure for the reach of shore immediately west of Michigan City Harbor.

125. Indiana Dunes National Lakeshore Planning Newsletter. NPS To Revise Three Lakeshore Reports. Denver Service Center: National Park Service; March 1991.
Note: reprint.
This newletter summarizes the comments made at the public review and comment period for three draft national lakeshore reports closed on December 3, 1990. Responses to each comment explain and clarify the NPS position. The National Park Service will correct errors and clarify ambiguous aspects of the draft documents.

126. Indiana Department of Natural Resources (For Indiana State Planning Services Agency). Shoreline Erosion Along the Indiana Coast of Lake Michigan. Subtitle: Erosion, DNR; 4-30-79; Technical Report No. 307.
Of the approximately 45 shoreline miles along Lake Michigan, 21.8 miles are protected from the process of erosion, 10.2 miles have recession rates less than 1 foot per year, while the remaining 13 miles are classified as erosion hazard areas. It is concluded that in view of the existing legislative authority, the local units of government are best suited to establish and administer a shore erosion management program along the Indiana shoreline of Lake Michigan.

127. Indiana Shoreline Erosion, Indiana (U.S. Army Engineer District). Shoreline Erosion Protection At Indiana Dunes National Lakeshore General Design Memorandum. 111 North Canal Street; Chicago, Illinois 60606-7206: Department Of The Army. Chicago District, Corps of Engineers; April, 1990.
Note: reprint.
The purpose of this project is to mitigate shore erosion damages along the Indiana Dunes Lakeshore.

128. Larsen, C.E. Late Holocene Lake Levels in Southern Lake Michigan, in Collison, C., ed., Coastal Geology, Sedimentology, and Management; Chicago and the Northshore: Illinois State Geological Survey Guide-book series 12; 1974.
Note: p. 39-49.

129. Larsen, C.E. A Stratigraphic Study of Beach Features on the Southwestern Shore of Lake Michigan: New Evidence of Holocene Lake Level Fluctuations. Illinois State Geological Survey, Environmental Geology Notes; 1985a; 112: 31 p.

130. Larsen, Curtis E. Long-term trends in Lake Michigan Levels, a View from the Geologic Record. Proceedings: Symposium on shoreline processes; First Indiana Dunes Research Conference; May 1986: 5-22.
Note: see also Wilcox, Douglas A.
Thirty years ago Olson (1958a,b) showed a strong relationship between times of dune formation at the Indiana Dunes and low-level periods of Lake Michigan. He indicated that an extended low level had occurred about 400 years ago (A.D. 1550) following a high-level period at about 600 years ago (A.D. 1350). This prehistoric record was not fully appreciated by those contemporaries who assumed lake level changes over the past 3,000 years to have taken place on a time scale like that of the past century's historic record. Stratigraphic studies along the southern shore of Lake Michigan now show a record of Lake level change that extends at least 2,000 years into the past. High-level periods occurred between A.D. 400 and 650, between A.D. 950 and 1225, and between A.D. 1500 and 1850. These left geologic records in stream mouth alluvial deposits now 1 and 2 m above the modern channels. Intervening periods of low level are dated by peat and marsh deposits now beneath the modern level of Lake Michigan. The historic lake level record of the past 125 years appears to represent a low phase on a naturally fluctuating trend. Both prehistoric and historic records show lake level changes over this period to have been climate related. The current episode of high lake levels, when seen in geologic perspective, represents a return to normal long-term climatic trends.

131. Marie, James R. (U.S. Geological Survey). Model Analysis of Effects on Water Levels at Indiana Dunes National Lakeshore Caused by Construction Dewatering: U.S. Dept. of the Interior; July 1976; Water-Resources Investigations 76-82.
Note: Mich. City.
Two comprehensive models were developed to investigate possible hydrologic effects within the Indiana Dunes National Lakeshore caused by planned dewatering at the adjacent Bailly Nuclear Generator Construction Site. The results of this study have been used by the National Park Service to help evaluate the environmental impact of the dewatering, particularly the effects on the ecosystem of the lakeshore.

132. Olson, J.S. Lake Michigan Dune Development: 3, Lake Level, Beach, and Dune Oscillations. Journal of Geology; 1958a; 66: 473-483.

133. Olson, J.S. Rates of Succession and Soil Development on Southern Lake Michigan Sand Dunes. Botanical Gazette; 1958b; 119: 125-170.

134. Reshkin, Mark. A Regional Management Approach is Needed to Lake Michigan Coastal Erosion in Indiana. First Indiana Dunes Research Conference. Indiana Dunes: A Century of Scientific Inquiry. Proceedings: Symposium on Shoreline Proceeses; May 1-3, 1986: pp. 47-52.
Public concern is again escalating over Lake Michigan shoreline erosion along the Indiana coast. Three areas affected are Long Beach, Beverly Shores and Ogden Dunes. Shoreline erosion is a chronic and most severe condition when lake levels are high. It can be managed but not cured. Management must be practical and continuous. Hardened structures are appropriate for some areas, beach nourishment for others and whether to attempt any protection of some areas is a policy question. Achieving regional management requires: 1. completing the studies of erosion proccesses to determine erosion rates; 2. determining how much of the erosion in each reach is natural and how much is human-induced; 3. establishing goals and priorities for erosion mitigation with the degree of mitigation determined on the basis of the responsibility to protect significant natural landmark areas, cost-effectiveness as it relates to the economic value and growth of commercial recreational activities, and the degree of public sector responsibility to aid in the protection of residential area. Selection of a management agency and the necessary legislation and funding mechanisms should involve participation of all levels of government.

135. School of Civil Engineering, Purdue University (Great Lakes Coastal Research Laboratory). Executive Summary; Shoreline situation Indiana Dunes National Lakeshore. Purdue University; June, 1986 booklet.
The Indiana Dunes National Lakeshore (IDNLS) was established in 1966 during a period of record rise in lake-level, but at a time when absolute lake-level was still below average. In 1974 after lengthy study, discussion, and compromise the first major "hard" coastal shore protection structure was constructed along IDNLS coastline (a 13,000 foot long rock revetment constructed to protect Lake Front Drive in Beverly Shores, IN). In that same year a major "soft" shore protection structure, in the form of a beach nourishment

fill, was placed in front of Mt. Baldy west of Michigan City, In. The Great Lakes Coastal Research Laboratory, Purdue University was selected as the monitering agency in 1975 to determine the effectiveness and impact along the coast of these structures. The purpose of this Shoreline Situation Report is to present a complete data base on and rigorous assessment of the shoreline and adjacent nearshore area within the IDNLS. This report contains a thorough evaluation of coastal parameters and characteristics useful to engineers, planners and managers of Indiana's coastal lands. Emphasis is placed on coastal processes as they relate to historic and contemporary erosion. Particular attention is given to position changes of the shoreline, bluff top, nearshore sand bars, and dune vegetation. Beach and nearshore sediments are analyzed with respect to their contemporary grain properties and compared to historic data to determine areas of change. An important aspect of this report deals with man-made structures on the coast and their impact on overall coastal stability. Recognizably, the proximity of owners homes to the receding shoreline of Indiana presents a special set of problems. However, poorly conceived coastal erosion control structures can ultimately be more damaging than helpful to overall coastal integrity. The basic philosophy guiding preparation of this report is that only through judicious planning can optimum benefit be derived from Indiana's coastal resources.

136. Shedlock, Robert J.; Harkness, William E. (U.S. Geological Survey). Shallow Ground-Water Flow and Drainage Characteristics; Brown Ditch Basin Near the East Unit of IDNLS. Subtitle: Groundwater; 1-1-82; Water-Resources Investigations Report 83-4271.
Note: Covers Porter Co, Ind.
Brown Ditch consists of several segments that drain wetlands between dune ridges near the East unit of Indiana Dunes National Lakeshore in Porter County, Indiana, west of Michigan City.

137. Thompson, Todd A. Development of the Late Wisconsin to Early Holocene Calumet and Toleston Dune/Beach Complexes in the Indiana Dunes National Lakeshore. First Indiana Dunes Research Conference. Indiana Dunes: A Century of Scientific Inquiry. Proceedings: Symposium on Shoreline Processes; May 1-3, 1986: pp. 1-4.
The Calumet and Toleston dune/beach complexes formed along the southeastern shore of Lake Michigan following the post-Two Creeks and post-Chippewa transgressions in ancestral Lake Michigan respectively. Vibracores and exposures along the shoreline show that much of the back-barrier coastal deposits

were preserved during the post-Chippewa transgression, whereas the post-Two Creeks transgression removed almost all of the coastal sequence. These variations in preservation are believed to be related to differences in rate of change in lake level, slope and topography of the predepositional surface, and amount of sediment supplied to the shoreline.

138. U.S. Army Corps of Engineers. Burns Waterway Small Boat Harbor, 1st Annual Report. Subtitle: Monitoring Program, Portage Co. Indiana; 5-1-89; 1st Annual Report.
Note: Covers Portage/Burns Waterway, Lake Michigan, Ogden Dunes to Gary.
Shoreline erosion.

139. U.S. Army Corps of Engineers. Burns Waterway Small Boat Harbor, 2nd Annual Report. Subtitle: Monitoring Program, Portage County, Indiana; 9-1-90; 2nd Annual Report.
Note: Covers Portage/Burns Waterway, Lake Michigan, Ogden Dunes to Gary.
Shoreline erosion.

140. U.S. Army Corps of Engineers. Environmental Impact Statement (Draft). Subtitle: Michigan City - Operation and Maintenance Activities; 8-1-77; EIS.
Note: Covers dredged material disposal, Michigan City Harbor.

141. U.S. Army Corps of Engineers (Chicago District). Indiana Shoreline Erosion 1982 Final Report. Subtitle: Final Feasibility Report and Environmental Impact Statement; 6-1-82.
Note: Covers between Michigan City Harbor and Illinois-Indiana State Line.
Recommendation for erosion control measures immediately west of Michigan City Harbor.

142. U.S. Army Corps of Engineers. Interim Report on Indiana Shoreline Erosion October 1975. Subtitle: Detailed Feasibility Report; 10-1-75.
Reconnaissance investigation of the effect of the Michigan City Harbors structure on adjacent shorelands.

143. U.S. Army Corps of Engineers. Project Maps: River and Harbor Works; 9-1-85; September 1985.
Note: Covers Wisconsin to Michigan shoreline of Lake Michigan.
Technical information on harbor engineering designs.

144. U.S. Army Corps of Engineers. Section III Reconnaissance Report - Michigan City Harbor, Indiana. Internal Report. Chicago district: U.S. Army Corps of Engineers.

145. U.S. Geological Survey. Surface-Water-Quality Assessment, Upper Illinois River Basin - Subtitle: NAWQA; 1-1-87; Open-File Report 87-473.
Note: Covers Northwest Indiana, Illinois, and Wisconsin. National Water Quality Assessment Program.

146. U.S. Geological Survey, Indiana State Board of Health. Streamflow and Water Quality of the Grand Calumet River Subtitle: Grand Calumet, Lake Co. Indiana and Cook Co. Illinois; October 1984; 1-1-87; Water-Resources Investigation Report 86-4208.

147. Weishar, L. L.; Wood, W. L. Impact of Long Period Water Level Fluctuations on Beach and Nearshore Changes in the Great Lakes (abs). EOS; 1982; 63(No. 3).
A fifteen year data set of nearshore beach and bathymetric profiles obtained along the southeastern shore of Lake Michigan has been analyzed using the method of empirical eigenfunctions. This analysis identified two primary modes of spatial variation. One is a dominant long period mode, while the other is a short period mode. A similar analysis of 120 years of monthly mean lake level records indicated two major long period trends in the record. These two long period trends are shown to be the probable sources of physical forcing of beach and nearshore profile change. This forcing is the result of long term modulation of local mean and wind-wave fields by the monthly mean lake level.

148. Weishar, L. L.; Wood, W. L. Systematic Changes in Beach Profile and Nearshore Topography. Proc. 2nd Conf. on Scientific research in the National Parks; 1979: pp. 87-100.
A three year set of monthly beach and nearshore topographic profiles have been obtained form the southeastern shore of Lake Michigan in the Indiana Dunes National Lakeshore (I.D.N.L.S.). This ongoing study was initiated to determine the temporal and spatial beach and nearshore characteristics of a typical sandy Great Lakes Coastline. Empirical eigenfunction analysis was performed on the three year (1976-1978) data set of beach and nearshore topographic profiles measured monthly from May to November along the coast of IDNLS. This empirical eigenfunction analysis results in a series of eigenvalues and their corresponding temporal and spatial functions which describe the variance in the data. This analysis determined that the major variations contained within the monthly data set could be explained by the first

three eigenvalues and their corresponding temporal and spatial functions. The first three eigenvalues represent approximately 97% of the total variance contained within the data. The majority of the variance contained within the data is represented by the first eigenvalue which represents the mean beach profile. The second most important eigenvalue is spatially reflected in the migration of the nearshore bars. The temporal signature of this eigenfunction corresponds to the passage of meteorologic systems. The third eigenvalue is spatially represented by small deviations from the mean along the entire profile line. This eigenvalue's temporal variation is reflected in the seasonal variation of lake level. The results of this analysis have been used to conceptualize a predictive model for beach and nearshore profile changes. The predictive model will combine spatial and temporal components to forecast changes in the beach and nearshore topographic profile. The spatial component will be represented by a mean beach profile, while the temporal components would be represented by wave climatology and lake level data.

149. Wilcox, Douglas A.; Hiebert, Ronald D.; Wood, James D. Jr., Editors. First Indiana Dunes Research Conference: Symposium on shoreline processes [Indiana Dunes National Lakeshore, 1100 N. Mineral Springs Road, Porter, Indiana 46304]. First Indiana Dunes Research Conference. Indiana Dunes: A Century of Scientific Inquiry; May 1-3, 1986; Indiana University Northwest, Gary, Indiana. Scientific Publications Office, 75 Spring Street, S.W., Atlanta, Georgia 30303: U.S. Dept. of Interior, National Park Service; 1986?
Note: The individual papers included in this symposium are entered under their authors in seperate bibliographies.
The theme of the conference was: Indiana Dunes - A century of Scientific Inquiry. It was attended by over 160 scientists, students, naturalists, and employees of the Indiana Dunes National Lakeshore. This edition of the proceedings is the result of the invited symposium on Shoreline Processes. The other symposia were on: Plant Succession, Visitor Aspects of Resource Management, and Natural History of NW Indiana. The contributed paper sessions focused on: Geohydrology and Aquatic Resources, Cultural Resources, Animal Sciences, Air Quality Monitoring and Effects, Plant Autecology, and General Plant Ecology.

150. Wood, W. L. Coastal Sedimentation and Stability in Southern Lake Michigan. Coastal and Environmental Geology of Southeastern Lake Michigan; 1976: pp. 1-37.
Note: Geological Society of America.

151. Wood, W. L. Coastal Degradation at Indiana Dunes National Lakeshore in the Vicinity of Beverly Shores, Indiana: Great Lakes Coastal Research Laboratory; 1979; Position Paper No. 10. pp. 7.

152. Wood, W. L. Coastal Response to Lake-level Variation and Storm Wave Occurrence in Southern Lake Michigan. Proc. Indiana Dunes Res. Conf.; 1986: pp. 71-83.
Seasonal changes in beach profile are caused by seasonal change in wave conditions incident at the shore. However, bottom variability immediately adjacent to the beach is complicated by the modulating effects of seasonal and long-term lake-level variation. In southern Lake Michigan the inner-bar position actively changes under the influence of storm waves, but appears to lack a well-defined seasonal pattern. Conversely, the outer-bar position is seasonally stable, yet exhibits a long-term movement pattern which is directly related to mean annual lake-level variation.

153. Wood, W. L. "Hydrologic System of the Great Lakes", in Decisions for the Great Lakes; 1982.
Note: Editors: Reshin, Mark; Daniels, Glenda.

154. Wood, W. L. Indiana Dunes National Lakeshore Pre-Nourishment Conditions and Recommended Monitor Program: U. S. Army Corps of Engineers; 1986; Final Report. pp. 78.

155. Wood, W. L. An Introduction to the Shoreline Problems of the Southern Lake Michigan Coast. Engineering Geology of the Greater Chicago Area and the South Shore of Lake Michigan; 1979: pp. 47-64.
Note: Association of Engineering Geologists.
Prior to the current period of high lake level, narrow bands of foredunes commonly occurred between the dune-bluff system and the lake. These foredunes and wide beaches provided protection for the dune-bluff system and supplied sand to active dune fields. During the recent period of high lake levels on Lake Michigan, the entire shoreline has been subjected to excessive erosion. In areas where high dunes and bluffs exist, erosion has been accentuated by undercutting and slumping of the foreslopes. The presence of erosion control structures, industrial jetties, and navigational breakwaters creates additional environmental pressure on the coastal region. Erosion control structures range from man-made construction alternatives, designed to "wall-off" the entire beach frontage from the lake, to the placement of natural sand nourishment on the beach with the intent of balancing ongoing rates of erosion. Industrial jetties are normally built across the coastal zone in order

to transport effluents offshore or to protect coastal industrial sites. Navigational breakwaters are necessary for the commercial and recreational boat traffic; however, the presence of navigational breakwaters causes one of the major erosion problems in the coastal zone. The region upon which this field trip focuses is composed of high dunes and bluffs and is classified, therefore, as a critical erosion area. One aspect of today's field trip (Michigan City, Indiana Dunes National Lake Shore and Mt. Baldy with geologic history) is to observe some of the previously mentioned coastal structures and to discuss their impact on coastal sedimentation and stability.

156. Wood, W. L.; Davis, S. E. Effectiveness and Environmental Impact of Beach Nourishment at the Indiana Dunes National Lakeshore: Great Lakes Coastal Research Laboratory; 1978; Technical Paper No. 10. pp. 24.

157. Wood, W. L.; Davis, S. E.; Weishar, L. L.; Price, C.; Hagerman, K. R.; Shunk, M. Indiana Dunes National Lakeshore Monitoring Program: U. S. Army Corps of Engineers; 1978; Progress Report No. 8. pp. 72.

158. Wood, W. L.; Davis, S. E.; Weishar, L. L.; Price, C.; Hagerman, K. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1979; Progress Report No. 10. pp. 24.

159. Wood, W. L.; Davis, S. E.; Weishar, L. L.; Price, C. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1979; Progress Report No. 9. pp. 61.

160. Wood, W. L.; Davis, S. E.; Weishar, L. L.; Hinze, L. M. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1980; Interim Report No. 2. pp. 29.

161. Wood, W. L.; Davis, S. E.; Weishar, L. L. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1982; Final Report. pp. 47.

162. Wood, W. L.; Davis, S. E. Indiana Dunes National Lakeshore Monitoring Program: National Park Service; 1984; Final Report. pp. 42.

163. Wood, W. L.; Davis, S. E. Indiana Dunes National Lakeshore Shoreline Situation Report, Reach 3: National Park Service; 1984; Interim Report. pp. 53.

164. Wood, W. L.; Davis, S. E. Indiana Dunes National Lakeshore, Shoreline Situation Report: National Park Service; 1986; Final Report. pp. 330.

165. Wood, W. L.; Davis, S. E.; Weishar, L. L. Potential Influence of Marquette Park Small Boat Harbor on Nearshore Hydrodynamics and Sediment Transport: Great Lakes Coastal Research Laboratory; 1979; Technical Paper No. 11. pp. 18.

166. Wood, W. L.; Magnus, R. R.; Thacker, P. A.; Price, C.; Weishar, L. L. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1977; Progress Report No. 5. pp. 58.

167. Wood, W. L.; Magnus, K. R. Microtopography and Possible Stream Channels on the Shallow Bottom of Southern Lake Michigan. Journal of Sedimentary Petrology. Note: Submitted for publication.

168. Wood, W. L.; Magnus, K. R.; Thacker, P. A.; Davis, S. E.; Meadows, G. A.; Price, C. Performance of Beach Nourishment at the Indiana Dunes National Lakeshore: U.S. Army Corps of Engineers; 1976; Interim Report. pp. 71.

169. Wood, W. L.; Meadows, G. A.; Davis, S. E.; Magnus, K. R.; Rouch, J. R. An Evaluation of the Effectiveness of Beach Nourishment and Revetment Structures at the Indiana Dunes National Lakeshore: U.S. Army Corps of Engineers; 1975; Progress Report No. 2. pp. 44.

170. Wood, W. L.; Meadows, G. A.; Cox, J. C. The Feasibility of the Coastal Installations Proposed for West Park and Marina Development at Michigan City, Indiana: Department of Geosciences, Great Lakes Coastal Research Laboratory, Purdue University; 1973; Summary Report. pp. 5.

171. Wood, W. L.; Meadows, K. R.; Davis, S. E.; Rouch, J. R. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1975; Progress Report No. 3. pp. 55.

172. Wood, W. L.; Price, C.; Weishar, L. L. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1977; Progress Report No. 6. pp. 65.

173. Wood, W. L.; Thacker, P. A.; Davis, S. E.; Magnus, K. R.; Rouch, J. R. Indiana Dunes National Lakeshore Monitoring Program: Army Corps of Engineers; 1976; Progress Report No. 4. pp. 55.

174. Wood, W. L.; Weishar, L. L. Beach Response to Long Period Lake-level Variation. Proc. 19th Int. Conf. on Coastal Eng.; 1984; 19: pp. 1571-1583.
A 4-year set of beach and offshore profiles, measured at monthly intervals, is evaluated to determine the effect of wind-wave forcing and long period (1 year or greater) lake-level variation on beach profile change in the "tideless" Great Lakes. This evaluation indicates two distinct regions of change in the beach and nearshore area of these profiles. The beach-berm region responds directly to lake-level modulation of wind-wave forcing. This response occurs on two time scales (seasonal and long period), but always in direct relation to mean lake-level variation. The inner-bar actively changes under the influence of wind-waves, but appears to lack a well-defined seasonal pattern. Empirical eigenfunction analysis is applied to these data in order to statistically quantify the significance of these observed changes. This analysis provides confirmation of a hypothesized long-period (years) variation of the beach and berm in direct response to the lake-level variation.

175. Wood, W. L.; Weishar, L. L. Impact of Long Period Water Level Fluctuations on Beach and Nearshore Changes in the Great Lakes. EOS; January 19, 1982; 63(3): 22b-9.
Note: Abstract.
A fifteen year data set of nearshore beach and bathymetric profiles obtained along the southeastern shore of Lake Michigan has been analyzed using the method of empirical eigenfunctions. This analysis identified two primary modes of spatial variation. One is a dominant long period mode, while the other is a short period mode. A similar analysis of 120 years of monthly mean lake level records indicated two major long period trends in the record. These two long period trends are shown to be the probable sources of physical forcing of the beach and nearshore profile change. This forcing is the result of long term modulation of local mean and wind-wave fields by the monthly mean lake level.

176. Wood, W. L.; Weishar, L. L.; Price, C.; Davis, S. E. Indiana Dunes National Lakeshore Monitoring Program: U.S. Army Corps of Engineers; 1978; Progress Report No. 7. pp. 58.

177. Wood, W. L.; Weishar, L. L. Influence of Lake Level Variation and Storm Waves on Coastal Stability (invited paper). Proc. 3rd Workshop on Great Lakes Coastal Erosion and Sedimentation; 1982: pp. 63-66.
Seasonal changes in beach profile caused by changes in incident wave conditions have long been recognized on most of the world's sandy coastlines. However, seasonal changes in the offshore region immediately adjacent to a beach are less well understood. Since wind-waves are a primary energy source in this offshore region as well as on beaches, it is presumed that related seasonal changes may be observed on both. During the past 4 years a set of precisely measured offshore and beach profiles has been collected at monthly intervals along the southeastern shore of Lake Michigan. The four years of bathymetric profile data were initially evaluated in order to identify dominant areas of profile change. This evaluation indicated three distinct areas of profile change: the beach and berm, the inner-bar, and the outer-bar region. Each of these regions was found to vary independently of the other two. In order to evaluate impact of storm waves on beach and offshore response a series of profiles were collected on 2 to 5 day intervals during one month periods in spring and fall 1978 and 1979. During each survey period observations were made (at three hour intervals) on wind speed, wind direction, and wave height.

178. Wood, W. L.; Weishar, L. L.; Davis, S. E. Storm Impact on Systematic Changes in Beach and Nearshore Topography. Proc. 2nd Conf. on Scientific Research in the National Parks; 1979: pp. 101-110.
Changes in beach and nearshore topography have been monitored, for the past five years, along a section of coastline at the Indiana Dunes National Lakeshore. Empirical eigenfunction analysis of beach and nearshore data have shown that topographic changes are systematically related to seasonal wind wave and lake level variations. Anomalous variations in these periodic, systematic beach and nearshore topographic changes indicated that the eigenfunction analysis was sensitive to episodic events. A detailed analysis of topographic changes, at close time intervals, has shown that storm events are readily detected as significant variations in the temporal eigenfunction, weighted by its corresponding eigenvalue. Most significant in these results is the suggestion that storm impact on a coast can be predicted, in a statistical context, from climatological data. Specifically, these climatological data can be used to develop a probability distribution of episodic storm events and their intensity. Since this distribution is the episodic portion of the "forcing" on the second eigenfunction (wind

waves and currents), it can be used to predict changes in beach and nearshore topography. Herein lies the potential to develop models capable of predicting both periodic and episodic changes in topography for sandy coastlines of the Great Lakes.

179. Wood, William L. Coastal Response to Lake-Level Variation and Storm Wave Occurrence in Southern Lake Michigan. First Indiana Dunes Research Conference
Subtitle: Indiana Dunes: A Century of Scientific Inquiry
Proceedings: Symposium on Shoreline Processes; May 1-3, 1986: pp. 23-33.
Seasonal changes in beach profile are caused by seasonal change in wave conditions incident at the shore. However, bottom variability immediately adjacent to the beach is complicated by the modulating effects of seasonal and long-term lake-level variation. In southern Lake Michigan the inner-bar position actively changes under the influence of storm waves, but appears to lack a well defined seasonal pattern. Conversely, the outer-bar position is seasonally stable, yet exhibits a long-term movement pattern which is directly related to mean annual lake-level variation

180. Wood, William L.; Davis, Stephen E. (Great Lakes Coastal Research Laboratory). Indiana Dunes National Lakeshore Situation Report. Subtitle: Shoreline Situation Report; 10-1-86.
Note: Covers Indiana Dunes National Lakeshore Property. Coastal parameters and characteristics, coastal processes.

181. Wood, William L.; Davis, Stephen E. A Perspective on the Present and Future Conditions of the Indiana Dunes National Lakeshore Coastline. First Indiana Dunes Research Conference
Indiana Dunes: A Century of Scientific Inquiry
Proceedings: Symposium on Shoreline Processes; May 1-3, 1986: pp. 34-46.
The recently completed Indiana Dunes National Lakeshore, Shoreline Situation Report provides detailed description and analysis of historic and present coastal conditions. Detailed beach and offshore survey data from 1966 to present indicate that changes in relative coastal stability may be more dramatic in offshore areas than on the shore. This result is most dramatic at and downrift from coastal engineering structures. Coastal recession rates are highly variable over short horizontal lengths of coastline and do, therefore, require careful consideration with respect to long-term prediction. Consideration of present coastal conditions raises some difficult questions with respect to long-term management of IDNLS shoreline.

182. Wood, William L.; Gutschick, Raymond C.; Gonsiewski, James (Western Michigan University, Dept. of Geology). Field Trip Guidebook: Coastal and Environmental Geology - Subtitle: Southern Lake Michigan; 1-1-76; Kalamazoo.
Note: Covers Southern Lake Michigan, Mt. Baldy Indiana.
10th Annual Meeting- Geological Society of America.

183. Wood, William L.; Hoover, Julie A.; Stockberger, Todd M.; Zhang, Yan (Great Lakes Coastal Research Laboratory, Purdue University). State of Indiana Coastal Situation Report
Subtitle: Coastal Situation Report; 6-1-88.
Note: Covers shoreline of Indiana.
Comprehensive erosion, structure, processes review.

184. Wood, William L.; Madalon, Leonard J.; Wood, Christine L. (SEACO Inc. West Lafayette, Indiana). NIPSCO Beach Nourishment Sediment Evaluation for Southern Lake Michigan
Subtitle: Final Report; 6-1-90; Final Report.
Note: Covers NIPSCO Bailly plant, NIPSCO Michigan City plant
* Not available for distribution.

RECREATION

185. The Abonmarche Group (For the Lake Michigan Marina Development Commission). Estimate of the demand for recreational boat slips along the Lake Michigan Shoreline in northern Indiana.; Aug. 1990.
Note: reprint.
An analysis of recreational boating characteristics in the northern Indiana area. A survey of existing, planned and proposed marinas along the shoreline including study of the number of slips by length and purchase or rental prices. Estimation of the potential demand for new recreational boat slips for the period of 1990 through 1995, as well as an estimate of overall demand for the year 2000. Preparation of findings and conclusions pertaining to changes in market conditions and trends.

186. Absher, J.D.; Collins, J.R. Southern Lake Michigan Sportfishery: Angler Profiles and Specialization Index for Illinois and Indiana; 1987: University of Illinois, Urbana-Champaign, IL; ISSN: IL-IN Se· Grant.
Sportfishing is a major pursuit of many people that frequent Lake Michigan. Besides the intangible benefits it affords anglers, it contributes to the economic growth of the Lake region. The goals of this project were to provide baseline data on the use of the SLM sportfishery and to further refine and test the concept of recreational specialization. Results from this study have begun to develop a profile of the Illinois and Indiana SLM (southern Lake Michigan) angler and to develop a SLM angler taxonomy useful to many of the Lake's sportsfishing providers. With need for more definitive information about the SLM angler, the first objective of this study was to provide seperate profiles for the Illinois and Indiana SLM angler. The profiles consisted of over 220 items covering 13 major areas of inquiry. Each state was treated seperately and completely. The results were not easily encapsulated. The reader is referred to the table of contents for specific angler characteristics of interest (sociodemographics, fishing and behavior habits, motivations and satisfactions, management preferences, health risks, and non-southern Lake Michigan anglers). This angler taxonomy (low specializaion anglers, medium specialization anglers, and high specialization anglers) has provided evidence not only that there is an inherent diversity of behaviors, preferences, and motives within the realm of sportsfishing, but that this diversity can be systematically explained in terms of an activity specialization scale based on five characteristics of motivation. The specialization scale can

help in managing the SLM angler population. To treat SLM anglers as a homogeneous unit could be misleading and could also fail to provide optimized benefits for obviously distinct segments of this angler population.

187. Bartholomew, Wayne ; Joray, Paul ; Kochanowski, Paul. An Analysis of the Economic Impact of the Marinas and Launching Facilities in Michigan City on the Michigan City Economy. [Report for the Michigan City Port Authority.]. Michigan City, IN; April 1981.
Note: 2 copies.
The marinas and boat launching facilities are an integral part of the Michigan City economy. The purpose of this research project is to estimate the economic impact of these facilities and boating in general on the Michigan City economy. The total impact is measured by using the export base model to project flow of income throughout the Michigan City economy that results from the direct income gains. Three major conclusions can be drawn from our analysis of the impact of boating upon the Michigan City economy. First, the impact upon the economy is substantial, ranging from approximately $13.4 million annually to approx. $17.4 million. This latter figure includes the estimated special impacts. Secondly, the impact upon the economy is extremely widespread. It is fair to say that anyone who sells either a product or service in Michigan City and anyone who works for a company that sells a product or service in Michigan City benefits from boating. Third, the lakeshore is an important resource that holds considerable comparative advantage for Michigan City vis-a-vis other cities in Indiana. This resource can make a major contribution to the Michigan City economy and to its residents if it is carefully developed. The impact of boating upon the Mich. City economy is substantial. Our surveys estimate that private marinas and events (Coho Club and Shriners Salmon Derby) contribute a direct economic impact of about $2.4 million, an indirect income impact of $2.1 million and a total impact of $4.5 million. We estimate that the public marinas and launching facilities generate a direct impact of $2.5 million, an indirect impact of $2.3 million, and a total impact of $4.8 million. Michigan City's In The Water Boat Show is estimated to have a $4.1 million impact. Finally, the families who own year round and summer homes for boating-related activities, and whose imcome is from outside of Michigan City, contribute an income impact of approximately $1.3 million. Thus the total impact is nearly $15 million annually. Many people in the community view the benefits from activities like boating as accruing only to those who use the facilities or sell goods and services directly to the users. However, virtually

everyone in Michigan city benefits in some manner from the $15 million in extra income brought into the community. It is true that the income goes initially to those who sell directly to boaters, but the income is soon spent on other items, thus increasing the incomes of other Michigan City residents, and also contributes to the local tax base.

188. Chicago District Economics Branch (Department of the Army, Chicago District, Corps of Engineers). Lake Michigan Regional Boating Study and Analysis. DRAFT. Chicago, IL: ACE; May 1973.
Note: CZM.
This study is a comprehensive economic analysis of the need for small boat harbors on Lake Michigan. It includes descriptive, analytical, and quantitative material relevant to small boat harbor studies. The first objective was to describe and analyze the present patterns of boating on Lake Michigan via the information provided by a sample survey of boaters in the region. The second objective was to estimate the change in demand for Lake Michigan boating facilities.

189. City of Hammond; Hughes Associates. Hammond Marina Access Study. Final Report.; August, 1980; Project Indiana CZ084-80-04.
Note: NRPC.
The Lake County Park and Recreation Board has proposed the development of a 200-600 boat marina to be located on the Lake Michigan shore of the City of Hammond. A major concern of the City of Hammond is providing access to the site which is safe and convenient for marina users and which produces a minimum of disruption in existing traffic patterns and commercial, industrial and residential uses in the area.

190. Commercial and Recreational Harbor Dredging Task Force. Great Lakes Commercial and Recreational Harbor Dredging: Issues and Recommendations; 1988.
Note: Mich. City.
Final Report to the Great Lakes Commission.

191. Conroy, Kathleen/Lake County Parks and Recreation Department (For the Lake County Indiana Parks and Recreation Board). Park & Open Space Plan 1988. Lake County, IN.: Lake County Parks and Recreation Department; July 1988.
Note: reprint.
A complete and useful guide for the long range development of a county park system. This plan will set forth goals, policies, and standards to meet county open space and recreation needs to the year 2010. This plan will also

provide the Park Board with a blueprint for acquisition and development of recommended county park sites.

192. Crowe Chizek and S. B. Friedman & Company (For City of Gary, Indiana). Market Analysis For A Proposed Marina In Gary, Indiana.: Crowe Chizek and S. B. Friedman & Company; Oct. 1991.
Note: reprint.
The site, located at the eastern lakeside portion of the USX property near the public boat launch, is suitable for marina development if planned improvements and management actions address several physical limitations and environmental conditions which need to be ameliorated.

193. D'Appolonia Consulting Engineers, inc. (For Lake County Parks and Recreation Board, Crown Point, IN). Draft Environmental Impact Assessment, Gary Marina Site.; 1976; Project No. MW76-726.
Note: NRPC.
The proposed Marquette Park Small Harbor, referred to here as Gary Marina is located at the lakefront on the southern shore of Lake Michigan in Gary City, Lake County, IN. The objective of the proposed Gary Marina is to provide the citizens of the region, particularly of Lake County, with an access to Lake Michigan, a natural resource that has limited accessibility for public use in Lake County. Should the marina project be implemented it will offer opportunity for a harbor of refuge, boating, fishing, swimming, water skiing, picknicking, nature walks, and other outdoor recreation activities.

194. D'Appolonia Consulting Engineering, Inc. (For Lake County Parks and Recreation Board, Crown Point, IN). Draft Environmental Impact Assessment. Hammond Marina Site.; 1976; Project No. MW76-726.
Note: NRPC.
The proposed Hammond Marina site is located in Hammond, Lake County, Indiana, on the southern shore of Lake Michigan. The objective of the proposed projects are directly concerned with the quality of life, community services and maximum development of potential recreational sources in support of individual needs as well as to fulfill specific public demands. There will be provisions for boating, fishing, biking, swimming, water skiing, nature walks, picknicking, etc.

195. Dawson, C.P., Lichtkoppler, F.R. and Pistis, C. The Charter Boat Fishing Industry in the Great Lakes; 1988: Presented at the 50th Midwest Fish and Wildlife Conference, Columbus, OH. Note: 3 copies.
An overview of the charter boat fishing industry was compiled from studies in the Great Lakes States of Wisconsin, Illinois, Indiana, Michigan, Ohio, Minnesota, and New York: The revitalization of the warm and coldwater fishery resource in the Great Lakes was spurred by the stocking of five salmonoid fish species in the 1960's and 1970's and management efforts that enhanced wild fish stocks. Since 1975, the Great Lakes charter boat industry grew from several hundred boats-for-hire to over 3,000 boats by 1988. The average charter vessel was a single engine, gas powered craft, 25'-30' in length and capable of carrying six passengers for hire to fish with hook and line. The average estimated capital investment for the boat, fishing equipment, and trailer/truck was $34,0000 to $47,000 in 1985-87. Captains took an average of 42 to 70 charter trips from April to Oct. during the 1985-87 seasons. The three most important attributes customers sought in a charter boat captain were hospitality skills, ability to locate fish, and boating safety. Many other factors were of less importance (e.g., catch trophy fish, charter price). Charter boat selection was influenced by reasons for chartering: challenge and excitement, relaxation, to enjoy nature and the lakes, and chance to get away. Total trip expenditures by charter boat fishing customers totaled $5.3 million in Minnesota (1988) and went as high as $59.5 million in Michigan (1985) with approximately 40 percent being spent within 10 miles of the charter boat dock. Operating expenses generally equal revenues generated for businesses running the average number of charters per year. Only charter businesses with 61 or more trips generated sufficient revenues to equal operating and capital expenses; approximately 20% of the businesses in Ohio and New York run more than 61 charters per season. Charter boat operations took in revenues ranging from $1.1 million in Minnesota (1988) and $44 million in New York (1986) to $6.4 million in Ohio (1985) and $13.8 million in Michigan (1985). While continued slow growth of the industry is anticipated, many challenges and issues face the industry: (1) marketing improvements; (2) demographic changes in the population base; (3) changing preferences and expectations of charter fishing clients; (4) quality and quantity of warmwater and coldwater fishery resource; (5) toxic contaminants in fish; (6) changes in coldwater fish stocking programs; and (7) changes in U.S. Coast Guard and state charter boat licensing programs.

196. Department of Parks & Recreation - City of Whiting, Indiana, and the State of Indiana/State Planning Agency - Indianapolis, Indiana (Department of Parks & Recreation/State of Indiana/State Planning Agency). Whiting Park Shoreline and Park Development Study.; July 1980.
Note: reprint.
This report summarizes the investigations and findings related to the technical and economic development of the required park facilities. Plans to develop an expanded beach area for Whiting Park are presented and conceptual alternative plans for the overall development of the park waterfront and park access are prepared. Critical project elements are addressed and cost estimates for the development alternatives have been prepared. The alternatives have been evaluated from technical, economic, functional, and aesthetic criteria. The end product of the study is the recommendation of the most favorable park development alternative.

197. Donohue Engineers and Architects. Introducing the Robert A. Pastrick Marina. East Chicago, Indiana. Sheboygan, Wisconsin: Donohue; 1987.
Note: CZM.
When the steel industry faltered in the early 1980s, thousands of steelworkers were laid off in East Chicago, Indiana. Facing high unemployment, failing businesses, and fewer alternative occupational opportunities, the community looked toward its lakefront - an unused, untapped natural resource. East Chicago resolved to have an operating marina for the 1987 boating season and hired Donohue in 1985 to turn that idea into reality. The Robert A. Pastrick Marina officially opened July 31, 1987. This report contains pictures and plans of this marina.

198. The East Chicago Park & Recreation Board (For the United States Department of the Interior Urban Park and Recreation Recovery.). Local Recovery Action Program. South Holland, Illinois: Paul H. Handing & Associates; 1992.
Note: reprint.
The East Chicago Park and Recreation Board of East Chicago, Indiana has a vision to make their city the best possible for all of their citizens. The first step has been taken by developing a 5-year Comprehensive Park and Recreation Plan which has been submitted to the state of Indiana. Last year a R.A.P. Plan was submitted for Nunez Park & Pool. Construction will be underway this year. This report, which deals with a new recovery action program for the City of East Chicago, Indiana, is an important continuing step in the process.

199. Environmental Assessment (For the City of Portage Port Authority). Environmental Assessment: Marina Development on the Burns Waterway System. Chicago, Illinois: Howard Tammen Needles & Bergendoff; 1991.
Note: reprint.
The Environmental Assessment considers the potential impacts of the projects on natural and cultural resources, and the socio-economic and physical environment. Special attention was focused on wetland, water quality and impacts on the waterway system.

200. Gary, Indiana Parks & Recreation. Parks & Recreation Comprehensive Plan Update, Gary, Indiana, 1990-1995. Gary, Indiana: Parks and Recreation; 1990-1995.
Note: reprint.
This revised 1990 Park Plan has been compiled to include current statistics and information concerning park and recreation facilities in order to effectively and efficiently address the problems of the expansion of and the rehabilitation of the Gary Department of Parks and Recreation.

201. Globetrotters Engineering Corp.; Warzyn Engineering, Inc. Schematic Design and Cost Estimates. Gary/Marquette Park Marina, Indiana Dunes National Lakeshore.; 1982.
Note: NIRPC.
An early report including alternative sites for the marina.

202. Hill, C. L., B. J. Ryan, B. A. McGregor, and M. Rust (For the U.S. Department of the Interior, U.S. Geological Survey, National Park Service). Our Changing Landscape - Indiana Dunes National Lakeshore. Denver, CO.: U.S. Government Printing Office; 1991; U.S. Geological Survey Circular 1085.
Note: reprint. Free on application to the Books and Open-File Reports Section, U.S. Geological Survey Federal Center, Box 25425, Denver, CO. 80225.
Earth-science information provides us with estimates of extent and rates of change. We need this information to transform the challenges presented here into opportunities for locating new or additional land, water, and mineral resources; for emphasizing prevention of contamination rather than cleanup; and for increasing our ability to live in harmony with nature.

203. Holm, Nancy Peterson. Inventory of Lake Michigan Research Projects: 1984-1987. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1987.
A review was conducted to assess the existing research programs of various agencies and universities working on Lake Michigan.

204. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography: 1860-1988 Geological and Physical Processes. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1988.
This bibliography covers research publications from 1860 to mid-1988 on geological and physical processes in Lake Michigan.

205. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 2: 1977-1986. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989b.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology hydrology, management, socio-economics, and recreation.

206. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 1: 1960-1976. Champaign, Illinois: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989a.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

207. Indiana Dunes National Lakeshore / Indiana (For the U.S. Department of the Interior / National Park Service). General Management Plan / Indiana Dunes Natinal Lakeshore / Indiana.; 1980.
Note: reprint.
The trend of growing awareness of the importance of creating national parks near urban areas.

208. Indiana Department of Natural Resources (For Indiana State Planning Services Agency). Public Access to the Indiana Shoreline of Lake Michigan and Tributaries -Subtitle: Recreation; 4-30-79; Technical Report No. 305.
The purpose of the Public Access Study is to assess the Indiana shorefront of Lake Michigan for public recreational access, and to provide the necessary information for the development of state policy as determined by the Executive Council of the State Planning Services Agency. Principal to the study is the demand, supply and shortage analysis for each major recreation opportunity in the shoreline area.

209. Indiana Department of Natural Resources, Division of Outdoor Recreation. Indiana Outdoor Recreation: An Assessment and Policy Plan for 1989-Draft [unpublished report]. Indianapolis, IN.; 1988.

210. Indiana DNR Outdoor Recreation, Fish and Wildlife (DNR). Guidelines for Indiana Waters: A Fishing and Boating Access Program; 6-1-89.
Notebook of requirements.

211. Johnson Johnson & Roy (For the City of Portage/Portage Port Authority). Burns Waterway: Boat Capacity Study. Ann Arbor, Michigan: Johnson Johnson & Roy/inc.; Oct. 1990.
Note: reprint.
A boat capacity study for the Burns Waterway and related portins of the East and West Branches of the Little Calumet River in Portage, Indiana. Channel geometry, volume of boats in use, boat speeds and sizes, and boat slip and launch pattern provided a means of assessing the reliability of the analytical results.

212. Johnson, Johnson & Roy, Inc. (Ann Arbor, MI). East Chicago lakefront study East Chicago., Indiana. Conceptual Design Plan.; April 1978. NRPC.
Note: Summary record of critical concepts from project meetings held in East Chicago, Nov. 3, 1977, and Jan. 5, March 16, and May 4, 1978.
The purpose of this report is to identify development opportunities which optimize citizen use and appreciation of East Chicago Indiana's Lake Michigan shoreline. Recent recreation use patterns at Jeorse Park suggest that the existing facility does not encourage local residents to take full advantage of this limited and unique natural resource. Johnson, Johnson & Roy of Ann Arbor, MI., were retained by the city in January, 1978, to prepare a Conceptual Design Study and Plan. This plan not only recommends broad recreation opportunities, but also identifies methods for

maximizing existing and desired uses. Economic evaluation and funding recommendations also included in the study assist in project implementation. This report graphically records and explains the proposed concept design plan and how it can be implemented.

213. Johnson, Johnson & Roy, Inc (Ann Arbor, MI.). Gary Indiana. Marina and Waterfront Development.; 1987.
Note: NRPC.
The objective of this memorandum is to develop a technical data base for use in the planning and design of the proposed Gary, IN, waterfront and marina development. Conclusions have been drawn from numerous prior studies to formulate a strategy that will allow for the creation of a desirable and achievable waterfront development. Upon the foundation of this data-gathering and analysis effort, the design team can begin to chart a course toward creating appropriate design guidelines, a preferred development program, and an implementation strategy to guide the city of Gary in achieving its aspiration of creating a first class waterfront development.

214. Johnson, Johnson & Roy Inc. Jeorse Park. Road Access Study, East Chicago, Indiana; July 1980.
Note: CZM.
Jeorse Park is East Chicago's only lakefront public open space. Its unique character demands that every effort be taken to realize the full recreational potential of this facility. Currently underutilized, the "East Chicago Lakefront Study" identified how Jeorse Park should be improved. Marina and boating facilities, passive play areas, walkways and beach, fishing areas, and new parking lots and service roads are proposed. Although Jeorse Park can readily accomodate these activities and potentially attract greater numbers of users, the Park is difficult to reach. The Park user must either negotiate the intense traffic activity during these periods, or plan to use the facilities during slack hours. It is the purpose of this study to identify what alignments might be feasible from a conceptual design standpoint to rectify this accessibility problem.

215. Koch, Robert A., Fisheries Biologist (Fisheries Section; Division of Fish and Wildlife). Commercial Catch Monitoring in the Indiana Waters of Lake Michigan. July, 1978 - May, 1979. Indianapolis, IN: Indiana Department of Natural Resources; 1979.
Note: CZM.
The major objectives of this project were to: 1) Determine the total catch (number and weight) by species of the two full time commercial fishermen operating in Indiana waters; 2) Determine the incidental catch of salmonids; 3) Determine population characteristics of yellow perch in the commercial catch and; 4) Determine the reliability of the commercial catch reporting system. Results and recommendations of this study are included.

216. Koch, Robert A. (Fisheries Section; Indiana Department of Natural Resources). A Creel Survey of the Indiana Waters of Lake Michigan. June 1978 - May 1979. Indianapolis, IN: Division of Fish and Wildlife; 1979.
Note: CZM.
The major objectives of this project were to: 1) Determine fish harvest by all sport fisheries along the Indiana shoreline over a one year period. 2) Determine the feasibility of developing an alternative method for data expansion. Tables display the results of this survey, and it is recommended that efforts be continued to computerize the Lake Michigan creel survey.

217. Lehman & Lehman, Inc. (For Hammond Park and Recreation Board). Hammond '91/'95 Park and Recreation Master Plan Update. Marion, Indiana: Lehman & Lehman, Inc.; 1990.
Note: reprint.
Statements of policies and objectives to help define the role and function of the Hammond Park and Recreation Department to enable it to meet the challenge of providing sufficient open space and facilities for the leisure time needs and interests of all residents as well as to enhance the physical and social characterisitics of the Hammond community.

218. LMMDC (Lake Michigan Marina Development Commission). Lake Michigan Marina Development Commission, Annual Report Subtitle: Annual Report (12 months ended June 30, 1987); 6-1-87; Annual Report 1987.

219. LMMDC (Lake Michigan Marina Development Commission). Lake Michigan Marina Development Commission, Annual Report Subtitle: Annual Report (12 months ended June 30, 1988); 6-1-88; Annual Report 1988.

220. LMMDC (Lake Michigan Marina Development Commission). Lake Michigan Marina Development Commission, Annual Report Subtitle: Annual Report (12 months ended June 30, 1989); 6-1-89; Annual Report 1989.

221. LMMDC meeting (News). Lakefront Development - Subtitle: Reprint Post-Tribune, March 1988; 3-1-88.
Note: Covers articles on marina development.

222. Musser, D.; Smidley, S. (Illinois-Indiana Sea Grant Program, Urbana-Champaign). State and Federal Regulations Related to Boating on Lake Michigan. Urbana-Champaign, IL: I-ISGP; Oct. 1985. (Rep. Il.-In. Sea Grant Program).
Note: 39 pp.
The topics covered in this report include registration and titling of vessels, equipment requirements, operation requirements and basic rules of the road. Regulations governing charter boat or commercial boat operations are not included.

223. Peterson, T.E. (Midwest Research Inst., Kansas City, Mo.). Literature Review of surveys methodologies inventories and analyses pertaining to recreation boating beaches commercial fishing and charter boat operation in the Great Lakes. bibliography in: Citations from the NTIS Bibliographic Database -Recreational Boating (Jan 79 - Sep 88): U.S. Dept. of Commerce, National Technical Information Service (NTIS).
Note: p. 83.
The Great Lakes Basin provides a good quality of life through its beautiful scenery, fishing, swimming, power boating, and sailing, as well as through the agricultural, mining, manufacturing, power, and transportation industries. This bibliography presents a review of the literature that was developed as a part of a study conducted by Midwest Research Institute (MRI) for the Buffalo District U.S. Army Corps of Engineers. The overall objective of the study was to determine the effects proposed water level regulation plans would have on certain Great Lakes beaches, boating facilities, commercial fishing and charter boat operations. In addition to utilizing two national computerized literature services, a number of state, university and local sources were examined. For the purpose of clarification, the various studies, findings, and methodology examined during our search are categorized as follows: (1) Marinas and Boating; (2) Beaches and Swimming; (3) Commercial Fishing and Charter Boating; (4) Demand Analysis; (5) Cost-Benefit Analysis; and (6) Miscellaneous Studies.

224. Piechota, A. M.; O'Leary, J. T.; Fischer, B. C. Recreational Boating in Indiana. West Lafayette, IN: Purdue University, Indiana Agricultural Experiment Station; 1989; Station Bulletin #574.
Recreational boating is the nation's fourth largest leisure industry and represents a major recreational activity in Indiana. In 1987, there were over 200,000 motorized boats registered with the Indiana Department of Natural Resources. This was a significant increase over the number of boats registered in 1986. There were also thousands of unregistered boats such as sailboats, canoes, and rowboats. With over 30% of the population participating in boating activities (Indiana Department of Natural Resources, 1987), Indiana's 1986 boating-related purchases totaled $153 million. Indiana has over 400 boating-related businesses, with approximately 29,000 Hoosiers employed in positions either directly or indirectly related to boating. Furthermore, the national growth trend of 10 million new participants annually is reflected by the 30-1200 percent five year sales increase reported by Indiana Business. This results from an increase in the number of boats sold and a trend toward larger, more expensive boats.

225. Poulin, K. A.; Haynes, J. M. Construction Techniques, Environmental Impacts and Laws/Regulations for Recreation Development on the Great Lakes: An Annotated Bibliography and Discussion of Critical Needs in New York; 1986.
Note: 2 copies.
The objectives of this project were to: 1) develop an annotated bibliography that reviews coastal recreation development practices and relevant environmental impacts, mitigations, laws and regulations, especially for the Great Lakes, 2) evaluate the results of Objective 1 to determine a) whether major gaps in technical/environmental knowledge exist and b) whether sufficient information currently exists to rationally plan coastal development (short-term vs. long-term vs. cumulatively) on the Great Lakes generally, and Lake Ontario specifically. Perceived long-term/cumulative environmental damage could ultimately ruin many recreation opportunities as well as permanently damage coastal resources. It is important that engineers, builders, developers, resource managers, administrators, politicians and citizens be able to consider all of the alternative means of achieving desirable social goals in the coastal zone. With existing knowledge, improved evaluation tools, better planning and regulatory organization, proper decisions can be made to modify or avoid those projects for which the social/environmental cost is too high. The key remaining questions are whether or not our society and its subunits will 1) agree

upon and implement long-term, environmentally sound goals for the coastal zone and 2) spend initially greater time, effort and money to evaluate and mitigate long-term and cumulative impacts, so as to optimize sustainable coastal resource benefits.

226. Ralph Burke Associates (For: Lake County Parks and Recreation Board, Crown Point, Indiana). Lakeshore Park & Marina Master Plan Development, Lake County, Indiana. Park Ridge, IL 60068: Ralph Burke Associates; March 1976; Project No. 7528.
Note: CZM.
Ralph H. Burke Associates has been authorized by the Lake County Park and Recreation Board to prepare the initial phase of a Lake County Lakeshore Park and Marina Master Plan Development. This report will constitute the Phase I portion of a five phase unilateral contract to include a Master Plan development for a park and marina, environmental assessment, financial feasibility analysis, design and construction services and project representation.

227. Ralph Burke Associates (For: Lake County Parks and Recreation Board, Crown Point, IN). Park and Marina Master Plan Study, Lake County, Indiana. Preliminary Draft Report. Park Ridge, Illinois 60068: Ralph Burke Associates; 1982; Project No. 81040.
Note: CZM.
Based upon the inabililty to acquire the NIPSCO property as a marina site, the Lake County Parks and Recreation Board has authorized Ralph Burke Associates to prepare this site selection and master plan study for a park and marina to be located between the existing NIPSCO property on the west and Whiting City Park on the east. The boating demand for the 1976 report "Lakeshore Park and Marina Master Plan Development" is also to be updated based upon changes in boating ownership that have occurred since the original marina master plan study was published.

228. Samdahl, D. M. 1987 Survey of Charterboat Operators on Southern Lake Michigan; 1988; (IL-IN-SG-R-88-1): University of Illinois, Urbana-Champaign, IL; ISSN: Illinois-Indiana Sea Grant.
A questionnaire was developed that incorporated aspects of the other Great Lakes charterboat surveys as well as issues unique to charterboat operators on southern Lake Michigan. The results of the survey are reported and discussed. The 142 respondants to this mailed survey represent about half of the charterboat operators in Illinois and Indiana. In general, these captains are primarily middle-aged married men with a

fairly high level of education. Most charter businesses were organized as a sole proprietorship; half hired crew members in addition to the owner/operator. Charter businesses were generally in operation on a part-time basis even during the busiest time of the year (May, June, and July), and captains mostly received only a small share of their income from chartering, averaging $8,000 per year. Only one boat was used in most businesses; that boat was devoted primarily to chartering and not often used for other purposes and was an average 10 years old, 29 feet long, and could carry six passengers. Average fees charged were $220 for a half-day trip and $320 for a full-day. Multiplying average revenue from fees by the total number of charterboat operators in Illinois and Indiana, we can estimate the total regional revenue generated from fees to be $2.5 million dollars. Charter operations typically reflect an owner/operator with one boat who makes a few trips a week for five or six months. Although this work contributes only a small amount to the annual income of most operators, the total regional impact is enormous.

229. Seketa, George; Schoonveldt, Michael, Investigators. Lake Michigan Breakwater & Pier Report: House Bill 1069: Division of Fish and Wildlife.
Note: copy obtained from George Seketa.
This report studies the feasibility of constructing fishing piers or modifying existing breakwater facilities to accomodate shore line fisherman. Good dependable shoreline fishing opportunities for salmon, trout, and perch fishing along the Lake Michigan Shoreline is fairly restrictive throughout the total Indiana Lake Michigan Shoreline. The greatest potential for development of permanent shoreline fishing opportunities exists at the Port of Indiana, Midwest Steel, and Jeorse Park and Buffington Pier areas. Usage, construction costs, and federal funds are some of the topics discussed in this report.

230. Somersan, A. Impacts of Recreation in the Coastal Zones: Economic Impact and Needs of Wisconsin's Great Lakes Boaters-1975. Madison, WI: Wisconsin Univ.-Madison; 1976; NTIS number PB-263-933. 52 p.
The major objective of the study is to identify the dependency between Great Lakes boaters and the economy of the coastal communities. The report also identifies the socioeconomic profile of the Great Lakes ramp users and marina users, and summarizes the preference and needs of boaters for facilities and service.

231. Strang W. A.; Ditton, R. B. The Lake Michigan Charter Fishing Industry: A Product of Love and Taxes. J. Great Lakes Res; July 1976; 2(1): 89-98.
Little is known about the Lake Michigan charter fishing industry. This study was conducted to describe Lake Michigan charter fishing boat operators and their customers and to evaluate the industry's financial status and local economic impact. Field work in 1973 revealed 98 charter operators working on Lake Michigan from Wisconsin ports. From a geographically proportionate sample, 44 extensive interviews were completed. The industry generated $670,000 in sales in 1973. Low average sales and profits do not provide financial incentives to entrepreneurs. Financial opportunity, however, appears to have played a minor role in the decision to enter the business. Major motivations appear to be tax advantages and life style rewards. A profile of charter customers was developed through a mail survey of a sample of 483 charter customers. Catch data were collected from operators surveyed. Catch varied with the proportion of operator income obtained from charter fishing. Port communities were affected economically by the industry. Applying a community multiplier of 2.16 to the $1.6 million of direct expenditures yields an economic impact of $3,456,000 on Wisconsin's Lake Michigan community in 1973. The industry is also important in that it provided fishermen with access to the Great Lakes lake trout and salmon fisheries. Without that access, these fisheries would be largely reserved for the wealthy.

232. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan, East Chicago
Subtitle: East Chicago; 9-1-86.
Note: Covers East Chicago.
Economic feasibility of marina development.

233. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan, Portage
Subtitle: Portage; 9-1-86.
Note: Covers Portage.
Economic feasibility of marina development.

234. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan, Hammond, Indiana
Subtitle: Hammond; 9-1-86.
Note: Covers Hammond.
Economic feasibility of marina development.

235. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan, Michigan City
Subtitle: Michigan City; 9-1-86.
Note: Covers Michigan City.
Economic feasibility of marina development.

236. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan, Gary
Subtitle: Gary; 9-1-86.
Note: Covers Gary.
Economic feasibility of marina development.

237. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan,
Subtitle: Plan; 9-1-86.
Note: Covers Hammond, East Chicago, Gary, Portage, Michigan City.
Economic feasibility of marina development.

238. TenEch Engineering, Inc,; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan
Subtitle: Executive Summary, Financial Feasibility and Economic Impact Study; 9-1-86.
Note: Covers 5 Indiana shoreline cities.
Economic feasibility of marina development.

239. Theobold, W. F. Tourism Development Plan, Lake County, Indiana.
tourism/ recreation/ Lake County/ Indiana.

240. U.S. Army Corps of Engineers Chicago District. Burns Waterway Small Boat Harbor Monitoring Program Portage County, Indiana. 3rd Annual Report; March 1991.
Note: Mich. City.
The conclusions drawn in this report will be used to evaluate the shoreline conditions and how they pertain to the construction of the Burns Small Boat Harbor, how successful the mitigative efforts have been, if additional mitigation or modifications to the existing monitoring procedure are needed, and to identify monitoring needs for the following year.

241. U.S. Department of Interior; City of Gary, Indiana. Gary marina. Draft environmental impact statement; 1989.
Note: NIRPC.
Compliance instrument for executive order 11990. The protection of wetlands is discussed. 1,000+ slip marina is proposed to be located between USX breakwater and Marquette Park.

242. Warzyn Engineering, Inc. Gary Waterfront Marina Village. Preliminary feasibility study; 1985.
Note: NIRPC.
There is an unfilled demand for 4,000 boat slips in northern Indiana. The U.S. Steel property is not as environmentally sensitive as other potential sites.

243. Wendell Campbell Associates, Inc., Architects, Planners, Construction Managers (For: City of Gary, Indiana). Marquette Park Small Boat Harbor Feasibility Study. Chicago, Illinois: Wendell Campbell Associates, Inc.; April 15, 1976.
Note: CZM.
Marquette Park has historically been the primary recreation spot for the citizens of Gary and the people who reside in the Greater Gary Area. The lake is a tremendous attraction for boating, water skiing and fishing. This attraction creates a consumer demand that can be converted into an economic and recreation asset to the city through the development of a small boat harbor at Marquette Park. This study was commissioned to determine the physical development of the harbor and how that physical development should be programmed in order that the harbor would be economically feasible. The location of the boat harbor and the demand for boating and fishing facilities are reviewed. The design concept for the initial harbor facilities and the final development have been prepared with prime consideration given to the hydrographic conditions, construction cost and generated revenues.

244. Williams-Kuebelbeck & Associates, Inc.(Real estate economic, financial and management consultants, Irvine, CA.); Epstein Civil Engineering, Inc.(Chicago, IL.). Indiana Marina Market and Economic Study; October 31, 1985.
Note: NRPC.
Based upon the findings presented in this study, the following important conclusions have been drawn which summarize the potential for marina development along the Indiana shoreline of Lake Michigan. 1) There is a large, untapped demand for boat slips in the South Lake Michigan market area. While the bulk of this unfulfilled demand is generated by the Illinois submarket, Indiana also stands in a

good position to develop additional marina facilities along its Lake Michigan shoreline. 2) Indiana is faced with the opportunity to increase the demand for marina facilities by seeking to include other recreation facilities and attractions at marina sites (with the highest potential west of the Dunes to attract visitors from the Chicago area). 3) Creation of a revolving loan fund to assist in financing and construction, and lowering the tax burden placed on boat owners in Indiana is advised. 4)Available choices to Indiana are to include narrow development focusing on boat storage and related facilities, or a broader approach that emphasizes more extensive waterfront development. The latter approach seems more promising. 5) Major constraints on development include: lack of suitable sites; insufficient land area at available sites, and a lack of funding sources. 6) Overall, there's a bright future ahead for marina development in Indiana.

SOCIOECONOMIC

245. The Abonmarche Group (For the Lake Michigan Marina Development Commission). Estimate of the Demand for Recreation Boat Slips Along The Lake Michigan Shoreline In Northern Indiana. Benton Harbor, MI., Grand Rapids, MI.: The Abonmarche Group; Aug. 1990.
Note: reprint.
Recreation boating characteristics/Survey of existing marinas/Potential demand for new recreational boat slips/ Findings and conclusions pertaining to changes in market conditions and trends.

246. Absher, J.D.; Collins, J.R. Southern Lake Michigan Sportfishery: Angler Profiles and Specialization Index for Illinois and Indiana; 1987: University of Illinois, Urbana-Champaign, IL; ISSN: IL-IN Sea Grant.
Sportfishing is a major pursuit of many people that frequent Lake Michigan. Besides the intangible benefits it affords anglers, it contributes to the economic growth of the Lake region. The goals of this project were to provide baseline data on the use of the SLM sportfishery and to further refine and test the concept of recreational specialization. Results from this study have begun to develop a profile of the Illinois and Indiana SLM (southern Lake Michigan) angler and to develop a SLM angler taxonomy useful to many of the Lake's sportsfishing providers. With need for more definitive information about the SLM angler, the first objective of this study was to provide seperate profiles for the Illinois and Indiana SLM angler. The profiles consisted of over 220 items covering 13 major areas of inquiry. Each state was treated seperately and completely. The results were not easily encapsulated. The reader is referred to the table of contents for specific angler characteristics of interest (sociodemographics, fishing and behavior habits, motivations and satisfactions, management preferences, health risks, and non-southern Lake Michigan anglers). This angler taxonomy (low specializaion anglers, medium specialization anglers, and high specialization anglers) has provided evidence not only that there is an inherent diversity of behaviors, preferences, and motives within the realm of sportsfishing, but that this diversity can be systematically explained in terms of an activity specialization scale based on five characteristics of motivation. The specialization scale can help in managing the SLM angler population. To treat SLM anglers as a homogeneous unit could be misleading and could also fail to provide optimized benefits for obviously distinct segments of this angler population.

247. Bartholomew, Wayne ; Joray, Paul ; Kochanowski, Paul. An Analysis of the Economic Impact of the Marinas and Launching Facilities in Michigan City on the Michigan City Economy. [Report for the Michigan City Port Authority.]. Michigan City, IN; April 1981.
Note: 2 copies.
The marinas and boat launching facilities are an integral part of the Michigan City economy. The purpose of this research project is to estimate the economic impact of these facilities and boating in general on the Michigan City economy. The total impact is measured by using the export base model to project flow of income throughout the Michigan City economy that results from the direct income gains. Three major conclusions can be drawn from our analysis of the impact of boating upon the Michigan City economy. First, the impact upon the economy is substantial, ranging from approximately $13.4 million annually to approx. $17.4 million. This latter figure includes the estimated special impacts. Secondly, the impact upon the economy is extremely widespread. It is fair to say that anyone who sells either a product or service in Michigan City and anyone who works for a company that sells a product or service in Michigan City benefits from boating. Third, the lakeshore is an important resource that holds considerable comparative advantage for Michigan City vis-a-vis other cities in Indiana. This resource can make a major contribution to the Michigan City economy and to its residents if it is carefully developed. The impact of boating upon the Mich. City economy is substantial. Our surveys estimate that private marinas and events (Coho Club and Shriners Salmon Derby) contribute a direct economic impact of about $2.4 million, an indirect income impact of $2.1 million and a total impact of $4.5 million. We estimate that the public marinas and launching facilities generate a direct impact of $2.5 million, an indirect impact of $2.3 million, and a total impact of $4.8 million. Michigan City's In The Water Boat Show is estimated to have a $4.1 million impact. Finally, the families who own year round and summer homes for boating-related activities, and whose imcome is from outside of Michigan City, contribute an income impact of approximately $1.3 million. Thus the total impact is nearly $15 million annually. Many people in the community view the benefits from activities like boating as accruing only to those who use the facilities or sell goods and services directly to the users. However, virtually everyone in Michigan city benefits in some manner from the $15 million in extra income brought into the community. It is true that the income goes initially to those who sell directly to boaters, but the income is soon spent on other

items, thus increasing the incomes of other Michigan City residents, and also contributes to the local tax base.

248. Carl L. Gardner & Associates, Inc., and Michigan City Planning Department. Comprehensive Plan Report, Michigan City, Indiana. Volume III.; July 1971; Hud Project No. Ind. P-112.
Note: CZM.
This report consists of the third and final phase of the Comprehensive Plan Report in which long-range proposals are made regarding the future development of the Michigan City Lake Front, Utilities System and Capital Improvements. The Lake Front Plan includes an analysis of the existing lake front characteristics - followed by three alternative proposals for future development. A final solution which is a composite for the three alternatives (as determined by the Michigan City Lake Front Committee) is presented along with priorities for phased development and land acquisition.

249. City of Michigan City. Michigan City Comprehensive Plan; June 1988. City Hall, Michigan City, Indiana.
Note: Mich. City.

250. Conroy, Kathleen (For the Lake County Indiana Parks and Recreation Board). Park & Open Space Plan 1988. Lake County, IN.: Lake County Parks and Recreation Department; July 1988.
Note: reprint.
It is the purpose of this study to provide the lake County Parks and Recreation Board with a complete and useful guide for the long range development of a county park system. This plan will set forth goals, policies, and standards to meet county open space and recreation needs to the year 2010. This plan will also provide the Park Board with a blueprint for acquisition and development of recommended county park sites.

251. Crowe Chizek and S. B. Friedman & Company (For the City of Gary, Indiana). Market Analysis for a Proposed Marina in Gary, Indiana. Gary, Indiana: Crowe Chizek and S. B. Friedman & Company; Oct. 1991.
Note: reprint.
The site, located at the eastern lakeside portion of the USX property near the public boat launch, is suitable for marina development if planned improvements and management actions address several physical limitations and environmental conditions which need to ameliorated.

252. Department of the Army. Shoreline Erosion Protection At Indiana Dunes National Lakeshore General Design Memorandum. Chicago, Illinois: U.S. Army Engineer District, Chicago Corps of Engineers; April 1990.
Note: reprint.
This General Design Memorandum presents the final design for beach replenishment at the Indiana Dunes National Lakeshore (IDNL).

253. Donohue Engineers and Architects. Introducing the Robert A. Pastrick Marina. East Chicago, Indiana. Sheboygan, Wisconsin: Donohue; 1987.
Note: CZM.
When the steel industry faltered in the early 1980s, thousands of steelworkers were laid off in East Chicago, Indiana. Facing high unemployment, failing businesses, and fewer alternative occupational opportunities, the community looked toward its lakefront - an unused, untapped natural resource. East Chicago resolved to have an operating marina for the 1987 boating season and hired Donohue in 1985 to turn that idea into reality. The Robert A. Pastrick Marina officially opened July 31, 1987. This report contains pictures and plans of this marina.

254. Dull, Daniel F. (Department of Geography, Indiana University). Lake County, Indiana, in Maps. Bloomington, IN: Dept. of Geography, IN Univ.; 1971; Occasional Publication No. 6. (Indiana University Foundation, Geography Publications Series).
Note: CZM.
This is a small thematic atlas of Lake County, Indiana, and its maps are designed to give their user a general overview of the historical and cultural development of this county. There are three types of cartographic products in this atlas: maps that were redrawn adaptations of existing maps, maps that were compiled by combining elements contained on two or more existing maps, and maps that were compiled from statistical sources.

255. The East Chicago Park & Recreation Board (For the United States Department of the Interior Urban Park and Recreation Recovery). Local Recovery Action Program. South Holland, Illinois: Paul H. Handing & Associates Landscape Architects, Planners; Feb. 1992.
Note: reprint.
The East Chicago Park and Recreation Board of East Chicago, Indiana has a vision to make their city the best possible for all of their citizens. The first step has been taken by developing a 5-year Comprehensive Park and Recreation Plan

which has been submitted to the state of Indiana. Last year a R.A.P. Plan was submitted for Nunez Park & Pool. Construction will be underway this year. This report, which deals with a new recovery action program for the City of East Chicago, Indiana, is an important continuing step in the process.

256. Environmental Assessment (For the City of Portage Port Authority). Environmental Assessment: Marina Development On The Burns Waterway System. Chicago, Illinois: Howard Tammen Needels & Bergendoff; 1991.
Note: reprint.
The Environmental Assessment considers the potential impacts of the projects on natural and cultural resources, and the socio-economic and physical environment. Special attention focused on wetlands, water quality and impacts on the waterway system.

257. Feingold, Eugene M., Legal Consultant (Indiana State Planning Services Agency). Legal and Administrative Inventory. Indianapolis, IN; September 1976; Technical Report 105; CZM Indiana CZ-5-11.
Note: CZM.
The Coastal Zone Management Act of 1972 declared that it is the National Policy to preserve, protect, develop, and where possible, to restore or enhance, the resources of the nation's coastal zone for this and succeeding generations. The coastal zone is to extend inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters, which include the Great Lakes area. The State of Indiana, acting through its State Planning Services Agency, is developing a management program for the land and water resources of its coastal zone. For study purposes, the Indiana program has set the preliminary boundaries of the coastal zone inland to about the middle of Lake, Porter and LaPorte Counties which border Lake Michigan and are within its water shed.

258. Haynes, Kingsley E., Ph.D.; et al., Indiana University (For: Indiana State Planning Services Agency). Energy Facility Siting Review: The Indiana Coastal Zone Management Program. Indianapolis, IN: Indiana State Planning Services Agency; October 31, 1979; Technical Report No. 306; Project Indiana CZ-001-80-01.
Note: CZM.
A physical inventory of socioeconomic parameters which may affect energy demand is included, as well as a survey of existing energy systems in the region. Current State and

Federal policies which may affect energy growth in the coastal zone are reviewed. A scenario of growth in regional electricity need is drawn, and State policy alternatives to meet future energy needs in the coastal zone are presented. Institutional problems in implementing these policies are also examined.

259. Haynes, Kingsley E., Ph.D.; et al., Indiana University (For: Indiana State Planning Services Agency). Indiana Coastal Energy Facilities Inventory. Bloomington, IN: School of Public and Environmental Affairs, IN Univ.; November 30, 1979; Project Indiana CZ-001-80-02.
Note: CZM.
This is an inventory of the energy facilities that occur in the Indiana coastal zone of Lake Michigan. Facility address, type, activity, capacity, operating date, and expansion information is given.

260. Haynes, Kingsley E.; Schoepfle, O. Benjamin; Shapiro, Robert W., Indiana University (For: Indiana State Planning Service Agency). The Permit Process for Energy Facilities in Indiana. Alternative Considerations; November 30, 1979; Coastal Energy Impact Program, Appendix I to Report on Permit Consolidation, Submitted August 15, 1979.
Note: CZM.
The enactment of many separate laws and regulations, each addressing specific problems of land use, planning, administration, or environmental impact has created an increasing need for more holistic approaches to and the streamlining of decision-making process. This discussion focuses on the permit process for energy facility siting in Indiana and how the process might be consolidated by using the permit systems of four other states; Washington, Wisconsin, Oregon, and Minnesota as models. It is hoped that illustrations of these models will suggest some alternatives for increasing the efficiency and effectiveness of the Indiana permit system.

261. Heikoff, Joseph M. Shorelines and Beaches in Coastal Management: A Bibliography. Monticello, Illinois: Council of Planning Librarians Exchange; 1975; (Bibliography 879): 63 pp.

262. Holm, Nancy Peterson. Inventory of Lake Michigan Research Projects: 1984-1987. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1987.
A review was conducted to assess the existing research programs of various agencies and universities working on Lake Michigan.

263. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography: 1860-1988 Geological and Physical Processes. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1988.
This bibliography covers research publications from 1860 to mid-1988 on geological and physical processes in Lake Michigan.

264. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 2: 1977-1986. Champaign, IL: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989b.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

265. Holm, Nancy Peterson; Morgan, Beth McArdle. Lake Michigan Bibliography-Volume 1: 1960-1976. Champaign, IIlinois: Department of Energy and Natural Resources, Illinois State Geological Survey; 1989a.
A bibliography was compiled of all research literature on Lake Michigan covering the subjects of biology, chemistry, geology, physical limnology, meteorology, hydrology, management, socio-economics, and recreation.

266. Indiana Department of Natural Resources. Coastal Zone Management Program. Preliminary First Year Natural Resource Inventory. (Draft): Indianapolis; July 1976.
Note: CZM.
Compiles an inventory of significant natural and man-made coastal resources including an inventory of the existing data on the natural resources of the state's Lake Michigan coast, brief discussion papers on the problems and issues of the area, and an analysis of the collected data for its use in the Coastal Zone Management Program.

267. Indiana State Planning Services Agency. Economic Impact Models: The Indiana Coastal Zone Management Program. Indianapolis, IN; June 1979.
The majority of this report is concerned with demonstrating the contribution that economic analysis can make to Coastal Zone Management. The Coastal Zone Management Act of 1972 is among the children of Earth Day. The impetus for the Act stemmed from a growing recognition that the nation's coastal areas (including the shoreline of the Great Lakes) constituted a unique and serious policy problem. Forty-five percent of the nation's population lived in coastal counties, which constituted only a small fraction of its land area, and

the proportion was increasing. Urbanization of the coast generated conflicting demands for land among potential users; especially outdoor recreation, industry, water transportation, electric utilities, and residential uses. The pollution, landfill operations and erosion attending many of these uses often impacted one of the most delicate and biologically productive ecosystems; the estuarine areas. Thus the CZM Act reflected mainly a two-fold concern with ecological preservation and land use regulation. The role of economic development in CZM programs is clearly indicated in the preamble of the 1972 Act. The role of economic development considerations in Indiana's CZM program is even clearer than in the federal mandate. Governor Bowen has described the main purposes of the Indiana program as "achieving a balance which allows for economic expansion while maintaining the quality of the environment", placing economic and environmental issues on equal footing. This report illustrates and applies techniques of regional economic analysis to the Indiana CZM region. Chapter 2 describes a number of regional economic models which have potential applications in CZM. This chapter also demonstrates what is required for a comprehensive understanding of the Zone's economic functioning and the economic impacts of CZM policies and action programs. Chapter 3 attempts to apply some of these models to illustrate on an industry-by-industry basis the Zone's major sources of regional employment, income and growth. Chapter 4 contains impact analyses of two problems into the Coastal Zone: air quality non-attainment and declining steel employment.

268. Indiana Department of Commerce, Planning and Research Group (For: The Department of Planning and Research, Dept. of Commerce, IN). Economic Feasibility Proposals of West Park and Marina Development. Michigan City, Indiana. T. "Ted" Pantazis, Director ed. Indianapolis, Indiana: Indiana Department of Commerce; Project Ind. P-1009.
Note: CZM.
This project involves development of a multifaceted recreation area including both land and water activities. The land area is approximately 200 acres containing both passive and active recreation areas. The water area, which is protected by an extensive breakwater system, contains a marina, boat launching ramps and fishing piers. An offshore area is proposed for fish spawning. This facility, if properly conceived and constructed, will serve an estimated area of approximately one million citizens. Today approximately seven percent of this population are marina and

boating enthusiasts. The average percentage increase in the sport of boating is four percent per annum.

269. Indiana State Planning Services Agency. Indiana Coastal Zone Management Program. Annual Report. Indianapolis, IN; June 1, 1975 - September 30, 1976; Technical Report 107.
Note: CZM.
This report serves to conclude Indiana's first year efforts toward the development of a management program for the southern Lake Michigan shoreline. The activities of the first year program, including data inventory, public participation and program coordination, are summarized. There is also a discussion of the problems and issues in the coastal area, and an analysis of the physical, social and economic data for the purpose of aiding in the establishment of policy framework.

270. Indiana State Planning Services Agency. Indiana Coastal Zone Management Program Goals, Objectives, and Policies. A draft framework paper; October 10, 1978.
Note: CZM.
The purpose of this framework paper is to bring forward to the Executive Council of the State Planning Services Agency for its consideration early in the third year program, a concise statement of the primary problems and issues which exist in the coastal zone and the possible policies and solutions for their resolution. After undergoing thorough public and governmental review, it is hoped that this document will provide a basic framework for the Indiana Coastal Zone Management (ICZM) Program.

271. Indiana Department of Commerce. The Indiana Management Plan: Economic Impact Models: Indiana Department of Commerce; June, 1979; Technical Report No. 308.
Note: CZM.
Report demonstrates the contribution that economic analysis can make to coastal management. It describes a group of regional economic models applicable to the coastal zone such as economic base analysis, shift shore analysis, input-output models, econometric models locational analysis models (cost or demand-oriented models), cost benefit analysis. Some models are applied on an industry-by-industry basis to identify the major source of employment and income and to provide a guide for the determination of permissable and priority of uses. Two problems pertaining to the coastal zone are evaluated: the consequences of air quality non attainment and of declining steel employment.

272. Indiana State Planning Services Agency (Lake Michigan Shoreline Program). Indiana's Shoreline: A Resource for Everyone. Indianapolis, IN: Indiana State Planning Services Agency.
Note: (CZM) booklet.
This is a booklet aimed for public display that discusses the evolution of the Indiana shoreline, areas of concern, development, access, habitats, natural hazards, habitats, resources, recreation, energy, and lakeshore management. It also includes a chart on Shoreline Management Projects & Studies with completion dates, budgets, etc.

273. Indiana State Planning Services Agency (By: Indiana Department of Natural Resources). Inventory of Plans, Programs, and Projects. Part I. Indianapolis, IN: DNR; September 1976; Technical Report No. 103.
Note: Coastal Zone Management Program.
The following Inventory of Plans, Projects and Programs is an effort to catalog and abstract the various Federal, State, Inter-State, and Regional governmental activities involving the natural resources and natural processes within the Indiana Coastal Zone Management Study area.

274. Indiana State Planning Services Agency (By: Northwestern Indiana Regional Planning Commission). Inventory of Plans, Projects and Programs. Part 2; September, 1976; Technical Report No. 103.
Note: Coastal Zone Management Program.
This document presents an inventory of plans, projects and programs which relate to the coastal zone study area in Lake and Porter Counties. The purpose of this inventory is to identify problems and issues of general concern to communities within the study area and to assist in the development of the role of various agencies in the management of the coastal zone.

275. Indiana State Planning Services Agency (By: Michiana Area Council of Governments). Inventory of Plans, Projects and Programs. Part 3; September 30, 1976; Technical Report 103.
Note: Coastal Zone Management Program.
This report contains abstracts of 34 projects from the Indiana coastal zone area.

276. Indiana Department of Natural Resources (For Indiana State Planning Services Agency). An inventory of man-made land along the Indiana shoreline of Lake Michigan; April 30, 1979; Tech. Rep. No. 304.
Note: NRPC.
This inventory of man-made lands was undertaken in an effort to compile a complete record of authority to fill permits and patents. Whenever possible, an attempt is also made to obtain or locate the plats of survey which accompany the filing of such documents. The DNR, Secretary of State, State Auditor, Lake County Surveyor, Lake County Auditor, Lake County Recorder's Offices, and the archives of the Indiana State Library provided records of man-made fills in Lake Michigan.

277. Indiana Dunes National Lakeshore (Indiana Dunes National Lakeshore). Land Protection Plan (Draft); 7-01-87.
Note: Covers National Lakeshore, Lake, Porter, Laporte counties.
Identification of land uses and land needs of IDNLS.

278. Indiana State Planning Servic Agency. Technical Memorandum II: Socioeconomic Description of the Indiana Coastal Zone. Highland, IN: Indiana State Planning Services Agency; 1976.

279. Indiana Department of Commerce; Ranos, C. Economic Impact Models: The Indiana Coastal Zone Management Program; June 1979; Technical Report No. 301.
The majority of the report is concerned with demonstrating the contribution that economic analysis can make to Coastal Zone Management.

280. Johnson, David A.; Russell, John R., Ball State University (Indiana State Planning Services Agency). Esthetic Resource Assessment. Indianapolis, IN; September 1976; Technical Report 104.
Note: CZM.
This deals with producing definite guidelines for the assessment of esthetic resources to aid in the program for Coastal Zone Management. The College of Architecture and Planning Team (Ball State) must inventory esthetic resources and provide visual aid documents and narrative information for use in public educational and public participation activities.

281. Johnson, Johnson & Roy, Inc. (Ann Arbor, MI). East Chicago lakefront study East Chicago, Indiana. Conceptual Design Plan; April 1978. NRPC.
Note: Summary record of critical concepts from project meetings held in East Chicago, Nov. 3, 1977, and Jan. 5, March 16, and May 4, 1978.
The purpose of this report is to identify development opportunities which optimize citizen use and appreciation of East Chicago Indiana's Lake Michigan shoreline. Recent recreation use patterns at Jeorse Park suggest that the existing facility does not encourage local residents to take full advantage of this limited and unique natural resource. Johnson, Johnson & Roy of Ann Arbor, MI., were retained by the city in January, 1978, to prepare a Conceptual Design Study and Plan. This plan not only recommends broad recreation opportunities, but also identifies methods for maximizing existing and desired uses. Economic evaluation and funding recommendations also included in the study assist in project implementation. This report graphically records and explains the proposed concept design plan and how it can be implemented.

282. Johnson, Johnson & Roy Inc. Jeorse Park. Road Access Study, East Chicago, Indiana; July 1980.
Note: CZM.
Jeorse Park is East Chicago's only lakefront public open space. Its unique character demands that every effort be taken to realize the full recreational potential of this facility. Currently underutilized, the "East Chicago Lakefront Study" identified how Jeorse Park should be improved. Marina and boating facilities, passive play areas, walkways and beach, fishing areas, and new parking lots and service roads are proposed. Although Jeorse Park can readily accomodate these activities and potentially attract greater numbers of users, the Park is difficult to reach. The Park user must either negotiate the intense traffic activity during these periods, or plan to use the facilities during slack hours. It is the purpose of this study to identify what alignments might be feasible from a conceptual design standpoint to rectify this accessibility problem.

283. Johnson Johnson & Roy/inc. (Ann Arbor, Michigan) (For the City of Portage Port Authority). Burns Waterway Boat Capacity Study. Ann Arbor, MI.: Johnson Johnson & Roy/inc.; Oct. 1990. Note: reprint.
Through an on-site boat survey conducted on June 30, 1990, a wide range of data related to boat use and user characteristics was collected. A follow-up mail survey of Waterway slip-holders and marina operators assisted in the evaluation of existing waterway conditions, as well as providing a means of assessing the reliability of the analytical results. The physical data obtained during the survey--channel geometry, volume of boats in use, boat speeds and sizes, and boat slip and launch patterns--provided the basis for estimating boat capacity at various locations on the Waterway. Survey results are included in separate appendages. Interpretation of the analytical results are provided by descriptive figures, tables, and charts. Finally, potential scenarios of development, and channel improvements and modifications are evaluated to determine their relative impact upon the Waterway.

284. Lambert, John F. Jr. Land Acquisition in the National Parks: Examples from Yosemite National Park and Indiana Dunes National Lakeshore. Harvard Environmental Law Review; 1982; 6(1): 35.

285. LMMDC (Lake Michigan Marina Development Commission). Lake Michigan Marina Development Commission, Annual Report Subtitle: Annual Report (12 months ended June 30, 1987); 6-1-87; Annual Report 1987.

286. LMMDC (Lake Michigan Marina Development Commission). Lake Michigan Marina Development Commission, Annual Report Subtitle: Annual Report (12 months ended June 30, 1988); 6-1-88; Annual Report 1988.

287. LMMDC (Lake Michigan Marina Development Commission). Lake Michigan Marina Development Commission, Annual Report Subtitle: Annual Report (12 months ended June 30, 1989); 6-1-89; Annual Report 1989.

288. LMMDC meeting (News). Lakefront Development Subtitle: Reprint Post-Tribune, March 1988; 3-1-88. Note: Covers articles on marina development.

289. Michiana Area Council of Governments (Coastal Zone Management Program). Economic and Social Inventory. Part 2. Indianapolis, IN: Indiana State Planning Services Agency.; September 30, 1976; Technical Report 102. (Project Indiana CS-5-4).
Note: CZM.
This report accompanies the work done by the Northwestern Indiana Regional Planning Commision in Part 1 of the inventory, and provides data on air and water quality, population trends/projections, employment, housing, public facilities, land use and ownership, etc.

290. Moshman Associates, Inc. Burns Waterway Harbor Export Coal Feasibility.; October 1981; Final Report. Project Indiana CZ086-81-01.
Note: CZM.
Based upon critical review of recently completed and published reports, the history, current status, and future outlook for world coal trade and U.S. exports of soft coals were examined. Preliminary siting, design, construction, and operating cost estimates for a two to three million annual ton capacity terminal at Burns Waterway Harbor (BWH) were developed, as were total transportation cost estimates. Conclusions as to economic feasibility were reached and potentially rewarding actions were suggested.

291. Moshman Associates, Inc. (For: Indiana Port Commission). Port of Indiana Burns Waterway Harbor. Economic Impact, 1977. Washington, D.C.: Moshman Assoc., Inc.; June 1978; Final Report.
Note: CZM.
This study was undertaken at the request of the Indiana Port Commission pursuant to a proposal dated February 10, 1978. This study's purposes are to provide quantitative measures of the direct and indirect socio-economic impacts generated by Burns Harbor. The motivation underlying these study purposes are to apprise State and Federal officials, specifically those of the Economic Development Administration, of this Port's effects upon the domestic sub-economies in its geographic sphere of influence. Moreover, it was hypothesized that the impacts measurements would result in findings which would render Burns Harbor eligible for the award of a public works grant. Another purpose is the Port Commission's desire to obtain new inputs for its policy-making and planning purposes.

292. NIRPC. A Socio-economic Description of the Indiana Coastal Zone.: Indianapolis; August 1976; Technical Memorandum II.
Note: CZM.
Describes the socioeconomic conditions in the state's coastal zone in terms of population trends, population characteristics, personal and family finance, and employment. Regional forecasts of population and employment are made.

293. Northwestern Indiana Regional Planning Commission (Coastal Zone Management Program). Economic and Social Inventory. Part 1. Indianapolis, IN: Indiana State Planning Services Agency; September, 1976; Technical Report 102.
Note: CZM (Part 2 of this inventory was prepared by the Michiana Area Council of Governments).
Lake Michigan forms the northern boundary for Lake and Porter Counties and the State of Indiana. The 33 miles of shoreline is shared by the nation's largest steel-making complex, power-generating plants, a major shipping port, private homeowners, and the Dunes State and National lakeshore Parks. The potential exists for further development of land in the coastal area. What direction this development should take, how much should be allowed, and what should be preserved as public open space for future generations are the major issues being addressed in the Coastal Zone Management Program. A methodology for resolving these issues is the major goal. This report provides the basic data necessary to begin designing a management program that will direct the future uses and prevent abuses of Indiana's coastal zone.

294. Northwestern Indiana Regional Planning Commission. Indiana Coastal Zone Management Program. Inventory of plans, projects, and programs; 1976; Tech. Report 103, Part 2.
Note: NRPC.
The purpose of this inventory is to identify problems and issues of general concern to communities within the study area and to assist in the development of the role of various agencies in management of the coastal zone.

295. Northwestern Indiana Regional Planning Commission. A Socio-Physical Description of the Indiana Coastal Zone. Indianapolis, IN: NIRPC; August, 1976; Technical Memorandum III.
Note: CZM.
Describes for the state's coastal zone such social parameters as housing, cultural resources, historical and architectural landmarks, educational resources, recreational resources, parks and recreation needs, community facilities and services, and others.

296. Ralph Burke Associates (For: Lake County Parks and Recreation Board, Crown Point, Indiana). Lakeshore Park & Marina Master Plan Development, Lake County, Indiana. Park Ridge, IL 60068: Ralph Burke Associates; March 1976; Project No. 7528.
Note: CZM.
Ralph H. Burke Associates has been authorized by the Lake County Park and Recreation Board to prepare the initial phase of a Lake County Lakeshore Park and Marina Master Plan Development. This report will constitute the Phase I portion of a five phase unilateral contract to include a Master Plan development for a park and marina, environmental assessment, financial feasibility analysis, design and construction services and project representation.

297. Recreation Planning Associates Ltd. Michigan City Development Plan: Indiana Coastal Zone Management Program Demonstration. 2400 East Devon Avenue, Suite 165, Des Plaines, IL; December 1980.
This is the third and final report to be submitted to the State of Indiana and City of Michigan City, addressing the redevelopment opportunities related to the Trail Creek portion of Michigan City's North-End Area. This section will summarize the Initial Problem Analysis, indicate the Market Opportunities, and describe the Recommended Development Plan.

298. Recreation Planning Associates. North-end Area. Task I: Problem Analysis. (Planning study of: Trail Creek Waterfront Redevelopment, Recreational Boating Plan, National Lakeshore Transit and Information Center; June 1980.
Note: CZM.
A study of the North End of Michigan City, Indiana demonstrating general economic conditions and development opportunities, physical characteristics of the several "North End" neighborhoods, and a preliminary overview of funding and implementation issues.

299. Recreation Planning Associates; et al. Michigan City Development Plan. Indiana Coastal Zone Management Program Demonstration; 1980.
Note: NIRPC.
Planning study of: I. Trail Creek Waterfront Redevelopment, II. Recreation Boating Plan, III. National Lakeshore Transit and Information Center.

300. Recreation Planning Associates; et al. North-end Area. Initial Plan and Strategy for Redevelopment. Phase III: Action Plan; June 1980.
Note: CZM.
This is the third and final report to be submitted to the City of Michigan City, Indiana, addressing the redevelopment opportunities of Michigan City's "North End". This report, which is based on the previous two reports as well as client response, is a refinement of the efforts of earlier phases and provides the Project Team's recommendations regarding the redevelopment program and implementation strategy.

301. Seketa, George; Schoonveldt, Michael, Investigators. Lake Michigan Breakwater & Pier Report: House Bill 1069: Division of Fish and Wildlife.
Note: copy obtained from George Seketa.
This report studies the feasibility of constructing fishing piers or modifying existing breakwater facilities to accomodate shoreline fisherman. Good dependable shoreline fishing opportunities for salmon, trout, and perch fishing along the Lake Michigan Shoreline is fairly restrictive throughout the total Indiana Lake Michigan Shoreline. The greatest potential for development of permanent shoreline fishing opportunities exists at the Port of Indiana, Midwest Steel, and Jeorse Park and Buffington Pier areas. Usage, construction costs, and federal funds are some of the topics discussed in this report.

302. State of Indiana, State Planning Agency / City of Whiting, Indiana / Stanley Consultants, Chicago, Illinois (For the Department of Parks & Recreation City of Whiting, Indiana). Whiting Park Shoreline and Park Development Study. Indianapolis, Indiana: State of Indiana, State Planning Services Agency; July 1980.
Note: reprint.
This report summarizes the investigations and findings related to the technical and economic development of the required park facilities. Plans to develop an expanded beach area for Whiting Park are presented and conceptual alternative plans for the overal development of the park waterfront and park access are prepared. Critical project elements are addressed and cost estimates for the development alternatives have been prepared. The alternatives have been evaluated from technical, economic, functional, and aesthetic criteria. The end product of the study is the recommendation of the most favorable park development alternative.

303. TenEch Engineering, Inc.; Association with Plantec Corp
(Submitted to Lake Michigan Marina Development Commission).
Marina Development Plan, Portage
Subtitle: Portage; 9-1-86.
Note: Covers Portage.
Economic feasibility of marina development.

304. TenEch Engineering, Inc.; Association with Plantec Corp
(Submitted to Lake Michigan Marina Development Commission).
Marina Development Plan
Subtitle: Executive Summary, Financial Feasibility and Economic Impact Study; 9-1-86.
Note: Covers 5 Indiana shoreline cities.
Economic feasibility of marina development.

305. TenEch Engineering, Inc.; Association with Plantec Corp
(Submitted to Lake Michigan Marina Development Commission).
Marina Development Plan, Hammond, Indiana
Subtitle: Hammond; 9-1-86.
Note: Covers Hammond.
Economic feasibility of marina development.

306. TenEch Engineering, Inc.; Association with Plantec Corp
(Submitted to Lake Michigan Marina Development Commission).
Marina Development Plan, Michigan City
Subtitle: Michigan City; 9-1-86.
Note: Covers Michigan City.
Economic feasibility of marina development.

307. TenEch Engineering, Inc.; Association with Plantec Corp
(Submitted to Lake Michigan Marina Development Commission).
Marina Development Plan, Gary
Subtitle: Gary; 9-1-86.
Note: Covers Gary.
Economic feasibility of marina development.

308. TenEch Engineering, Inc.; Association with Plantec Corp
(Submitted to Lake Michigan Marina Development Commission).
Marina Development Plan,
Subtitle: Plan; 9-1-86.
Note: Covers Hammond, East Chicago, Gary, Portage, Michigan City.
Economic feasibility of marina development.

309. TenEch Engineering, Inc.; Association with Plantec Corp (Submitted to Lake Michigan Marina Development Commission). Marina Development Plan, East Chicago
Subtitle: East Chicago; 9-1-86.
Note: Covers East Chicago.
Economic feasibility of marina development.

310. Teska Associates, Inc. Waterfront Development Plan, Portage, IN. Evanston, Il; 1988.
This report describes the future development potential of an important location within the City of Portage, Indiana.

311. Theobold, W. F. Tourism Development Plan, Lake County, Indiana.
tourism/ recreation/ Lake County/ Indiana.

312. Thurow, Charles; Daniel, Glenda; Brown, Timothy H. Impact of the Great Lakes on the Region's Economy. 435 North Michigan Avenue, Chicago, IL: Center for the Great Lakes; August 1984.
Note: A report to the Council of Great Lakes Governors.
This is an analysis of the relationship between the availability of Great Lakes water and future economic growth in the region. From a number of interviews and written reports analyzing the region's economic and environmental health from broader or different perspectives, the Center sought: 1) to document the ways water is used by different economic sectors in the region, 2) to gather estimates of the amount of money generated for the regional economy or particular water-dependent sectors of that economy, 3) to isolate examples of innovative marketing and promotional strategies which focus on the region's water resources and which might profitably be adapted for use in region-wide strategies. The resulting report presents a summary of the Center's findings along with conclusions and recommendations for action by the Council of Great Lakes Governors and other Public and private-sector policymakers in the region.

313. U.S. Army Corps of Engineers. Chicago District Project Maps. River and Harbor Works; 1985.
Note: Mich. City.
Includes the Calumet Harbor and River, Indiana Harbor, Burns Waterway Harbor, Beverly Shores and Michigan City Harbor.

314. U.S. Army Corps of Engineers. Indiana Shoreline Erosion: Final Feasibility Report and Environmental Impact Statement. Chicago, Illinois: U.S. Army Corps of Engineers; June 1992.
Note: reprint.
This study investigated the shoreland erosion problems between Michigan City Harbor, Indiana and the Illinois-Indiana State line. As a result of the study this report recommends shore erosion control measures for the reach of shore immediately west of Michigan City Harbor.

315. Wendell Campbell Associates, Inc., Architects, Planners, Construction Managers (For: City of Gary, Indiana). Marquette Park Small Boat Harbor Feasibility Study. Chicago, Illinois: Wendell Campbell Associates, Inc.; April 15, 1976.
Note: CZM.
Marquette Park has historically been the primary recreation spot for the citizens of Gary and the people who reside in the Greater Gary Area. The lake is a tremendous attraction for boating, water skiing and fishing. This attraction creates a consumer demand that can be converted into an economic and recreation asset to the city through the development of a small boat harbor at Marquette Park. This study was commissioned to determine the physical development of the harbor and how that physical development should be programmed in order that the harbor would be economically feasible. The location of the boat harbor and the demand for boating and fishing facilities are reviewed. The design concept for the initial harbor facilities and the final development have been prepared with prime consideration given to the hydrographic conditions, construction cost and generated revenues.

316. Williams-Kuebelbeck & Associates, Inc.(Real estate economic, financial and management consultants, Irvine, CA.); Epstein Civil Engineering, Inc.(Chicago, IL). Indiana Marina Market and Economic Study; October 31, 1985.
Note: NRPC.
Based upon the findings presented in this study, the following important conclusions have been drawn which summarize the potential for marina development along the Indiana shoreline of Lake Michigan. 1) There is a large, untapped demand for boat slips in the South Lake Michigan market area. While the bulk of this unfulfilled demand is generated by the Illinois submarket, Indiana also stands in a good position to develop additional marina facilities along its Lake Michigan shoreline. 2) Indiana is faced with the opportunity to increase the demand for marina facilities by seeking to include other recreation facilities and attractions at marina sites (with the highest potential west

of the Dunes to attract visitors from the Chicago area). 3) Creation of a revolving loan fund to assist in financing and construction, and lowering the tax burden placed on boat owners in Indiana is advised. 4)Available choices to Indiana are to include narrow development focusing on boat storage and related facilities, or a broader approach that emphasizes more extensive waterfront development. The latter approach seems more promising. 5) Major constraints on development include: Lack of suitable sites; insufficient land area at available sites, and a lack of funding sources. 6) Overall, there's a bright future ahead for marina development in Indiana.

317. Wood, William L.; Meadows, Guy; Cox, Jack, Dept. of Geosciences, Great Lakes Coastal Research Laboratory, Purdue Univ. (For: Department of Commerce, IN). Summary Report on The Feasibility of the Coastal Installations Proposed for the West Park and Marina Development at Michigan City, Indiana. Economic Feasibility Proposals of West Park and Marina Development. Michigan City, Indiana. T. "Ted" Pantazis ed. Indiana Department of Commerce. Indianapolis, IN: Indiana Dept. of Commerce.
Note: CZM.
The following brief summary report was prepared by the staff of the Great Lakes Coastal Research Laboratory to assist the Indiana Department of Commerce in assessing the feasibility of coastal installations proposed for the West Park and Marina Development at Michigan City, Indiana. The position supported herein is, that existing designs for breakwater and coastal defense systems will have deleterious effects on local and adjacent coastal provinces. It should be understood that this position is taken to be temporarily efficacious and does not imply that no solution is possible. Furthermore this position is designed to stress the concern for a total integrated coastal management concept in the assessment of the environmental impact of any coastal installations in the Michigan City or adjacent areas.

Appendix 1: Environment

318. Appleby. Environmental Science and Technology; 1979; 13(4): 478.
Note: No official abstract.
in Correspondence section.
This paper deals with a relationship between the lead concentration in Lake Michigan sediments and the annual emission of lead into the atmosphere.

319. Auer, M.T.; Heidtke, T.M.; Canale, R.P. (Dep. Civ. Eng., Michigan Technol. Univ., Houghton, MI 49931). Trophic State Response to Nonpoint Pollution Control: Application of Coupled Microcomputer Models to the Great Lakes. In: Perspectives on Nonpoint Source Pollution: Proceedings of a National Conference; May 19-22, 1985; Kansas City, Missouri. Washington DC: U.S. EPA, Office of Water Regulations and Standards; 1985: 147-152.
Note: EPA 440-5-85-001.
Phosphorus loading from the Fox River (Wisconsin) produces a gradient in trophic state along the major axis of Green Bay (Lake Michigan) ranging from hypereutrophic to oligotrophic. Water quality problems associated with the gradient include high turbidity, excessive algal growth, and dissolved oxygen depletion. The Fox River contributes 78% of the tributary total phosphorus load to Green Bay; more than half of that load originates from nonpoint sources. A unit area load (UAL) based microcomputer model is used to generate estimates of non-point total phosphorus loads as a function of land use and soil texture in the Fox River watershed. Phosphorus loads are input to a water quality microcomputer model which calculates the total phosphorus and chlorophyll concentrations, water transparency, and trophic state corresponding to that load. Changes in water quality and trophic state are examined under existing conditions and two hypothetical land use scenarios: 100 percent woodland and 100 percent high tillage cropland.

320. Bartholic, J.F. Fiscal year 1985 Program Report: Michigan Institute of Water Research; Sep. 1986; NTIS Order No.: PB87-159422/GAR: 35 pp.
Note: Grant DI-14-0001-G-1024.
The major thrust of the Michigan Institute of Water Research during the 1985 program year involved activities related to its research program, state-wide water resources planning activities and the technology transfer program. Water management planning along with surface and ground-water contamination problems are the top priority issues in the

state at the present time. Research projects funded by the Institute of Water Research to address these problems and issues are listed.

321. Beeton, A.M. The World's Great Lakes. J. Great Lakes Res.; 1984; 10(2): 106-113; ISSN: 0380-1330.

322. Bell, G.L.; Eadie, B.J. Variations in the Distribution of Suspended Particles During an Upwelling Event in Lake Michigan in 1980. J. Great Lakes Res.; 1983; 9(4): 559-567; ISSN: 0380-1330.

323. Bockstael, N. E.; Hanemann, W. M.; Strand, I. E. Measuring the Benefits of Water Quality Using Recreational Demand Models, "Benefit Analysis Using Indirect or Imputed Market Methods,"Draft; 1984.

324. Bowers, J.A.; Gensemer, R.W. (Univ. Michigan, Great Lakes and Mar. Waters Cent., Div. Biol. Sci., Ann Arbor, MI 48109). Improved Population Estimates of Mysis relicta in Lake Michigan. in IAGLR-86 Program. International Association for Great Lakes Research 29th Conference; May 26-29, 1986; Scarborough, Ont. Canada. International Association for Great Lakes Research, Buffalo NY; 1986: 26.
Note: abstract only.

325. Brandt, S.B.; Patrick, V.; Mason, D.M.; Argyle, R.L.; Wells, L. Spatial and Temporal Patchiness and Abundance of Pelagic Fishes in Lake Michigan. 32nd Conf. on Great Lakes Research; 30 May-June 2 1989; Madison, WI. Buffalo, NY: Int. Assoc. for Great Lakes Research; 1989: 32 (summary only).
Lakewide abundances and patchiness of fishes were assessed in Lake Michigan during spring and summer 1987, fall 1988 and winter 1989. Data compiled using underwater acoustics and extensive midwater and bottom trawling illustrate the highly dynamic features of fish distributions. Palaeogic fishes exhibited lakewide seasonal migrations, small-scale diel migrations, clear associations with habitat structure and dynamic patchiness. Statistical evaluations of the acoustic measures of fish density and biomass-size spectra were used to estimate lakewide prey-fish abundances, patchiness and ultimately, production.

326. Brown, E.J., Jr.; Argyle, R.L.; Payne, N.R.; Holey, M.E. Yield and Dynamics of Destabilized Chub (Coregonus spp.) Populations in Lakes Michigan and Huron, 1950-1984. Can. J. Fish. Aquat. Sci.; 1987; 44(no. suppl. 2): 371-383; ISSN: 0706-652X.

327. Carrick, H.J.; Fahnenstiel, G.L. Biomass, Size Structure, and Composition of Phototrophic and Heterotrophic Nanoflagellate Communities in Lakes Huron and Michigan. Can. Journal of Fish. Aquat. Sci.; 1989; 46(11): 1922-1928; ISSN: 0706-652X.

328. Carrick, H.J.; Lowe, R.L. Response of Lake Michigan Benthic Algae to In Situ Enrichment with Si, N, and P. Can. J. Fish. Aquat. Sci.; 1988; 45(2): 271-279; ISSN: 0706-652X.
The possibility that benthic algae in the nearshore area of Lake Michigan might be growth limited by Si was tested using nutrient-releasing substrata. Nutrient treatments were Si, N + P, Si + N + P, and controls (CONT) and were sampled after 7, 14, and 31 d of exposure. Addition of Si alone had little stimulatory effect on algal biomass, while enrichment with Si + N + P led to the greatest increase in chlorophyll a, particulate Si, total biovolume, and diatom biovolume after 14 d of incubation. By day 31, communities on CONT and Si substrata exhibited little change in biomass and remained dominated by diatoms, while algal biomass on both N + P and Si + N + P substrata increased more than eightfold and consisted mainly of Stigeclonium tenue (Chlorophyta) and Schizothrix calcicloa (Cyanophyta). These results indicate that benthic diatoms in Lake Michigan are not currently limited by Si, but may become Si limited following enrichment with N + P.

329. Chang, W.Y.B.; Rossmann, R. (Univ. Michigan, Great Lakes Res. Div., 2200 Bonisted Blvd, Ann Arbor, MI 48109). Effects of Power Plant Entrainment on Phytoplankton Response. in Congress in France 1983. Proceedings.
Congress of the International Association of Limnology; 21 Aug, 1983; Lyon, France. Stuttgart (FRG): Schweizerbart'sche Verlagsbuchhandlung; 1984: 2493-2497. (Trav. Assoc. Int. Limnol. Theor. Appl.; v. vol. 22, no. 4); ISBN: 3-510-54026-3.
Note: ISSN 0368-0770.
Effects of power plant entrainment on phytoplankton response consist primarily of four types: thermal and hydromechanical impacts, and the impacts of biofouling control and of erosion and corrosion of power plant components. A study focusing on these issues was conducted between February 1980 and May 1982 at the D.C. Cook Plant on the southeastern shore of Lake Michigan. The results show that changes in chlorophyll and phaeophytin concentration are not significant in water which has passed through the condenser cooling system, but the reduction in primary productivity as measured by C14 was remarkable, ranging from 20%-80%. While the former show no significant damage done by increased temperature and

hydromechanical abrasion on phytoplankton, the latter indicates a significant inhibition of the photosynthesis of these phytoplankton.

330. Chmura, Gail L.; Ross, Neil W. The Environmental Impacts of Marinas and Their Boats: A Literature Review with Management Considerations. Narragansett, Rhode Island: University of Rhode Island; 1978; Marine Memorandum 45. 32 pp.
The purpose of this review is to summarize all aspects of marina and boat-related environmental effects. Discussion focuses on studies of each component's effects, the management options needed to reduce negative effects and expand positive ones, and future research needs.

331. Christensen, E.R.; Goetz, R.H. (Dep. Civ. Eng., Univ. Wisconsin, Milwaukee, WI 53201). Declining Atmoshperic Fluxes of Pb, Zn, Cd, and PCBs to Lake Michigan. in IAGLR-86 Program. International Association for Great Lakes Research 29th Conference; May 26-29, 1986; International Association for Great Lakes Research, Buffalo, NY; 1986: 28.
A deconvolution method has been developed to extract the historical input record of particle-associated pollutants to a lake from their sedimentary profiles influenced by mixing. Based on known mixing and compaction paramenters of the sediment, a time vs. depth matrix E is generated from a known unit input flux, and the input record F is then calculated by inverting E and multiplying with the existing profile vector C. The method has been successfully tested and applied to Pb, Zn, and Cd in several sediment cores from Lake Michigan. Using 15-year time intervals, it is shown that there is about a 44% decrease in Pb levels during 1969-84, a 34% decrease in Cd levels during 1954-84, and about a 23% decrease in Zn levels during 1960-84.

332. Christensen, E.R.; Goetz, R.H. Historical Fluxes of Particle-bound Pollutants from Deconvolved Sedimentary Records. Environ. Sci. Technol.; Nov. 1987; 21(11): 1088-1096.
A deconvolution method to extract the historical input records of particle-associated pollutants from their sedimentary profiles, influenced by mixing, is developed. Application of the method to Pb, Zn, and Cd in several Lake Michigan sediment cores shows that pollution with these metals started around 1894 in the southern part of the lake and 15-30 years later further north. A maximum was obtained during 1954-1969 for Pb and Zn and during 1939-1954 for Cd, while current levels have declined 45-35% relative to these maxima in accordance with available atmospheric loading data (Pd) and U.S. consumption figures (Zn and Cd).

333. Claflin, L.W. (Maryland Off. Environ. Programs, Div. Model. and Anal., 201 West Preston St., Baltimore, MD 21201). Associations Between the Phytoplanktonic and Physicochemical Regimes of Lake Michigan. International Symposium on the Phycology of Large Lakes of the World; St. John's, Nfld. (Canada). Stuttgart (Frg.): Schweizerbart'sche Verlagsbuchhandlung; 1987; 25: 97-121. (Munawar, M.); ISBN: 3-510-47023-0.
Note: ISSN 0071-1128.
Phytoplanktonic and physicochemical data were collected on a Lake Michigan transect between Milwaukee, Wisconsin and Ludington, Michigan from 6 October 1971 to 29 October 1972. Spatial and temporal patterns of the data were visually displayed with contour and isometric profection plots. Five phytoplanktonic groups and four physicochemical groups were identified by principal components analysis. The fall-winter-spring group varied directly with nitrate nitrogen and silica and inversely with temperature, pH, and phenolphthalein alkalinity. The spring mixing group varied directly with specific conductance and total alkalinity. The early and late summer stratification groups varied directly with temperature, pH, and alkalinity and inversely with nitrate nitrogen and silica. The fall mixing group varied directly with total phosphorus and soluble reactive phosphorus.

334. Conley, D.J.; Quigley, M.A.; Schelske, C.L. Silica and Phosphorus Flux from Sediments: Importance of Internal Recycling in Lake Michigan. Can. J. Fish. Aquat. Sci.; 1988; 45(6): 1030-1035; ISSN: 0706-652X.
Estimated lake-wide sediment fluxes of silica and phosphorus (P) were determined and then compared with other components in the biogeochemical cycle to investigate the importance of sediment regeneration in Lake Michigan. Dissolved silica (Si) and soluble reactive phosphorus (SRP) fluxes from sediment were measured by the incubation of intact sediment cores. Differences in the supply rates and in the biogeochemical recycling rates of Si and P can lead to seasonal Si depletion in the water mass and influence the outcome of seasonal phytoplankton species succession by limiting Si availability necessary for diatom production.

335. Conley, D.J.; Schelske, C.L. Processes Controlling the Benthic Regeneration and Sedimentary Accumulation of Biogenic Silica in Lake Michigan. Arch. Hydrobiol.; 1989; 116(1): 23-43; ISSN: 0003-9136.
Processes controlling the benthic regeneration of biogenic silica (BSi) and factors affecting the accumulation of BSi in Lake Michigan sediments were investigated. Dissolved silica (DSi) fluxes measured directly by core incubation ranged from 2.3-10.3 mg SiO2 cm(-2)/yr and were 1-10 times greater than diffusive DSi fluxes calculated from pore water DSi concentration gradients which ranged from 0.4-5.3 mg SiO2 cm(-2)/yr. Benthic invertebrates were probably not a significant factor in enhancing DSi fluxes. DSi fluxes measured from cores could be predicted from the surficial sediment BSi concentration in cores by a saturation curve. At high surficial BSi concentrations DSi fluxes appeared to be limited by diffusive transfer of DSi into overlying waters. Experiments in which the upper 2 mm of sediment was removed confirmed the importance of BSi on the sediment surface to DSi fluxes.

336. Crowder, L.B.; McDonald, M.E.; Rice, J.A Understanding Recruitment of Lake Michigan Fishes: The Importance of Size-Based Interactions Between Fish and Zooplankton. Can. J. Fish. Aquat. Sci.; 1987; 44(no. suppl. 2): 141-147; ISSN: 0706-652X.
Mechanisms controlling recruitment of fishes appear to be strongly size dependent. It is now established that size-selective predators can dramatically reduce zooplankton size, but little is known about the effects of zooplankton size on growth and recruitment of fish through the post-larval stage. Based on recent research on resource use, foraging behavior, and recruitment dynamics of larval and juvenile fishes, the authors suggest two hypotheses. First, young-of-year and juvenile pelagic fishes may have the major size-structuring effects on epilimnial zooplankton in Lake Michigan. And second, if large zooplankton are uncommon as they were in Lake Michigan in the 1960s, growth rates and recruitment of native fishes will be reduced.

337. Cuthbert F.J. Tern Populations and Changing Lake Levels: Implications for Management and Conservation. 32nd Conference on Great Lakes Research; May 30-June 2, 1989; Madison, WI; 1989; in 32nd Conference on Great Lakes Research. Int. Assoc. for Great Lakes Research, Buffalo, NY: 40 (Summary only).

338. Cuthbert, F. Intraseasonal Movement Between Colony Sites by Caspian Terns in the Great Lakes. Wilson Bull.; Dec 1985; 97(4): 502-510.

339. D'itri, F.M. Pollution of a Marina Area by Watercraft Use. J. Water Poll. Control Fed.; 1973; 45(1): 97-104.

340. David, E.L. Public Perceptions of Water Quality. Water Research; 1971; 7(3): 453-457.
Water pollution is perceived by the general public to be of increasing concern as a major problem facing the state. The most widely used indicators of water pollution seem insufficient in light of the public definition of, and concern about, water pollution.

341. Dorazio, R.M.; Bowers, J.A.; Lehman, J.T. Food-web Manipulations Influence Grazer Control of Phytoplankton Growth Rates in Lake Michigan. J. Plankton Res.; 1987; 9(5): 891-899.
Stocking piscivorous salmonids in Lake Michigan produced dramatic alterations in food-web structure, including higher numbers of large-bodied zooplankton (especially Daphnia pulicaria), lower summer chlorophyll concentrations and increased water transparency. Experimental determinations of epilimnetic phytoplankton growth rates and of zooplankton grazing rates indicate that herbivorous zooplankton controlled algal dynamics during the summer of 1983 because grazers occupied the surface waters throughout the day. In 1985, however, both large- and small-bodied Daphnia made approximately equal contributions to total grazer biomass, and all grazers displayed pronounced diel vertical migrations, visiting epilimnetic waters only at night. This prohibited zooplankton from controlling algal dynamics because grazing losses did not exceed phytoplankton growth rates. The changes in zooplankton community composition and behavior observed in summer 1985 probably resulted from increased predation by visually orienting planktivorous fish, especially bloater chub (Coregonus hoyi).

342. Dunn, D.L. Cadmium-113m as a Biogeochemical Tracer for Cadmium in Lake Michigan. DISS. ABST. INT. PT. B-SCI. & ENG.; Nov. 1988; 49(5): 133 pp.
Note: Diss. Ph.D.: Order No.: DA8816265.
Cadmium is a toxic trace metal responsible for several debilitating pathological conditions. Anthropogenic activity has greatly enhanced environmental cadmium mobility. There has been concern about the fate of cadmium in potable water supplies. The Great Lakes are major sources of freshwater for much of the populated United States and Canada. The Lake

Michigan watershed has been sampled for Cd-113m. This long-lived metastable isotope of cadmium allowed independent evaluation of cadmium distribution in this dynamic ecosystem. Cd-113m analysis was not hampered by contamination or loss. The Cd-113 activities confirm the expected semiconservative behavior for cadmium.

343. Eadie, B. J.; Landrum, P. F.; Faust, W. Polycyclic Aromatic Hydrocarbons in Sediments, Pore Water and the Amphipod Pontoporeia hoyi from Lake Michigan. Chemosphere; 1982; 11(9): 847.

344. Eck, G.W.; Wells, L. Recent Changes in Lake Michigan's Fish Community and Their Probable Causes, with Emphasis on the Role of the Alewife (Alosa pseudoharangus). Can. J. Fish. Aquat. Sci.; 1988; 44(no. suppl. 2): 53-60; ISSN: 0706-652X. The exotic alewife (Alosa pseudoharengus), which had proliferated to extremely high levels of abundance in the mid 1960s, declined, particularly in the early 1980s. The authors believe that the sharp decline in alewives in the 1980s was caused primarily by poor recruitment during the colder than normal years of 1976-82. The authors present evidence suggesting that the mechanism by which alewives affect native species is not by competition for food, as has often been hypothesized, and discuss the possibility that it is predation on early life stages.

345. English, J. N.; Surber, E. W.; McDermott, G. N. Pollutional Effects of Outboard Motor Exhaust -- Field Studies. J. Water Pollut. Control Fed.; 1963; 35: 1121-1132.

346. Evans, M.S. Large-Lake Responses to Declines in the Abundance of a Major Fish Planktivore - the Lake Michigan Example. Canadian Journal of Fish and Aquatic Science; Sept 1990; 47(9): 1738-1754; ISSN: 0706-625X. Alewife (Alosa pseudoharengus) abundances declined dramatically in southeastern Lake Michigan over 1973-77, several years before the lakewide decline occurred. The regional effects of this decline on adult copepod abundances, zooplankton biomass, and water clarity are examined. Zooplankton biomass, zooplankton mean dry weight, and water clarity apparently were not affected by the decline in alewife abundance in either the inshore or offshore region. The results of this study are evaluated in terms of the lakewide decline in alewife abundance, the summer 1983 dominance of Daphnia pulicaria in offshore waters, the 1983 marked improvement in offshore water clarity, and later changes in summer offshore C. pulicaria populations.

347. Evans, M.S.; Schelske, C.L. (Great Lakes Res. Div., Univ. Michigan, Ann Arbor, MI 48109). Seasonal Aspects of Total Dry Weight and Biogenic Silica Flux, Lake Michigan. in IAGLR-86 Program. International Association For Great Lakes Research 29th Conference; May 26-29, 1986; Scarborough, Ont. (Canada): International Association for Great Lakes Research, Buffalo, NY; 1986: 32.
Note: abstract only.
Total dry weight flux varied seasonally in Lake Michigan with highest rates observed in spring. During spring, zooplankton fecal pellets and fecal matter accounted for approximately 35-55% while phytoplankton accounted for 12-18% of total dry weight flux. However, in terms of biogenic silica, phytoplankton accounted for approximately 36% of the flux. Melosira and Stephanodiscus were the major components of this silica flux. During summer, organic aggregates and zooplankton exoskeletons accounted for much of the dry weight flux. Biogenic silica flux rates were low and individually sinking phytoplankton cells appeared to contribute proportionately less to silica flux than in spring. Flagilaria and Tabellaria were important components of summer biogenic silica flux.

348. Fahnenstiel, G.L.; Carrick, H.J. Primary Production in Lakes Huron and Michigan: In Vitro and In Situ Comparisons. J. Plankton Res.; Nov 1988; 10(6): 1273-1283.
Oxygen- and carbon-14-based primary production estimates from 9-16 h in vitro incubations were compared in lakes Huron and Michigan. For surface mixing layer comparisons, gross O2/C14 photosynthetic quotients (gross PQ) averaged 2.2, and net O2/C14 photosynthetic quotients (net PQ) averaged 1.4. In situ production estimates were determined by measuring water-mass oxygen changes and oxygen transfer across the air-water interface. In situ production estimates were approximately twice in vitro production estimates for both surface mixing layer and deep chlorophyll layer comparisons.

349. Fahnenstiel, G.L.; Scavia, D. Dynamics of Lake Michigan Phytoplankton: Recent Changes in Surface and Deep Communities. Can. J. Fish. Aquat. Sci.; 1987; 44(3): 509-514; ISSN: 0706-652X.
Lake Michigan phytoplankton dynamics were studied from the end of spring isothermal mixing (May) through midstratification (July-August) in 1982-84. Phytoplankton composition shifted from a diatom-dominated community (75% of phytoplankton carbon) during May to a phytoflagellate-dominated community (71% of phytoplankton carbon) during July-August. This summer phytoflagellate dominance in the 1980s is distinctly different from the summer blue-green and

green algae dominance in the 1970s. Foodweb interactions caused by a changing zooplankton composition and nutrient supply changes were two possible causes. A deep chlorophyll layer (DCL) developed after the onset of thermal stratification.

350. Fahnenstiel, G.L.; Scavia, D. (Great Lakes Environmental Research Lab., NOAA, 2300 Washtenaw Ave., Ann Arbor, MI 48104). Phytoplankton Dynamics and Primary Production in Lake Michigan, 1982-84. in IAGLR-86 Program. International Association For Great Lakes Research 29th Conference.; May 26-29, 1986; Scarborough, Ont. Canada. International Association for Great Lakes Research, Buffalo, NY; 1986: 32. Note: abstract only.
Phytoplankton dynamics and primary production, studied from late spring isothermy through mid stratification 1982-1984, were consistent with recent reported changes in the Lake Michigan ecosystem. Significant changes from the 1970s were noted in summer epilimnetic phytoplankton composition and size of the deep chlorophyll layer. Trends in primary production were not as clear. Average summer assimilation ratios did not exhibit significant changes from the 1970s. Integral water column production trends could not be adequately compared. Phytoplankton growth during summer stratification was limited by the supply of phosphorus.

351. Fehringer, N.V.; Walters, S.M.; Kozara, R.J.; Schneider, L.F. Survey of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in Fish from the Great Lakes and Selected Michigan Rivers. J. Agric. Food Chem.; Jul.-Aug. 1985; 33(4): 626-630.
Fish from the Great Lakes region and selected Michigan rivers were analyzed for residues of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) by using combinations and modifications of published methods. Portions of homogenates of skinless fish fillets were digested in ethanolic KOH and TCDD was extracted with hexane. TCDD was separated from coextractives by passing through a silica gel supported sulfuric acid column followed by collecting the TCDD fraction of eluate from three high-performance liquid chromatographic systems. Capillary gas chromatography (HRGC) with electron capture (EC) detection was used for residue screening. Residues found by HRGC-EC were confirmed by HRGC low-resolution mass spectrometry by using a 12-ion monitoring scheme. Fish from Saginaw Bay (Lake Huron), the Tittabawassee River in Michigan, and Lake Ontario contained the highest levels of contamination. No TCDD residues at or above the minimum confirmable level of 10 ppt were found in fish from Michigan rivers other than the Tittabawassee.

352. Fogarty, S. A Citizen's Action Guide. Great Lakes Toxic Hotspots; 1985: Lake Michigan Federation. Chicago, Il.

353. Gannon, J. J. Health Aspects of Great Lakes Water as Related to Water Supply and Recreational Uses; 1970; ISBN: MICHU-SG-70-200.
Note: Sea Grant.

354. Gardner, W.S.; Chandler, J.F.; Laird, G.A. Organic Nitrogen Mineralization and Substrate Limitation of Bacteria in Lake Michigan. Limnol. Oceanogr.; Mar. 1989; 34(2): 478-485.
Labile organic nitrogen mineralization and the apparent degree of bacterial substrate limitation were examined to consider seasonal relationships between substrate availability and bacterial activity in Lake Michigan. Accumulation rates of ammonium nitrogen in amino acid fortified and unfortified samples of epilimnetic Lake Michigan water, incubated in the dark, provided reasonable estimates of potential and actual rates of organic nitrogen mineralization.

355. Gavin, J.M.; Gardner, W.S.; Quigley, M.A. Effects of Food Removal on Nutrient Release Rates and Lipid Content of Lake Michigan Pontoporeia hoyi. Can. Journal of Fish. and Aquatic Science; July 1989; 46(7): 1125-1130; ISSN: 0706-652X.
Note: NOAA Environmental Research Lab, 2205 Commonwealth Blvd., Ann Arbor, MI 48105.

356. Gerloff, G.C.; Muth, J.V. (Wisconsin Univ., Madison, WI, Botany Dept.). Nutritional ecology of Great Lakes Cladophora glomerata.; Jan. 1984. (NTIS Order No.: PB84-136571).
Note: Grant EPA-R-804402.
Various bioassays, primarily plant analysis, were utilized to evaluate relative nutrient supplies and primary growth limiting nutrients for Cladophora glomerata growth in parts of Green Bay, Lake Michigan, known to differ markedly in degree of pollution. Preliminary studies indicated emphasis should be on evaluations of five nutrients: phosphorus, nitrogen, boron, sulfur, and vitamin B1. The bioassays indicated that phosphorus very likely is the critical nutrient in nuisance C. glomerata growths and that at times phosphorus supply actually is reduced to growth-limiting concentrations. However, the possibility that vitamin B1 may at times be critical of C. glomerata cannot as yet be eliminated.

357. Giesy, J.P.; Newsted, J.; Garling, D.L. Relationships Between Chlorinated Hydrocarbon Concentrations and Rearing Mortality of Chinook Salmon (Oncorhynchus tshawytscha) Eggs from Lake Michigan. J. Great Lakes Res.; 1986; 12(1): 82-98; ISSN: 0380-1330.
A study was conducted to investigate a possible correlation between chlorinated hydrocarbon concentrations and rearing mortality of chinook salmon (Oncorhynchus tshawytscha). Eggs, collected from adult Lake Michigan chinook salmon in October, 1982, were analyzed for chlorinated hydrocarbon concentrations and rearing mortality. Polychlorinated biphenyls, toxaphene, and fifteen other chlorinated hydrocarbons were quantified. Also concentrations of individual PCB congeners were quantified. Some 78 quantifiable PCB congeners were found, only three of which were non-ortho substituted. Mean concentrations of Aroclor 1242, 1254, and 1260 were 1.7, 5.4, and 1.1 ug/g respectively. The concentration of toxaphene-like material was 3.3 ug/g, and the mean concentration of the total DDT complex was 1.0 ug/g. Concentrations of chlorinated hydrocarbons ranged about 10-fold among individual fish. When the residues were classified into 4 principal components, 2 of the principal components which contained primarily the toxaphene and PCB concentrations were negatively correlated with survival of fry to the swim-up stage.

358. Gooch, J.W.; Matsumura, F. Evaluation of the Toxic Components of Toxaphene in Lake Michigan Lake Trout. J. Agric. Food Chem.; Sep.-Oct. 1985; 33(5): 844-848.
Lake trout (Salvelinus namaycush) from Lake Michigan were analyzed for residues of the insecticide toxaphene and two of the primary toxic constituents, toxicants A and B. Using various chromatographic techniques and mass spectrometric confirmation, the authors have identified these toxic congeners in Lake Michigan lake trout residues. Levels of toxicants A and B have been found to be roughly 1 order of magnitude or more less than the estimated total toxaphene residue. Since the environmentally derived toxaphene is extensively altered in comparison to the technical material, measurement of toxic congeners may be a more toxicologically relevant measure of toxaphene derived residues.

359. Goodale, T.L.; Ditton, R.B. Attitudes and Actions: Perceiving and Responding to a Degraded Water Resources. In: International Association of Great Lakes Research. Proc. 16th Conference on Great Lakes Research; 1973: pp. 912-919.

360. Graney, R.L.; Keilty, T.J.; Giesy, J.P. Free Amino Acid Pools of Five Species of Freshwater Oligochaetes. Can. J. Fish. Aquat. Sci.; Mar. 1986; 43(3): 600-607; ISSN: 0706-652X.

361. Grant, J.E. Michigan's Process for Regulating Toxic Substances in Surface Water Permits. World Conf. on Large Lakes; 18 May, 1986; Mackinac Island, MI. Chelsea, MI: Lewis Publ.; 1988: 317-328; ISBN: 0-87371-090-8.
A necessary aspect of fisheries management is a water pollution control program that will not only provide nontoxic water quality conditions but also ensure that fish do not contain unacceptable levels of toxic substances for human consumption. Michigan has recently promulgated revisions to Rule 323.1057 of its Water Quality Standards that establish a regulatory process that will protect public health and the environment from discharges of toxic substances from point source surface water discharges. This paper reviews the development of the rule amendments and discusses key aspects of the adopted rules and guidelines.

362. Great Lakes Water Quality Board. 1989 Report on Great Lakes Water Quality. Appendix A. Progress in Developing and Implementing Remedial Action Plans for Areas of Concern in the Great Lakes Basin.; 1989; Report to the International Joint Commission.
Note: Mich. City.
42 Areas of Concern have been identified in the Great Lakes Basin 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. As a result of a recomendation of the Great Lakes Water Quality Board, the eight Great Lakes States and the Province of Ontario committed themselves in 1985 to developing and implementing a Remedial Action Plan (RAP) to restore all beneficial uses in each Area of Concern within their geological boundaries.

363. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Environmental Impact Statement (Final). Ann Arbor, MI: Public Information Office, Great Lakes Basin Commission; 1976.
Note: CZM.
Preparation of a Framework Study evaluating the water and related land resources of the Great Lakes Basin, in an attempt to obtain a consensus among involved States and Federal agencies on the general rate at which future development of these resources should proceed, which types of

development should be encouraged or discouraged, and which geographic areas should receive special consideration for development or preservation. The Framework Study is an overview of the entire Great Lakes Basin, and will serve as a guide to programs and studies needed to consider more specific resource problems and smaller geographic areas. The Commission has developed a Proposed Framework for the Basin through the year 2020, which envisions a rate of economic growth and development slightly lower than that which would follow from a projection of past growth trends. The Environmental Imapact Statement is a conceptual study, not an authorized plan for construction. It is very general, with little description of detailed effects, but it is believed to adequately highlight the most significant impacts that can be covered in a Level A study.

364. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Fish. Appendix 8. Ann Arbor, MI: Public Information Office, Great Lakes Basin Commission; 1976.
Note: CZM.
The objective of this report is to examine long-range fishery development programs for the waters of the Great Lakes Basin, predicated on the historical development of the fishery, present status and problems, and projections for future supply and demand. Alternative approaches have been considered in response to various physical, ecological, social, economic, and institutional conditions that are expected in future years.

365. Grieb, T.M.; Driscoll, C.T.; Shofield, C.L.; Bowie, G.L.; Porcella, D.B. Factors Affecting Mercury Accumulation in Fish in the Upper Michigan Peninsula. 9th Annual Meeting of the Society of Environmental Toxicology and Chemistry Symposium on Metal Chemistry and Bioavailability in Acid Waters; Nov 13, 1988; Arlington, VA (USA); 1990; Environ. Toxicol. Chem., vol 9, no. 7: 919-930.

366. Griffin, John J.; Goldberg, Edward D. Impact of Fossil Fuel Combustion on Sediments of Lake Michigan: A Reprise. Environmental Science and Technology; 1983; 17(4): 244.
The size distribution of charcoals in sediments of Lake Michigan reflects the onset of the industrial revolution and the increased intensities of fossil fuel combustion during the twentieth century. Prior to 1900 the less than 1um fraction was dominant, and its source was primarily biomass burning. In the subsequent years coal and oil burning became evident with larger particles, especially greater than 32 um, making larger contributions to the total charcoal concentrations. The input of the larger particles is a

consequence of near fallout of particles from energy-producing plants near the lake.

367. Hanson, F.B. Bioeconomic Model of the Lake Michigan Alewife (Alosa pseudoharengus) Fishery. Can. J. Fish. Aquat. Sci.; 1987; 44(no. suppl. 2): 298-305; ISSN: 0706-652X.

368. Hartig, J.H.; Jude, D.J. Ecological and Evolutionary Significance of Cyclopoid Predation on Fish Larvae. J. Plankton Res.; May 1988; 10(3): 573-577.
Of 412 cyclopoids found preying on fish larvae in Lake Michigan, 411 were adult females. It is suggested that adult, female cyclopoid predation on fish larvae may represent an important mechanism both to reduce intraspecific competition for food (ie. between sexes) and maximize net energy intake for reproduction.

369. Heinz, G.H.; Haseltine, S.D.; Reichel, W.L.; Hensler, G.L. Relationships of Environmental Contaminants to Reproduction in Red-breasted Mergansers (Mergus serrator) from Lake Michigan. Environ. Pollut. (A Ecol. Biol.); 1983; 32(3): 211-232.
In 1977 and 1978, the authors studied red-breasted mergansers Mergus serrator nesting on islands in northwestern Lake Michigan to determine whether environmental contaminants were having effects on reproduction. The authors looked for effects of individual contaminants and combinations of contaminants on reproductive measurements such as nest desertion, failure of eggs to hatch, death of newly hatched ducklings leaving the nest and eggshell thickness. They also looked for relationships between the levels of some contaminants in blood samples of 39 incubating females and reproductive success. A small degree of eggshell thinning was attributed to DDE and a few other statistical tests were significant, but no contaminant or combination of contaminants measured seemed to have a pronounced effect on the aspects of reproduction we followed.

370. Hendry, K.K.; Conlan, K.N.; White, G.S.; Proudlove, A. Bewsher; Hawkins, S.J. Water Quality in Disused Docks: Their Potential for Recreational and Commercial Fisheries. In: Coastal Water Resources Sum.; May 1988. Wilmington, N.C.: Amer. Water Resources Assn.; 1988. 225 pp.

371. Hesselberg, R.J.; Hickey, J.P.; Nortrup, D.A.; Willford, W.A. Contaminant Residues in the Bloater (Coregonus hoyi) of Lake Michigan, 1969-1986. Journal Great Lakes Research; 1990; 16(1): 121-129; ISSN: 0380-1330.
Note: Natl. Fish. Res. Cent., U.S. Fish and Wildl. Serv., 1451 Green Rd., Ann Arbor, MI 48105, USA.
Residues of DDT, PCBs, dieldrin in Lake Michigan bloaters (Coregonus hoyi) decreased between 1969 and 1986. All values for contaminant residues were measured and reported as ug/g of whole fish, wet weight; the error limits represented the 95% confidence interval half widths. Total DDT content declined 87% from 9.9 in 1970, when its use was banned, to 1.3 in 1974, and then averaged 0.88 in 1978-1986 with a low of 0.67 in 1986. PCBs first analyzed in 1972, declined 64% (from 5.7 to 2.2) between 1972 and 1980 and were at 1.64 in 1986. The great decline in PCBs occurred following the 1976 ban.

372. Hoffman, D.J.; Rattner, B.A.; Sileo, L.; Docherty, D.; Kubiak, T.J. Embryotoxicity, Teratogenicity, and Aryl Hydrocarbon Hydroxylase Activity in Forster's Terns on Green Bay, Lake Michigan. Environ. Res.; Feb. 1987; 42(1): 176-184.

373. International Joint Commision. Procedures for the Assessment of Contaminated Sediment Problems in the Great Lakes. Windsor, Ontario: Great Lakes Regional Office.; 1988.

374. Jackivicz, T. P., Jr.; Kuzminski, L. N. The Effect of the Interaction of Outboard Motors with the Aquatic Environment - A Review. Environ. Res.; 1973; 6: 436-454.

375. Jenkins, W. A. Environmental Effects of Pollutants Associated with Marina Development: A Synthesis of Existing Research. In: The Fate and Effects of Pollutants: A Symposium. College Park: University of Maryland, Sea Grant Program; 1985; Tech. Rep., UM-SG-TS-85-02: 63-64.
Note: [Abstract Only].

376. Jones, W.W.; Winters, J.; Doxstater, G. (Sch. Public and Environ. Aff., Indiana Univ., Bloomington, IN. 47401). Lake Management in Indiana - New Approaches to Old Problems. 8 Annual International Symposium on Lake and Watershed Management; 15-18 Nov.1988; St. Louis, MO. Arlington, VA: North American Lake Management Soc.; 1988: p. 17 (summary only).

377. Jude, D.J.; Tesar, F.J.; Deboe, S.F.; Miller, T.J. Diet and Selection of Major Prey Species by Lake Michigan Salmonines, 1973-1982. Trans. Am. Fish. Soc.; Sep. 1987; 116(5): 677-691.

378. Jude, D. J.; Tesar, F. J. Recent Changes in the Inshore Forage Fish of Lake Michigan. Can. J. Fish. Aquat. Sci.; 1985; 42: 1154-1157.

379. Keen, Cecil S. Lake/Land Breeze Circulations on the Western Shore of Lake Michigan. Journal of Applied Meteorology; 1978; 17(2): 1843.
A classic lake breeze circulation cell that formed on the western shore of Lake Michigan on 4 September 1974 is studied in great detail. Wind measurements are made with surface anemometers and serial pibals, with air trajectories monitored via tetroons. Aircraft measurements map the thermal internal boundary layer and small and large aerosol distributions. Recirculation of pollutants is indicated from analysis of the tetroon data. Aerosol measurements suggest size sorting of small versus large particles as they are transported through the complex three dimensional flow. These wind data also form the basis of a kinematic diagnostic study of mesoscale pollution transport in coastal areas, to be reported in a subsequent paper.

380. Keen, Cecil S.; Lyons, Walter A.; Schuh, Jerome A. Air Pollution Transport Studies in a Coastal Zone Using Kinematic Diagnostic Analysis. Journal of Applied Meteorology; 1979; 18(5): 606.
Data from a mesoscale wind analysis of a vigorous lake/land breeze circulation on 4 September 1974 along the western shoreline of Lake Michigan are available. A computer program takes subjectively analyzed observed and estimated u and v components of the wind for a 24 h period, calculates vertical motions, and then estimates the trajectory of any particle(s) released within the coastal zone. The computed three-dimensional trajectories are presented using computer graphics displays. They reveal highly complex transport processes for aerosols released from typical line and multistack point sources. Aerosol recirculation and size sorting can be found within the lake breeze cell.

381. Keilty, T.J.; White, D.S.; Landrum, P.F. Short-term Lethality and Sediment Avoidance Assays with Endrin-Contaminated Sediment and Two Oligochaetes from Lake Michigan. Arch. Environ. Contam. Toxicol.; Jan. 1988; 17(1): 95-101.

382. Kenneunen, R. E.; Peterson, J.; Stewart, S.; Swinehart, C. Sea Grant Research and Community Development Lake Michigan's Bottomland Pr. Marine Parks and Conservation Challenge and Promises; 1985: 78-184.; ISBN: Reprint: MICHU-R-85010.

383. Kilham, S.S. Dynamics of Lake Michigan Natural Phytoplankton Communities in Continuous Cultures Along a Si:P Loading Gradient. Can. J. Fish. Aquat. Sci.; Feb. 1986; 43(2): 351-360; ISSN: 0706-652X.
The hypothesis that phytoplankton species assort themselves along resource ratio gradients according to their relative competitive abilities for the potentially limiting resources was tested using natural communities from Lake Michigan. Algae were grown in six continuous cultures for 46 d on a gradient consisting of four silicon to phosphorus (Si:P) loading ratios: 313:1 (two cultures), 71:1, 4.6:1, and 0.9:1, and 0.9 (two cultures). Diatoms were the superior competitors for P and dominated the three high Si:P ratio cultures at steady state. Green algae dominated the three low Si:P ratio cultures. Results illustrate that phytoplankton natural community continuous cultures provide a method for evaluating potential changes in community structure resulting from long-term changes in loading ratios of resources.

384. Kitchell, J.F. The Scope for Mortality Caused by Sea Lamprey. Trans. Am. Fish. Soc.; July 1990; 119(4): 642-648.
Note: Presented at From Environment to Fish to Fisheries: A Tribute to F.E.J. Fry - Symp. at 118 Annu. Meet. of the American Fisheries Soc., Toronto, Ont. Canada (Sep 12, 1988).
Subsequent to development of the lampricide program, sea lampreys Petromyzon marinus in Lake Michigan have demonstrated increased growth rates in parallel with expanded stocking rates of salmon and trout. Based on bioenergetics modeling of maximum and minimum growth and feeding rates, the author estimated sea lamprey effects as the "scope for mortality", which depends on host size and sea lamprey size. For small host fishes, sea lamprey-induced mortality may have increased approximately sixfold over the past two decades.

385. Kitchell, J.F.; Hewett, S.W. Forecasting Forage Demand and Yield of Sterile Chinook Salmon (Onocorhynchus tshawytscha) in Lake Michigan. Can. J. Fish. Aquat. Sci.; 1987; 44(no. suppl. 2): 384-389; ISSN: 0706-652X.

386. Laird, G.A. Distribution of Labile Dissolved Organic Carbon in Lake Michigan. Limnol. Oceanogr.; Mar. 1990; 35(2): 443-447.
Bioassay-measured, labile dissolved organic carbon (LDOC) concentrations were compared in near-bottom and near-surface Lake Michigan water between April and October 1986. In five of seven experiments, the LDOC concentration was higher in near-bottom water. LDOC reached 40.2% of the total DOC pool in the near-bottom water in late May and 13.8% in the near-

surface water in early July. Concentration in near-bottom water was highest during early stratification; concentration in surface water varied less but was highest in early July. The data suggest that an allochthonous source of labile organic C may be important.

387. Lambert, John F. Jr. Land Acquisition in the National Parks: Examples from Yosemite National Park and Indiana Dunes National Lakeshore. Harvard Environmental Law Review; 1982; 6(1): 35.

388. Landers, D.; Gloss, S.P; Grieb, T.M.; Driscoll, C.T.; Schofield, C.L. Mercury Levels in Fish from the Upper Peninsula of Michigan (ELS Subregion 2B) in Relation to Lake Acidity. Ecol. Res. Ser. U.S. Environ. Prot. Agency NTIS; 1990; Order number PB90-263484/GAR.: 116 pp.
Note: Environmental Protection Agency, Corvallis, OR. Environmental Research Lab.

389. Larsen, C.E. (U.S. Geol. Surv., Reston, VA 22070). Long-term Variation in the Levels of Lakes Michigan and Huron: A Lesson from the Geologic and Paleoclimatic Records. Klein-Helmuth, B.C.; Savold, D. in 1987 AAAS Annual Meeting: 153rd National Meeting; 14-18 February; Chicago. Washington DC: AAAS; 1987: 12.
Note: summary only.
The historic record of Great Lakes level changes currently used for planning and engineering purposes in the region begins in 1860, but only the record from 1900 is used for forecasting. The range of variation between high and low average monthly levels over this period is about 5 ft. Geologic records for the past 2,000 years show a greater range of variation. Dated alluvial deposits near stream mouths along the Lake Michigan shore show the contemporaneous base level (lake level) was 4-8 ft above the present base level. Buried peats from cattail marshes adjacent to the lakeshore near Waukegan, IL show that lake level to have been once from 5-7 ft lower than during historic. Paleoclimatic and archeologic records suggest that these long-term fluctuations were due to periodic changes in precipitation and evaporation within the basin.

390. Lauritsen, D.D.; Mozley, S.C.; White, D.S. Distribution of Oligochaetes in Lake Michigan and Comments on Their Use as Indices of Pollution. J. Great Lakes Res.; 1985; 11(1): 67-76; ISSN: 0380-1330.
Benthic samples were taken from 286 stations covering all areas of Lake Michigan in 1975 as part of sedimentological survey of the Great Lakes. From these samples a total of 27 oligochaete species were identified. Stylodrilus heringianus was the most abundant species in the lake and densities were inversely related to organic content of the sediments. Tubificids exhibited localized concentrations in Green Bay and in northern and southern basins. Comparison of several methods using oligochaete data to assess water quality showed similar patterns, indicating that Southern Green Bay and parts of the northern and southern basins of the lake are organically enriched environments. With the exception of the northern basin, which had not previously been surveyed, these conclusions are consistent with earlier regional oligochaete surveys of the lake.

391. Lesht, B.M.; Rockwell, D.C. (Environ. Res. Div., Argonne Nat'l Lab., Argonne, IL 60439). Nutrient Enrichment in the Benthic Nephoid Layer of Lakes Erie, Huron, and Michigan, 1983-1984. in IAGLR-86 Program. International Association for Great Lakes Research 29th Conference; May 26-29, 1986; Scarborough, Ont. Canada. International Assoc. for Great Lakes Research, Buffalo, NY; 1986: 39.
Note: abstract only.
Data collected during the 1983-84 water quality surveys of lakes Erie, Huron, and Michigan show that summertime concentrations of both particulates and nutrients in the lower ten meters (at least) of the water column are significantly enriched relative to the overlying waters. Most pronounced in Lake Michigan, this enrichment was also observed in Lake Huron and in the eastern basin of Lake Erie during both years. By integrating the water column mass of total phosphorus and dissolved reactive silica before, during and after stratification the authors estimate that as much as 30% of the whole lake burden of these nutrients may be suspended within the benthic nepheloid layer before turnover.

392. Liston, C. R.; Brazo, D. C.; Bohr, J. R.; Gulvas, J. A. Abundance and Composition of Lake Michigan Fishes Near Rock Jetties and a Breakwater, with Comparisons to Fishes in Nearby Natural Habitats. In: D'Itri, F. M. Artificial Reefs: Marine and Fresh Applications. Lewis Publishing: Chelsea, MI; 1985. 491-513.

393. Loftus, A.J.; Taylor, W.W.; Keller, M. An Evaluation of Lake Trout (Salvelinus namaycush) Hooking Mortality in the Upper Great Lakes. Can. J. Fish. Aquat. Sci.; 1988; 45(8): 1473-1479; ISSN: 0706-652X.

394. McMahon, P.J.T. The Impact of Marinas on Water Quality. Water Sci. Techno.; 1989; 21: 39-43.

395. Merna, J.W. Contamination of Stream Fishes with Chlorinated Hydrocarbons from Eggs of Great Lakes Salmon. Trans. Am. Fish. Soc.; Jan. 1986; 115(1): 69-74.
Pacific salmon Oncorhynchus spp. have been stocked in the Great Lakes where they accumulate body burdens of chlorinated hydrocarbons. The transport of these contaminants to resident communities in spawning streams was studied in two tributaries of Lake Michigan accessible to anadromous spawners and one control tributary blocked to them. No polychlorinated biphenyls (PCBs), DDT, or dieldrin were detected in the sediments or biota of the control stream, or in sediments of the test streams. However, trout Salmo spp. and, to a lesser extent, sculpins Cottus spp. accumulated PCBs and DDT as a result of eating contaminated salmon eggs. Eggs constituted as much as 87% (by weight) of the total stomach contents of trout collected during the salmon spawning season early October to early January. Salmon eggs contained 0.46-9.50 mg PCBs/kg, and 0.14-1.80 mg DDT/kg. Consumption of eggs varied greatly among individual trout, and there was strong correlation between numbers of eggs in the stomachs and PCB and DDT concentrations in the fillets.

396. Metzler, G.; Sager, P. E. A Preliminary Study of the Macrobenthos of Wave-Swept and Protected Sites on the Lake Michigan Shoreline at Toftpoint Natural Area, Wisconsin USA. Trans. Wisc. Acad. Sci. Arts Lett.; 1986; 74: 126-132.

397. Miller, G.S.; Saylor, J.H. Currents and Temperatures in Green Bay, Lake Michigan. J. Great Lakes Res.; 1985; 11(2): 97-109; ISSN: 0380-1330.
Current velocities and water temperatures were measured in the 4 main passages between Green Bay and Lake Michigan and at several sites within the bay during summer and fall 1977. Monthly resultant currents indicate there is anticlockwise circulation in the bay during dominant southwesterly wind and a reversal of this pattern during episodes of northeasterly wind. It is common for 2 layers to flow through the mouth of the bay in opposite directions during the stratified season. Cold hypolimnetic lake water entering through the mouth and extending far into the bay maintains stratification and promotes flushing. The effects of resonance of forced and

free long wave disturbances are prominent in current records; these oscillations are coherent and in phase across the mouth.

398. Miller, T.; Crowder, L.B.; Binkowski, F.P. Effects of Changes in the Zooplankton Assemblage on Growth of Bloater and Implications for Recruitment Success. Trans. Am. Fish. Soc.; May 1990; 19(3): 483-491.
Note: McGill Univ., 1205 Ave. Dr. Penfield, Montreal. Quebec. H3A 1B1, Canada.

399. Moll, R.; Brahce, M. Seasonal and spatial distribution of bacteria, chlorophyll, and nutrients in nearshore Lake Michigan. J. Great Lakes Res.; 1986; 12(1): 52-62; ISSN: 0380-1330.
Bacterial abundances and metabolic activity were related to chlorophyll concentrations, nutrient concentrations, and the physical environment in the vicinity of the Grand River discharge into Lake Michigan. The results show that bacteria and phytoplankton displayed almost opposite seasonal and spatial distributions. Bacterial abundances were at their annual high in the late summer and early fall when chlorophyll concentrations and primary productivity were at a seasonal low and nutrient concentrations were at their annual nadir. These results indicate that bacterial populations were not highly stimulated by the presence of algae or algal extracellular excretions. However, a complete separation of bacterial and algal dynamics was difficult because of the ecological overlap between microalgae and bacterioplankton. Analysis of bacterial abundance, chlorophyll concentration, and glucose uptake by size fractions showed that Lake Michigan has an abundant crop of microalgae.

400. Morandi, Larry B.; Greg H. Lazarus. Water Resources Management: Issues and Policy Options. National Conference of State Legislatures; Denver; 1982.

401. Morehead, N.R.; Eadie, B.J.; Lake, B.; Landrum, P.F.; Berner, D. The sorption of PAH onto Dissolved Organic Matter in Lake Michigan Waters. Chemosphere; April 1986; 15(4): 403-412.
The polynuclear aromatic hydrocarbons are hydrophobic organic contaminants (HOC) that associate with dissolved organic matter (DOM) in natural water systems. The DOM-HOC complex is sufficiently stable to allow measurement of an association constant, Kb. For individual HOC in different natural waters, Kb ranges over two orders of magnitude. Results show that the Kb is more dependent on the source of the DOM than

the water solubility of the HOC but that for a specific water sample, correlation of Kb with solubility does exist.

402. Morrison, W. David, Jr. The Impacts of Development of Wetlands on Water Quality. Detroit, Michigan: Southeast Michigan Council of Governments; 1979: 111 pp.

403. Problems of the Great Lakes Region: Conference Proceedings. Traverse City, MI; June 9-11, 1980; ISBN: MICHU-SG-81-900.

404. Quigley, M.A.; Robbins, J.A. Phosphorus Release Processes in Nearshore Southern Lake Michigan. Can. J. Fish. Aquat. Sci.; 1986; 43(6): 1201-1207; ISSN: 0706-652X.

405. Quigley, M.A.; Robbins, J.A. Silica Regeneration Processes in Nearshore Southern Lake Michigan. J. Great Lakes Res.; 1984; 10(4): 383-392; ISSN: 0380-1330.
The seasonal depletion of dissolved silica to levels that limit diatom production is particularly critical in Lake Michigan's nearshore zone where diatom biomass is greatest, and where silica regeneration from sediments is not well-understood.

406. Reber, Jan Marie, Master's Student. Photo-enhanced Toxicity and Developmental Effects of River Sediment Elutriates to Early Life Stages of the Fathead Minnow; August 1991; Master's Thesis.
Note: Purdue University.

407. Rice, J.A.; Crowder, L.B.; Holey, M.E. Exploration of Mechanisms Regulating Larval Survival in Lake Michigan Bloater: A Recruitment Analysis Based on Characteristics of Individual Larvae. Trans. Am. Fish. Soc.; Sep. 1987; 116(5): 703-718.

408. Richman, S.; Sager, P.E., Banta, G.; Harvey, T.R.; Destasio, B.T. (Lawrence Univ., Biol. Dep., Appleton, WI 54912). Phytoplankton Standing Stock, Size Distribution, Species Composition and Productivity Along a Trophic Gradient in Green Bay, Lake Michigan. in Congress in France 1983. Proceedings.; 21 Aug. 1983; Lyon, France. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart (FRG); 1984: 460-469. (Trav. Assoc. Int. Limnol. Theor. Appl; v. 22, no.1); ISBN: 3-5105-4023-9.
Note: ISSN 0368-0770.
A distinct feature of Green Bay is a south to north gradient evident in increases in mean depth, water volume and light penetration, and decrease in nutrient concentration and specific conductance. These physico-chemical gradients

correlate well with gradients in standing stock distributions of phytoplankton in terms of numerical density, biovolume concentration, chlorophyll a concentration, and species composition and with primary productivity. These parameters are closely correlated with one another and clearly establish spatial variations in trophic conditions oriented along the longitudinal axis of the bay from very high hypereutrophic conditions in the extreme southern to mesoeutrophic/ oligotrophic status in the northern bay.

409. Rodgers, P.W.; Swain, W.R. Analysis of Polychlorinated Biphenyl (PCB) Loading Trends in Lake Michigan. J. Great Lakes Res.; 1983; 9(4): 548-558; ISSN: 0380-1330.
PCB concentrations in coregonid fishes (bloater chubs) collected from Lake Michigan between 1972 and 1980 are used to infer an historical loading trend for polychlorinated biphenyls (PCBs). A mass balance model was developed to describe the dynamics of PCBs by assuming that historical fish concentrations are proportional to concurrent water column concentrations of PCB. The validity of this assumption is strengthened, since the data represent a single species of fish (a pelagic feeder), a specific age class of that species, and a single laboratory performing the collections and analysis of data. The results of model analysis indicate that PCB loading to Lake Michigan during the period of observation can be described by a linearly decreasing trend. The calibrated model also forecasts the response of selected fish species to various loading scenarios. Forecast results indicate that a continuously decreasing load will result in compliance with U.S. and Canadian guideline value for human consumption by 1987.

410. Rossmann, R. (Michigan Univ., Ann Arbor. Great Lakes Research Div.). Trace Metal Concentrations in the Offshore Water of Lakes Erie and Michigan; Nov. 1984; NTIS Order No.: PB85-199396/GAR. (Special Report Mich. Univ. Great Lakes Res. Div.).
Note: Grant EPA-R-005709-01.
During 1981, water samples were collected from ten Lake Erie and ten Lake Michigan stations. In both Lake Erie and Lake Michigan, large percentages of aluminum, iron, and manganese were associated with particulate matter. A substantial fraction of the total berylium, cobalt, copper, lead, tin, vanadium, and zinc were associated with Lake Michigan particulate matter. In Lake Erie, it appears that a significant fraction of the particulates may have been resuspended sediment.

411. Scavia D.; Fahnenstiel, G.L.; Evans, M.S.; Jude, D.J.; Lehman, J.T. Influence of Salmonine Predation and Weather on Long-term Water Quality Trends in Lake Michigan. Can. J. Fish. Aquat. Sci.; Feb. 1986; 43(2): 435-443; ISSN: 0706-652X.
Trends in Lake Michigan water quality over 1975-84 appear to reflect reduced nutrient loadings as indicated by gradual declines in spring total phosphorus (TP) and summer epilimnetic chlorophyll a (Chl a). Deviations from these trends during 1977 and 1983-84 were apparently caused by abiotic and biotic factors, respectively. Prolonged ice cover during 1977 decreased sediment resuspension resulting in lower TP, reduced Chl a levels, and increased water clarity. A similar dramatic result occurred in 1983 and to a lesser extent in 1984, but via a different mechanism. Burgeoning populations of stocked salmonines reduced populations of the planktivorous alewife (Alosa pseudoharengus), which allowed large Daphnia to flourish. Because the Daphnia are more voracious and nonselective grazers than the formerly dominant calanoid copepods, they reduced seston concentrations, causing dramatic increases in Secchi disk transparency

412. Scavia, D.; Lang, G.A.; Kitchell, J.F. Dynamics of Lake Michigan Plankton: A Model Evaluation of Nutrient Loading, Competition, and Predation. Can. J. Fish. Aquat. Sci; Jan. 1988; 45(1): 165-177; ISSN: 0706-652X.
Lake Michigan's offshore ecosystem has been altered dramatically during the past decade. These changes occurred concurrently with reduced P load, P concentration, and abundance of the dominant zooplanktivore, the alewife (Alosa pseudoharengus). In this analysis the authors pose alternative hypotheses of nutrient loading and species interactions as determinants of zooplankton and phytoplankton species composition in the summer epilimnion. They evaluate these hypotheses with a food web model that was calibrated to measurements of the 1980s Lake Michigan plankton composition and algal production, sedimentation, and growth rates and literature estimates of zooplankton secondary production and nutrient excretion.

413. Schelske, C.L. Historic Trends in Lake Michigan Silica Concentrations. Int. Rev. Gesamt. Hydrobiol.; 1988; 73(5): 559-591; ISSN: 0020-9039.
Historic data on soluble silica in the offshore waters of Lake Michigan were compiled and analyzed to determine whether the data supported a decrease in silica concentration which had been hypothesized previously on the basis of other studies. Although the data base was limited and no data were obtained for offshore waters prior to 1954, the available data support the conclusion that the silica concentration decreased rapidly after 1954. The thesis is developed that rapid silica depletion occurred in the 15-year period from 1954-1969 when the winter maximum concentration decreased from approximately 4.4 to 1.4 mg SiO_2/I and the summer minimum decreased from approximately 2.2 to < 0.2 mg SiO_2/I. The decrease in silica concentration is attributed to increased production and sedimentation of diatoms that resulted from increased anthropogenic phosphorus loading.

414. Schelske, D.L.; Sicko-Goad, L. Effect of Chelated Trace Metals on Phosphorous Uptake and Storage in Natural Assemblages of Lake Michigan Phytoplankton. Journal of Great Lakes Research; 1990; 16(1): 82-89; ISSN: 0380-1330.
In experiments with natural phytoplankton assemblages from Lake Michigan, additions of chelated trace metals and orthophosphate increased phosphate uptake more than additions of orthophosphate alone. Enhanced phosphate uptake is attributed to the storage of polyphosphate by phytoplankton which can be triggered by high concentrations of trace metals. Similar effects were obtained with a surface phytoplankton assemblage collected in April and with a metalimnetic assemblage collected in September. Microscopic examination showed that polyphosphate formation was enhanced in populations of Melosira islandica and Scenedesmus opoliensis. These results and data from the literature suggest that polyphosphate storage may play an important role in the phytoplankton population dynamics of Lake Michigan, especially in bays and nearshore areas where tributary inputs of phosphorous and trace metals are high.

415. Schloesser, D.W.; Hiltunen, J.K.; Owens, R.W. Rediscovery of Lake Balls in Lake Michigan. J. Freshwat. ecol.; 1983; 2(2): 159-163; ISSN: 0270-5060.
For the first time in 70 years, the occurrence of a "lake ball" in Lake Michigan is here reported in the literature. According to a published system of classification, the object the authors collected in 1978 was a "false" lake ball. Dissection revealed that it was colonized by 5 chironomid larvae and 162 oligochaetes. The species and numerical

proportions of the oligochaetes indicated that it was formed in or near the mouth of a eutrophic tributary rather than in the open waters of Lake Michigan where it was found. Because of their mobility, false lake balls may be ecologically important, serving as natural vehicles for the dispersal of invertebrates.

416. School of Public and Environmental Affairs - Indiana University. Indiana Coastal Energy Facilities Inventory. Bloomington, IN: Indiana University; August 1979.
Note: CZM.
A detailed inventory of Indiana's coastal related energy facilities including: name of facility, operator, address, facility type, activity capacity, operating data, expansion dates, anticipated expansion dates, peak operating employment, source of information.

417. Schwartz, Pamela M.; Jacobson, Sandra W.; Fein, Greta; Jacobsen, Joseph L.; Price, Harold A. Lake Michigan Fish Consumption as a Source of Polychlorinated Biphenyls in Human Cord Serum, Maternal Serum, and Milk. American Journal of Public Health; March 1983; 73(3): 293.

418. Seelye, J. G.; Hesselberg, Robert J.; Mac, Michael J. Accumulation by Fish of Contaminants from Dredged Sediments. Environmental Science and Technology; 1982; 16: 459-464.
Note: Correction 16:886.

419. Seelye, J. G.; Mac, M. J. Size-Specific Mortality in Fry of Lake Trout (Salvelinus namaycush) from Lake Michigan. Bulletin of Environmental Contamination and Toxicology; September 1981; 27(3): 376.

420. Sprules, W.G.; Brandt, S.B.; Stewart, D.J.; Munawar, M.; Jin, E.H.; Love, J. Biomass Size Spectrum of the Lake Michigan Pelagic Food Web. Can. J. Fish. Aquat. Sci.; Jan 1991; 48(1): 105-115; ISSN: 0706-652X.
Biomass size spectra for the complete Lake Michigan pelagic food web from picoplankton to salmonids were constructed for nine sampling transects around the lake in May and September 1987. Size spectra were typical for freshwaters, having distinct peaks corresponding to major size groups. Biomass concentration of algae, zooplankton, and planktivores conformed to particle-size model predictions, but piscivore biomass was lower than predicted because these species are stocked. Our analyses suggest that piscivore production is constrained by food web structure. Bloater, which comprise 72% of planktivore biomass, make up less than 20% of salmon diets. We estimate that piscivore production could be double

the current value of 0.27 g/m squared/year if the forage fish community changed to include species more available to salmon.

421. Stauffer, Thomas M. Effects of DDT and PCB's on Survival of Lake Trout Eggs and Fry in a Hatchery and in Lake Michigan. Transactions of the American Fisheries Society; March 1979; 108(2): 178.

422. Stedman, R.M.; Argyle, R.L. Rainbow Smelt (Osmerus mordax) as Predators on Young Bloaters (Coregonus hoyi) in Lake Michigan. J. Great Lakes Res.; 1985; 11(1): 40-42; ISSN: 0380-1330.

423. Stedman, R.M.; Bowen, C.A. Introduction and Spread of the Threespine Stickleback (Gasterosteus aculeatus) in Lakes Huron and Michigan. J. Great Lakes Res.; 1985; 11(4): 508-511; ISSN: 0380-1330.

424. Steinhart, C. E.; Schierow, L. J.; Chesters, G. An Environmental Quality Index for the Nearshore Waters of the Great Lakes. University of Wisconsin Madison, WI: Water Resource Center; 1981; Great Lakes Environmenatal Planning Study #42.
14 pp.
[Abstract Only].

425. Stewart, D.J.; Binkowski, F.P. Dynamics of Consumption and Food Conversion by Lake Michigan Alewives: An Energetics-modeling Synthesis. Trans. Am. Fish. Soc.; Sep. 1986; 115(5): 643-661.

426. Swackhamer, D.L. The Role of Water-particle Partitioning and Sedimentation in Controlling the Fate and Transport of PCBs in lakes. Diss. Abst. Int. Pt. B-Sci. & Eng.; Jan. 1986; 46(7): 279 pp.
Note: Diss. Ph.D.: Order No.: FADDA8512329.
The spatial distribution and Aroclor composition of PCBs in Lake Michigan water and sediments were determined. The average PCB concentrations in surficial sediments were 81 ng/g, 26 ng/g, and 7.2 ng/g for depositional, translational, and non-depositional zones, respectively, with an average Aroclor composition of 18% 1242, 33% 1248, and 49% 1254. The average PCB concentration in water was 1.8 ng/L. Differences in concentration and Aroclor composition in both sediments and water were used to identify point sources to the lake at Green Bay, Waukegan, Calumet Harbor, and Benton Harbor.

427. Talavage, J. Optimal Regulation of Rural Ecosystem Pollution. Environment and Planning; November 1977; 9(11): 1281.

428. Tarapchak, S.J.; Herch, L.R. Phosphate Uptake by Microorganisms in Lake Water: Deviations from Simple Michaelis-Menten kinetics. Can. J. Fish. Aquat. Sci.; Feb. 1986; 43(2): 319-328; ISSN: 0706-652X.
Orthophosphate uptake rates by natural Lake Michigan microbial assemblages were measured to test a hypothesis that the instantaneous velocity of P uptake at low added substrate concentrations is higher than predicted by the simple Michaelis-Menten equation. Analysis of data from most experiments verified this prediction.

429. Tarapchak, S.J; Moll, R.A. Phosphorus Sources for Phytoplankton and Bacteria in Lake Michigan. Journal Plankton Research; July 1990; 12(4): 743-758.
Size-fractionation experiments on the uptake of phosphate (PO4) and recently excreted dissolved organic phosphorous (E-DOP) from phytoplankton suggest that algae and bacteria rely on different forms of phosphorous (P) in the epilimnion of P-limited Lake Michigan. Rate constants for PO4 uptake in 0-1 um fractions generally were low relative to those measured in wholewater, suggesting that most of the uptake was by algae. Uptake of 33E-DOP in 0-1 um fractions approximated uptake in wholewater, indicating uptake principally by bacteria. Concurrent experiments showed that E-DOP and PO4 were taken up by different transport systems; bacteria have transport systems for E-DOP compounds; and cell-surface phosphatase-mediated PO4 supply to phytoplankton from E-DOP was negligible. Results suggest that pathways of PO4 and E-DOP flux in microplankton communities of P-limited large and small lakes may differ.

430. Taylor, W.W; Smale, M.A.; Freeberg, M.H. Biotic and Abiotic Determinants of Lake Whitefish (Coregonus clupeaformis) Recruitment in Northeastern Lake Michigan. Can. J. Fish. Aquat. Sci.; 1985; 44(no. suppl. 2): 313-323; ISSN: 0706-652X.

431. Turney, W.G. Control of Pollution from Pleasure Boats. J. Water Pollut. Control Fed.; 1971; 43(3): 447-453.

432. Turney, W.G. (Michigan State Dep. Nat. Resour., S.T. Mason Building, Box 30028, Lansing, MI 48909). Michigan's Legislative Policies Regarding Lake Environmental Issues. in Shiga Conference 1984 on Conservation and Management of World Lake Environment; 27 Aug. 1984; Otsu, Japan: Shiga Prefectural Gov., Otsu (Japan); 1985: 282-288.
A description is given of the Great Lakes system and inland lakes of Michigan with respect to the state's legislative policies covering pollution control, in particular toxic and hazardous materials.

433. U.S. Army Corps of Engineers. Monthly Bulletin of Lake Levels for the Great Lakes.
Note: Mich. City.

434. Udd, E.; Fridgen, J.D. (Dep. For., Kansas State Univ., Manhattan, KS 66502). Anglers' Perceptions of Toxic Chemicals in Rivers and Sport Fish. Lucas, R.C. Proceedings - National Wilderness Research Conference: Current Research.; 23-26 July 1985; Colorado State University, Fort Collins, CO; July 1986: 245-250. (INT-212. Gen. Tech. Rep., Intermt. Res. Stn.).
Anglers' response to toxic chemical contamination of rivers and sports fish were tested on three rivers in Michigan. Across three levels of contamination, there was no difference among anglers in terms of their awareness of, responses to or avoidance of contaminants, even on the river with high levels of toxic chemical contamination. Management, health and recreation experience implications are discussed.

435. unknown. Cesium-137 Activities in Fish Residing in Thermal Discharges to Lake Michigan. Health Physics; May 1976; 30(5): 411.

436. Vanderploeg, H.A.; Eadie, B.J.; Liebig, J.R.; Tarapchak, S.J.; Glover, R.M. Contribution of Calcite to the Particle-size Spectrum of Lake Michigan Seston and its Interactions with the Plankton. Can. J. Fish. Aquat. Sci.; 1987; 44(11): 1898-1914; ISSN: 0706-652X.
The authors determined the contribution of calcite to the total particle-size spectrum of Lake Michigan seston during different seasons in 1978-83 and 1985, employing a novel Coulter counter method, to examine the intensity and ecological effects of calcite whitings that result from autogenic precipitation of calcite. The whitings were most intense during September, when 12-56% of the total particle volume was calcite. Overall, food web dynamics were more controlling of than controlled by whitings. Year-to-year variation in calcite concentration was probably caused by

predation-controlled variation in primary production, which drives calcite precipitation through CO2 uptake.

437. Warren, G.J. Predation by Limnocalanus as a Potentially Major Source of Winter Naupliar Mortality in Lake Michigan. J. Great Lakes Res.; 1983; 9(3): 389-395; ISSN: 0380-1330. Predation by adult Limnocalanus macrurus may have a significant impact on naupliar mortality in Lake Michigan. Nauplier mortality rates were estimated from plankton samples from winter and early spring of 1981, and compared with estimates of potential mortality due to predation by adult Limnocalanus. Predation, rather than competition for food, is probably, the main influence on nauplier mortality.

438. Warren, G.J.; Evans, M.S.; Jude, D.J.; Ayers, J.C. Seasonal Variations in Copepod Size: Effects of Temperature, Food Abundance, and Vertebrate Predation. J. Plankton Res.; Sep. 1986; 8(5): 841-853.

439. Wells, L. Changes in Lake Michigan's Prey Fish Populations with Increasing Salmonid Abundance, 1962 to 1984. SPEC. PUBL. GLFC; 1985; NO. 85-3: 13-25.
Along with dramatic increases in salmonid populations in Lake Michigan during the last two decades, striking changes in prey fish populations have occured. Alewives increased to great abundance in the mid 1960s, suffered an enormous dieoff in 1967, recovered partly in the early 1970's, then fluctuated to low levels in 1982-84. According to some biologists the recent decline resulted from salmonid predation, but according to others it was due in considerable degree to adverse thermal conditions. Several species (smelt, chubs, deepwater sculpins, yellow perch, and emerald shiners) declined to low levels in the mid 1960s, apparently as a result of interference with their reproduction by the abundant alewife declined.

440. Westphal, J.M.; Halverson, W.F. Assessing the Long-term Effects of an Environmental Education Program: A Pragmatic Approach. J. Environ. Educ.; 1985-86; 17(2): 26-30.
Citizen involvement in public decision-making processes affecting the environment requires an informed and motivated citizenry. This paper examines the long-term effects of an environmental education program specifically designed to involve citizens in environmental affairs concerning water quality in Lake Michigan. Feedback from the participants indicates a wide range of attitudinal and behavioral change as a result of program participation. The most common changes were: greater awareness of the problem and more

confidence in discussing environmental issues in public forums.

441. Winnell, M.H.; White, D.S. The Distribution of Heterotrissocladius oliveri Seather (Diptera: Chironomidae) in Lake Michigan. Hydrobiologia; Feb 1986; 131(3): 205-214.
Fifty one chironomid species were identified from 504 samples collected at depths ranging 8 to 267 m in Lake Michigan, U.S.A. Heterotrissocladius oliveri Saether occured in 32% of these samples and had an average abundance of .0022 m which was similar to other estimates from the Great Lakes. Maximum average lake-wide density was at 30-60. At depths > 60 m, H. oliveri was the dominant chironomid species comprising 75% of total Chironomidae. Although still oligotrophic in nature, high density occurences in both high and low sedimentation areas of the lake suggest the trophic indicator status of H. oliveri might be broader than previously thought.

442. Winnell, M.H.; White, D.S. Ecology of Some Chironomidae (Diptera) from Southeastern Lake Michigan, U.S.A. Trans. Am. Entomol. Soc.; Sep. 1985; 111(3): 2[illegible]-360.
In nine year study of the benthic environment of southeastern Lake Michigan, 90 taxa of Chironomidae were collected. Of these, 20 were present in sufficient quantities to provide information on densities, yearly population fluctuations, relationships to water depths, correlations with sediment types, growth, and emergence periods.

443. Wood, William L. Managing Coastal Erosion Through the NFIP, Delineation of Erosion Hazard Shorelands. Great Lakes Shoreland Management Workshop Series; 1990; 2: 13-15.
Note: article.
The National Research Council formed the Committee on Coastal Erosion Zone Management in 1988 to provide advice on appropriate erosion management strategies, supporting data needs, and applicable methodologies to administer these strategies through the National Flood Insurance Program. The committee agreed that an erosion element of the National Flood Insurance Program should have three primary objectives. First, it should transfer economic costs of erosion losses from all federal taxpayers to the property owners at risk by charging premiums that approximate the risks of loss. The program should eventually become actuarial. Second, the program should discourage inappropriate development from occurring in erosion zones as delineated by FEMA or the states. Third, the program should strongly support the improvement of development and redevelopment practices in

erosion-prone areas. In order to meet these objectives FEMA must take steps to facilitate erosion hazard reduction.

444. Wood, William L. Managing Coastal Erosion Through the National Flood Insurance Program. Journal of American Shore and Beach Preservation Association (Shore and Beach); April 1990; 58(2): 3.
Note: article.
In response to a request from the Federal Emergency Management Agency/Federal Insurance Administration (FEMA/FIA) in 1988, the National Research Council (NRC) established the Committee on Coastal Erosion Zone Management under the auspices of its Water Science and Technology Board and the Marine Board. The committee was asked to provide advice on appropriate erosion management strategies, supporting data needs, and applicable methodologies to administer these strategies through the National Flood Insurance Program. Population and economic pressures have transformed the lightly developed shorelines of earlier years into higher density resorts and urban complexes, e.g.: Ocean City, Maryland; Clearwater, Florida; Galveston, Texas.

Appendix 2: Hydrology

445. Bernabo, J.C. Quantitative Estimates of Temperature Changes Over the Last 2,700 Years in Michigan Based on Pollen Data. Quaternary Research; 1981; 15: 143-159.

446. Clemens, Robert H. Selected Environmental Criteria for the Design of Artificial Structures on the Southeast Shore of Lake Erie. South Carolina: Coastal Resources Division South Carolina University, Department of Geology; 1976; Technical Report No. 8-CRD.

447. Crane, Thomas; Great Lakes Commission (Great Lakes Commission). Drought Planning, Management and Water Level Changes - Great Lakes; 1-1-90; Guidebook.
Note: Covers Great Lakes.
Response to the 1988 drought. Planning for future drought.

448. DeCooke, B.G.; Megerian, E. Forecasting the Levels of the Great Lakes. Water Resources Research; 1967; 3: 397-403.

449. Detroit District, Corps of Engineers (Corps of Engineers). Great Lakes Water Level Facts
Subtitle: Corps of Engineers; 1-1-86.
Note: Covers Great Lakes.
Physical features of Great Lakes, water level fluctuations, factors influencing lake levels.

450. Dorr, J.A.; Eschman, D.F. Geology of Michigan. Ann Arbor, Mi: University of Michigan Press; 1970.
Note: 476 pages.

451. Fraser, G.S.; Hester, N.C. Sediment Distribution in a Beach Ridge Complex and its Application to Artificial Beach Replenishment. Illinois State Geological Survey Environmental Geology Notes; 1974; 67: 26 p.

452. Great Lakes Shoreland Management Workshop Series (International Joint Commission, Water Levels Reference Study). Delineation of Erosion Hazard Shorelands, Cleveland, Ohio. Subtitle: Erosion Hazard, Workshop Summary; 6-21-90; Workshop Summary.
Note: Covers all 8 Great Lakes States.
Shoreline erosion - setback legislation/questionaire answers.

453. Great Lakes Science Advisory Board (G. L. Science Advisory Board). Great Lakes Science Advisory Board; 1-1-87.
Ecosystem approach to the Great Lakes - policy and programs; monitoring and surveillance; research.

454. Great Lakes Water Quality Board (IJC). Great Lakes Water Quality Board; 1-1-89; Appendix A.
Progress in developing and implementing remedial action plans for areas of concern in the Great Lakes Basin.

455. Great Lakes Water Quality Board (IJC). Great Lakes Water Quality Board; 1-1-90.
Progress in developing remedial action plans for areas of concern in the Great Lakes Basin.

456. Great Lakes Commission (Great Lakes Commission). Water Level Changes
Subtitle: Factors Influencing the Great Lakes; 1-1-86.
Note: Covers the Great Lakes.
Lake levels, flooding, Shoreline Erosion Task Force- basic information about the Great Lakes; factors affecting lake levels.

457. Great Lakes Commission, Ann Arbor MI (GLC). Great lake Commercial and Recreational Harbor Dredging:
Subtitle: Issues and Recommendations; 11-1-88; Final Report.
Note: Covers eight Great Lakes states shorelines.
Confined Disposal Facilities (CDF's), navigation, lake levels.

458. Hands, E.B. Prediction of Shore Retreat and Nearshore Profile Adjustments to Rising Water Levels on the Great Lakes [U.S. Army Corps of Engineers]. U.S. Army Corps of Engineers Technical Paper 80-7.
Note: p.119.

459. Hansel, A.K.; Mickelson, D.M.; Schneider, A.F.; Larsen, C.E. Late Wisconsin and Holocene History of the Lake Michigan Basin. Geological Association of Canada Special Paper 30; 1985: 39-53.
Note: In Karrow, P.F; Calkin, P.E.: Quaternary evolution of the Great Lakes.

460. Hartmann, Holly C.; Donahue, Michael J. (Great Lakes Commission). Great Lakes Water Level Forecasting and Statistics Symposium. Subtitle: Water Level Forecasting and Statistics, Proceedings; 5-17-90; Proceedings of Symposium.
Note: Covers Great Lakes.
Assess strengths and weaknesses of water level forecasting; response to publics questions; develop a communication methods of statistics to users.

461. Hester, N.C.; Fraser, G.S. Sedimentology of a Beach Ridge Complex and its Significance in Land Use Planning. Illinois State Geological Survey Environmental Geology Notes; 1973; 63: 24 p.

462. Hough, J.L. Geology of the Great Lakes. Urbana, IL: University of Illinois Press; 1958.
Note: 313 p.

463. IJC. International Joint Commission-United States and Canada
Subtitle: Activities Report 1986; 1-1-86.
Note: Covers 1912-1986.

464. IJC Task Force (International Joint Commission). 1985-86 High Water Levels in the Great Lakes-St. Lawrence River Basin
Subtitle: Interim Report to the International Joint Commission; 10-1-88.
Note: Covers all Great Lakes.
Ability of man's existing control structures to influence the Great Lakes water levels. Appendix A Summary-Great Lakes Water Levels Task Forece to International Joint Commission October 1987.

465. Keen, Cecil S.; Lyons, Walter A. Lake/Land Breeze Circulations on the Western Shore of Lake Michigan. Journal of Applied Meteorology; 1978; 17(12): 1843.
A classic lake breeze circulation cell that formed on the western shore of Lake Michigan on 4 September 1974 is studied in great detail. Wind measurements are made with surface anemometers and serial pibals, with air trajectories monitored via tetroons. Aircraft measurements map the thermal internal boundary layer and small and large aerosol distributions. Recirculation of pollutants is indicated from analysis of the tetroon data. Aerosol measurements suggest size sorting of small versus large particles as they are transported through the complex three-dimensional flow. These wind data also form the basis of kinematic diagnostic study of mesoscale pollution transport in coastal areas, to be reported in a subsequent paper.

466. Lake Levels, Flooding and Shoreline Erosion Task Force (Great Lakes Commission). Great Lakes Shore Erosion and Flooding Assistance Programs; 1-1-87.
Note: Covers Great Lakes.
Shore erosion control, Federal assistance projects, permits, shore protection and flooding assistance programs.

467. Larsen, C.E. Geoarchaeological Interpretation of Great Lakes Coastal Environments. Stein, J.K.; Farrand, W.R., editors. Archaelogical sediments in context, peopling of the Americas. Edited Series No. 1 ed. University of Maine, Orono: Institute for Quaternary Studies; 1985b.
Note: p. 99-110.

468. Larsen, C.E. Prehistoric Levels of Lake Michigan-Huron: Their Potential in Shoreland Planning. Proceedings of the Shoreland Planning Conference; (1973); Lake Michigan Federation, Chicago; 1973: 169-195.

469. Lee, Kwang K. Longshore Currents and Sediment Transport in West Shore of Lake Michigan. Water Resources Research; December 1975; 11(6): 1029
Longshore sediment transport presents an important problem at the shores along the Great Lakes. Direct field measurements were made on the parameters related to waves, beaches, longshore currents, and sediment transport. By using the field data from Lake Michigan, the longshore currents are found to be linearly related to the longshore momentum flux of incident waves at the breaker line, and also the longshore sediment immersed weight transport rate is found in terms of the longshore wave energy flux per unit length of beach.

470. Leverett, F.; Taylor, F.B. The Pleistocene of Indiana and Michigan and the History of the Great Lakes. U.S. Geological Survey Monograph; 1915; 53: 529 p.

471. Liu, P. Statistics on Great Lakes levels. Proceedings of the 13th Conference on Great Lakes Research; Ann Arbor, International Association for Great Lakes research; 1970: 360-368.

472. Meadows, G. A.; Wood, W. L. Long Period Surf Zone Motions. Ocean Engineering.
Note: Submitted for publication.

473. Meadows, G. A.; Wood, W. L. Unsteady Longshore Currents in a Uniform Wave Field (abs). EOS; 1975; 56(No. 12): pp. 1009.
Field observaions show, at a fixed point in the surf zone variations in excess of 150% of the mean longshore current velocity occur over time periods from three to eighty seconds. These unsteady motions in longshore currents persist horizontally across the surf zone and vertically from the surface to the bottom. The dominant period of these fluctuations corresponds to that of the incident breaker period, however, significant longer period fluctuations are also evidenced.

474. Meadows, Lorelle A. (Editor) (Michigan Sea Grant, Department of Naval Architecture and Marine Engineering). Great Lakes Coastal Erosion Research Needs
Subtitle: Workshop Summary; 7-8-87; MICHU-SG-88-900.
Note: Covers Great lakes.
Shoreline erosion, lake level fluctuation, field experimentation needs, data collection methods.

475. Sorensen, Robert M.; Seelig, William N. Hydrodynamics of Great Lakes Inlet-Harbors Systems. In: Proceedings of the Fifteenth Coastal Engineering Conference, Volume II; 1977: 1646-1665.
Note: American Society of Civil Engineers.
Honolulu, Hawaii.

476. Stockberger, M. Todd; Wood, William L. (American Society of Civil Engineers). Application of Equilibrium Beach Concepts to Sandy Great Lakes Profiles. Edge, Billy L. Twenty-Second Coastal Engineering Conference
Proceedings of the international conference; July 2-6, 1990; Delft, the Netherlands. 345 East 47th Street, New York, NY 10017-2398: American Society of Civil Engineers; volume 3: 2291.
This study was designed to evaluate the equilibrium beach concept for conditions of "rapidly" varying water level, experienced on the North American Great Lakes. It was determined that the mathematical expression h(x) = Ax{to the 2/3} is appropriate for describing sandy beach and nearshore profiles of the Great Lakes. In addition, a correlation was found between lake-level change and the shape factor A, that indicates a phase lag in beach and nearshore response to "rapidly" changing water level. Results from this study also raise some questions about the reliability of determining the shape factor A directly from sediment size. Reliability in the determination of A may be related to the stability shape of the profile relative to its equilibrium shape.

477. U.S. Department of the Interior [Great Lakes Basin Commission]. Great Lakes Basin Framework Study, Appendix 12: Shore Use and Erosion. Ann Arbor, MI; 1975.
Note: p. 56-57.

478. U.S. Geological Survey. Low-flow Characteristics of Indiana Streams. Subtitle: Streams - Open File Report; 1/1/83; Open File Report. 82-1007.

479. Water Quality Board (IJC). Great Lakes Water Quality Board. Subtitle: Report to the International Joint Commission; 1-1-87.

480. Weishar, L. L.; Wood, W. L. An Evaluation of Offshore and Beach Changes on a Tideless Coast. Journal of Sedimentary Petrology; 1983; 53(No. 3): pp. 847-858.
A 4-year set of beach and offshore profiles, measured at monthly intervals, is evaluated to determine the effect of wind-wave forcing and long-term lake-level variation on profile change in the Great Lakes. This evaluation indicates three distinct areas of profile change: the beach-and-berm, the inner-bar, and the outer-bar regions. The beach-and-berm region exhibits a classical transition from a narrow highly eroded (winter) profile to a broad fully deposited (summer) profile, during ice free months. The inner bar moves actively under the influence of wind-waves, but appears to lack a well-defined seasonal pattern. The outer bar advances onshore from early spring to early winter in response to lake-level modulation of incident wind-waves. Empirical eigenfunction analysis is applied to these data in order to statistically quantify the significance of these observed changes. This analysis provided confirmation of a hypothesized long-term (years) variation of the outer bar in direct response to lake-level variation.

481. Wood, W. L. Ambient Hydrodynamic Flow Fields Associated with the TEKTITE II Habitat: Department of the Interior, National Oceanographic and Atmospheric Administration; 1971; Final Report. pp. 10.

482. Wood, W. L. Application of Short-Crested Wave Theory in the Design of Three Dimensional Coastal Hydrodynamic Models: Office of Naval Research, Department of Geosciences, Great Lakes Coastal Research Laboratory, Purdue University; 1980; Final Report. pp. 26.

483. Wood, W. L. The Breaking of Waves on a Submarine Bar (abs). EOS; 1972; 54(No. 4): pp. 316.

484. Wood, W. L. "Circulation of the Great Lakes", in Decisions for the Great Lakes; 1982.
Note: Editors: Reskin, Mark; Daniels, Glenda.

485. Wood, W. L. Coherent Turbulent Structure in Breaking Waves. (abs) Proc. 4th Conf. on Atmospheric and Oceanic Waves and Stability: pp. 17.

486. Wood, W. L. Dependency of Surf Zone Motions on Longshore Bottom and Wave Variability (abs). EOS; 1976; 57(No. 12): pp. 934.
An analysis of the three-dimensional equations of motion has been carried out under the assumption that the initial conditions and boundary conditions at the outer surf zone are not independent of distance parallel to shore. Meyer and Turner (1967) have shown, for initial conditions and boundary conditions independent of distance parallel to shore, that when the longshore profile slope is gentler than the normal profile slope "weakly three-dimensional" surf can be analyzed directly by two-dimensional theory. However, solution of the equations of motion under the former assumption results in a non-linear time dependent free surface variation which is a function of both bottom slope and crest height variablility. Evaluation of this theoretical free surface variation using field observations shows a strong dependency of surf zone water motions on longshore variations in the incident wave field. Notable application of two-dimensional theory is not valid under these conditions.

487. Wood, W. L. A Ducted Impellor Flowmeter for Shallow-Water Measurements of Internal Velocities in Breaking Waves: Office of Naval Research, Department of Geology, Michigan State University; 1968; Technical Report No. 1. pp. 58.

488. Wood, W. L. An Energy Evaluation Within the Nearshore Zone (abs). EOS; 1970; 51(No. 4): pp. 322.
An intensive instrumentation network was established in the nearshore zone of Lake Michigan near Pentwater, Michigan for the purpose of determining nearshore wave energy distributions over a broad spectrum of wind and wave conditions. For purposes of analysis the nearshore zone is only divided into "near breaking", "breaking", and "reforming" areas and the waves are classified into three symmetry groups. The mass transport energy beneath the wave crest of "extremely asymmetric" waves was a maximum of seven times as great as that under the crest of "slightly asymmetric" and "symetric" waves. In the "near breaking" area the "slightly asymmetric" and the "symmetric" waves have about the same mass transport energy under the wave crest.

However, the "symmetric" waves contained twice as much mass transport energy beneath the wave crest as the "slightly asymmetric" wave in both the "breaking" and "reforming" areas. A high potential energy correlates directly with this high mass transport energy in "symmetric" waves. As a result the "energy transmission coefficient" is much higher for "symmetric" waves within the nearshore zone.

489. Wood, W. L. The Formation of Complex Cuspate Forelands as a Result of Structural Influences on Nearshore Wave and Current Processes (abs). Transactions of American Geophysical Union; 1968; 49(No. 1): pp. 190.

490. Wood, W. L. Horizontal Particle Velocity Profiles Beneath the Crests of Waves Breaking on a Submarine Bar: Office of Naval Research, Department of Natural Science, Michigan State University; 1970; Technical Report No. 3. pp. 68.

491. Wood, W. L. Influence of Breaking Wave Decay on Longshore Current Velocity. Proc. 20th Congress IAHR; 1983: pp. 70-74.

492. Wood, W. L. An Inventory of Data Acquisition Systems for Coastal Processes Experiments. Nearshore Sediment Transport Study Workshop on Instrumentation for Nearshore Processes; 1977; Sea Grant Publication 62: pp. 175-181.
Note: invited paper.
A primary concern in planning for the National Sediment Transport Study (NSTS) is to establish the suitability and availability of data acquisition systems. Success of the large-scale field experiments, planned for this study, is integrally dependent upon the ease and reliability of recording large amounts of data on a synchronous time base. A new data acquisition system will be designed and funded specifically for the NSTS experiments. The NSTS steering committee requested that an inventory of existing data acquisition systems, suitable for recording field data during coastal processes experiments, be conducted within the research community of the U.S. A questionnaire was issued with five primary objectives: to inventory existing data acquisition systems; to determine the current status of these systems; to assess the compatability of these systems; to determine the suitability of these systems for coastal process experiments; and to determine the availability of these systems for the NSTS large-scale experiments. The results of the survey provided a number of generalizations which will be useful in the planning for the NSTS large-scale experiments.

493. Wood, W. L. A Physical and Geological Oceanographic Cruise Game (abs). EOS; 1977; 58(No. 11): pp. 867.

494. Wood, W. L. Relationship of Wave and Current Energy to Coastal Destruction Along a Barred Coastline of Northeastern Lake Michigan (abs). Proc. 9th Conf. on Great Lakes Reasearch; 1966: pp. 15.

495. Wood, W. L. A Shallow-Water Instrument System for Monitoring Wave and Current Parameters in the Nearshore Zone: Office of Naval Research, Department of Geology, Michigan State University; 1970; Technical Report No. 2. pp. 53.

496. Wood, W. L. Short-crested Waves at a Coast. Proc. 2nd Conf. on Coastal Meterology; 1980: pp. 104.

497. Wood, W. L. Stability of Glacial Till Beach Nourishment Sand. American Society of Civil Engineering paper 3374; 1978: pp. 1-17.
Note: invited paper.

498. Wood, W. L. Stability of Glacial Till Beach Sand. Journal of Waterways, Port, Coastal, and Ocean Engineering.
Note: Submitted for publication.

499. Wood, W. L. Surf Zone Analysis Utilizing Computer Graphic Projections (abs). EOS; 1973; 54(No. 4): pp. 316.
A surf zone analysis has been developed which calculates the best fit curves of the free surface from time histories of an array of monitoring stations located through the surf zone. These curves are extrapolated through time to construct computer graphic projections of the free surface transformation. Analysis of a group of breaking waves, utilizing this technique, has illustrated its uniqueness to conventional methods in interpreting surf zone dynamics. The primary advantage of the analysis is that it provides a restored visualization of the surf zone and subsequently enhances the data for appraising breaking wave transformations. A potential extension of this technique may be used to evaluate the surface circulation within the surf zone.

500. Wood, W. L. Three Dimensional Conditions of Surf: Office of Naval Research, Department of Geoscience, Great Lakes Coastal Research Laboratory, Purdue University; 1977; Technical Report No. 4. pp. 15.

501. Wood, W. L. Three Dimensional Conditions of Surf. Proc. 15th International conf. on Coastal Engineering; 1977; 15: Chap. 30, pp. 525-538.
Wave height variability along the crest of breaking waves is shown to be a significant factor in the assessment of surf zone dynamics. Variations in excess of 50 percent of the maximum wave height can occur along a single crest without significant variations in bathymetry. The horizontal scale of this longshore variability in crest height corresponds to the wave length of incident breaking waves. Four possible mechanisms for this variability are postulated and then evaluated individually on the basis of field observations. A major result of these evaluations is that two-dimensional shallow-water wave equations appear to be inappropriate for expressing natural surf zone wave transformations and water motions even under the condition of waves encroaching on a plane sloping bottom. Consequently, three-dimensional equations of surf should be used for describing most natural surf zone dynamics.

502. Wood, W. L. Transformations of Breaking Wave Characteristics over a Submarine Bar: Department of Natural Science, Michigan State University; 1970; Technical Report No. 4. pp. 114.

503. Wood, W. L. Transformations of Breaking Wave Parameters on a Submarine Bar (abs). EOS; 1971; 52(No. 4): pp. 258-259.
The effect of a submarine bar on the transformation of breaking wave parameters is to create a "filter" on wave celerity and length. The degree of filtering is directly related to the intensity of wave breaking. The filtering effect of the submarine bar suggests that this is the reason for better agreement between observed wave parameters and theory in the reforming zone shoreward of the submarine bar. The role of turbulence of flow induced by breaking is the most important factor in wave height attenuation shoreward of the submarine bar. As a result, theoretical expressions which utilize depth as a primary control factor for shallow water wave transformations in the nearshore zone must be re-evaluated with turbulent dissipation taken into consideration as a major factor.

504. Wood, W. L. A Turbulent Shear Flow Mechanism for Wind Generation of Ocean Waves (abs). Proc. 3rd Conf. on Atmospheric and Oceanic Waves and Stability; 1982: pp. 13.

505. Wood, W. L. Upper Trinity Bay Circulation Study: Oceanologic Research Laboratory Inc., Lockheed Electronics; 1972; Final Report. pp. 44.

506. Wood, W. L. Wave and Flow Transformations Associated with Waves Breaking on a Submarine Bar (abs). Proc. 2nd National Coastal and Shallow Water Research Conference; 1971: pp. 260.

507. Wood, W. L. A Wave and Current Analysis in the Nearshore Zone: Office of Naval Research, Department of Natural Science, Michigan State University; 1973; Final Report. pp. 146.

508. Wood, W. L. A Wave Analysis System for the Breaker Zone. International Symposium on Ocean Wave Measurement and Analysis; 1974; 1: pp. 774-787.

509. Wood, W. L. A Wave Analysis System for the Breaker Zone: Office of Naval Research, Department of Geosciences, Great Lakes Coastal Research Laboratory, Purdue University; 1975; Technical Report No. 1. pp. 15.

510. Wood, W. L. Wave Height Decay Due to breaking (abs). Bulletin American Meteorological Society; 1981; 61(No. 10).

511. Wood, W. L.; Davis, S. E.; Meadows, G. A.; Lesht, B. A. Boundary Layer Shear-flow Structure and Sediment Movement at the Seafloor Bed: NOAA, National Underseas Research Program; 1985; Report 84-13. pp. 7.

512. Wood, W. L.; Davis, S. E. Nearshore Response to Meteorologic Forcing Factors on the Tideless Great Lakes. (abs) EOS; 1985; 66(No. 46).
A series of beach and nearshore profiles measured concurrently with local meteorologic observations were analyzed using the method of empirical eigenfunctions. The spatial function having the second highest eigenvalue has a pronounced maximum in the region of the inner-bar crest. Temporal dependence of this inner-bar function shows sharp step-like increases and decreases associated with the passage of major wind-wave events. Wind-wave intensity (magnitude times duration) scales directly to the magnitude of temporal variation in the inner-bar function. Direction of inner-bar profile change (onshore or offshore) appears to be related to initial pre-shore position and not to storm intensity.

513. Wood, W. L.; Howell, G. L.; Cole, R. A. Crescent City Dolos Project. Proc. Coastal Engineering Res. Board; 1985: pp. 114-136.
At present there is not a design procedure available to coastal engineers for the prediction of structural strength requirements for dolos armor units. As armor unit sizes have increased, structural failures have increased in frequency. Several major failures of breakwaters around the world have been attributed to dolos structural failure. The objective of the Crescent City Dolos Project is to obtain high-quality data on the forces, motions, and resulting structural stresses of dolos armor units in a high-energy prototype environment. As part of the study, an international workshop was held to review the state of the art in structural investigations of dolos. The unanimous conclusion of the workshop was that detailed prototype studies, such as that at Crescent City, were necessary before further development of design methodology could be accomplished.

514. Wood, W. L.; Meadows, G. A. Living with America's Coastlines: Lake Michigan's Coast; scheduled for publication in 1986.

515. Wood, W. L.; Meadows, G. A. The Prediction of Breaking Wave Probability Distributions in the Surf Zone (abs). EOS; 1974; 55(No. 12): pp. 1136.
The utilization of probability distributions of breaking wave height and length adds a significant dimension to the prediction of surf zone kinematics and dynamics. A series of probability distributions at breaking are generated from a descrete set of deep water wave parameters under the assumption that the deep water sea surface is Rayleigh distributed. A second series of probability distributions at breaking are generated through a linear transformation of a set of probability distributions from deep water wave observations. Result: deep water transformation schemes utilizing probability distributions are proposed for the prediction of surf zone behavior.

516. Wood, W. L.; Meadows, G. A. Unsteadiness in Longshore Currents: Office of Naval Research, Department of Geosciences, Great Lakes Coastal Research Laboratory, Purdue University; 1975; Technical Report No. 3.

517. Wood, W. L.; Meadows, G. A. Unsteadiness in Longshore Currents. Geophysical Research Letters; 1975; 2(No. 11): pp. 503-505.
Classically, field and laboratory investigations have relied on averaged results from Lagrangian measurements to establish longshore current velocities. Likewise, conservation equations have been time averaged in the formulation of longshore current theories. Recent experimental measurements by the authors indicate that at a fixed point in the surf zone variations in excess of 159% of the mean current velocity occur over time periods from three to eighty seconds. These unsteady motions in longshore currents persist horizontally across the surf zone and vertically from the surface to the bottom. This persistence and magnitude of the observed velocity fluctuations from this investigation imply that time dependent analytic treatments of conservation equations are necessary in order to properly determine longshore current velocity.

518. Wood, W. L.; Meadows, G. A. Unsteady Longshore Currents in a Non-uniform Wave Field (abs). EOS; 1975; 56(No. 12): pp. 1010.
Significant unsteadiness in longshore currents has been observed with a periodicity equivalent to that of the incident breaker period. However, the assumptions that an incident wave field, at the outer limit of the surf zone, is statistically steady and uniform in the longshore direction are fundamental to existing longshore current theories and result in the prediction of steady currents. Recent field measurements show prominent non-uniformity, in the longshore direction, for wave height distributions incident at the outer surf zone. Analysis of these data indicate that transverse motion is occurring along the crest and that this motion intensifies as the wave approaches breaking. Consideration of this non-uniformity in wave height provides an order of magnitude approximation for a periodic longshore velocity component which may contribute significantly to unsteadiness in longshore currents.

519. Wood, W. L.; Weishar, L. L. Influence of Seasonal Wind Variation on Coastal Stability in the Great Lakes (abs). EOS; 1982; 63(No. 3).
Empirical eigenfunction analysis of four years of beach and nearshore topographic data results in the identification of one significant short term mode of variability and one long term mode. A similar analysis of directionally filtered wind speed data for this same time period identifies a variational trend in the first temporal eigenfunction which correlates with the short term variational trend in beach and nearshore

topography. A sensitivity analysis shows that the method of empirical eigenfunctions is capable of detecting changes in beach and nearshore topography caused by single storm events.

520. Wood, William L. Effects of Seawalls on Profile Adjustment Along Great Lakes Coastlines. Journal of Coastal Research; Autumn 1988; 4(Special Issue No. 4): 135-146.
An extensive Great Lakes beach and nearshore profile data base is analyzed to determine the influence of seawalls on beach and nearshore profile change. Empirical eigenfunction analysis of these profile data supports the conclusion that the primary region of spatial change (outer-bar) is similar for armored and unarmored lengths of shoreline. Correlation of profile response between armored and unarmored lengths of shoreline is strongest for periods of rising lake-level and weaker during periods of falling lake-level. Analysis of sub-aerial beach response in front of extensive lengths of seawall indicates that beach width diminishes systematically from the downdrift to the updrift end. This observed narrowing also appears to be directly related to a lack of upland sediment source.

521. Wood, William L. (Director, Great Lakes Coastal Research Laboratory, Dept. of Civil Engineering, Purdue University). The Effects of Sea Level Variation on the Coast. Proceedings of the International Joint Commission Functional Group 5 Workshop; 1989: 214-217.
Dr. Wood gave a detailed treatment of the state of knowledge about Great Lakes water level variations, centering on coastal engineering and erosion issues. He identified important concerns associated with both rising and falling water levels. In addition, he discussed the temporal and spatial scales of water level variations and identified program needs in each category. Rising lake levels create a number of issues pertinent to coastal engineering and erosion. To establish coastal construction lines, or set-back limits, we must very clearly differentiate between encroachment, recession, and erosion. Coastal flooding becomes important with the advent of rising water levels. In addition, structural overtopping during high water levels is a primary concern of designers.

522. Wood, William L. Managing Coastal Erosion Through the National Flood Insurance Program. Journal of American Shore and Beach Preservation Association (Shore and Beach); April 1990; 58(2): 3.
Note: article.
In response to a request from the Federal Emergency Management Agency/Federal Insurance Administration (FEMA/FIA) in 1988, the National Research Council (NRC) established the Committee on Coastal Erosion Zone Management under the auspices of its Water Science and Technology Board and the Marine Board. The committee was asked to provide advice on appropriate erosion management strategies, supporting data needs, and applicable methodologies to administer these strategies through the National Flood Insurance Program. Population and economic pressures have transformed the lightly developed shorelines of earlier years into higher density resorts and urban complexes, e.g.: Ocean City, Maryland; Clearwater, Florida; Galveston, Texas.

523. Wood, William L., Committee on Coastal Engineering Measurement Systems (National Research Council's Commission on Engineering and Technical Systems). National Needs for Coastal Engineering Measurement Systems. 50th Coastal Engineering Research Board Meeting, Virginia Beach, VA.; 1988.
Note: Paper presented based on abstract only.
The committee appointed to undertake a two-year study of the present state and future needs of coastal measurement systems was charged with the tasks of: assessing the needs for coastal data and measurement systems; determining the availability and suitability of existing instrumentation and measurement systems; and developing a set of recommendations regarding instrumentation and measurement system development. The committee was also responsible for providing guidance on development priorities. In general, the committee agreed that there is a pressing need for development of instruments and measurement systems. To stimulate this development there is a perceived need for resource commitment at the national level. There is need for better coordination at the national level and for a forum to provide information, collaboration, and interaction on coastal measurement systems development. The committee also found that some existing conceptual and mathematical models need theoretical improvement and rigorous field testing (in an interactive fashion), while better physically based models are derived and field tested. All of these findings are presently under review prior to publication of the final report.

524. Wood, William L. Wave Analysis System for the Breaker Zone. ASCE; 1974; 1: 774-787.
Note: Proceedings of the International Symposium on Ocean Wave Measurement and Analysis [ASCE/New Orleans, La./Sept. 9-11, 1974].
The measurement and analysis of breaking wave parameters and their transformation within the breaker zone must be approached in a considerably different manner from that used on open ocean waves. Free surface time histories taken within the breaker zone should be interpreted with caution due to ambiguities arising from the rapid variations in wave parameters which subsequently create errors in transforming the temporal records to a spatial reference frame. A large number of wave sensors should be used to adequately measure the nonlinear transforming wave system. Based on these considerations a variety of wave analysis techniques are discussed with respect to their applicability in the breaker zone. A multiparametric wave analysis system is described which was developed to evaluate wave transformations, wave stability, and wave energy distribution in the breaker zone. This computer analysis system receives input data from an extensive network of shallow water monitoring stations and calculates a series of wave parameters, indices, and energy estimates. These calculated data are output in a matrix format referenced both spatially and temporally, for subsequent use in a variety of wave analysis and display schemes.

Appendix 3: Recreation

525. Abonmarche Group. Estimate of the Market Opportunity for Recreational Boat Slips for 9 Shoreline Regions and the State of Michigan. P.O. Box 1088, Benton Harbor, MI 49022: Abonmarche Group; Jan. 1991.
Note: NRPC.
With this study, the DNR Boating Programs Branch has decided to re-examine current market potentials (ie market demand present in 1990) for boat storage slips. Some conclusions of this study follow; 1) recreational boating demand remains quite strong, 2) supply of wet and dry boat storage has increased significantly, 3) geographic market areas are shrinking and have been redefined, 4) potential new supply will further impact market size and location, 5) market potential for new slips will not be fullfilled by 1995, 6) overall occupancy has declined as newer slips have been added, 7) occupancy rates differ by type of marina facility, 8) pricing has been modified as occupancy has decreased, 9) economic turmoil has disrupted boat buyer purchasing decisions, 10) environmental, financial and construction concerns limit the potential for new marina facilities.

526. Chaney, Charles A. Marinas: Recommendations for Design, Construction and Maintenance. Chicago, Illinois: National Association of Engine and Boat Manufacturers, Inc.; 1961.

527. Chien, Han. Projecting Use of a Proposed New Lake Michigan Marina: A Spatial Analysis Approach. East Lansing, MI: Michigan State University; 1975.
Note: Ph.D. Dissertation.

528. De Gaspari, J. Dealers of the Great Lakes. Boating Industry; 1987; July: 53-58.
The Great Lakes states have taken some economic hard knocks. Nevertheless, boating remains deeply ingrained among the region's sizeable and enthusiastic boating public. Overall, boating dealers throughout the five Great Lakes states averaged $1,452,414 in annual marine sales, including products sold and services rendered. Indiana dealers averaged $836,363. John Hatfield of Howe Marine feels that sales will continue to grow as long as the consumer interest rate stays below 10%.

529. Dickmen, F.N. Great Lakes Slip Survey: Sales Rental 1986. Great Lakes Boating; 1986; July.
A survey was conducted to provide boaters with information about docking slip sales and rentals for comparison shoppers. It gives information on the size of slips and water depth, charges, amenities, space available, as well as other information about many marinas (along with their addresses).

530. Dippel, Carol J.; Meier, Sharon K.; Stitt, Harold J. Integrated Impact Assessment: A Case Study. Ann Arbor, Michigan: University of Michigan, School of Natural Resources; 1980: 124 pp.

531. Ditton, R. B. The Social and Economic Signifigance of Recreational Activities in the Marine Environment. Green Bay, WI: University of Wisconsin; 1972.
This paper discusses recreation in coastal zones, redefines recreation, discusses the economics of coastal zone recreation, and discusses what future use of marine environments for recreation depends on: It has been recognized that recreation use is the most rapidly growing demand on water. Demographers estimate that the U.S. population will approximately double by the year 2,000 and 175 million people will be living in the coastal zone, including the Great Lakes. The Bureau of Outdoor Recreation (BOR) found, moreover, that increases in the demand for many types of outdoor recreation far outstrips population increases. Their studies revealed that there was a 12% increase in fishing, and 18% increase in boating and a 15% increase in swimming during the half decade from 1960-65, while the population increase was estimated at only 8% during that period. Recreation must be redefined to be viewed as an experience that is freely engaged in largely during leisure, from which an individual derives some satisfaction. In other words, recreation experiences must have a qualitative value, and esthetics can not be ignored in planning. It has been estimated that the total recreational value of the coastal zone is about $300 million if each person participates 5 days annually. In conclusion, individuals, adjacent shoreland owners, businessmen, polluters, etc. must begin to assume implicit responsibility for the sustained yield of our coastal zones if society is to realize the full social and economic significance of recreational activities in the marine environment.

532. Ditton, R. B.; Goodale, T. L. Water Quality Perceptions and the Recreational Use of Green Bay, Lake Michigan. WIS-SG-73-3040 and NOAA-73101003; 1973.
How people perceive Green Bay as a recreation resource, how perceptions differed between groups, and how these perceptions related to recreation use patterns, are identified. Whereas seven of 10 household heads interviewed participated in boating, or swimming, only 3 of 10 used Green Bay during the preceding 12 months, indicating that Green Bay was not a focal point of water-based recreation among residents of the five-county study area. Chi square test groups differed significantly on most comparisons when used to describe the Bay and its most bothersome physical and water quality characteristics. Generally, participants and those who use the Bay were less apt to cite unpleasant smell and dead fish as major problems and more apt to cite such problems as winds, waves and cloudiness. Comparisons between three user groups (fishermen, boaters, and swimmers) indicated swimmers and boaters differed most in their perception of the Bay and its troublesome characteristics, with fishermen occupying a position between the two groups.

533. Eckenstahler, Charles. Determining Market Demand for Boat Slips. In: Readings in Waterfront Development. Grand Rapids, MI: The Abonmarche Group; 1989.
This article discusses how Laventhol & Horwath determines market potential for a specific project: The MBIA and DNR among others, have projected the need for 15,000- 20,000 additional boat slips in the state of Michigan by the year 2000. Consequently, a flurry of marina projects are being planned, but a developer must determine how much of the need can be captured at one particular site. Boater surveys indicate that most boaters travel less than 45-60 minutes from home (or work) to their dock. This radius defines the primary market area. A secondary market area, defined as a 1-2 hour drive time, is also plotted since a portion of the boating population therein will possibly use the proposed facility depending upon the number and location of existing marinas and transportation routes. Demand is determined through study of historic per capita boat registration ratios for the market area(s) (say for the past 3 or 5 years). These ratios (adjusted for growth) are used to project the future number of boats demanded utilizing projections of future population for the market area(s). The art of market feasibility analysis is drawing conclusions from the data and determining the portion of demand that can be captured by a specific project.

534. Fridgen, J.D. Images and Perceptions of the Great Lakes: Implications for Tourism in Michigan. Ann Arbor: MI Sea Grant 82-84; 1983.
The purpose of this paper is to present the results of a study conducted during the summer of 1980. The objectives of the study were to: 1. compare how inland and coastal boat owners in Michigan responded to fuel constraints, 2. compare perceived changes in boating activities between the 1979 and 1980 boating seasons for these two groups, 3. compare expressed boat fuel consumption between 1979 and 1980 boating seasons and between the two groups.

535. Fridgen, J. D. Recreational Boater Owner's Response to Energy Constraints. In: Michigan Tourism How Can Research Help?; East Lansing, MI. MSU: Ag. Exp. Stn.; 1982; Spec. Rept. No. 6: p. 143-147.

536. Fridgen, J.; Taber M.; Gillings, G. Michigan Marinas; 1982; (MICHU-SG-82-600): University of Michigan, Ann Arbor, MI; ISSN: Michigan Sea Grant.
This list of marina names and addresses was developed as a product of the Sea Grant project: "The Perceived Influence of Fuel Price and Availability Upon Great Lakes Boating Behavior Among Urban Michigan Boaters." Marina operators were contacted to assess how energy was affecting their business and their customers. To draw a sample of marina operations to survey, this list was developed. Michigan is a land of many lakes and, of course, the Great Lakes. Water resources in Michigan offer extensive recreation and pleasure boating opportunities. Recreation delivery systems have grown in proportion to the increase in water-based activities. One of the prime industries serving the boater interested in using water resources is the marina. In Michigan there are almost 500 Great Lakes marinas and more than 500 inland marinas.

537. Great Lake Fishery Commission. Lake Michigan Committee, Annual Meeting; Sault Ste. Maire; 1989.

538. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Outdoor Recreation. Appendix 21. Ann Arbor, Michigan: Great Lakes Basin Commission; 1975.
Note: CZM.
Appendix 21, Outdoor Recreation, is part of a comprehensive planning study for the conservation, development, utilization, management, and enhancement of the water and related land resources of the Great Lakes Basin. It is a single-purpose framework plan to improve the quantity and quality of outdoor recreation opportunities within the Great

Lakes Basin. To meet foreseeable short- and long-term needs, consideration is given to the timely development and management of these resources as essential aids to the economic development and growth of the region: the preservation of resources to insure that they will be available for future use, and the well-being of all the people as the overriding determinant in such planning.

539. Holecek, D. F. A Model of Michigan Tourism. Columbus, Ohio; 1982; ISBN: MICHU-SG-82-314.
Note: System with implication for research.

540. Holecek, D. F.; Stynes, D. J.; Fridgen, J. D.; Moncreef, L. W. Michigan Tourism Symposium: Reflections and Recommendations; 1982; ISBN: MICHU-SG-82-311.

541. Holecek, Donald F.; Smiley, E. Thomas. Management Guidelines for Michigan's Great Lakes Bottomland Preserves. Ann Arbor, Michigan: University of Michigan Sea Grant Program; 1982; (MICHU-SG-82-201): 22 pp.
Although bottomland preserves, or underwater parks as they are more commonly known, are new in Michigan, several do exist in other areas of the U.S. and in other countries as well. These guidelines draw heavily from management experiences with existing park/preserves and land based facilities with similar management objectives. The guidelines begin with a description of the components of a preserve system and the interactions between its components. Individual components and interactions are then singled out and management problems likely to be associated with each are identified. Recommendations for dealing with these problems are provided in the report.

542. Jaworski, E.; Raphael, C. N. Fish, Wildlife, and Recreational Values of Michigan's Coastal Wetlands. Lansing, MI: Mich. Dept. of Nat. Res.; 1978; Phase 1 & 2. 98 pp.

543. Jaworski, Eugene; Raphael, C. Nicholas. Coastal Wetlands Value Study in Michigan. Fish, Wildlife, and Recreational Values of Michigan's Coastal Wetlands. Twin Cities, Minnesota: United States Fish and Wildlife Service, Region III; 1978: 225pp.

544. Jordan, S. W.; Talhelm, D. R. Economic Impacts of Sport Fishing in Ottawa County; 1983: Michigan State University.

545. Klancnik, Fred P. Planning Marinas for the 1990's [Marina/ Dock Age]; January/February 1990. University of Wisconsin, Madison, WI.
This paper briefly describes national and regional trends in the recreational boating industry and then focuses on the author's recent experiences in the Great Lakes area. Applicable marina planning criteria are contained in an appendix of this paper along with project descriptions.

546. Kusler, Jon A. Regulations to Reduce Conflicts Between Recreation Water Uses. Madison, Wisconsin: University of Wisconsin, Department of Natural Resources; 1970; Research Report 65.

547. Mahoney, Edward M.; Brunke, Mary; Pistis, Charles. 1985 Michigan Charter Fishing Study; March 1986; MICHU-SG-87-509; ISSN: Michigan State University, East Lansing, MI.
Note: 2 copies.
This study was designed to: 1) provide a description of Michigan's charter fishing market, 2) estimate direct expenditures associated with charter fishing trips, and 3) determine the amount captains have invested in their charter boats. This is the first comprehensive study of Michigan's charter boat market.

548. Meltz, D.; Schink, D.; Somersan, A. 1979 Survey of Wisconsin's Great Lake Marinas.; 1980: University of Wisconsin Ext. Madison, WI.
Note: 2 copies.
This report focuses on Great Lakes marina characteristics and the internal management problem areas hindering profitable operating performance. This report identifies physical, demand, and management characteristics of Wisconsin's Great Lakes marinas. Information on the current status of these facilities is inventoried and statistically summarized by region and type of facility. The Lower Lake Michigan region averages 127 slips per marina, and the highest concentration of large slips is also here where 31% of them are greater than 39 feet in length. Statewide, seasonal slip rental fees average $12.56 per foot, and occupancy rates are close to 100% at all the facilities surveyed. Generally, marinas with boat sales have more sophisticated accounting systems, more formalized marketing strategies, and employed personnel more efficiently. The survey included 12 yacht clubs and 9 public marinas. This report also identifies problem areas in the marinas that become apparent during the survey and upon review of the statistics. These problems are categorized and recommendations and comments as to their ultimate solution are given. Some of the problems that are mentioned are: 1)

the need to pay attention to changes in boating trends so that boat sizes can be monitored and adjustments (slip size) can be made, 2) pricing of slip fees must be reviewed to consider the number on waiting lists for slips, the size and type of boats for which slips are demanded, policies of competing facilities and their expansion plans. Other problems dealt with are updating waiting lists with relevant information, planning for expansion, marketing, personnel for this seasonal job, ownership, management, accounting, payment, repairs and maintenance, etc.

549. Muench, Bruce. 1979 Sport Fishing Creel Survey on the Illinois Portion of Lake Michigan: Illinois Department of Conservation, Division of Fisheries and Wildlife; 1981.
A direct contact fisherman creel census was conducted on the Illinois portion of Lake Michigan from May 15 to November 15, 1979. A total of 1,760,000 hours of fishing effort was calculated to have occurred during that period. Proximity of good quality launching areas controlled to some extent the intensity of boat fishing at different sites. Availability to the public of access to piers and breakwaters controlled to a greater extent the intensity of shore fishing. Yellow perch fishing was more important in north and south Cook County than in Lake County and was the principal species in the anglers' creel from the shore and dominated the total catch. Overall catch rate in the shore sport fishery on Lake Michigan was similar to the catch rate on inland State-owned lakes in 1979. The boat fishery, because of the general absence of yellow perch, had a much lower fish catch rate than shore fishery. Information is also provided for coho salmon, chinook, rainbow trout, and lake trout. The value of the sport fishery in our part of Lake Michigan probably exceeds $10 million annually.

550. Parish, Gary E.; Morgan, J. Michael. History, Practice and Emerging Problems of Wetlands Regulation: Reconsidering Section 404 of the Clean Water Act. Land and Water Law Review; 1982; 17(1): 43-84.

551. Pistis, Charles. Community Enhancement of a Great Lakes Charterboat Fishery in Grand Haven, Michigan in The Great Lakes Charterboat Fishing Industry--Selected Papers presented at the Great Lakes Sea Grant Network Charterboat Fishing Workshop. In: The Great Lakes Charterboat Fishing Industry (selected papers presented at the Great Lakes Sea Grant Network Charterboat Fishing Workshop); November 12-13, 1985; Spring Lake, MI.
Charterboat fisheries have an economic impact on coastal communities. Quantifying the economic importance of

recreational fisheries can result in community efforts to enhance and market the industry. Grand Haven, Michigan, developed centralized charterboat dockage to link the charterboat fleet with its downtown businesses. The facility known as Chinook Pier has become a focal point of Grand Haven's waterfront revitalization program.

552. Plass, K.; Chase, S.; Fischer, B. C.; McKinney, J.; Schwartz, E. J.; Snyder, F.; White, D. G. Profile: The Great Lakes Charter Sailing Industry; 1989; (WIS-SG-89-435): University of Wisconsin Sea Grant Institute.
Note: 2 copies.
This report presents the results of a survey conducted during the fall of 1987 by Sea Grant programs in Illinois-Indiana, Michigan, Minnesota, New York, Ohio, and Wisconsin. This report describes the status of the Great Lakes charter sailing industry in 1987 and estimates the 1987 gross income generated by the 31 participating businesses from charter sailing and charter sailing instruction. Lake Superior had the most charter sailboats, with 48 percent of the fleet. Next, in order, came Lake Michigan, Erie, Ontario, and Huron. Wisconsin had more charter sailboats than any other state, with 58% of the fleet. Next, in order, came Ohio, Michigan, New York, Illinois, Indiana, and Minnesota. The 351 sailboats were used for an estimated 12,189 charter days in 1987. This was an increase of almost 16% from 1986. The businesses that taught sailing trained 2,174 people during 1987, an increase of almost 61% over 1986. Great Lakes charter sailing and sailing instruction generated at least $2.5 million in 1987 gross income for the 31 business surveyed. This was based on an estimate of $1.95 million provided by 84% of the businesses, which accounted for 74% of the boats. The total direct and indirect regional impact was estimated at $3.25 million to $4.5 million, based on fees paid to these businesses. This does not include money spent for trip-related expenses like food and lodging.

553. Schott, Robert W. The Impact of Great Lakes Recreational Boating on the Economy of Michigan. Michigan State University; 1975.
Unpublished M.S. Thesis.

554. Somersan, Ayse; Neuman, Michael. Impacts of Recreation in the Coastal Area: Demand and Supply of Recreation in Wisconsin's Coastal Counties. Madison, Wisconsin: State of Wisconsin Coastal Zone Management Program; 1977: 94 pp.

555. Stoffle, R. W.; Rasch, D. L.; Jensen, F. V. Urban Sports Anglers and Lake Michigan Fisheries Policies. Coastal Zone Mang. J.; 1983; 10(4): 407-427.
Over the past few years an unusually intense struggle over the future of the Lake Michigan fishery has occured in the Wisconsin coastal communities of Racine and Konosha. This struggle has engaged participants on the local, state, and national levels in the debate over the fishery as it is potentially impacted by the presence of environmental toxins, the rising cost of fish stocking and management, and conflicting user group demands. We describe three cases where urban sports anglers, with the assistance of university-based social scientists, participated in state and city public policy decisions. After discussing this research and its policy implications, we propose a general public participation paradigm termed the Reciprocal Development Model. The concept that best describes our applied work is developmental change. This concept implies a deliberate and guided process that normally results in the emergence of increased societal or community capacity to create, plan, implement, and assess its own adaptive strategies. Today, public agency decision-makers operate in a radically altered social environment. Laws stemming from the ecology movement and the demand for participatory democracy have caused agencies that manage public goods, such as those that make up our coastal environments, to elicit, receive, and consider many more and often conflicting public demands. These conditions suggest that agency personnel should consider establishing more policy-specific relationships with academically-based social scientists.

556. Strang, W.A. The Use of Market Segmentaton in Planning for a Recreation-based Economy. Madison, WI: University of Wisconsin; 1971.

557. Stynes, D. J. Trends in Recreational Boating in Michigan. In: Michigan Tourism: How Can Research Help?; East Lansing, MI. MSU: Ag. Exp. Stn.; 1981; Spec. Rpt. No. 6: p. 137-141.
One in a series of three reports whose objectives are 1) provide up-to-date information on recreational boating in Michigan, 2) develop boater market segments by testing and evaluating alternative segmentation bases including demographics, equipment, boat use and storage, and reasons for boating, 3) develop and test an integrated system of planning models for estimating and forecasting boating activity and the resulting economic impacts on state and local economies.

558. Stynes, D. J.; Brothers, G. L.; Holecek, D. F.; Verbyla, D. Spending Patterns and Economic Impact of Michigan Recreational Boat Owners: Michigan Sea Grant; 1983; ISBN: Michigan Sea Grant MICHU-SG-83-210.
This paper summarizes the methods and results of an expenditure survey of Michigan boaters conducted in 1981. Michigan registered boat owners spent over one billion dollars on boating in 1981. This spending was divided between new and used boat purchases (10%), craft-related expenses (24%) and trip-related expenses (66%). The average boat owner spends $469 a year on craft-related items and about $39 per day on 33 days of boating each year. This amounts to an average of $1,787 per boat per year. The average annual spending of owners of different type of craft varies from about $1,000 for small power and sail boats to over $8,000 for power boats over 25 feet in length stored at a marina. These estimates are based upon a survey of expenditures of over 1,000 registered boat owners in 1981. The report details survey methods and reports spending patterns of different boater segments within 10 spending categories. Food (28%), equipment (21%), boat fuel (18%), and auto fuel (16%) make up the largest proportions of the boating budget. Most boating occurs close to home, but out-of-state registered boat owners spent $41.5 million in Michigan in 1981. An electronic spreadsheet program to estimate the spending impacts of alternative boating marketing and development actions is presented and then applied to two simple examples. By testing possibilities on the spreadsheet program, spending impacts of alternative development and marketing programs can be estimated. Guidelines for interpreting and applying the program are presented.

559. Stynes, D. J.; Holecek, D. F. Recreational Boating: A Synthesis of Current Information. MI: Michigan Sea Grant; 1982; ISBN: MICHU-SG-82-203.
This paper documents previous boating studies in Michigan, summarizes boating information for potential users, provides access to boating data bases, synthesizes and compares existing knowledge about GL boating, and provides direction for future research and data collection efforts. Based upon boat registration statistics, statewide boating surveys, marina inventories, and boating research in Michigan, this report summarizes information on Great Lakes recreational boating in Michigan from research and planning studies conducted prior to 1980. Information is reported in four major areas: (1) boat registration and use, (2) marina facilities, (3) economics of boating activity, and (4) boating and fuel use. Boating statistics are based upon boat

registration data, recreational boating surveys conducted between 1965 and 1977, a 1977 marina inventory, and a number of boating research studies.

560. Stynes, D. J.; Safronoff, D.; Feltus, D. Michigan Boater Market Segment; 1982; ISBN: MICHU-SG-82-502.

561. Stynes, Daniel J.; Safronoff, David. 1980 Michigan Recreational Boating Survey. East Lansing, MI: Michigan Sea Grant, Michigan State University; 1982; MICHU-SG-82-202. In 1980 the Michigan Sea Grant Program undertook a survey of registered boat owners in the state. This report documents the methods and basic results of the survey. Based upon almost 4,000 respondents it is estimated that registered boats in Michigan logged 16.9 million boat days in 1980. This is an increase of 23% over 1977 levels. About one third of all boat days took place on the Great Lakes and connecting waters, the remaining two thirds occuring on inland lakes and streams. Boaters averaged 33 days of boating in 1980 with larger boats stored at waterfront sites the most active. Fishing is the most popular boating activity, accounting for over half of all boat days and almost 60% of all Great Lakes boat days. The largest increase in boating between 1977 and 1980 was in small boat activity on the Great Lakes.

562. Talhelm, D.R. Defining Angling Supply: The Key to Recreational Fishery Resource Evaluation. East Lansing MI.: Dept. of Fisheries and Wildlife, Michigan State Univ.; 1988. Few angling demand studies accurately evaluate realistic management alternatives. Typically such studies estimate the all-or-none value of an existing site without evaluating the qualitative changes managers are concerned about and without specifying (or misspecifying) the influence of alternative sites. Angling supply is not adequately specified. Specific angling "products" can be defined by observing which sites anglers consider alike and which they consider different, using a kind of discriminant analysis. Thus, if any two sites offer the same product they are "perfect" substitutes, so anglers only go to the most convenient (least expensive) site. Angling supply differs from the supply of most products because the consumer is also the producer: the angler must transport himself to the site for the product to exist for him. The supply of each specific angling product is defined by the costs anglers must incur to fish at the least expensive location offering that product. For anglers from a specific origin the distance and "price" of each product is constant, so the supply of each product is perfectly elastic (horizontal). Here, several variations in angling success rate and fish species composition at several

locations in Michigan were evaluated, simulating various fishery management strategies.

563. Talhelm, D. R.; Jordan, S. W.; Holecek, D. F. 1986 Michigan Recreational Boating Survey. Lansing, MI: Michigan Department Natural Resources; 1988.
This paper reports the results of a survey of owners of 10, 089 of the 637,500 boats registered (licensed) in Michigan for the 1986 boating season. We asked about recreational boating activity in Michigan waters only. About half of the boaters surveyed responded. About 5% of the respondents live outside of Michigan. Boating activity in Michigan on registered boats increased by some 48% from 1980 to 1986. About 61% of the boating took place on island lakes, 28% on the Great Lakes, and 11% on inland rivers and streams. Fishing and pleasure boating were the most important activities accounting for 52% and 36% of total use. Boaters spent about $1.83 billion for boating with registered boats in 1986. About 598,000 boats with valid registrations were actually used on Michigan waters in 1986, an 18% increase over the number in 1980. Most boats under 21 feet long are relatively "trailerable", and are often kept at non-waterfront sites. About 60% were transported to launch sites at least once, compared with 39% of boats 21-26 feet long and 7% of larger boats. About 51,000 boats, 8.5% of the total, were usually kept at marinas. However, ony 40,000 of those occupied seasonal spaces at the marinas. The other 11,000 were kept in auxiliary spaces at the marinas, perhaps on trailers or on blocks, or on larger boats (eg, dinghy).

564. Talhelm, D.R.; Jordan, S.W.; Holecek, D.,F. 1986 Michigan Recreational Boating Survey: Executive Summary. Michigan State University, East Lansing, MI; November 1988.

565. Talhelm, D. R.; Jordan, S. W.; Holecek, D. F. Summary of the 1986 Potential Market for Seasonal Marina Slips For Michigan Marinas Having Access to the Great Lakes. East Lansing, MI: Department of Park and Recreation Resources, Michigan State University; 1988.
This paper summarizes by county the potential market in 1986 for seasonal marina slips in Michigan marinas having access to the Great Lakes. Our estimates are based on the results of 2 surveys. The first was a survey of owners of 10,089 of the 637,500 boats registered in Michigan in 1986, asking about recreational boating activities and preferences for the 1986 boating season. The second was a survey in 1986 and 1987 of owners of boats occupying seasonal slips at randomly selected marinas having access to the Great Lakes in Michigan's lower peninsula. The questionnaire asked mainly

about marina preferences and user costs. This report is a snapshot of marina needs in 1986. It does not consider the effects of the large amount of marina construction since then, nor the probable continued increase in use of large boats on the Great Lakes. From 1974 to 1986, the amount of Great Lakes use by large boats (21 feet or longer) grew 2.7 fold. From 1980 to 1986, it increased almost nine percent per year. In general we found "full service" marinas, "family" marinas, and "economy" marinas; and segments of the user population corresponding to each type. The total potential market of 36,000 slips is our estimate of the number of additional seasonal slips boaters would like to have occupied in 1986, beyond the 30,000 already occupied in 1986. This potential could only be fulfilled if the "right" kinds of marinas were available at just the right locations to satisfy the wide variety of boater preferences.

566. Trudeau, Thomas. The 1984 Charter Boat Sport Catch from the Illinois Waters of Lake Michigan: Illinois Department of Conservation, Division of Fisheries; 1986.
This report is a summary of the salmonid catch by charter boat anglers from the Illinois waters of Lake Michigan in 1984. The Illinois Dept. of Conservation issued permits to 218 charter operators in 1984. Four operators submitted reports but did not have a 1984 charter boat permit. In 1984 charter boat operators reported about 5,600 trips and carried nearly 28,200 anglers. Nearly 96 percent of these anglers were Illinois residents. In 1984 coho dominated the catch by number (66%), followed by chinook salmon (17%), lake trout (11%), rainbow trout (5%), and brown trout (2%). The salmonid catch for Waukegan area waters was 63 percent of the total salmonid catch. This was higher than the 1983 Waukegan catch (48%) but similar to the 1982 catch (67%). The 1984 lake trout catch was less than half of the 1983 catch, and may be a reflection of the increased 1984 coho catch as compared to that of 1983.

567. Underwood, Ray. Marketing the Charterboat Fishing Industry in Michigan. In: The Great Lakes Charterboat Fishing Industry (selected paper presented at the Great Lakes Sea Grant Network Charterboat Fishing Workshop); November 12-13, 1985; Spring Lake, MI; 1985.
This report discusses the Michigan Boating Industries Association; membership, purpose, what it offers, etc. It is addressed to the charterboat fishing industry, and points out ways to develop the market for this business. Professionalism, public awareness, legislation, trade shows, magazine advertisements, etc. are mentioned as important factors in promoting this industry.

568. Underwood, Raymond. Marketing the Charterboat Fishing Industry in Michigan in The Great Lakes Charterboat Fishing Industry--Selected papers presented at the Great Lakes Sea Grant Network Charterboat Fishing Workshop, Spring Lake, Michigan: Sea Grant; November 12-13, 1985. 47-52.
The Michigan Boating Industries Association was founded in 1958 and its sole purpose at that time was to promote the Detroit Boat and Fishing Show and to sell boats. Over the years, the Detroit Show has developed into the second largest dealer-owned, winter, public show in the United States and the association has broadened the scope of its activity to include a whole spectrum of services that will also eventually apply to the Michigan Charterboat Association.

569. Wilkinson, Paul F. Environmental Impact of Outdoor Recreation and Tourism: A Bibliography. Monticello, Illinois: Vance Publishing Co.; 1978.
90 pp.

570. Wortley, C.A. (Wisconsin University) [Sea Grant Inst.]. Docks and Marinas Bibliography: U.S. Department of Commerce National Technical Information Service (NTIS); Oct, 86. (in: Citations from the NTIS bibliographic database; Recreational Boating (Jan 70 - Sep 88); u8706).
The UW-Madison engineer--coordinator of the national Docks and Marinas Conference held each year in Madison-- has compiled a list of some 200 technical publications on the construction and operation of marina related environmental problems, hydraulic engineering, wood preservation, geotechnical and structural engineering, mechanical and electrical systems, and ice engineering.

571. Wortley, C.A. (Wisconsin University, Madison). Great Lakes small-craft harbor and structure design for ice conditions: an engineering manual [Sea Grant Inst.]. Citations from the NTIS Bibliographic Databases - Recreational Boating (Jan 79 - Sep 88): U.S. Department of Commerce, National Technical Information Service (NTIS); Oct 88. Purdue Univ. Library, ACQ Dept., Stewart Center, West Lafayette, IN 47907.
Great Lakes harbors and marinas don't get hit by hurricanes. But each winter they are subjected to the pressures of another powerful natural force, ice. Each year, winter ice on the Great Lakes causes more than $100,000 in damages -- bending iron railings, twisting docks into crazy shapes and pulling pilings out of the lake bed. This UW Sea Grant Advisory Report represents the culmination of 10 years of observations throughout the region and abroad. The first part of the report describes the properties of ice and its behavior under various conditions, and introduces and reviews

the applicable principles of ice engineering, soil mechanics and geotechnical engineering, and foundation design. The second part of the book covers preliminary design considerations -- site geology, climate, economy and the available types of small-craft harbor structures.

572. Wortley, C.A.; Frankenstein, G.E. Rebuilding Infrastructure for Pleasure Boating. Proc. Fifth Int'l. Conf. on Cold Regions Engineering.: TCEE/ASCE Univ. Minnesota; 1988.: 188-201.

Appendix 4: Socioeconomic

573. Abonmarche Group. Estimate of the Market Opportunity for Recreational Boat Slips for 9 Shoreline Regions and the State of Michigan. P.O. Box 1088, Benton Harbor, MI 49022: Abonmarche Group; Jan. 1991.
Note: NRPC.
With this study, the DNR Boating Programs Branch has decided to re-examine current market potentials (i.e. market demand present in 1990) for boat storage slips. Some conclusions of this study follow; 1) recreational boating demand remains quite strong, 2) supply of wet and dry boat storage has increased significantly, 3) geographic market areas are shrinking and have been redefined, 4) potential new supply will further impact market size and location, 5) market potential for new slips will not be fullfilled by 1995, 6) overall occupancy has declined as newer slips have been added, 7) occupancy rates differ by type of marina facility, 8) pricing has been modified as occupancy has decreased, 9) economic turmoil has disrupted boat buyer purchasing decisions, 10) environmental, financial and construction concerns limit the potential for new marina facilities.

574. Bender, Norman, K. Financial Management Application and Tax Considerations. In: The Great Lakes Charterboat Fishing Industry (Selected Papers from the Great Lakes Sea Grant Network Charterboat Fishing Workshop); November 12-13 1985; Spring Lake, MI; 1985.

575. Braden, Patricia L.; Rideout, Susan R. Consumer Investment in Shore Protection. Ann Arbor, MI: University of Michigan Sea Grant Program; 1980; (MICHU-SG-80-200): 7 pp.

576. Bradley, Earl H., Jr.; Armstrong, John M. A Description and Analysis of Coastal Zone and Shoreland Management Programs in the United States. Ann Arbor, MI: Coastal Zone Management Program, University of Michigan; 1972; (MICHU-T-72-006).

577. Commercial and Recreational Harbor Dredging Task Force. Great Lakes Commercial and Recreational Harbor Dredging: Issues and Recommendations; 1988.
Note: Mich. City.
Final Report to the Great Lakes Commission.

578. David, M.; Eheart, W.; Joeres, E.; David, E. Marketable Permits for the Control of Phosphorus Effluent into Lake Michigan. Water Resources Research; April 1980; 16(2): 263-270.
Transferable discharge permits (TDP) can be used to achieve desired abatement levels at costs that approach the minimum. The emphasis in the discussion is on the implementation of such a system, the public choice problem in its adoption, and an assurance that regardless of which polluters provide waste treatment there is a mechanism for equitable sharing in the costs of that abatement. The argument is applied to phosphorus abatement in the Wisconsin portion of the Lake Michigan basin. The level of demand and supply for TDP's among 53 waste treatment plants is simulated, and the necessary steps to create a market are outlined. Enforcement, price changes, and future adjustments in the permissible effluent loading are shown to be compatible with the marketing process proposed.

579. De Gaspari, J. Dealers of the Great Lakes. Boating Industry; 1987; July: 53-58.
The Great Lakes states have taken some economic hard knocks. Nevertheless, boating remains deeply ingrained among the region's sizeable and enthusiastic boating public. Overall, boating dealers throughout the five Great Lakes states averaged $1,452,414 in annual marine sales, including products sold and services rendered. Indiana dealers averaged $836,363. John Hatfield of Howe Marine feels that sales will continue to grow as long as the consumer interest rate stays below 10%.

580. Ditton, R. B. The Social and Economic Signifigance of Recreational Activities in the Marine Environment. Green Bay, WI: University of Wisconsin; 1972.
This paper discusses recreation in coastal zones, redefines recreation, discusses the economics of coastal zone recreation, and discusses what future use of marine environments for recreation depends on. It has been recognized that recreation use is the most rapidly growing demand on water. Demographers estimate that the U.S. population will approximately double by the year 2,000 and 175 million people will be living in the coastal zone, including the Great Lakes. The Bureau of Outdoor Recreation (BOR) found, moreover, that increases in the demand for many types of outdoor recreation far outstrips population increases. Their studies revealed that there was a 12% increase in fishing, an 18% increase in boating and a 15% increase in swimming during the half decade from 1960-65, while the population increase was estimated at only 8% during

that period. Recreation must be redefined to be viewed as an experience that is freely engaged in largely during leisure, from which an individual derives some satisfaction. In other words, recreation experiences must have a qualitative value, and aesthetics can not be ignored in planning. It has been estimated that the total recreational value of the coastal zone is about $300 million if each person participates 5 days annually. In conclusion, individuals, adjacent shoreland owners, businessmen, polluters, etc. must begin to assume implicit responsibility for the sustained yield of our coastal zones if society is to realize the full social and economic significance of recreational activities in the marine environment.

581. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Aesthetic and Cultural Resources. Appendix 22. Ann Arbor, MI: Public Information Office, Great Lakes Basin Commission; 1976.
Note: CZM.
The information and recommendations contained in this appendix are based on map inventory and evaluation of the aesthetic and cultural resources within the Basin in conjunction with a broad-scale analysis of factors that presently affect them. Recommendations have been made for proper development of planning and for further study of the most significant resources.

582. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Alternative Frameworks. Appendix 1. Ann Arbor, Michigan: Great Lakes Basin Commission; 1976.
Note: CZM.
The primary function of the Alternative Frameworks Appendix is to document the Great Lakes Basin Framework Study plan formulation process and to present the results of that process. In draft form, it also served as a basic working document for those individuals and organizations directly involved. The basic purpose of the Great Lakes Basin Framework Study is to identify geographic areas and resource categories where future demands as compared with available supplies may create problems in meeting the needs of the people of the Basin for water and related land resources.

583. Great Lakes Commission. The Economic Impacts of a Uniform Deep-Draft User Charge on Great Lakes Shipping. Worcester: Data Resources, Inc.; September 1983.

584. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Environmental Impact Statement (Final). Ann Arbor, MI: Public Information Office, Great Lakes Basin Commission; 1976.
Note: CZM.
Preparation of a Framework Study evaluating the water and related land resources of the Great Lakes Basin, in an attempt to obtain a consensus among involved States and Federal agencies on the general rate at which future development of these resources should proceed, which types of development should be encouraged or discouraged, and which geographic areas should receive special consideration for development or preservation. The Framework Study is an overview of the entire Great Lakes Basin, and will serve as a guide to programs and studies needed to consider more specific resource problems and smaller geographic areas. The Commission has developed a Proposed Framework for the Basin through the year 2020, which envisions a rate of economic growth and development slightly lower than that which would follow from a projection of past growth trends. The Environmental Imapact Statement is a conceptual study, not an authorized plan for construction. It is very general, with little description of detailed effects, but it is believed to adequately highlight the most significant impacts that can be covered in a Level A study.

585. Great Lakes Basin Commission (Great Lakes Basin Framework Study). Report. Ann Arbor, MI: Public Information Office, Great Lakes Basin Commission; 1976.
Note: CZM.
The Great Lakes Basin Framework Study was begun in 1967 to develop an information base and to prepare components for a future comprehensive, coordinated, joint plan (CCJP). This plan will guide the conservation, use, and development of water and land resources in the Great Lakes area through the year 2020. The Framework Study Report, 25 appendix volumes and an environmental impact statement present a portion of the Great Lakes Basin Commission's work toward this goal.

586. Heikoff, Joseph M. Coastal Resources Management: Institutions and Programs. Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc.; 1977: 287 pp.

587. Heikoff, Joseph M. Marine and Shoreland Resources Management. Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc.; 1980: 214 pp.

588. Kenny, David; Hoffman, Edward; Tichacek, Gregg. Urban Waterfront Renewal: The Illinois Experience. 53 West Jackson Boulevard, Chicago, IL; April 1983.
This report focuses on urban waterfront revitalization activities in Illinois with two objectives in mind: one, to develop a body of information that will encourage and assist local urban waterfront revitalization efforts and the other, to identify an appropriate role for the State in supporting these efforts.

589. Pistis, Charles. Community Enhancement of a Great Lakes Charterboat Fishery in Grand Haven, Michigan in The Great Lakes Charterboat Fishing Industry--Selected Papers presented at the Great Lakes Sea Grant Network Charterboat Fishing Workshop. In: The Great Lakes Charterboat Fishing Industry (selected papers presented at the Great Lakes Sea Grant Network Charterboat Fishing Workshop; November 12-13, 1985; Spring Lake, MI.
Charterboat fisheries have an economic impact on coastal communities. Quantifying the economic importance of recreational fisheries can result in community efforts to enhance and market the industry. Grand Haven, Michigan, developed centralized charterboat dockage to link the charterboat fleet with its downtown businesses. The facility known as Chinook Pier has become a focal point of Grand Haven's waterfront revitalization program.

590. Pratt, Diana B. Acquisition of Public Access Sites to the Great Lakes. Ann Arbor, Michigan: University of Michigan Sea Grant Program; 1979; (MICHU-SG-79-214): 57 pp.

591. Pratt, Diana B. The Legal Rights of the Public in the Foreshores of the Great Lakes. Ann Arbor, Michigan: University of Michigan Sea Grant Program; 1981; (MICHU-SG-81-209): 24pp.

592. Raphael, C. Nicholas; Jaworski, Eugene. Economic Value of Fish, Wildlife, and Recreation in Michigan's Coastal Wetlands. Coastal Zone Management Journal; 1979; 5(3): 181-194.

593. Somersan, A. Impacts of Recreation in the Coastal Zones: Economic Impact and Needs of Wisconsin's Great Lakes Boaters-1975. Madison, WI: Wisconsin Univ.-Madison; 1976; NTIS number PB-263-933. 52 p.
The major objective of the study is to identify the dependency between Great Lakes boaters and the economy of the coastal communities. The report also identifies the socioeconomic profile of the Great Lakes ramp users and marina users, and summarizes the preference and needs of boaters for facilities and service.

594. Strang W. A.; Ditton, R. B. The Lake Michigan Charter Fishing Industry: A Product of Love and Taxes. J. Great Lakes Res; July 1976; 2(1): 89-98.
Little is known about the Lake Michigan charter fishing industry. This study was conducted to describe Lake Michigan charter fishing boat operators and their customers and to evaluate the industry's financial status and local economic impact. Field work in 1973 revealed 98 charter operators working on Lake Michigan from Wisconsin ports. From a geographically proportionate sample, 44 extensive interviews were completed. The industry generated $670,000 in sales in 1973. Low average sales and profits do not provide financial incentives to entrepreneurs. Financial opportunity, however, appears to have played a minor role in the decision to enter the business. Major motivations appear to be tax advantages and life style rewards. A profile of charter customers was developed through a mail survey of a sample of 483 charter customers. Catch data were collected from operators surveyed. Catch varied with the proportion of operator income obtained from charter fishing. Port communities were affected economically by the industry. Applying a community multiplier of 2.16 to the $1.6 million of direct expenditures yields an economic impact of $3,456,000 on Wisconsin's Lake Michigan community in 1973. The industry is also important in that it provided fishermen with access to the Great Lakes lake trout and salmon fisheries. Without that access, these fisheries would be largely reserved for the wealthy.

595. Wood, W. Economic Impact of the Winthrop Harbor/Zion Marina; 1984: Waukegan, IL.

596. Wood, William L. Coastal Management Alternatives for Reducing Storm Impacts at a Coast. Journal of American Shore and Beach Preservation Association (Shore and Beach); Oct. 1990; 58(4): 72.
Note: article.
The risk posed by residency along our nations coatlines was vividly illustrated by the recent passage of Hurricane Hugo across the South Carolina Coast. Wind, water, and erosion damage caused by Hugo was in excess of 300 million dollars and unaccountable losses were estimated to approach 2 billion dollars. Evident in the aftermath of Hugo's fury is the need to evaluate present coastal management policy and to assess its effectiveness as an alternative for reducing storm related losses. The National Flood Insurance Program and the more recent "Jones/Upton Amendment" provide for a regulated program of federal insurance for homeowners at risk from flooding due to extreme high water levels and erosion. This article deals with this current legislation, objectives and concerns of coastal management approach, and data and research needs.

597. Wood, William L. Managing Coastal Erosion Through the National Flood Insurance Program. Journal of American Shore and Beach Preservation Association (Shore and Beach); 1990; 58(2): 3.
Note: article.
Population and economic pressures have transformed the lightly developed shorelines of earlier years into higher density resorts and urban complexes, e.g. Clearwater, Florida; Galveston, Texas. In response to a request from the Federal Emergency Management Agency/ Federal Insurance Administration (FEMA/FIA) in 1988, the National Research Council (NRC) established the Committee on Coastal Erosion Zone Management under the auspices of its Water Science and Technology Board and the Marine Boad. The committee was asked to provide advice on appropriate erosion management strategies, supporting data needs, and applicable methodologies to administer these strategies through the National Flood Insurance Program.

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