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Federal Water-Related Research, Development and Management Programs in the Great Lakes Region

Interagency Committee on Marine Science and Engineering
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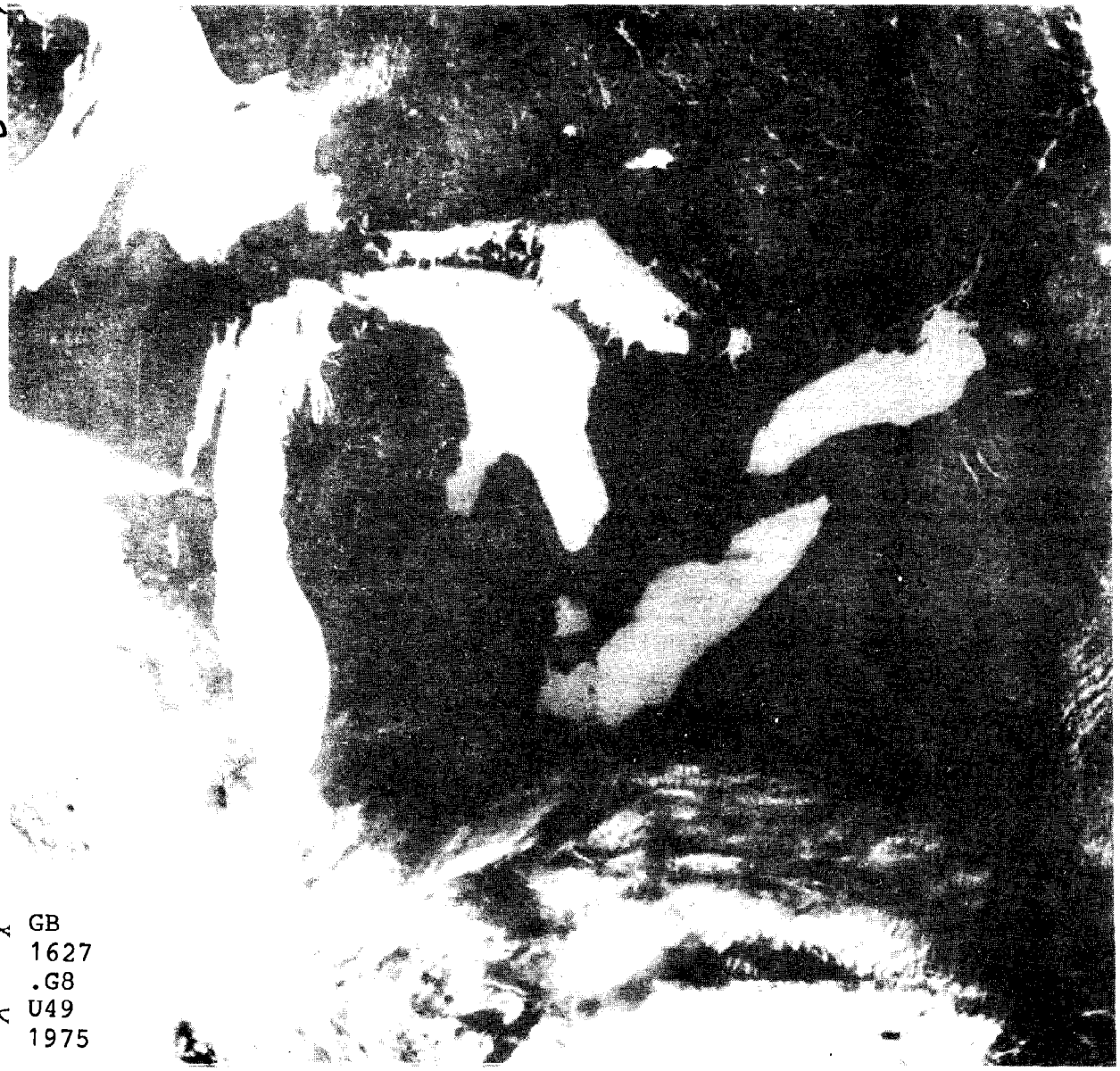

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Federal Water-Related Research, Development and Management Programs in the Great Lakes Region

U.S. DEPARTMENT OF COMMERCE NOAA
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2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

Prepared by:
Interagency Committee on Marine Science and Engineering
Federal Council for Science and Technology
In Response To The
National Ocean Policy Study
U.S. Senate

October 1975

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1. INTRODUCTION

Request from the National Ocean Policy Study

This report is in response to a request from Senator Ernest F. Hollings, Chairman of the National Ocean Policy Study, to Dr. Robert M. White, Chairman of the Interagency Committee on Marine Science and Engineering (ICMSE). The request was that ICMSE should conduct a study on the Federal programs in the Great Lakes area. Senator Hollings's letter of request and Dr. White's reply accepting the assignment on behalf of ICMSE are reproduced as Appendices 1 and 2 of this report. As Senator Hollings's letter explains:

> "Part of ocean affairs of particular interest to the National Ocean Policy Study is to understand the Federal programs being carried out in the coastal zone, in order to maximize the benefits from the Federal effort."

The "coastal zone" is the most complicated geographic region on the earth's surface, offering a great variety of opportunities for resource use, recreation, transportation, and waste disposal. These result in vigorous competition for the use of the coastal zone by various segments of the public, with many of the competitors striving for different and often diametrically opposed results. Each of these pursuits for the use of coastal zone assets has an array of supporting institutional activities to aid in its development and preservation. Increasingly in the American society the Federal Government is being asked to assume this development and preservation role.

For a variety of reasons the Great Lakes region has had a higher level of Federal assistance and activity than many other areas of the country, and this could make the task of understanding the interrelationships among the programs more difficult than usual. In another sense, however, the Great Lakes region may be one of the most manageable of the regions of the country because of its geographic unity. Again to quote Senator Hollings's letter of request:

> "The Great Lakes is one area of concern and interest; as a unique part of the coastal zone, it is faced with special problems. A number of Federal agencies are involved in research and management activities there. It would be of considerable interest to understand better the nature of the programs in the Great Lakes area, which because of its geographic nature provides a discrete region whose character may more easily be capable of understanding."

Sources of information

This report was compiled from material supplied by the Federal agencies on their activities and programs in the Great Lakes region. In addition, staff of the Interagency Committee on Marine Science and Engineering made two visits to the Great Lakes region to obtain first hand information on Federal programs under way there.

Each of the sections of this report describes a particular area of aquatic research, development and management, with the activities of the agencies summarized. The international and regional coordinating mechanisms are described in Section 8. The Appendices include tables of Federal expenditures on Great

Lakes water-related activities, summaries of the activities of the Federal agencies, the Federal facilities in the Great Lakes region, and the statutory and legislative responsibilities of the Federal agencies in respect to research, development and management.

Description of the Great Lakes

The Great Lakes constitute the largest freshwater system in the world. Their basin occupies about 780,000 sq. km., of which approximately 246,000 are lake surface; the United States part of the lakes occupies 158,000 sq. km. The total shoreline of the Great Lakes is 10,490 km., of which 5,900 km. are in the United States. Not only is the surface water area large, but some of the lakes are very deep: Lake Superior has a maximum depth of 397 m. and an average depth of 148 m. This water mass is large enough to affect the climate of the adjacent region, and to cause the lakes to take on many characteristics of the ocean. Table 1 summarizes the climatic, watershed, physical and chemical features of the lakes.

Such an immense water system in the heartland of the North American Continent has had a profound effect on human settlement, industry and activities. There are many valuable natural resources associated with the lakes, and with the land surrounding them. As a consequence, while the basin occupies 4 percent of the land area of the United States, 14.4 percent of the population of the nation live in the region (1970 figures). Population trends in each

TABLE 1 CLIMATIC, WATERSHED, PHYSICAL, AND CHEMICAL FEATURES OF THE GREAT LAKES*

Item	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
			Climatic		
Forest region[a]	GL-SL Boreal	GL-SL Deciduous	GL-SL Deciduous	Deciduous	GL-SL Deciduous
Climatic region[b]	Dfb	Dfb	Dfb, Dfa	Dfb, Dfa	Dfb
Mean July temp (C)	16-18	18-21	18-24	21-24	21-24
Precipitation (cm)	60-100	60-100	60-100	60-100	60-100
Growing season (days)	140-160	160-200	160-240	220-240	200-220
			Morphometric		
Lake area (km^2)	82,414	58,016	59,596	25,719	19,477
Depth (m)					
maximum	397	285	229	64	237
mean	148	84	60	18	80
Shoreline length (km)	3,000	2,210	2,700	1,200	1,380
Shoreline development	2.0	2.6	3.1	2.1	2.8
Drainage area (km^2)	227,376	117,741	128,490	58,530	70,655
Altitude (m)	184	177	177	174	75
			Chemical		
TDS[c]	60	118	108	133	134
TA[d]	46	113	82	95	93
pH	7.9	8.2	8.1	8.1	8.0
Secchi disc (m)	10.0	6.0	9.5	4.5	5.5
Turbidity (JTU)	0.4	1.2	0.6	1.4	1.2

[a] GL-SL -- Great Lakes-St. Lawrence Forest Region (after Rowe 1959).
[b] Dfb -- cool summer but no dry season (northern Lake Michigan, eastern Lake Erie);
Dfa -- warm summer but no dry season (southern Lake Michigan, western Lake Erie).
[c] Total dissolved solids. Earliest available data. [d] Total alkalinity. Earliest available data.

*Ryder, R.A. 1972. The Limnology and Fishes of Oligotrophic Glacial Lakes in North America (about 1800 A.D.). Journal Fish. Res., Bd. Canada 29:617-628

drainage area of the Great Lakes are shown in Figure 1 for various years, from 1810 to 1970. The 1970 population in the United States part of the basin was 29,300,000.

Eight states -- Minnesota, Wisconsin, Indiana, Michigan, New York, Ohio, Illinois, Pennsylvania -- border on the Great Lakes. Federal lands comprise 4 percent of the lakeshore, state lands 14 percent, and private lands 82 percent.

Resources of the Great Lakes

The unique system that constitutes the Great Lakes has made it one of the most valuable national assets of both the United States and Canada. With the construction of canals and lock systems beginning in the 1820's, the lakes have become extensions of the ocean. From the Atlantic Ocean to Duluth, Minnesota, ocean ships travel 3,700 km. Deep draft vessels are able to come from every part of the world to the lake ports, making some of them among the major shipping centers of the world. Communities around the lakes are thus able to take advantage of the cheap transportation that water affords, and easy, economical, internal communication has been a major factor in the rapidly developed and solidly based commerce of the region. The canal and lock systems of the Lakes carry more tonnage than the combination of the Suez and Panama Canals at their height, and this is in the nine months of the year when the area is icefree. In 1970, 100 billion ton-miles of freight were carried.

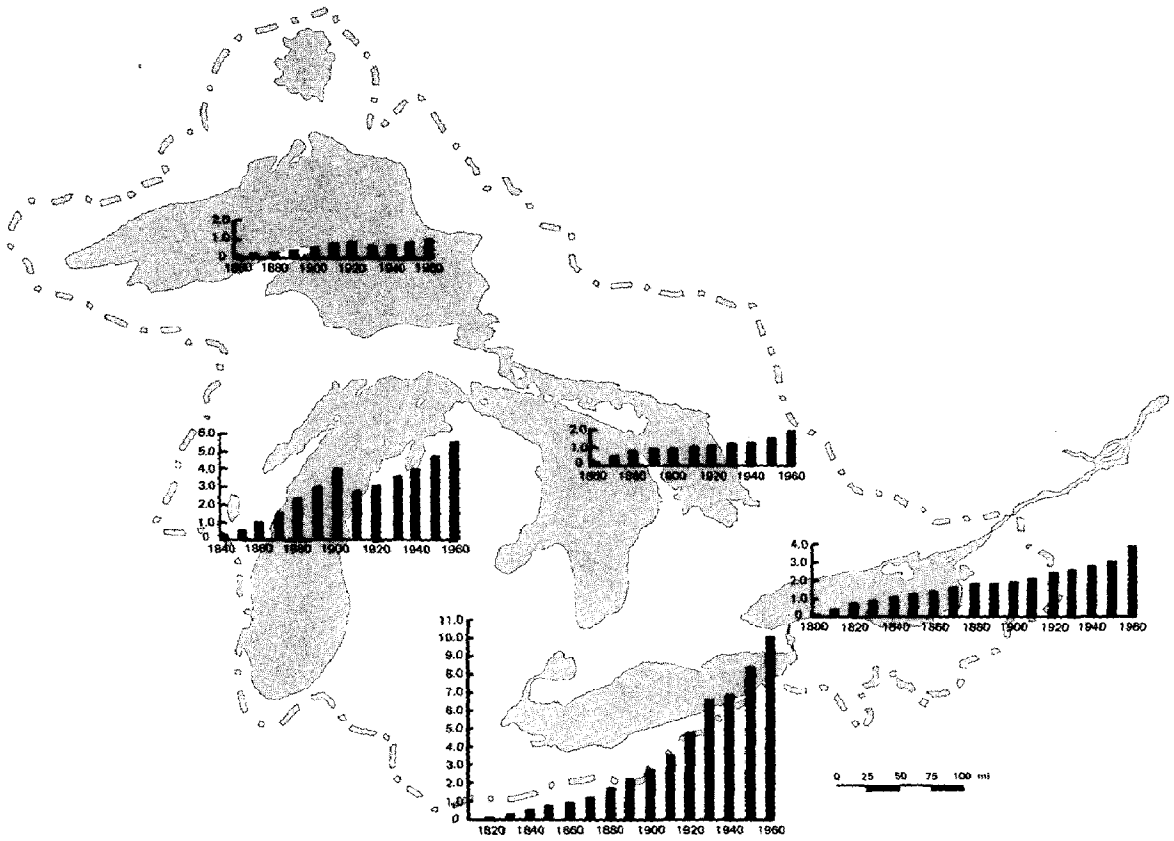

FIGURE 1: POPULATION TRENDS IN THE VARIOUS DRAINAGES OF THE GREAT LAKES

Source: Beeton, A.M., Changes in the Environment and Biota of the Great Lakes, In Eutrophication: Causes, Consequences, Correctives, pp. 150-187, National Academy of Sciences, 1969, Washington, D.C.

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The Great Lakes constitute a vast water storage resource. The deterioration of water quality, affecting as it does a multitude of activities, has been of major concern, and more public attention and effort has been focused on research and remedial action in this field than in any other.

There is a marked increase in turbidity of the water and in chemical loading, starting with Lake Superior and moving through the other lakes. Historical data show that Lake Superior has remained relatively unchanged since the first observations in the last century, while the other lakes began to change at the turn of the century (Christie 1974)*. Lakes Erie and Ontario showed the greatest rate of increase in the major ions and undissolved solids, with Lakes Huron and Michigan exhibiting intermediate values. Increases in calcium, sodium, potassium, phosphorus, chlorides and sulphates have been pronounced in Lakes Erie and Ontario, whereas only chlorides and sulphates have increased significantly in Lakes Huron and Michigan. These are taken to be major differences in the level of pollution. This is related to the rate of human population growth, which is illustrated in Figure 1. The heaviest nutrient and silt loads, from municipalities, industries and

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*Christie, W. J. 1974. Changes in fish species composition of the Great Lakes. Journal Fisheries Research Board Canada; 31(5): 827-854.

agriculture, are in the southern parts of the lakes, where population is heaviest.

Nearly all human activities in the Great Lakes region are directly affected by lake water quality. The familiar ecological irony applies here even more strongly than in many other regions: that the main characteristic that attracted people in the first place -- here the availability of abundant water of high quality -- is the attribute of the region most seriously affected by the people it drew.

Municipalities and industry draw directly on the lakes for their water supplies. At least 240 communities depend on the lakes for their domestic water, and industry takes even more water than domestic users. Recreation -- boating, swimming, and other activities -- are heavily dependent on clean and uncontaminated water, while the effect of pollution on fish and other living resources is profound. It is a measure of the poor level of our understanding of environmental degradation and its consequences that we have allowed the Great Lakes to proceed so far down the road before making effective efforts to halt and reverse the damaging trends. Lake Erie in particular has become a cause for national alarm, and very high monetary and social costs will be required to restore it to an acceptable level of water quality. It is encouraging to note that restoration is possible if

appropriate effort is applied. Recent surveys report that the water quality in Lake Erie has improved in recent years following stricter pollution control, stimulating renewed efforts in this activity.

The fisheries resources of the Great Lakes and the commercial and sport industries that depend on them have been seriously damaged. In the first half of this century valuable commercial fisheries existed in the lakes, operating mostly on lake trout, whitefish, walleye, yellow perch, smelt, chubs, blue pike, and lake herring. Three factors contributed to serious and sometimes catastrophic declines of the fish stocks, these being overfishing, the establishment of exotic species (principally the sea lamprey and the alewife), and habitat degradation. In the main bodies of the Upper Lakes, the first two of these seem to have been more damaging to the fish than the third, although pollution has had harmful effects in inshore regions of all lakes, and most pervasively in Lakes Erie and Ontario.

The severe reduction of lake trout and other large predacious fishes in the Great Lakes has been followed by marked and sometimes explosive increases in abundance of smaller species, notably alewives. It is still uncertain how the alewives got into the Great Lakes, although the evidence suggests that they entered through the Erie Canal. In any case they were first observed in Lake Ontario in 1873, later in the other lakes, and finally in

Lake Superior in 1943. They reached high population levels after the sharp reduction in abundance of the large predator species, lake trout, caused by the sea lamprey and overfishing. The alewives occupied the niche of the overfished chub herring population. There has been massive die-offs of alewives, especially in Lake Michigan and Lake Huron, resulting in large quantities of dead fish accumulating on beaches, to the detriment of tourist and other interests, and in the clogging of municipal and other water intakes.

The reduction in population of high-priced fishes caused the commercial catch to shift to others less valuable -- white bass, rainbow smelt, alewives. The proportion in the commercial catch of the high-valued species fell from 75-80 percent during the first half of the century to 33 percent in the late 1960's. The overall catch did not fall as drastically as this, but the high proportion of low-valued species caused the total value of the catch to be greatly reduced, and many enterprises failed.

The recreational fisheries of the Great Lakes have also suffered, though not to the same degree as the commercial fisheries. The introduction of salmon in Lake Michigan, for example, has created a flourishing sport fishery there.

There is hope that commercial and recreational fisheries can be restored. The sea lamprey has been partially controlled following the use of lamprey toxicants in the streams, without harming other species. The levels of the reproducing lamprey

population in Lake Michigan has thereby been reduced to 10-15 percent of peak numbers. At the same time lake trout are being planted, with some indication of natural reproduction occurring in Lake Superior. Further, catches of some other species have increased significantly.

Other recreational opportunities such as swimming and boating constitute major resources of the Great Lakes. A remarkable growth has taken place in recreational boating over the nation, including the Great Lakes area, largely as a consequence of increased leisure time and higher incomes. Nationwide recreational boating has increased by 250 percent in the period 1950-1970. Over 922,000 recreational boats are registered in the Great Lakes region, with approximately half under Michigan registry. Table 2 shows the 1968 registrations by lake, and the projections for 1980, 2000, and 2020. Table 3 indicates the kinds of recreational boating activities.

Rich mineral deposits exist in the Great Lakes region, which account for a substantial fraction of the national production of certain commodities. Nearly 70 percent of the United States iron ore originates in the Great Lakes basin, and the area yields other highly valued minerals, including lead, zinc, copper, and silver. Significant quantities of low valued industrial commodities are produced, including crushed stone, clays, sand, salt and limestone (Table 4).

TABLE 2 EXISTING BOAT REGISTRATION AND PROJECTED GROWTH BASED ON INCREASE IN POPULATION

(Thousands)

LAKE SYSTEM	1968	1980	2000	2020
Superior	61	64	70	80
Michigan	383	494	629	799
Huron	70	86	109	139
Erie	288	340	399	451
Ontario	120	137	171	215
Total Great Lakes	922	1,121	1,378	1,684

SOURCE: Great Lakes Basin Framework Study, Appendix 9, Vol. 2, Recreational Boating, Nov. 1973

Shore and nearshore areas of the lakes are preferred sites for the quarrying and excavation of industrial commodities, because of the economics of water transport. Shipment of large tonnages of northern Michigan limestone, which is used as a flux in the making of steel and constitutes the basic ingredient of the lime and cement industry, contributes significantly to traffic on the lakes. Sand and gravel, some dredged from the lake floors, are used locally and in distant metropolitan areas. Other commodities

TABLE 3 SUMMARY OF BOAT DAYS SPENT IN VARIOUS BOATING ACTIVITIES IN THE GREAT LAKES

(In percent)

ACTIVITY	FREQUENCY*
Salmon/trout fishing	19.8
Other fishing	34.3
Water skiing	11.8
Cruising	27.1
Hunting	1.9
Other	5.1
TOTAL	100.0

*Includes boats with length of 20 feet or less operating in the Great Lakes. Statistics differ for larger boats.

SOURCE: Great Lakes Basin Framework Study, Appendix 9, Vol. 2, Recreational Boating, Nov. 1973

of industrial importance include gypsum, and subsurface brines that contain a variety of chemicals.

Mineral production has had mounting impact on shoreline resources, requiring increasing amounts of land and water. By the year 2020 the areas affected by mining operations will increase 5-fold, to 2,300 sq. km., with water intake and discharge tripling

TABLE 4 GREAT LAKES REGION MINERAL PRODUCTION - 1968

COMMODITY	GREAT LAKES PRODUCTION (Short tons, except as noted)	% OF NATIONAL PRODUCTION
Clays and shale	4,139,014	7.2
Sand and gravel	128,947,000	14.1
Stone - crushed and broken	110,557,798	13.5
Lime	7,744,542	41.6
Iron ore - usable (long tons)	56,635,595	69.1
Lead*	1,396	0.4
Zinc*	66,194	12.5
Copper*	74,805	6.2
Silver* (troy ounces)	500,428	1.5
Magnesium compounds - MgO equivalent	266,406	50.7

*Recoverable contents of ores, etc.

SOURCE: Great Lakes Basin Framework Study, Appendix 5, Mineral Resources, May 1971

to 13,000 million l. per day. An important contribution of the Federal Government activity was the development in U.S. Bureau of Mines laboratories of techniques for the mining and milling of taconitic iron ores -- the "taconite process." This revitalized an industry that appeared to be dying. It has led to the

construction of new facilities, and has given incentive for building larger ships, extending the navigation season, and improving seaways. Ripple effects in the Great Lakes region may be traced through the steel to the auto and recreational industries. This development, however, has resulted in degradation of water qualities in Lake Superior.

The heavy population and industrial density around many parts of the lakes, and the complexity of many of the problems, have resulted in numerous requests for Federal assistance. These requests, and the high economic and social value of the Great Lakes and the unique and complex geographic and ecological system that they create, have stimulated considerable activity of the Federal Government, involving many Federal agencies.

2. NAVIGATION AND TRANSPORTATION

Introduction

The Great Lakes, with their connecting channels and the St. Lawrence Seaway, form a 3,700 km. waterway from the heart of the North American Continent to the Atlantic Ocean. This waterway provides the means of transporting more than 200 million tons of freight per year; the total U.S. and Canadian traffic on the Great Lakes was 237 million tons in 1970. It has been estimated that the cargo carried over the Great Lakes system generates more than $4 billion annually in direct and secondary income to the U.S. economy in the region. This is equivalent to about $18 for every ton carried, and the income is sufficient to support 500,000 families.

The amount of Great Lakes freight is expected to increase to 304, 401, and 515 million tons in 1980, 2000, and 2020, and to generate about $5.4, $7.2, and $9.2 billion per year in direct and secondary income, provided that growth is not limited by channel or lock capacities. The cost of providing the present 8.7 m. maximum draft navigation system is more than $2 billion, and the estimated cost of increasing the depth to 9.1 m. is at least $3 billion.

The severe winters experienced in the Great Lakes Basin makes icebreaking engineering and research of special relevance there. Since 1970, icebreaking and related activities have been focused in the Great Lakes-St. Lawrence Seaway Navigation Season Extension

Program, an interagency program. The objective of this program is to demonstrate the practicability of extending the navigation season. Activities include surveillance of ice conditions and ice formation, long and short range ice forecasts, collection and dissemination of ice and weather information, collection of technical data related to improved vessel design, and control of ice at locks and other critical channel areas. The program consists of two parts, a Survey Study and a Demonstration Program. The latter has already demonstrated the feasibility of extending the season in the Upper Lakes area. In the season 1974-1975, more than 7 1/2 million tons of cargo were shipped in the extended season through the month of February. The cargo shipped through the Soo Locks during the extended season increased 57 percent over the previous season. The Navigation Season Extension Program is described in more detail later in this section.

Activities related to navigation and transportation in the Great Lakes are carried out by the U.S. Army Corps of Engineers (which is the lead agency in the Navigation Season Extension Program), the Coast Guard, the Department of Commerce (NOAA's Great Lakes Environmental Research Laboratory, Office of Sea Grant, National Weather Service, National Ocean Survey, and Maritime Administration), the Environmental Protection Agency, the Department of Interior, the St. Lawrence Seaway Development Corporation and the National Aeronautics and Space Administration.

Navigation

Vessels transiting the Great Lakes are normally guided by visual and electronic aids to navigation. During the winter months the lighted buoys are withdrawn so that they will not be destroyed by ice. Many of these buoy stations are marked with unlighted buoys, but mariners are cautioned that during the ice season floating aids are subject to ice movement and may be unreliable. In addition, range markers and beacons ashore can be obscured by adverse weather. Therefore, existing navigation systems do not have the accuracy required for safe operation of large ore carriers in the confined channels and shallow drafts of the sometimes ice-clogged waterways connecting the Lakes. A precise Navigation Project has been carried out jointly by the Maritime Administration and the Coast Guard as a part of the Winter Navigation Board's program for Great Lakes season extension. The Coast Guard is conducting Loran-C research and development work as a Harbor and Harbor Entrance (HHE) radio navigation system. This will provide good Loran-C coverage over the entire region. With an all-weather position fixing capability, Great Lakes commerce could operate throughout the year under weather conditions which make visual aids to navigation relatively ineffective. As one step in this development program, the Coast Guard is planning to install and evaluate a low-power Loran-C "mini-chain" in the St. Mary's River. This project will demonstrate the feasibility of providing radio

navigation service to repeatable positioning of surface vessels in the restricted areas of the river within an accuracy range of 9 to 18 meters. In addition to the St. Mary's River Demonstration Project, the Coast Guard plans to expand the existing Loran-C system to provide general coverage for the entire Great Lakes region by February 1980; this will provide a geographical position fixing capability of 400 meters or better for this area. In order to meet the navigational requirements of confined channels and ice-clogged conditions in the Great Lakes it may be necessary to augment this general system by establishing "mini-chains" in certain areas in the Great Lakes. This is dependent upon the outcome of the St. Mary's River Demonstration Project. Other alternatives using Loran-C are also being studied.

Radar beacons for emergency position indication are being developed and tested by the Coast Guard as part of the Great Lakes Navigation Season Extension Program. Radar beacons (RACONS) are used to identify a specific radar contact where there are many targets, enhance an insufficient signal from a target, establish a radar contact where there is none, and to mark bridge spans. One RACON is permanently installed on Huron Cut LB 12 and nine are provided for temporary installation in the Great Lakes during winter months.

Radio beacons enable a vessel to determine its line position from a station by utilizing a radio direction finder. The Coast

Guard cooperates with Canada in operation of a Radio Beacon System involving 61 U.S. and 34 Canadian stations. Frequency limitations require stations to share frequencies, each station transmitting one minute out of six. A Coast Guard plan is being formulated to modernize and upgrade the Great Lakes Radio Beacon System. International coordination will be required prior to implementation of the plan.

The Coast Guard operates approximately 5,033 aids to navigation in the Great Lakes region. A support system (vessels, boats, overhaul facilities, etc.), of the Ninth Coast Guard District maintains these.

Some hydrographic research on the Lakes has direct applicability to navigation. Surface waves represent a potential physical hazard to navigation, while wind tides and seiches are important to the depth of water in navigational channels and in harbors. NOAA's Great Lakes Environmental Research Laboratory (GLERL) conducts a research project on surface waves and surface oscillations (wind tides and seiches), to develop improved climatological information on their spatial and temporal natural distribution and variability, and to develop a data archive to support the research studies and user needs.

A model study is being conducted by the Department of Transportation's St. Lawrence Seaway Development Corporation of dangerous cross currents in the Polly's Gut area of the St. Lawrence River, and of methods to minimize their effects on navigation.

Navigation and transportation requires accurate and up-to-date charts and sailing directions. The Lake Survey Center of NOAA's National Ocean Survey (NOS) conducts field operations to secure hydrographic and onshore data. Three kinds of surveys are conducted: (1) revisory surveys, which include coastal mapping and harbor entrance soundings--these provide data for publication of new editions of most charts on a triennial basis; (2) inshore surveys, which are hydrographic surveys of water from the shoreline to a depth of 11 m., made to update older surveys of these waters; and (3) field surveys for photogrammetric mapping and hydrographic support. Information is also assembled and verified from aerial photographs, the Corps of Engineers, the Coast Guard, the U.S. Power Squadron, the Coast Guard Auxiliary, other U.S. agencies, and Canadian agencies. From these activities it produces new nautical charts and updates existing charts for the Great Lakes.

NOAA's Office of Sea Grant supports two projects at the University of Wisconsin related to shoreline mapping by remote sensing: a computerized method for the rapid, accurate, and economic delineation of shorelines from aerial photography, and the development of a regional file of LANDSAT (formerly called Earth Resources Technology Satellite (ERTS)) data.

Full-detailed descriptions of the physical conditions of charted waters are contained in the Great Lakes Pilot, a 600-page annual publication produced by NOAA's National Ocean Survey. This

complements Great Lakes charts and carries significant information that cannot properly be shown on charts.

Activities related to navigation include operation and maintenance of locks, maintenance of navigation channels and aids in U.S. waters of the St. Lawrence River, and control of vessel traffic on the international section of the St. Lawrence River and Lake Ontario. These are responsibilities of the St. Lawrence Seaway Development Corporation. Efforts are underway by the Corporation to develop and implement traffic routing schemes, traffic control, joint Canadian-U.S. vessel traffic systems and speed regulations, and to improve port and waterways safety and environmental quality.

Safety programs

A crew and passenger survival and safety program is conducted by the Coast Guard under the Great Lakes season extension program for identifying the effectiveness of survival systems, developing performance specifications for group life saving systems, and testing group life saving devices. The Coast Guard's Port Safety and Security program develops regulations for unified rules of the road for inland waters, speed regulations to prevent damage to vessels, bridges, and structures, and joint U.S.-Canadian vessel traffic systems and traffic separation schemes to improve safety. Safety of life and property on recreational and merchant vessels involves the inspection and certification of vessels and equipment,

licensing and certification of vessel personnel, and investigation of marine casualties. To encourage greater State participation and consistency in boating education, boating safety, and particularly greater safety patrol and enforcement activities, the Coast Guard makes grants to the States to develop programs.

Ice

A system capable of acquiring information on the location, area, type and thickness of ice on the Great Lakes has been developed by an Ice Reconnaissance System Project, an element of the Great Lakes-St. Lawrence Seaway Extended Navigation Season Demonstration Program. This is a cooperative program initiated by NASA's Lewis Research Center, and involving the Coast Guard, NOAA, and NASA. It completed its first year in FY 1975, and will continue through FY 1976. In the initial effort, ice information was acquired by a side-looking airborne radar provided by NASA, and flown in a Coast Guard aircraft. The data were relayed from the aircraft to the ground through a radio channel on a Synchronous Meteorological Satellite, SMS/GOES-1. From the ground station the data were sent by telephone line to the Coast Guard Ice Navigation Center in Cleveland where they were converted into pictorial format and used by a National Weather Service ice forecaster to prepare a daily ice summary-annotated graphic ice chart. Both the radar image of ice cover and the graphic ice charts were then sent by marine radio facsimile to the National Weather Service (Detroit),

to the Ice Forecasting Central (Ottawa), and to a number of vessels for use by the ship captains in planning their routing. A field test of the system will be repeated during the 1975-1976 winter season. The Coast Guard is making plans to take over the system on an operational basis beginning with the 1976-1977 winter season.

The usefulness of multifrequency passive microwave imaging radiometers on high altitude aircraft and earth orbiting satellites to determine variations in lake ice thickness and to delineate various types of ice is being investigated by NASA's Goddard Space Flight Center. Analysis of data acquired over Lake St. Clair and Lake Erie shows that this technique will be useful to vessel operators during the winter season.

Investigations to determine the feasibility of using the multiwavelength visible and near-infrared remote sensors on the unmanned LANDSAT and manned SKYLAB earth orbiting satellites to provide information on ice cover on the Great Lakes have been supported by NASA. These investigations show that it is practical to monitor alterations of ice cover on a synoptic, broad area coverage. During the winter of 1974-1975 Lake Erie ice cover was imaged by the Very High Resolution Radiometer (VHRR) on the NOAA-4 satellite. Imagery will be compiled by NOAA's National Environmental Satellite Service (NESS) to illustrate ice formation, evolution, and dissipation. Tape data will be computer-manipulated to enhance ice features. Meteorological conditions in adjacent land

areas will be used to analyze ice dynamics. The NOAA satellite SMS/GOES will also be employed to study short term (hourly) dynamics when ice changes are rapid. NESS produces and distributes Great Lakes Ice Charts from photo-interpretation of satellite images from December through April each year. Applications research to improve satellite snow mapping techniques is a major part of NESS's hydrology research program. Recent advances include a method for crudely estimating snow depth from VHRR visible-spectrum data, even in wooded areas, and establishing the usefulness of thermal infrared data for snow mapping.

Icebreaking operations are conducted by the U.S. Coast Guard, and advance icebreaker concepts to be developed include a clogged channel clearing device for use through mush/slush ice. An air bubbler system has been installed by the Maritime Administration aboard the U.S. Steel Company's ore carrier LEON FRASER in an effort to improve its performance in mush ice. A layer of air bubbles is pumped up around the bow of the ship beneath the waterline to prevent ice buildup. Model tests of this system indicated a reduction of resistence of 23 percent. Full scale tests are being evaluated from technical and economic standpoints. The problems of island-to-mainland transportation, and vessel navigation at turns have received attention by the U.S. Army Corps of Engineers as part of the Extended Navigation Program. To maintain transportation between the mainland and Sugar Island, a ferry was

successfully modified to increase its ice operating capabilities. A bubbler-flusher was operated at the mainland dock to ease docking of the ferry. An air propelled boatsled was developed for Lime Island to provide island residents with suitable winter transportation. A study was undertaken to determine the feasibility of using heated water from electric power plants to reduce ice thicknesses above a navigation channel at a site in Saginaw Bay.

Climatological information on the formation, growth and decay of Great Lakes ice cover is provided by an ice research project conducted by NOAA's Great Lakes Environmental Research Laboratory. This project develops numerical models to simulate and forecast the freezeup, breakup, areal extent and thickness of the ice cover, defines the natural distribution and variability of the ice cover, and provides a lake ice advisory service. Ice information is also supplied by the National Weather Service Forecast Office in Cleveland, Ohio.

Information on ice formation and movement at the end of the normal Great Lakes navigation season, and predictions of ice breakup in the spring, are furnished to the Coast Guard and shipping interests by the National Weather Service Forecast Office in Detroit.

Weather forecasting

The National Weather Service Forecast Offices (WSFO's) in Minneapolis, Milwaukee, Chicago, Indianapolis, Detroit, Cleveland, and Buffalo provide warning and forecast services for the Great

Lakes area. Forecasts out to 48 hours are issued twice daily, and an extended outlook out to four days is issued once daily. Area or statewide warnings are issued to the public in critical weather situations, as are various specialized forecasts and warnings. This provides the main forecast service for the marine and aviation programs, as well as guidance for the agricultural and fire weather programs. Forecasts and warnings for ships and recreational boating on the Great Lakes and for lake shore warnings of high winds, water level, and waves are provided by Weather Service Forecast Offices (WSFO's) at Chicago (Lakes Michigan and Superior), Detroit (Lakes Huron and St. Clair), Cleveland (Lake Erie), and Buffalo (Lake Ontario). During the boating season other NWS offices issue forecast summaries for recreational boating for near shore (8 km. from shore) waters.

Advisories are issued by WSFO, Cleveland, for "storm surges" in Lake Erie. WSFO, Chicago, issues seiche warnings for southern Lake Michigan, and WSFO, Detroit, does the same for Saginaw Bay in Lake Huron. Observations from American and Canadian ships and local observations from Coast Guard installations and other cooperators supplement the information received from the basic weather service. The warnings and forecasts are disseminated by NOAA Weather Radio, Coast Guard and commercial radiotelephone stations, and by commercial radio and television stations. The climatological information collected by NOAA's Great Lakes Environmental Research Laboratory

provides improved prediction tools to support the National Weather Service operational service.

A UHF communication system has been installed by the Maritime Administration in cooperation with the Lakes Carriers Association. The system uses a network of shore-based antennas to relay messages between the ships and their home offices. The earlier systems were overcrowded and unreliable, and they are being phased out by the Federal Communications Commission. The UHF system will allow better operational control of the ships and it will permit a range of new services. One of these will be the transmittal of weather advisory maps via teleprinter; in return, the ships can report local weather conditions to a central control station for use by the Weather Service.

Harbors and channels

All the Federal activity in dredging in the Great Lakes is performed by the Corps of Engineers. The Corps maintains Federal navigation facilities, including maintenance on 78 channel and harbor projects. In the Great Lakes about 16.5 million cubic meters of material are removed annually to keep the harbors and waterways open. But some harbors have not been dredged for four years, and there is a dredging backlog of 11.5 million cubic meters. This is due partly to a ban on open-lake disposal of material classified as polluted by EPA. Congress authorized a diked-disposal program in 1970, to provide confined diked areas for

polluted dredged material, but not a sufficient number of these have been built to handle the volume of polluted fill. To date, 65 of the 115 Great Lakes harbors have been classified as polluted, and dredged material from these harbors will require 47 separate diked-disposal sites.

In cooperation with the States, the Corps has constructed a series of Harbors of Refuge at about 50 km. intervals to provide safe mooring for recreational craft using Great Lakes waters. These harbors are maintained by the Corps.

With the support of the Office of Sea Grant, the University of Wisconsin is reappraising the nature and function of ports in the Great Lakes region. These ports are entering a critical phase in their evolution, in which the facilities must be extensively modified and developed, new cargo handling methods incorporated, and the impact of new types of vessels assessed. The resulting information will be used to develop a program for the development and management of the Great Lakes and the St. Lawrence Seaway system.

Ships

An aspect of Federal activity in support of navigation and transportation in the Great Lakes region is improvement of ship design, construction and operation. A project has been conducted by the Maritime Administration (MARAD) to determine the structural responses of ships with different load lines and characteristics

to the sea conditions in the lakes. Instrumentation has been placed aboard three ships to establish a data base for possible modification in the rules governing ship-building and operation. MARAD also has a ship-building research program under way to lower the costs of new vessels by automating shipyards, developing new equipment, and adapting ship designs to the construction process.

To measure the resistence of ship hulls to ice conditions, tests are being conducted by the Coast Guard on the USCGC POLAR STAR to establish operational limitations and icebreaking procedures. This will provide design data for future icebreakers, including hull impact loads, bow design effectiveness, and icebreaking resistance.

MARAD works with industry on navigation and transportation projects. In order to move ships through ice fields and clogged channels, research is being conducted on improved hull forms, air bubbler devices, and improved position determination in ice fields. Model tests on different hull forms and drafts for Great Lakes ships operating in ice have been carried out at the Wartsila test basin in Finland. These tests evaluated various designs to improve the resistance characteristics of these ships, and lengthen their effective operating seasons.

A program to improve the energy efficiency of water transportation includes a Coast Guard demonstration of fuel substitution. Shale-derived fuel is used aboard a Great Lakes ore-carrier; this is conducted jointly by the Coast Guard, MARAD and the Navy under ERDA sponsorship.

Economic and social research

Economic and social research is conducted to evaluate Great Lakes navigation/transportation activities. The Corps of Engineers is the lead agency for the Economic Evaluation Work Group of the Great Lakes Navigation Season Extension Program, whose objective is to establish the cost-effectiveness and economic feasibility of extending the navigation season. Origin/destination matrices are compiled for commerce shipped on the Great Lakes during the extended navigation seasons to project the potential waterborne commerce that would result from season extension. Questionnaire surveys have been conducted with shipping companies to estimate the transportation and stockpiling savings that would result from waterborne transport capability during the winter months. These data will provide the economic benefits to be derived from various increments of navigation season extension.

The University of Michigan conducted a study for MARAD on the economic tradeoffs of extending the Lakes shipping season. Increased revenues and decreased stockpile requirements were balanced against a range of cost factors under various operating assumptions. A computer program is available to evaluate alternatives; this has been used by several ship operators for planning purposes. A market analysis of Great Lakes domestic and international waterborne trade via the St. Lawrence Seaway was recently completed by MARAD, and an investigation is being conducted by MARAD on the sociological

impact of the extended navigation season on vessel crews, lock operators, and terminal operators.

Coordination

The Great Lakes-St. Lawrence Seaway Navigation Season Extension Demonstration Program is a major cooperative effort among Federal agencies. Its purpose is to test the practicability of an extended season on the Great Lakes. Shipping in the Lakes has been suspended in past years from about mid-December until early April because of ice and weather conditions. Substantial economic losses have resulted, since expensive stockpiling of materials has been necessary to carry industry through the winter, or other modes of transportation have had to be employed. The 1965 River and Harbor Act (P.L. 89-298) authorized an investigation of the feasibility of extending the navigation season. A study by the U.S. Army Corps of Engineers concluded that the present technology was sufficiently advanced to make winter operations in the Great Lakes and St. Lawrence Seaway System physically feasible, but did not establish the economic feasibility of such operations.

This action was followed by the River and Harbor Act of 1970 (P.L. 91-611), establishing the Demonstration Program. This is under the leadership of the Army Corps of Engineers; the other agencies involved are the Coast Guard, the St. Lawrence Seaway Development Corporation, the Maritime Administration, the National Oceanic and Atmospheric Administration, Environmental Protection Agency, the

Department of Interior, Great Lakes Commission, and Great Lakes Basin Commission. The National Aeronautics and Space Administration and the Energy Research and Development Administration serve as technical advisors.

The study was conducted using two basic concepts: multi-objective planning, and investigations of alternatives. Four alternatives were evaluated: navigation extension to the end of January, to the end of February, year-round, and no action. These were evaluated on the basis of engineering practicability and economic justification, with environmental, social, and other related considerations.

The investigations under way or completed are (1) a survey study to determine the feasibility of methods for extending the navigation season on the Great Lakes-St. Lawrence Seaway System; and (2) a program to demonstrate the practicability of extending the navigation season. The third year of the program was completed, and legislation authorized a 2-1/2 year extension of the program to December 1976. An insurance study was conducted to determine ways to provide reasonable insurance rates to shippers and vessels operating during the extended navigation season.

Work groups were formed for execution of each of seven elements of the Demonstration Program, with one of the participating Federal agencies responsible as lead agency. Each lead agency carries out its program activities with its own forces, with support from other

Government agencies, or by contract. The work groups and lead agencies are as follows: Ice Information, National Oceanic and Atmospheric Administration; Ice Navigation, U.S. Coast Guard; Ice Engineering, U.S. Army Cold Regions Research and Engineering Laboratory; Ice Control, St. Lawrence Seaway Development Corporation; Ice Management in Channels, Locks and Harbors, Corps of Engineers; Economic Evaluation, Corps of Engineers; Environmental Evaluation, Environmental Protection Agency. Within the Ice Navigation Work Group, Human Factors Subgroups were established for Coast Guard, industry and labor. The membership of the Environmental Evaluation Work Group includes representatives of the eight Great Lakes States.

A Working Committee, composed of the representatives of seven Work Groups, along with regional, advisory and observer groups, provides coordination of program activities.

The Working Committee makes recommendations to the Winter Navigation Board as a result of Work Group activity, and implements Board directives through the Work Groups. The Committee coordinates and develops priorities for Work Group activities, proposes distribution of funds, and provides for the input of opinions from advisory groups. Work Group studies are cited in later sections of this report on specific environmental impacts and operational considerations, such as effects on recreation and on fisheries resources.

The Winter Navigation Board is composed of senior representatives of the agencies involved in the program. It is responsible for setting overall policy and for evaluation of the results.

The Great Lakes-St. Lawrence Seaway Navigation Season Extension Demonstration Program has been a particularly effective coordinating process because of the financial resources available for distribution to the participating agencies by the Board.

3. RESOURCE MANAGEMENT AND DEVELOPMENT

LIVING RESOURCES

Fish and wildlife resources of the Great Lakes are valuable national assets, providing high-protein food, recreation to millions of people, and significant income, particularly through fishing and hunting.

The status of the fish stocks in the Great Lakes is one of the primary concerns of the region. Populations of formerly abundant and valuable fishes have been significantly reduced by the depredaations of the sea lamprey, by overfishing and by pollution. There have been severe fluctuations and serious declines in certain fish populations. Lake Erie walleyes, which are caught by both commercial and sport fishermen, are at a low level. The yellow perch population, which is the bread-and-butter fish in Lake Erie, is declining rapidly. The longjaw cisco (a whitefish) and the famous blue pike may be extinct and are on the "endangered species" list; several others are classified as "threatened," by the Fish and Wildlife Service. But populations of low-value species such as alewives and smelt have increased. In 1967, the loss to beach resort owners and other tourist trade from the massive mortality of alewives, which piled up on Michigan beaches, was estimated at $50 million.

Many of these problems are still unsolved or only partially solved. Nonetheless, fish stocking programs for Pacific salmon

and other species, considerable success in controlling the lamprey, and improvements of water quality in many parts of the lakes (discussed in Section 7) are making it possible for Great Lakes fish stocks to be restored.

The Federal agencies most involved in living resources research, development and management are the Department of Interior (Fish and Wildlife Service) and the Department of Commerce (NOAA's National Marine Fisheries Service, Great Lakes Environmental Research Laboratory, and Office of Sea Grant). The Fish and Wildlife Service has the Federal responsibility for Great Lakes recreational fisheries and, by administrative agreement with the National Marine Fisheries Service, for Great Lakes commercial fisheries research. Federal commercial fisheries activities are administered by the Northeast Regional Office in Gloucester, Massachusetts, through a liaison office in Ann Arbor, Michigan. The Corps of Engineers cooperates with the Fish and Wildlife Service in studies of the effects of dredging and other Corps activities on fish and wildlife.

Fisheries research

In the Great Lakes the Federal Government conducts research on fish stocks, protects fish and wildlife habitat, assists the States in fishery management and participates in the Great Lakes Fishery Commission (See Section 8) on international fishery management.

Research by the Fish and Wildlife Service (FWS) of the Depart-

ment of Interior is carried out at eight laboratories and biological stations centered at the Great Lakes Fishery Laboratory in Ann Arbor, Michigan. The objective of FWS activities is to provide a scientific basis for the fishery management programs of individual States and of the Great Lakes Fishery Commission. The program includes the assessment of fish stocks in the five lakes, measurements of productivity, studies of fish physiology, life histories, spawning ground and nursery surveys, methods of controlling sea lampreys, fish diseases, fish culture, and acquisition of commercial and sport fishing data. The FWS also has programs on the determination of the presence and effects of pollutants as they relate to fish abundance. These activities are coordinated with those of EPA and other agencies involved in environmental control, and provide baseline data for evaluating the environmental impact of water and land-use projects.

The Great Lakes Fishery Laboratory participated in the International Field Year for the Great Lakes (IFYGL) (See Section 4) on Lake Ontario by conducting an intensive fish population assessment. This was a cooperative effort with the State of New York and the Province of Ontario to provide estimates of the size of fish populations, notably smelt and alewives, both of which are forage species for the salmon and trout being introduced into the Lakes. Research includes physiological requirements of fishes of the Great Lakes, and environmental factors affecting them.

Measurement of temperature effects on the rate of development and survival of eggs and fry, observations of the attraction and avoidance of various temperatures by fishes, and the interaction of the influences of temperature and toxic contaminants, are among the topics studied.

The Fish and Wildlife Service provides a center for operation of the Great Lakes Fish Disease Committee, whose objectives are to prevent the introduction of diseases, control existing diseases, and eradicate diseases at State and Federal fish culture facilities. The Service provides coordination of fish disease control, diagnostic services, and technical assistance to fish hatchery operators in the control of diseases.

NOAA's National Marine Fisheries Service (NMFS) has an office in Ann Arbor, carrying out liaison activities among the commercial and sport fisheries, the Federal and State agencies, the Great Lakes Fishery Commission, and the Great Lakes Commission (an inter-State organization). Part of the responsibility of NOAA's National Marine Fisheries Service in the Great Lakes includes the compilation and publication of commercial fisheries statistics. These data, as well as others collected by the Fish and Wildlife Service, the States and other agencies in the course of research programs, are maintained by the FWS Great Lakes Fishery Laboratory at Ann Arbor in a fisheries data bank. These include commercial and sport fish catch and effort data, fish population data, and fish environmental information.

The National Marine Fisheries Service operates four financial programs to assist the fishing industry: Capital Construction Fund, Fisheries Loan Fund, Fisherman's Guaranty Fund Program, and the Fishing Vessel Obligation Guarantee Program. NMFS also administers grant-in-aid programs to the States under the Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309) and the Anadromous Fish Act of 1965 (P.L. 89-304). P.L. 88-309 authorizes the Secretary of Commerce to make grants to the States to assist them in carrying out research and development of the commercial fisheries. P.L. 89-304 authorizes the Secretary of Commerce to enter into cooperative agreements with States and other non-Federal interests for the conservation, development, and enhancement of the anadromous fishery resources of the Nation, the fish in the Great Lakes that ascend streams to spawn, and for the control of the sea lamprey in the Great Lakes. The program is administered at the Federal level jointly by NOAA's National Marine Fisheries Service and the U.S. Fish and Wildlife Service of the Department of Interior. The activities by the States on Great Lakes fisheries supported by these funds include a study to assess the yellow perch population in the Indiana waters of Lake Michigan, studies by the State of Michigan to assess the lake trout population in Lake Michigan related to sea lamprey control, an examination of the parasites and diseases of lake trout and other

commercial fish in Minnesota waters of Lake Superior, a study by the State of Ohio on the utilization of Lake Erie stocks of freshwater drum, and a State of Pennsylvania study of the commercial fish populations in the eastern basin of Lake Erie.

Additional Federal aid to the States is provided by the sport fishery restoration program funded under the Dingell-Johnson Sport Fish Restoration Act, administered by Interior's Fish and Wildlife Service.

The Office of Sea Grant supports university and State activities in fisheries research. With Sea Grant support, and in collaboration with the Wisconsin Department of Natural Resources, the University of Wisconsin is conducting a series of census experiments with coho salmon along the Wisconsin shore of Lake Michigan. These studies are designed to reveal whether salmon can be brought back to a particular spawning stream by exposing them to a distinctive odor in the water of that stream. Another research effort is to measure the economic value of Lake Michigan sport fisheries. Sea Grant-supported fisheries research at the University of Wisconsin includes the assessment of fish population in Lake Michigan to document the numbers and relative populations of various fish species, the adaptation of models to provide a predictive capability for commercially important populations, the application of a fish growth model to provide an understanding of predator-prey relationships, development of a depth-temperature-location telemetry system to assist in

research on fish behavior, the Lake Michigan forage fishery and food web, growth rates and energy requirements, environmental requirements of fish larvae, and factors influencing natural reproduction.

Several of the research projects underway at NOAA's Great Lakes Environmental Research Laboratory (described in Section 4) provide environmental information of importance to management and development of living resources. These include aquatic ecology models, planktonic succession and the natural distribution and variability of lake properties. The emphasis of this work is on the understanding and prediction of the water chemistry and lower trophic levels of the food chain, although the aquatic ecology simulation models span all the trophic levels. A GLERL project on water circulation, transport and diffusion, also described in Section 4, is fundamental to aquatic ecology modeling, and contributes to living resource management and development.

Hatching and stocking of fish

A major fisheries program in the Great Lakes is hatching and stocking of desirable species. Fish stocking programs have established large populations of lake trout, and chinook and coho salmon, especially in Lake Michigan.

Most of the lake trout stocked in U.S. waters are provided from eight Fish and Wildlife Service hatcheries. State fish hatcheries, some of which are partially federally funded, also supply fish, notably coho and chinook salmon. Stock-

ing programs in the Upper Lakes have resulted in spectacular salmon and trout fishing. There is good evidence of natural reproduction of lake trout in Lake Superior, but it is too early to determine stocking success in Lake Ontario. It is not yet certain whether walleye stocking in Lake Erie has been successful, but so far there has been no evidence of major improvement in the fishery.

Other fish stocking activities include a study being conducted by the State University of New York under sponsorship of NOAA's Office of Sea Grant on the economic impact of a salmonid introduction program on New York (Lake Ontario) fishermen. Interior's Bureau of Indian Affairs (BIA) supports fisheries programs of the tribes bordering the lakes, partly through cooperative efforts with the Fish and Wildlife Service and other Federal and State organizations. BIA supports studies of the development of a chinook salmon recreational facility and conservation program at the Grand Portage and Red Cliff Indian Reservations.

Sea lamprey control

Sea lampreys invaded the Upper Lakes during the 1930's and 1940's. Prior to the appearance of lampreys the annual commercial catch of lake trout was about 15 million pounds. By 1971, the catch was reduced to 0.3 million pounds, and today there is little or no U.S. commercial fishery for lake trout. In 1946, Congress directed the Fish and Wildlife Service to develop measures to control the sea lamprey. Since the control of lampreys is an inter-

national problem, the Great Lakes Fishery Commission, established by a Convention between Canada and the United States, was given a major responsibility for the activity. The object is to reduce lamprey populations to a level where their predation is not a limiting factor in restoring the productivity of salmonid and other fishes.

Acting as U.S. agent for the Great Lakes Fishery Commission, the Fish and Wildlife Service conducts stream surveys, destroys larval lampreys in streams and bays and evaluates the success of the program. Tributaries of Lakes Superior, Michigan, Huron, and Ontario are treated periodically with chemical lampricides. A substantial degree of control has been achieved in the Upper Lakes, and the program is keeping the lamprey there to about 10-15 percent of their abundance before control measures took effect. The control program in Lake Ontario is more recent, beginning in 1971. Lampreys are not abundant in Lake Erie, and it is not yet certain whether it is necessary to extend control to this lake.

The lamprey control program has resulted in an increased abundance of lake trout and whitefish. Together with the Pacific salmon and steelhead, which were deliberately introduced into the lakes, these species are the basis for expanding fisheries in Lakes Superior and Michigan. Before the ravages of the sea lamprey the lake trout had helped maintain a population balance among the fishes of the upper Great Lakes and had played a stablizing role in supporting the commercial fisheries. The re-establishment of the lake

trout is considered to be of prime importance.

The abundance of lampreys now is about the same as it was when the destruction of lake trout populations began. Continuous control must be exercised or the lampreys will increase again to destructive levels. This is made more difficult by a scarcity and high price for the chemical used to kill the larvae.

The Great Lakes Fishery Commission is sponsoring research to provide the information required by the Environmental Protection Agency for the registration of lampricides used in the aquatic environment. This will provide EPA with the data necessary for establishing residue tolerance limits of lampricides in water, fish, and foodstuffs.

Protection of fish and wildlife environment

There is a close relationship between fish and wildlife populations and their habitat. The water quality of the Lakes has deteriorated to a greater or lesser degree in different areas. Logging allowed the streams to warm, and pollution and dams destroyed spawning grounds or prevented fish from reaching them. Major ecological changes are continuing. Nutrient loading, toxic contaminants, waste heat discharges, dredging, changing water levels, and some of the activities associated with the extension of the navigation season adversely affect fish and wildlife. The extensive environmental protection programs conducted in the Great Lakes are described in Section 7. Some of the environmental research relating closely to fish and wildlife is summarized here.

The lakes contain enormous supplies of cold water which are excellent for industrial use and cooling purposes. Consequently, thermal pollution is a threat to the aquatic animals and plants which require a cold-water habitat. Waste heat from logging, dams and power generating plants, and the siting of such plants, have serious implications for fish and other aquatic life. Cooperative studies are underway to evaluate the environmental effects of the use of waste heat to reduce the ice cover in the shipping channel off the mouth of the Saginaw River as part of the Extended Navigation Season Demonstration Project.

The Great Lakes have been misused as waste sinks, and as a consequence they are contaminated with chemicals, including pesticides, heavy metals, and polychlorinated biphenyls (PCB's). There are some limited areas in the Lakes where fish contents of mercury exceed the levels established by the Food and Drug Administration for interstate commerce. This has resulted in prohibition against the sale of some fish, and sharp curtailment of sport and commercial fisheries. Similarly, high PCB and DDT levels in fish have been responsible for closure of the chub fishery in Lake Michigan and the catfish fishery in Saginaw Bay. Research by the Fish and Wildlife Service is concerned with the effects of mercury, PCB's and pesticides on fish growth, reproduction, and mortality. Research is primarily concerned with (1) evaluation of the effect pesticides have on fish and wildlife, and (2)

collection of information required for registration of specific chemicals. Chemicals being studied include TFM (3-trifluromethyl-4-nitrophenol) with Bayer 73 (2'5-dichloro-4'-nitrosalicylanilide) (a lamprey larvicide) and antimycin (a fish toxicant.) Hazards of pesticides to non-target species are being evaluated, based on field investigations and laboratory experimentation. The Fish Control Laboratory at LaCrosse, Wisconsin, carried out research on registration of chemicals for fishery management, and evaluation of the hazards of pesticides to the fish and aquatic environment. The Great Lakes Fishery Laboratory at Ann Arbor, Michigan, is investigating the level of pesticides in Great Lakes fish and evaluating pesticidal effects on fish.

The overenrichment of the Great Lakes from municipal, industrial, and agricultural wastes, particularly in Lake Erie, is well known. The mining waste problem in Lake Superior from taconite processing has been highly publicized. Because of concern about the possible deleterious effects of channel dredging on aquatic life, Fish and Wildlife Service biologists, in cooperation with the Corps of Engineers, are studying the bottom fauna of the St. Mary's River following blasting and dredging. The Fish and Wildlife Service is conducting a continuing study on western Lake Erie to determine the nature of the aquatic habitat and measures required to preserve it.

Endangered species

Two species of fish are presently classified as "endangered" in the Great Lakes area: the longjaw cisco, Coregonus alpenae found in Lakes Michigan, Huron and Erie, and the blue pike, Stizostedion vitreum glaucum from Lakes Erie and Ontario. Although no official listing has been released, the following species are classified by the Fish and Wildlife Service as "threatened": lake sturgeon, Acipenser fulvescens, deepwater cisco, Coregonus johannae blackfin cisco, Coregonus n. nigripinnis. Research on the longjaw cisco is being conducted by the laboratory at Ann Arbor, Michigan. The blue pike program is conducted by personnel from the Minneapolis Regional Office.

Wildlife

A wildlife refuge system involving approximately 56,000 hectares exists in the Great Lakes basin. Its purpose is to provide a network of land and water where recreational benefits associated with waterfowl and other forms of aquatic wildlife are preserved and managed. Activities in the refuges include hunting, bird watching, management of wildlife, and nature appreciation.

Wildlife research is conducted in the Great Lakes region by Cooperative Wildlife Units at several universities, funded by the Fish and Wildlife Service. The Ohio Wildlife Unit at Ohio State University has two projects: environmental pollutants in relation

to Lake Erie herons and egrets, and Winous Point waterfowl studies. The Wisconsin Wildlife Unit at the University of Wisconsin is conducting research on polychlorinated biphenyls and other environmental contaminants in Wisconsin wildlife.

Regulation and law enforcement

The Great Lakes States have jurisdiction over the fish and wildlife within their borders. Exceptions are the Federal responsibilities for migratory waterfowl, and the Great Lakes Fishery Commission's responsibilities for sea lamprey control, where interstate and international action is needed. Continuity of protection measures must be provided for migratory animals throughout their ranges; crossborder authority must exist to control shipments of diseased, illegal, or illegally taken fish and wildlife; rare and endangered species must be protected.

The courts have recently recognized fishing rights in Lake Superior as retained Indian rights. As a result, the rights are now being controlled by tribal ordinances which are exempt from State controls.

Coordination

Eight Great Lakes States, the Federal Government of Canada, the Province of Ontario, several national and international commissions, and several U.S. Federal agencies have programs relating to fish and wildlife in the Great Lakes. The Great Lakes Fishery Commission is the primary agency through which coordination of

fisheries matters is carried out. The Commission headquarters is at the Fish and Wildlife Service Great Lakes Fishery Laboratory in Ann Arbor, Michigan.

The success of the sea lamprey control program and of the introduction of Pacific salmon have led to a recovery of Great Lakes fish stocks, with the result that the coordination of fishery research and management is now more complex. Accordingly, the Great Lakes Fishery Commission has been devoting more time to the development of management tools -- assessment of stocks, cooperative regulation planning by fisheries agencies, control of exploitation, and maintenance of an environment of the highest possible quality.

Fisheries in the U.S. portions of the Great Lakes are regulated by the State conservation agencies. The Fish and Wildlife Service provides research data essential to scientific fishery management. Coordination of management activities is carried out mostly through the Lake Committees of the Great Lakes Fishery Commission. Each Lake Committee of the Commission has representation of Federal and State agencies as well as sport and commercial fishermen and the public at large. In addition, the Commission arranges meetings with various citizen groups.

Coordination of fishery research on the lakes, including that by the universities, is provided by the Scientific Advisory Committee of the Great Lakes Fishery Commission. Coordination with the Canadians is mostly through the appropriate committees of the Commission.

U.S. funding to the Great Lakes Fishery Commission, which in turn funds the sea lamprey control and part of the fisheries research program, is provided by the Department of State.

The Great Lakes responsibilities of the National Marine Fisheries Service consists of providing liaison between its technological and other units and other Federal agencies and the sport and commercial fisheries; providing Federal aid to the States for commercial fisheries research and development; providing some financial assistance to industry; and publication of production statistics. The kind of services provided by the liaison activity include development of product technology, inspection and grading, and economic and marketing research.

Coordination is maintained between the Fish and Wildlife Service and the National Marine Fisheries Service and the States at the Washington, D. C., regional, and field levels. Through the Commercial Fisheries Research and Development Act and the Anadromous Fish Conservation Act close coordination is maintained with the States by the National Marine Fisheries Service in research and development of Great Lakes commercial fisheries.

MINERAL RESOURCES

Since discovery of copper on the Michigan Peninsula during the 1840's and iron ore at various places near Lake Superior in the 1850's, minerals have had a leading role in development of the Great Lakes region and continue to be among its most important assets.

The association of resources for the production of steel (iron ore, coal and limestone), linked as they are by the lakes themselves, has been particularly important, supporting growth of the great industrial complex that lies along the shores of the lakes. In turn, growth of the complex has created heavy demands on land and water use and on other resources, including recreational opportunities for the labor force.

The Great Lakes States have regulatory responsibilities for most mineral and mining activities on lands within their borders, including those beneath U.S. waters of the lakes. As a result, much of the Federal effort devoted to mineral resources development and management is conducted through cooperative programs with State agencies. Principal Federal responsibility for these cooperative programs and for direct effort devoted to Federal lands of the region rests with the Department of the Interior (Geological Survey, Bureau of Land Management, Bureau of Mines and the Mining Enforcement and Safety Administration). The Corps of Engineers and the Department of Commerce's Office of Sea Grant support a limited number of projects that relate to resource exploration and development.

Geological and mineral resource assessments

Maps are prepared of the geology and associated energy and mineral resource potentials of the Great Lakes by the Department of the Interior's U.S. Geological Survey (USGS), mostly in cooperation with resource agencies of the bordering states. Current studies stress application of new concepts and techniques to fill gaps in

geologic knowledge of the region, to improve assessments of the resource potentials, and to gain a better understanding of the environmental aspects of the geologic conditions and processes.

Modern geologic map coverage of the Great Lakes region is spotty. However, in areas where maps have particular value in assessing mineral potentials of importance, such as those of the iron and copper ranges of the Lake Superior region, the coverage is nearly complete. Current USGS-State efforts are confined to filling gaps in the coverage for an inland area to the north of the lake, and for the Marquette Range of the northern Michigan Peninsula. During 1974, USGS published a special "Geologic Map of the Isle Royale National Park, Keweenaw County," which provides a substantial addition to maps of the region.

Current USGS efforts focus on regional investigations of selected aspects of the geologic environment that will permit better definition of resource potentials, and guide exploration for mineral deposits beneath the lakes and glacial deposits that form much of the surface of adjacent lands. During 1974, a joint USGS-Michigan program culminated with publication of an aeromagnetic map of the State and adjacent Lakes Superior, Michigan and Huron. The map integrates results of detailed aeromagnetic mapping of the mineral belt of the Michigan Peninsula with data collected by Michigan State University and others. In a joint effort with the State of New York, detailed aeromagnetic mapping

of the State's western counties and adjacent lake areas continues. Supporting studies on magnetic properties of rocks and ores that give rise to anomalies on the maps include laboratory examination of oriented samples from sites in Minnesota, Wisconsin, Michigan and elsewhere in the Great Lakes region.

In a cooperative project with the State of Michigan, USGS undertook a geochemical prospecting program during 1972 to test application of this technique to the search for and assessment of subsurface and sublake mineral resources in the intensely glaciated eastern portion of the northern Michigan Peninsula. Lacking early indications of significant results, the effort was terminated in 1974. A comparable program is now being planned for areas adjacent to the Wisconsin and Michigan shores of Lake Superior, where the promise of obtaining meaningful data is greater. A reconnaissance geochemical survey of gold in sedimentary rocks of the Great Lakes region was the subject of a special report issued near the close of 1973.

Mineral resource inventories for the Great Lakes and adjacent lands are monitored and continually updated by USGS through surveillance of scientific and commodity literature, contacts with State and industrial groups, and participation in field conferences. To support this effort, USGS maintains a Computerized Resources Information Bank (CRIB) to which data are added as obtained. State geological organizations are encouraged to join the USGS in this activity, and it is anticipated that State and Federal agencies will contribute

to this common resource bank from which each can draw as needed. A pilot study with the Minnesota Geological Survey began in 1974.

The USGS mapping and commodity assessments furnish guidelines and targets of use to the mining industry and others in the search for ore deposits both onshore and beneath the lakes.

Two mineral resource management and development projects are being conducted in the Lake Superior region by the University of Wisconsin with Sea Grant (Department of Commerce) support. In the first, a handbook is being developed to provide guidelines for conducting premining surveys. The second project involves the utilization of geophysical indirect sensing methods in conjunction with known chemical and geological information, to define general parameters associated with ore occurrence. This is to evaluate the prospects of offshore ore deposits in the Keweenaw Peninsula region of Lake Superior.

Minerals management on Federal lands

Responsibilities for issuing prospecting permits, leasing mineral rights, and managing mineral development on lands under jurisdiction of the Federal Government are shared by the Department of the Interior's Bureau of Land Management (BLM) and U.S. Geological Survey (USGS). The lands include those of the National Forest, Park and Wildlife Refuge Systems, Indian Reservations, and scattered properties acquired through early homesteading acts, forfeitures of Federal mortgages, and land trades. At some places the property

rights are "severed," with subsurface lands being owned by the Federal Government and surfaces belonging to the States, local governments or private interests.

In support of its responsibilities for issuing prospecting permits and mineral leases, and for use in general planning, BLM is compiling resource and ownership inventories for the Federal lands, including those associated with State, local government and private surfaces. The resources inventory incorporates information on wildlife, recreation, wilderness, cultural, historic and aesthetic values, as well as on mineral, water and other resource potentials. Field studies for this inventory have recently been completed in Minnesota and are now underway in Wisconsin. The complementary ownership inventory is being conducted in Minnesota, and will be extended to include Wisconsin and Michigan during FY '76.

USGS has responsibility for assisting BLM in aspects of the permitting and leasing process that involve assessment of mineral resource values, and for supervising mineral exploration and development that result from permits and leases issued. Current activities are confined almost entirely to subsurface petroleum in central Michigan, low-grade copper-nickel deposits in the Superior National Forest of northeastern Minnesota, and to prospecting in the Nicolet National Forest of northern Wisconsin. The International Nickel Company has proposed development of a large open pit mine on its lease within the Superior National Forest, and is preparing an environmental

assessment that includes consideration of potential impacts on the Great Lakes. The assessment is being conducted under general supervision of the U.S. Forest Service, with support of USGS and others.

Direct exploration for mineral resources by Federal agencies is confined to that of the Coastal Engineering Research Center of the Corps of Engineers, which has undertaken investigations to locate sources of sand beneath Lakes Michigan, Erie and Ontario for use in civil works projects. Field surveys along the eastern shore of Lake Michigan were initiated during early 1975.

Through an agreement with the U.S. Geological Survey and the U.S. Bureau of Mines, Interior's Bureau of Indian Affairs supports an information search and summary of mineral resources on Indian lands. Reports include information on the geology, mineral resources (energy, metals and non-metals), production data, and the potential for economic development of identified resources. The FY'75 program included the Grand Portage Reservation on the north shore of Lake Superior and the Fond du Lac Reservation southwest of the lake. Comparable information searches for reservations of Wisconsin and Michigan are planned for future years.

Mining

Most mining of iron, copper and other metals in the Great Lakes region takes place at appreciable distances from the lakes themselves, although the White Pine Copper Mine in Northern Michigan lies only 16 km from the shore of Lake Superior, and uses water pumped from the

lake in mining and milling operations. However, many of the related concentrating and processing plants are located near the shore for reasons of water availability, access to shipping and waste disposal. An example is the taconite processing plant of the Reserve Mining Company, whose discharges to Lake Superior have become a widely publicized environmental concern.

Most mining of industrial commodities such as limestone and sand and gravel takes place at or near the lakeshores, for reason of access to shipping. These operations include the world's largest limestone quarry at Roger's City, Michigan, and others along the south side of the Upper Michigan Peninsula that are among the world's largest. The excavation and shipment of sand from lakeshore dunes for foundry use by the auto industry in the Detroit area is a cause of environmental concern. Mining in the lakes is limited almost exclusively to the dredging of sand and gravel, to subsurface recovery of brines, and to excavation of salt beds that extend lakeward from land beneath Lakes Huron and Erie.

A wide range of research and engineering activities on the recovery, handling and consumption of minerals is conducted by the Department of the Interior's Bureau of Mines (USBM). The USBM laboratories at Minneapolis had a key role in the development of methods for the mining and processing of magnetic taconite ores as a source of iron. The processing of nonmagnetic taconite became reality when a plant in northern Michigan began operations in early 1975. This new process greatly extends the future of

the iron mining industry in the Great Lakes region, and it is hoped that the technology can be adapted to treat several billion tons of low-grade non-taconite ore from the Western Mesabi Range of Minnesota.

In other activities related to the mining of metals, USBM is conducting hydrometallurgical and pyrometallurgical research to develop economic methods for recovering copper and nickel from extensive low-grade ore deposits in northeastern Minnesota, north of Lake Superior.

Joint efforts of the mining industry and USBM Laboratories are attempting to improve the safety and environmental acceptability of mining techniques, and the reclamation of lands such as the limestone quarries and the sand and gravel pits along shores of the lakes which have been strip-mined. In cooperation with the States and the mining industry the Bureau collects data on the production and consumption of minerals, and provides advice and support to the States and other Federal agencies. One such activity provided an estimate of reserves of nearshore sand and gravel for use in Corps of Engineers construction. USBM provides and reviews environmental impact analyses that concern the minerals industries in the Great Lakes region. An assessment was completed recently of mineral industry water needs as a component of the Water Resources Council national study of water needs through the year 2000.

The Department of the Interior's Mining Enforcement and Safety Administration (MESA) performs research and conducts training programs to improve the health and safety of the working environment for miners. Most activities are undertaken cooperatively with State regulatory agencies, the mineral industries and the unions. Water used in the operations is tested to assure that portions used in human consumption meet quality standards. MESA has recently initiated educational programs to improve safety practices in salt mining and in the sand and gravel industry.

Water resources and supply

The growth of population, agriculture and industry in the Great Lakes region has had significant impact on water supplies which at one time were considered inexhaustible because of the vast reservoirs provided by the lakes themselves. Today water resource problems are the focus of much of the Federal effort devoted to the Great Lakes. Pollution is a major concern, and flooding is an important factor in coastal development.

The water resources of the Great Lakes region include streams, inland lakes, groundwater, and the large volumes of the lakes themselves. States have regulatory authority over the use of water within their jurisdictions, and many Federal activities are performed cooperatively with water resource agencies of the States. Among joint efforts, the Department of the Interior's U.S. Geological Survey (USGS), in cooperation with State and local government

agencies, maintains an extensive data network to monitor the quantity and quality of water that enters the Great Lakes. USGS supplements these data with information generated through various areal and specialized studies in each of the bordering States. The USGS data network within the Basin consists of about 900 stations to monitor surface waters carried by streams and 400 observation wells to measure ground-water levels. Water quality data are collected at selected stations and wells, and information on sediment loads is gathered periodically at some stream sites. Of the surface-water stations, 118 are located at the mouths of streams. Records from these stations, combined with those obtained by other Federal agencies, State and local authorities, and by Canadian counterparts, provide an inventory of most, but not all, surface-water flow from bordering lands to the lakes. With data for streams that flow between the lakes and for the St. Lawrence River at the outlet of Lake Ontario, they permit estimates of water budgets for the lakes. The USGS is expanding its network of gaging stations, and is upgrading instrumentation for monitoring an increasing number of water properties and constituents. Through its Office of Water Data Coordination it maintains a computer file of water data acquisition activities. It publishes a catalog for the Great Lakes watershed (Water Resources Region 04), summarizing information supplied by Federal, State and local agencies and private organizations.

USGS conducts research on problems of water availability, water use management, sediment transport, erosion, pollution and flooding. Most of the effort is in cooperation with the States and other Federal agencies. Analog and digital computer models are being developed. Examples include an analysis of water movement in a deep sandstone aquifer that serves as a source of water for Milwaukee, and an assessment of possible changes in water quality of the Indiana Dunes National Lakeshore that may result from the planned construction of a power plant. Aircraft and satellite remote sensing techniques are being developed in a collaborative effort funded by USGS, which includes participation of scientists from McMaster and Guelph Universities, the Canada Center for Inland Water and the Ontario Water Resources Department.

Research on water sources in the Great Lakes region is supported by the Department of the Interior's Office of Water Research and Technology (OWRT). This work is accomplished by allotments to water resource institutes operated by each State, matching grants to institute-sponsored research projects, and direct grants, contracts and other arrangements with individuals and organizations, both public and private. Activities include studies of basic hydrologic principles applicable to the Great Lakes and their tributary streams, management of water uses, and investigations on pollution.

OWRT manages the Water Resources Science Information Center, which serves as a focal point in the Federal Government for coordination and dissemination of technical information, and for planning and

accomplishment of many activities relating to the Federal Great Lakes program. The Center publishes an Abstract Journal and Annual Catalog of Research Activities that include resumes of published results and current water resources efforts relating to the Great Lakes region.

The Environmental Protection Agency (EPA), Energy Research and Development Administration (ERDA), and the Corps of Engineers (COE) support the collection and study of water resource data through contracts with States, universities, private firms and individuals. USGS provides direct support to many of these efforts and conducts some through its cooperative programs with State agencies which serve as EPA and ERDA grantees. The latter is illustrated by joint Wisconsin-USGS studies of the Menomonee River Basin and sediment movement in the Menomonee River. These are integral parts of a basin-wide pollution analysis conducted by EPA, and described in the section on Environmental Protection.

Studies on the distribution, character and balances of water resources as they contribute to planning are included in most programs conducted by the Great Lakes Basin Commission, and supported by the Water Resources Council. Programs of NOAA and others devoted to weather, climate and studies of the lakes themselves contribute both directly and indirectly to water resources knowledge of the Great Lakes Basin.

4. LIMNOLOGICAL AND METEOROLOGICAL RESEARCH

Introduction

The Great Lakes constitute the largest body of fresh water in the world. Research on the physical, chemical, biological, and geological characteristics of the Lakes is termed "limnology."

Many Federal agencies contribute to Great Lakes limnology and meteorology, including the Department of Commerce, the U.S. Army Corps of Engineers, the Environmental Protection Agency, the Energy Research and Development Administration, the Department of the Interior and the National Aeronautics and Space Administration. The National Science Foundation and the Office of Naval Research support limnological research on the Lakes by universities and others.

International Field Year for the Great Lakes

A major component of Great Lakes limnological research in recent years has been the International Field Year for the Great Lakes (IFYGL), a multi-agency cooperative program.

IFYGL is a comprehensive set of research studies on the limnology, hydrology and meteorology of Lake Ontario, the air above it, and its drainage basin. The observation period for the IFYGL was April 1972 to March 1973. The program has progressed to the point where analytical results are being reported. An international series of eight summary scientific reports is targeted

for completion in late 1977. An international summation symposium is scheduled for the fall of 1977.

Limnology: general

Several Federal agencies are engaged in research programs in limnology. The dynamic and interdependent nature of limnological processes is being studied by NOAA's Great Lakes Environmental Research Laboratory (GLERL) in the Aquatic Ecology Models Project. This will develop and test a hierarchy of mathematical models of the Great Lakes ecosystem which incorporate the functional relationships among the physical, chemical and biological quantities, and portray the changes of carbon in the ecological components. These models will increase understanding of these relationships and predict the consequence of alternate management strategies for the Lakes. Submodels will be developed to represent the dynamics of important properties, including inorganic carbon, phosphorus, nitrogen, phytoplankton and zooplankton. Important problems include the understanding and development of prediction models of the pathways, cycles and budgets of chemical and biological quantities. In addition to their value in management, these models will be used to evaluate the present status of knowledge and to identify areas which require further study.

Increased understanding of the space-time distribution of selected physical, chemical and biological-limnological variables should result from a GLERL project on Natural Distribution and

Variability of Lake Properties. Information on the distributions will be summarized for separate lakes, and for the Great Lakes system, and guidelines will be developed for sampling methods to monitor long term trends in the Great Lakes. Tasks underway include a physical-chemical study of the Detroit River, Lake St. Clair and the St. Clair River, analysis of Lake Ontario oxygen profiles, inorganic carbon dynamics, a study of Oswego Harbor, and an intercomparison of IFYGL chemical observations from various laboratories.

Much of the Great Lakes limnological research activity is focused on the understanding and control of pollution processes. This is described in the section dealing with Environmental Protection, Section 7.

Biological-chemical limnology

The biology-chemistry program in IFYGL consisted of experimental studies of the chemical balance of Lake Ontario, baseline studies to define the status of chemical quantities and biological species in the lake, and the development of numerical models of the annual cycle in the lake. Chemical balances are being developed for the nutrients. This work has been managed by EPA through its Grosse Ile Laboratory. The basic lake sampling network included 60 stations with up to 12 depths (1 m. to 200 m.) visited during 10-five-day lake-wide cruises during the period of May 1972 to June 1973. Phytoplankton studies of water samples identified four major phytoplankton assemblages.

Numerical models are under development by several IFYGL scientific groups to simulate the annual cycle in Lake Ontario of chemical and biological variables, including the dynamics of plankton, while others cover all trophic levels with more or less diversity. Aquatic ecology model development is in an early research stage; some testing and modification has been accomplished to date, and results, although preliminary, are encouraging.

A study of the competition and succession of plankton species in the Great Lakes over the annual cycle is being conducted by NOAA's Great Lakes Environmental Research Laboratory. Laboratory and field observations are made on plankton nutrient competition, zooplankton grazing, and zooplankton production dynamics. These experimental studies are designed to provide information to improve models of the relationships, and the results will be integrated into the aquatic ecology models.

A related research program, "Nutrient Enrichment and Eutrophication of Lake Michigan" is being conducted by the Energy Research and Development Administration (ERDA-Division of Biomedical and Environmental Research) under contract to the Great Lakes Research Division of the University of Michigan. The objective is to analyze the roles of phosphorus, silica, and nitrogen in relation to their control of phytoplankton abundance, production, and species composition. This information should be useful in evaluating the impact of energy-producing industries on Lake Michigan.

Research is under way to develop techniques for using benthos populations as indicators of environmental quality. A second program involves the measurement and analysis of nearshore productivity and plankton populations. Both are conducted by the Department of Interior's Fish and Wildlife Service.

Physical limnology

The thermal structure of Lake Ontario has been studied as part of IFYGL in terms of seasonal variations on the lake scale, and on smaller temporal and spatial scales. A series of studies addresses the energy balance of Lake Ontario.

The water movement program includes studies of surface waves, internal waves, circulation in the mid-lake and nearshore areas, diffusion, and dynamic modeling. Water temperature and current measurements portray the temporal scales of variability in Lake Ontario. Theoretical numerical models of the current, water temperature, and water level have been formulated using an approach similar to that of the numerical weather prediction models which have proven successful in meteorology. A study by NOAA's Great Lakes Environmental Research Laboratory on water circulation will develop climatological information on the natural distribution and variability of currents, thermal structure and interdependent meteorological and hydrologic properties, and improved models to simulate and predict water current, temperature, transport and diffusion. Data are collected to define the magnitude and scales

of natural variability and to support numerical model development and testing. Important problems include the coupling process (stress) between wind and water, thermal effects, the nearshore jet, transport and diffusion process, mechanisms of exchange between the inshore and open lake regions and processes of upwelling and downwelling.

Satellite technology is being used to measure lake surface roughness and related wind fields. Two NASA studies will attempt to develop techniques for the detection of underwater features and depth measurement using remotely sensed data. In Lake Ontario, Skylab data for limnological research and water management studies are being evaluated to determine if they can supplement or replace data collected by ship surveys. Three satellite systems are used by NOAA's National Environmental Satellite Service (NESS) to make observations over the Great Lakes, including the NOAA-2, 3, and 4 satellites, the Synchronous Meteorological/Geostationary Operational Environmental Satellite (SMS/GOES-1), and the LANDSAT 1 and 2 satellites. Surface resolutions vary from 80 meters to 8 km; operating wavelengths cover the visible, near-infrared and thermal-infrared portions of the electromagnetic spectrum; temporal coverage ranges from half-hourly (geosynchronous-SMS/GOES) to twice daily (NOAA satellites) to once every 18 days (LANDSAT). Using both LANDSAT satellites, multi-spectral scanner coverage can be obtained every 9 days. NOAA-4 VHRR data provide Great Lakes surface temperature charts in cloud-free areas. From analysis

based on NOAA VHRR data, NESS provides bi-weekly sea surface temperature charts of all the Great Lakes. Upwelling events are easily monitored, as are the strong nearshore circulations typical of spring and fall. Such temperature charts also serve as input to evaporation calculations. Near-surface water circulation features, as a function of an effective weighted wind stress, have been charted by LANDSAT for selected areas, including southern Lake Michigan, southern Lake Huron, Lake St. Clair, and Lake Ontario. The circulation patterns observed in most areas are in good agreement with surface studies. NOAA-satellite data further augment these analyses when a water color tracer is not obvious to LANDSAT, but a thermal feature exists. LANDSAT has shown the lake-wide significance of "whitings" - calcium carbonate precipitations which occur chiefly in Lakes Michigan, Erie, and Ontario after the water becomes highly supersaturated with CA^{++} and $CO_3^{=}$ ions during the warm summer months. Extreme turbidity occurs in the upper 10 meters of the water column, and the evolution and circulation of these conditions can be monitored.

Lake circulation is one of the variables measured in the remote sensing project conducted by the Earth Resources Observation Satellite (EROS) Program Office of the USGS. This is described in the section on Environmental Protection.

A year-round study is being made by ERDA of winds, lake temperatures, and near-shore currents at the Point Beach Power

Plant near Two Rivers, Wisconsin. Measurements are being made in the region 3 km. from shore where bottom depths are less than 20 m. A model is being developed relating winds to currents, and calibrated for local bathymetry. Measurements of eddy diffusivity (dispersion) are also being made in the surrounding current field and in the thermal plumes from three power plants.

Five studies related to the physical processes of Great Lakes limnology are supported in the States by the Office of Water Research and Technology (OWRT) of the Department of Interior. These are: a systems analysis of the western basin of Lake Erie, an investigation of the role of vertical diffusivity in dispersion processes, spring and fall thermal bar development in Lake Superior, thermal pollution and the second trophic level fauna in Lake Superior, and hydrologic models of the Great Lakes.

NOAA's Great Lakes Environmental Research Laboratory (GLERL), the Environmental Protection Agency, and various Canadian agencies, academic and private institutions are involved in a number of inter-agency programs in the area of water quality research. Under the IFYGL program, GLERL was assigned the lead role in measuring the bi-weekly heat budget of Lake Ontario to determine the variation and variability of heating processes, and to estimate evaporation from the lake. The circulation of Lakes Superior and Huron is the subject of two research efforts being conducted by GLERL and EPA, in conjunction with the Canada Center for Inland Waters, under the

Upper Great Lakes Reference of IJC. Related observations on the transport of pollutants within and between the Great Lakes were conducted by GLERL and EPA as part of the IJC water quality program.

The Great Lakes Environmental Research Laboratory conducts an Environmental Engineering Models and Applications Project to develop and test improved simulation and prediction models for user application. The concept is to develop a scientific basis for decisions for the development and utilization of Great Lakes resources without impairing water quality. Tasks include a study of Maumee Bay, a phosphorus model, a lake-scale water quality model, and an atlas of Lake Ontario physical properties as defined by IFYGL.

The studies of hydrologic models supported by OWRT contribute to a USGS program to develop three-dimensional mathematical models having general applicability to lakes, bays and estuaries. Such models are also fundamental to the construction of more sophisticated models for study of complex phenomena, such as distributions of biomass and dispersal of pollutants. Lake Michigan was chosen for a first test of a prototype model because the lake is a relatively simple water mass, and much data on its hydrologic parameters are available. Results of the test, conducted during 1973 by the Rand Corporation, are now being applied to improvement of this generalized model. Limited success in use of the prototype

has helped clarify future data needs and has demonstrated its potential applicability to model development programs of others engaged in Great Lakes research.

Information storage

The Environmental Science Information Center's Great Lakes Library at Detroit, operated by NOAA's Environmental Data Service (EDS), has an archival collection on the lake level and hydrologic data of the Great Lakes dating from 1840. About 85 percent of the literature is on hydrology and limnology. The collection, consisting of field survey notebooks, survey sheets, and associated reports and compilations, is being produced on microfilm for retention by the Corps of Engineers, Detroit District. Computerized literature search services from a large number of bibliographic data bases are available upon request. Approximately 50 percent of the data bases can be searched on-line at a terminal in the library. The library can obtain batch searches of the remaining data bases.

The Environmental Data Index (ENDEX) of EDS is an automated, comprehensive index and referral system describing environmental data collections. Information referring to the data include the institution, dates, locations, parameters, measurement methods, number of observations, data media, project affiliations, person to contact to obtain data, publications resulting from data, funding agency, file size, and abstracts. For the Great Lakes area over 1,000 data files have been described. Geographic

coverage includes the Great Lakes themselves and all states bordering on the Lakes. The system can be queried through a computer terminal at the National Ocean Survey Great Lakes Library in Detroit.

An information system for Great Lakes resource managers and planners is provided by the Environmental Information Advisory Service of NOAA's Great Lakes Environmental Research Laboratory (GLERL).

Hydrology

A major activity of the International Field Year for the Great Lakes was computation of the annual water balance of Lake Ontario. A similarly conceived project is underway to estimate Lake Ontario evaporation by inflow minus outflow (balance) calculations for an atmospheric volume overlying Lake Ontario. A model has been developed by NOAA's Great Lakes Environmental Research Laboratory to simulate and predict the hydrologic lake levels and flows in the connecting channels. Climatological information and improved models will be developed and tested to predict water levels, flooding and river flow for various time scales.

Flows in the connecting channel and the St. Lawrence River are subject of hydraulic studies being conducted by the Army Corps of Engineers. Many of them are post-dredging studies from the 8 m. Great Lakes connecting channels navigation project. These include

development and verification of mathematical models of the St. Mary's River, St. Clair and Detroit Rivers, and the Niagara River.

Hydrologic studies by the Corps of Engineers include the application of research results (in-house or made by others) to the measurement and estimation of the quantities which comprise the water balance of the lakes. Such studies are directed toward better control of the lake levels and outflows from all lakes. These studies are related to the Corps' commitment to the International Joint Commission Boards and other international committees.

In Section 2, Navigation and Transportation, other related research projects on limnology are described.

Meteorological research

The extent of the Great Lakes water area is sufficient to have a significant effect on the weather of the region. Storms and wave effects are often violent, and they affect commercial and other activities of the residents. This is especially the case with shipping and boating, and weather forecasts are therefore of even greater than usual interest in the region. Considerable meteorological research and service activity is carried on as a consequence, involving a number of Federal agencies. The National Weather Service of the Department of Commerce (NOAA) is the most active agency in the field, with the National Aeronautics and Space Administration, the Energy Research and Development Administration, and the Navy having some input into Great Lakes meteorology.

Direct measurements have been made of the turbulent eddy fluxes of momentum, heat, and moisture using instruments mounted on towers in the lake and on aircraft flown at low elevations over the lake. An analysis was made of the summer lake scale diurnal wind regime over and adjacent to the lake.

Improved forecasting data and climatological information are being obtained as a result of a study conducted by GLERL on the natural distribution and variability of surface phenomena. A project sponsored by the Office of Naval Research at Williams College, Williamstown, Massachusetts, is designed to relate major weather fronts to coastal dynamics. The field work for this project is performed on Lake Michigan.

Micrometeorological investigations of thermal energy exchange over the Great Lakes and over large and small cooling ponds have been conducted to obtain an understanding of transport processes, and the external factors that affect these processes, with regard to the design of efficient and environmentally acceptable waste heat disposal from power producing facilities. The measurement of transfer coefficients, effects of atmospheric stability upon heat exchange processes, and development of new methods of measuring air-water exchange can also be applied to the problem of assessing the mass-energy balance of an atmospheric pollutant input to large lakes. This is a project supported by ERDA. Methods are needed to assess atmospheric transport and dispersion climatology in the

special boundary and stability conditions peculiar to coastal sites of power plants. The turbulent dispersive properties of the lower atmosphere over open water are being studied in southern Lake Michigan. The information can be used to describe the behavior of atmospheric pollutants moving along trajectories over the Great Lakes, and as a model for predicting the dispersive properties in the lower atmosphere over the oceanic waters of the continental shelf.

A National Aeronautic and Space Administration (NASA) test site on Lake Superior provides sea surface and atmospheric data acquired by multi-level aircraft flights to relate measurements obtained from the Skylab's Earth Resources Experiment Package (EREP) to photographic and model determinations of whitecaps and foam densities.

NASA scientists and those from other Federal agencies have been evaluating the applicability to Great Lakes limnological and meteorological research programs of data obtained by visible, infrared, and microwave remote sensors on NASA's earth orbiting spacecraft (LANDSAT, NIMBUS, SKYLAB) and high altitude aircraft. The data have been of value in studies dealing with sediment transport, near-surface water circulation patterns, water mass boundaries, upwelling phenomena, bioproductivity and pollution detection and dispersal, and in monitoring power plant thermal effluents. Repetitive coverage of the lower portion of Lake

Michigan made possible by LANDSAT overflights showed cloud patterns which gave rise to anomolous rainfall inland from the eastern shore. The imagery showed that rainfall was generated by clouds which originated over the steel mills on the south shore of the lake, and aligned themselves in parallel rows as the southwest winds blew them across the lake.

Multi-color remote sensor imagery is being used to detect shoals and other shallow water bottom features which may represent hazards to boats, and which may influence the heights and directions of waves reaching the shore and the interaction of waves with the shoreline.

Weather information

The Great Lakes Marine Data Acquisition Program of NOAA's National Weather Service (NWS) consists of a network of coastal and ship observing stations which supplements the basic hemispheric network with synoptic observations. About 40 U.S. lake carriers make observations every six hours when under way on the Lakes, and report to the Weather Service Forecast Office (WSFO), Cleveland. Observations from American and Canadian ships, plus local observations from Coast Guard installations and other cooperators, supplement the guidance material received from the basic weather service.

The Great Lakes Marine Weather Program issues forecasts and warnings for ships and recreational boating on the Great Lakes, and for lake-shore warnings of high winds, water level, and waves.

These are provided by the Weather Service Forecast Offices at Chicago (Lakes Michigan and Superior), Detroit (Lakes Huron and St. Clair), Cleveland (Lake Erie), and Buffalo (Lake Ontario). During the boating season other NWS offices issue forecast and summaries for recreational boating for near-shore waters out to eight km. Advisories are issued by WSFO, Cleveland, for "storm surges" in Lake Erie; WSFO, Chicago, issues seiche warnings for southern Lake Michigan; WSFO, Detroit, does the same for Saginaw Bay in Lake Huron. The warnings and forecasts are disseminated by NOAA Weather Radio, Coast Guard, and commercial radiotelephone stations, and by television and radio stations.

Coordination

The International Field Year for the Great Lakes (IFYGL), the multi-agency and international United States-Canadian experimental field program mentioned at the beginning of this section, has provided considerable coordination of Great Lakes limnological and meteorological research. Field observations terminated in 1974 but analysis of the data and preparation of reports occupies a considerable number of scientists. Eight U.S. and four Canadian agencies are involved through the IFYGL Project Office, the U.S.-Canadian Joint Management Team, and scientific panels. Participating U.S. agencies include NOAA (Great Lakes Environmental Research Laboratory, National Weather Service, Environmental Data Service, National Environmental Satellite Service), EPA (Grosse Ile Laboratory and Region 2), the Corps of Engineers, Department of Interior

(Great Lakes Fisheries Laboratory and Geological Survey), Coast Guard, NSF, NASA, and the State of New York Department of Environmental Conservation.

About 1,000 scientists, engineers and technicians have participated, representing Canadian and U.S. Government agencies, numerous universities and private institutions. There are seven international and interagency panels of scientists, on: (1) terrestrial water balance, (2) lake energy balance, (3) lake meteorology and atmospheric water balance, (4) evaporation synthesis, (5) atmospheric boundary layer, (6) water movements, and (7) chemistry and biology. For the U.S., panel 1 is chaired by the Corps of Engineers, panels 2 through 6 by NOAA, and the last by EPA. NOAA is the U.S. lead agency, and project responsibility is assigned to the Great Lakes Environmental Research Laboratory (GLERL)(see Section 8).

GLERL, the EPA Grosse Ile Laboratory, and Interior's Great Lakes Fisheries Laboratory have informally coordinated their research programs both in terms of research plans and for the exchange of research results. GLERL is providing working level support for the Corps' Coastal Engineering Research Center in the collection of surface wave data on the Great Lakes.

5. RECREATION

Introduction

Intense use is made of the Great Lakes water and beach areas for recreation, and pressures on limited resources are increasing rapidly with mounting population and greater leisure time. Much of the conflict over land use is between recreation and other demands.

The Bureau of Outdoor Recreation of the Department of the Interior has a lead role for planning and coordinating recreational programs and facilities in the Great Lakes Region. Interior's National Park Service and Bureau of Indian Affairs are also involved, as are the Coast Guard, the Army Corps of Engineers and NOAA (Environmental Data Service and Office of Sea Grant).

Inventory of sites

A major activity in the field of recreation is the classification and analysis of existing and potential recreation sites and the acquisition of suitable areas. Recreational boating needs are considered in terms of the construction, operation, and maintenance of harbors, launching facilities, and marinas. The Bureau of Outdoor Recreation (BOR) of the Department of Interior assesses regional recreational needs, and aids the States in development of recreation plans. In support of a Great Lakes Basin Commission Study of the Maumee watershed, BOR has made an inventory of significant potential recreation sites. The resulting recommendations for the acquisition and development of the best sites will be provided to the Great Lakes Basin Commission.

The major water and water-related problems of the southeastern part of Michigan are being examined in a study sponsored by the Corps of Engineers. In the course of this work, the Bureau of Outdoor Recreation made a detailed evaluation of the shoreline of four southeastern Michigan counties to determine its potential in satisfying outdoor recreational needs in the Detroit metropolitan area. The Bureau inventoried potential recreation sites along the shores of Lakes Huron, St. Clair, and Erie, and the Detroit River, and suggested that several be conserved or developed.

Land acquisition

Aid in acquisition and development of recreation lands is provided through the Department of the Interior's Land and Water Conservation Fund, administered by the Bureau of Outdoor Recreation. About one-third of these funds are used for Federal land acquisition, and about two-thirds for assistance to the States to support planning, land acquisition and development of park and other recreation areas. In FY'75 such Federal expenditures in the Great Lakes area will include the purchase of land to be added to the Perry's Victory Memorial, and to the Sleeping Bear Dunes National Lakeshore. Some additional funds may be expended for deficiency awards and purchase of holdings within existing Great Lakes park and Forest Service areas.

Navigation facilities for recreation

Under the Federal Water Project Recreation Act (P.L. 89-72), the Federal Government may contribute up to 50 percent of the cost of constructing general navigation facilities serving recreational traffic.

Local interests are required to provide all lands, easements, rights-of-way, public wharves, and servicing facilities, including dredging in berthing areas and necessary policing. The Federal government (Coast Guard and Corps of Engineers) assumes study costs, the costs of navigation aids, and of maintaining general navigation facilities. These include a safe entrance channel, protected by breakwaters or jetties if needed, protected anchorage basins, and major interior access channels and turning basins. Minor access channels for maneuvering into the berths, stalls, or slips are provided by local interests. Berthing areas, docks, landings, berths, stalls, slips, and mooring areas at marinas are also provided and maintained at local or regional expense.

Recreational boating safety

The Coast Guard encourages the States to assume responsibility for recreational boating activities on State and jointly controlled waters. In support of this policy the Coast Guard administers a Boating Safety Financial Assistance program under which Federal funds are made available to participating States.

Coast Guard Boating Safety Detachments (BOSDETS) provide training for State, local and Federal marine law-enforcement officers, monitor enforcement on waters under U.S. jurisdiction, and provide boating safety education upon request. BOSDETS also visits marine dealers to provide them with information on boating laws and regulations, investigates consumer complaints, and conducts accident investigations. The United States Coast Guard Auxiliary, a civilian volunteer group which

is the Coast Guard's primary educational force, promotes safe boating through education courses. The Coast Guard Auxiliary also provides on the water education and assistance to the recreational boater by means of the Courtesy Motorboat Examination program and several types of Coast Guard-sponsored patrols (Safety Patrols, Search and Rescue Patrols, Regatta Patrols, Chart Updating Patrols, etc.). The Coast Guard Auxiliary is embarking on a "Dealer Visitation" program that will aid the Coast Guard, the marine dealer, and the boater.

The Coast Guard maintains search and rescue stations on the Great Lakes, six of which are manned by the U.S. Coast Guard Auxiliary during the boating season. Other volunteer agencies, including the United States Power Squadrons and the American National Red Cross, provide free boating courses.

Predictions of surface waves, wind tides and seiches are of major importance to the safety of recreational boaters on the Great Lakes. These forecasts are being improved by research which provides information on the depth of water in navigable channels and in harbors, and which develops improved techniques for operational environmental prediction services of the National Weather Service.

Thirty-nine Great Lakes recreational chart series, with from 12 to 47 charts in each, are produced by NOAA's National Ocean Survey. The Survey also produced the Great Lakes Pilot which provides detailed descriptions of the physical conditions of charted waters, and has information to supplement the Great Lakes charts.

The Harbor of Refuge program of the Corps of Engineers is designed to provide a chain of harbors for recreational craft about every 50 km. along the southern shore of Lake Superior. The Bureau of Outdoor Recreation provides planning assistance to the Corps of Engineers in evaluating and selecting potential locations for the refuge harbors.

Interior's Bureau of Indian Affairs assisted in the planning and construction of small boat marinas at the Grand Portage Indian Reservation on the north shore of Lake Superior, and currently supports planning for a marina at the Red Cliff Indian Reservation on the south shore. Construction of the Red Cliff marina is planned for FY'76, in conjunction with the development of nearshore campgrounds, and a 100-unit hotel.

Parks

The National Park Service manages two National Parks, four National Lakeshores, a National Monument and a Memorial Park that include islands and shoreline areas of the Great Lakes. The National Park system facilities in the Great Lakes region include: Apostle Island National Lakeshore, Wisconsin, Grant Portage National Monument, Minnesota, Indiana Dunes National Lakeshore, Indiana, Isle Royale National Park, Michigan, Perry's Victory and International Peace Memorial, Ohio, Pictured Rocks National Lakeshore, Michigan, Sleeping Bear National Lakeshore, Michigan, and Voyageurs National Park, Minnesota. Operation of the parks includes the maintenance of a large number of special facilities such as visitor centers, marinas, boat docks, launching ramps,

swimmingbeaches, lifeguard stations, patrol boats, buoys and markers, sanitary and water systems, camping and picnicking areas, and nature trails. NPS maintains a modest in-house research capability, and through contracts supports studies designed to enhance appreciation and operation of the Park System.

Project evaluation

The Bureau of Outdoor Recreation participates in Corps of Engineers and other Federal water resources development studies that involve relationships of proposed projects to future public recreation needs, the determination of impacts on outdoor recreation, natural and scenic resources, and associated environmental values, and the coordination of Federal and State outdoor recreation programs. Among current studies, BOR is evaluating potential impacts on recreation of an extended navigation season on the Great Lakes and St. Lawrence Seaway through a contract with Lake Superior State College.

For projects that involve Federal action, permits or licenses, BOR reviews governmental and private reports and proposals, environmental impact statements, and applications to the Corps for dredging, filling or excavating in navigable waters to assure that adequate consideration has been given to recreational potentials and alternatives, and to the preservation of natural, scenic, recreational and other environmental values, BOR also aids the Office of Coastal Zone Management and the States to secure a balance for recreation in State Coastal Zone Plans.

Recreation-related studies at the State University of New York/ Cornell are being supported by NOAA's Office of Sea Grant, and include investigations of the use of rented recreational boats, shoreland recreation behavior patterns, and public access problems.

6. COASTAL DEVELOPMENT AND PROTECTION

Introduction

The coastal zone is the most accessible and intensively used part of the Great Lakes aquatic environment. It is subject to heavy pressure for varied and often conflicting uses. There are approximately 5,900 kilometers of mainland shoreline in the United States Great Lakes, and 400 km of shoreline along Great Lakes connecting channels, including the St. Mary's River, the St. Clair River, Lake St. Clair, the Detroit River, and Niagara River. Of total shoreline about 33 percent is residential, 50 percent is agricultural, forest and undeveloped, 10 percent is recreational (public), with 7 percent for commercial-industrial and public uses.

The Great Lakes experience storm surges and flooding that threaten life and property, and cause erosion of coastal areas. According to the Corps of Engineers, over 30 percent of the Great Lakes shoreline is subject to significant erosion. Over the last 125 years, the average annual rate of loss in many areas has been from 0.3 to 1.5 meters. Some shoreline reaches and beaches are stable or accreting; these areas are typically located updrift from natural or artificial barriers.

Periods of high lake levels occurred in the late 1920's, the mid-1940's, and the early 1950's, and water levels in all of the Great Lakes have been abnormally high in recent years. The potential

for erosion and shore property damage by flooding increases with each high-water period. Continuous development of unprotected shorelands and rising shore property values increases these losses. Erosion of the shorelands causes physical loss not only of land areas but also trees and structures such as docks and docking facilities, and in extreme cases, homes and cottages. Roads and highways are eroded away or closed by inundation.

The Federal agencies active in coastal development and protection are the Army Corps of Engineers, the Department of Commerce (NOAA's Office of Coastal Zone Management, National Ocean Survey, National Weather Service and Office of Sea Grant), the Department of the Interior (Geological Survey), EPA, NASA, Department of State, NSF and Navy.

Base maps

Complete topographic map coverage of land areas within the Great Lakes basin will require nearly 2,600 standard 7.5-minute quadrangle sheets at a scale of 1:24,000. Of these about one-sixth will depict shorelines and adjacent portions of the lakes. At the end of FY '75 the U. S. Geological Survey was compiling new maps for about 13 percent of the basin and revising earlier maps for another 5 percent By 1977, coverage for land areas of the basin will be complete; however, about 30 percent of this coverage will consist of maps of the 15-minute quadrangle series, and these fail to meet present-day standards. Orthophoto quads are currently being

prepared for all areas that are not now covered by maps of the two series.

The 7.5-minute quadrangle coverage of urban areas will be updated on an approximate 5-year cycle. Current USGS revisions include Detroit, Lansing and Kalamazoo, Michigan, and Niagara Falls, Buffalo and Syracuse, New York. Photo inspection projects to determine needs for revision include Duluth, Minnesota, Superior, Oshkosh-Appleton, and the Red Cliff area, Wisconsin, and the eastern third of the Upper Michigan Peninsula and Flint-Ann Arbor area, Michigan. USGS is also revising a variety of smaller scale maps which embrace areas within the basin, at least in part. These include two county maps, two 1:250,000 scale quadrangle maps, three State base maps (Ohio, Pennsylvania and New York), and four 1:1,000,000 scale sheets of the International Map of the World Series (IMS).

USGS and NOAA's National Ocean Survey have undertaken joint research to improve map portrayal of the Nation's coastal wetlands for purposes of planning, development and other activities within the coastal zone. Methods for identifying and delineating wetlands are being studied through infrared, color-infrared and other aerial photographic and sensing techniques. Although most of the effort involves only Atlantic coastal areas, it is planned to extend the research to shores of the Great Lakes.

Erosion control

The major responsibility for shore erosion control, beach and shore stabilization, and storm surge protection rests with the Army Corps of Engineers. The Corps is authorized to investigate the causes of beach erosion, to construct shore protection works, and to provide assistance in major disasters and in floods and coastal storms. Many of the navigation structures and protective works on the Great Lakes were constructed at an earlier time when interest in shoreline changes was not as intense as it is today. These structures modify the pattern of littoral drift, usually with adverse effects on the downdrift side.

The wind tide is the primary cause of flooding along the shoreline of the Lakes. Major flooding occurs when the three water surface phenomena, wind waves and run-up, wind tide, and hydrologic lake levels, are at peak amplitude. Coastal erosion occurs primarily during storm periods when the wave action is most intense and during periods of high lake levels when bluffs are most exposed to wave action.

NOAA's Great Lakes Environmental Research Laboratory (GLERL) supports the Corps Coastal Engineering Research Center in research activities on wind waves, wind tide, and seiche climatology and prediction. The GLERL projects described in Section 4 provide information on water circulation, transport and diffusion, and on surface waves and oscillation in the nearshore as they affect shore

processes. A project at Purdue University studying wave energy in the coastal zone is funded by the Office of Naval Research.

Congressional authorization for construction of protection projects by the Corps of Engineers is on a case by case basis. Current policy for Federal participation in the cost of construction provides for the following:

(a) Federal property - full cost is borne by the Federal Government.

(b) State, county, or other publicly-owned property - usually up to 50 percent; occasionally up to 70 percent of costs for parks and conservation areas are borne by the Federal Government, with certain restrictions.

(c) Private property - there usually is no Federal participation in cost-bearing; this depends on whether public use and access are permitted.

Survey reports and implementation studies for control of flooding or erosion are authorized by Congress. Small Beach Erosion Control Projects of the Corps of Engineers are conducted under Special Continuing Authority. There are now 18 active projects of this type on the Great Lakes. Flood emergency operations are authorized whenever and wherever required and typically involve Federal, State and local authorities. For example, Operation Foresight is aimed at protecting 140 shore areas and 160 km of shoreline; construction of $25 million worth of temporary dikes

is essentially accomplished. Under the 1974 Flood Control Act, the Corps has initiated a number of studies to determine the need for protection of public utilities on the Great Lakes.

Navigation works and their operation and maintenance can have important local effects in creating erosion problems in the Great Lakes area. Harbor structures modify the pattern of littoral drift, with varying effects on the downdrift shoreline. Dredging or construction of shore protection works by private landowners or other property interests can often aggravate erosion and flooding problems along a reach of shoreline. While a landowner has the right to protect his property from erosion, the significant probability of damage to others due to changes in the pattern of littoral drift, for example, requires some form of public control. Such regulation may require beach nourishment downdrift of obstructions, or limit the length of projecting structures.

Bay studies at Apostle Island, and beach nourishment studies at Indiana Dunes, are supported by the National Park Service of the Department of Interior. Emphasis of the projects is on obtaining information that may be used to manage resources of the parks more effectively. Operation of the Park Service areas and grants for the development of State and local recreational facilities from the Land and Water Conservation Fund include support of many activities related to erosion control of shoreline areas. Most of the Park Service efforts are undertaken in cooperation with the

Army Corps of Engineers. The Department of Interior's minerals programs supply information on the nature of shoreline materials and sources of construction materials that are basic to the planning and accomplishment of the engineering programs.

Research on problems of coastal erosion and stabilization are being conducted by Great Lakes Sea Grant institutions. The University of Wisconsin administers two projects dealing with specific aspects of shoreline erosion -- coastal slump and shore ice. Field and laboratory measurements provide baseline estimates of the total sediment volume eroded in a winter, and the rate of erosion. Following the determination of the principal mechanisms of shoreline slumping and slope instability in the Lake Michigan area, the interrelationship between slumping and erosion trends will be assessed in order to predict erosion.

Several Sea Grant-supported projects are focused on the development of coastal zone and shorelands management and planning techniques. These are part of a continuous program of assistance to governments and public groups in applying scientific management expertise to coastal zone problems. A University of Michigan project is expanding and improving upon a gaming simulation, WALRUS (Water and Land Utilization System), which teaches decision makers the complexity of interrelated decisions and the impact of such decisions on the water quality of the Lakes.

A Sea Grant-supported project at the University of Wisconsin provides technical assistance to landowners on Lake Michigan who may be contemplating the installation of shoreline protection structures, particularly where hazardous conditions are imminent.

Prediction of flood conditions

Prior to the formation of NOAA in 1970, responsibility for research on lake levels and related problems rested with the Corps of Engineers. The Lake Survey District of the Corps had a competent staff collecting information on various limnological phenomena, including water current movements, sedimentation, shore erosion, and ice formation. The Corps was also responsible for the production of Great Lakes charts. These activities were in support of the Corp's responsibilities for lake level forecasting, for their engineering works. The Corps performs some engineering research in coastal areas of many parts of the Nation, including the Great Lakes. The cost of this research effort was about $4 million in FY '75. The work in the Great Lakes is partly a consequence of the international aspects of lake management.

With the creation of NOAA most of the Lake Survey District's activities were transferred to the new agency. However, the Corps retains responsibility for representing the U.S. on the International Joint Commission's international boards of control which manage lake levels (by manipulation of locks and other structures), and for engineering projects.

A lake level forecasting model is being developed jointly by NOAA's Lake Survey Center and Great Lakes Environmental Research Laboratory. A network of 51 permanent water level gages is operated in the Great Lakes by the Lake Survey Center of NOAA's National Ocean Survey. Water level data collected from these stations are processed and disseminated to other government agencies, industry, and the general public throughout the Great Lakes region. About 8,000 copies of the Monthly Bulletin of Lake Levels are mailed to interested persons and agencies, and about 9,000 transmittals of water level and other data are made each year. The six-month forecasts in the monthly bulletin are prepared by the Corps of Engineers. (See Section 4.)

The Lake Survey Center processes and tabulates for publication other water level-related data obtained from various agencies. This includes precipitation on the Great Lakes, diversion of water into and out of the Great Lakes, flow between the lakes, and outflow of Great Lakes rivers.

As part of a joint Corps of Engineers-NOAA study on the activities of the two agencies in the Great Lakes, the Environmental Data Service (EDS) of NOAA is reviewing the system used in the exchange of water level data in the Lakes. Both the Corps and Great Lakes Environmental Research Laboratory are dependent on these data for forecasts of several parameters derived from water levels.

In addition to the function of collecting and processing water level and vertical control data, NOAA's Lake Survey Center conducts technical and engineering studies which are required to install, maintain and operate the level and vertical control system.

The water levels of the Great Lakes and their outflow rivers are continually changing in both a cyclic and a random manner. The use of charted depths at a given time, for example by vessel operators, requires a vertical reference system analogous to the tidal datum network. This is provided by the Lake Survey Center.

Reference is made in Section 4 on Meteorology to the activities of the National Weather Service in forecasts and warnings of anomalous water levels, including surface waves, storm surges and seiches.

Prediction of lake levels and flood conditions are aided by the Great Lakes Environmental Research Laboratory's research activities on ice analysis, prediction and climatology, described in Section 2 of this report.

Flood insurance studies are being conducted by Interior's Geological Survey in cooperation with the Department of Housing and Urban Development. Studies include analysis of risks that may be encountered in urban and rural areas along the shores of the lakes as a result of storms and high stream flows. Relief, land use, and other factors are taken into consideration, and are recorded on topographic sheets for distribution to planners and others concerned with the protection of property along streams and the lake shores.

Control of lake level and water flow

Water levels in all of the Great Lakes have been abnormally high in recent years, leading to severe property damage. Lake water levels are partially regulated by control works in the St. Mary's and St. Lawrence Rivers, subject to International Joint Commission Orders of Approval. The State Department has reached provisional agreement with Canada to implement a change in the regulatory regime for Lake Superior recommended by the IJC in 1973, and has worked with the Corps of Engineers to develop legislation to implement that recommendation.

The factors which affect the fluctuation of Great Lakes water levels, and regulations to control these, are studied by the International Great Lakes Levels Board, a technical board of the IJC. The regulation of the levels of Lakes Superior and Ontario is carried out by the Corps in coordination with the Canadian Government.

The International Niagara Board of Control is responsible for supervision of the operation and maintenance of remedial works provided in the Niagara River under the 1950 Treaty with Canada. The works allow maximum power diversions around the Falls while maintaining Lake Erie and Niagara River water levels for navigation and shore property interests and Treaty flows over the Falls for scenic purposes.

Regulation and permits

The regulatory action presently applicable for proposed construction activities in navigable waters takes the form of permit requirements by the appropriate Federal or State agencies. Both Federal and State permits are required prior to initiation of dredging and construction of shore protection works along the shores of the Great Lakes, lakeward of the high-water line. Federal permits are issued by the Corps of Engineers usually only after a State permit has been obtained. Permits for construction work are reviewed by a number of Federal agencies for compliance with the authorities and with requirements of the Federal Water Pollution Control Act Amendments of 1972, the Marine Protection Research and Sanctuaries Act of 1972, the Fish and Wildlife Coordination Act (1934) and the Coastal Zone Management Act of 1972. The North Central Division of the Corps processed 4,000 permits in FY '74. Most permits are for private shore protection structure.

Planning

The Coastal Zone Management Act of 1972 establishes a basis for the management of the coastal areas. The purpose of the Act is to assist States in the development and implementation of management programs in cooperation with Federal, State, local, and regional government agencies. NOAA's Office of Coastal Zone Management (OCZM) is authorized to make annual program development grants of up to two-thirds of the cost of preparation of a state management program.

Coastal Zone Management is a voluntary program, but all of the Great Lake States are participating. Common issues of concern include lake level regulation, erosion and flooding, public access to the shoreline, commercial navigation and port development, sport and commercial fishing, the conservation and preservation of natural areas, and the control of land and water uses which affect the Great Lakes.

The Act provides that when a state has developed a Federally approved coastal zone management program, Federal actions affecting the coastal zone must be consistent with the program. The ability to participate in the decisions on Federal actions affecting the Great Lakes shorelines is important to State governments.

Some of the States have formed coastal zone program management committees comprised of representatives of State agencies, and in some cases of locally elected officials. In other States coordination has been effected through existing mechanisms. State activities include the compilation of inventories for land use, land ownership, zoning vegetation, water quality, wildlife habitat, and legal authorities affecting land and water uses in the coastal zone. Four activities common to all the Great Lakes inventory efforts are development of criteria for inventory classifications, the preparation of base maps, the acquisition of aerial photography, and the researching of State statutes, administrative codes, case law and legal ordinances.

Coordination at the regional and local level is being handled by regional planning commissions. These commissions are directed by policy boards comprised of locally elected officials and interested citizens. The commissions assist CZM program development by coordinating the programs of the Environmental Protection Agency, the Department of Housing and Urban Development, the Department of Transportation, and the Economic Development Administration.

Coordination

The Water Resources Council represents one of the principal planning, coordinating and policymaking bodies for the Great Lakes region. The purpose of the Council is to encourage the conservation and utilization of water and related land resources on a coordinated basis by Federal, State and local governmental and private groups. Under the Water Resources Council the Great Lakes Basin Commission serves as a planning and coordinating body for water and associated land resources development and use.

Coordination among the Great Lakes States and with Federal agencies is facilitated by the Great Lakes Basin Commission's Standing Committee on Coastal Zone Management. Membership includes representatives from the States, the Great Lakes Basin Commission, the Great Lakes Environmental Research Laboratory of NOAA, EPA, the U.S. Army Corps of Engineers, the Office of Coastal Zone Management, NOAA, the Department of Interior, and the Department of Housing and Urban Development. Issues being discussed by the

Committee include the Shoreland Damage Reduction Strategy of the Joint Federal Regional Council-Great Lakes Commission Task Force, the International Joint Commission's Great Lakes Levels Board report, shoreline recession rate measurement, and navigation in the Great Lakes. Coastal zone problems such as boundary delineation, determination of permissible uses, designation of areas of particular concern, and the determination of the authorities necessary for management are considered in workshops organized by the Committee. Federal agency guidelines for consultation and coordination during program development, and Federal agency review, are discussed at Standing Committee meetings.

7. ENVIRONMENTAL PROTECTION

Introduction

The processes of urbanization and industrialization have led to substantial deterioration in the quality of the aquatic environment of parts of the Great Lakes. Some regions, especially the near-shore areas, are contaminated with sewage and other organics, and with chemicals including pesticides, heavy metals and polychlorinated biphenyls (PCB's). In some parts of the lakes the content of mercury, DDT, and PCB's in fish exceeds the safe levels established by the Food and Drug Administration for interstate commerce. The situation in Lake Erie regarding over-enrichment with nutrients from industrial, agricultural and municipal wastes is well known, and the mining waste problem in Lake Superior from taconite processing has also been highly publicized.

Nearly all the Federal agencies working in the Great Lakes are involved in environmental protection, led by the Environmental Protection Agency. The others include the Energy Research and Development Administration; the Department of Interior (Fish and Wildlife Service, Geological Survey, Office of Water Resources Technology, Bureau of Mines, Mining Enforcement and Safety Administration, and Bureau of Indian Affairs); the U.S. Coast Guard; the Department of Commerce (NOAA's Environmental Data Service, Office of Sea Grant, and the Maritime Administration); the National

Aeronautics and Space Administration; the U.S. Army Corps of Engineers; the National Science Foundation; the Office of Naval Research; the Department of State; and the Water Resources Council.

Baseline studies and measurement of pollution

As a basis for environmental protection there is considerable activity in the collection of data on existing water quality, and on pollution problems in the Great Lakes. A research program is conducted by the Grosse Ile Laboratory of EPA to evaluate the impact of human activity on the Lakes, especially the behavior and the effect of pollutants. Studies are underway on water quality criteria and waste discharge control. The Grosse Ile Laboratory is particularly concerned with chemical and biological processes in southern Lake Huron and Saginaw Bay, and baseline studies are being concluded on Lake Erie. The Upper Lakes Reference Group of the IJC is concerned with the material balances and state of Lakes Huron and Superior. The data provided by these field studies will be used in the simulation of lake response to various waste loadings.

As part of the chemistry-biology program of the International Field Year for the Great Lakes (IFYGL), routine chemical analysis of water samples was performed at the Rochester Field Office of EPA to develop a better understanding of the material balance in lake waters. (See Section 4.)

Interior's U.S. Geological Survey collects data on water quality at many of its stream and groundwater stations, described

in Section 3. The amounts of chemical information collected varies. Some stations have been in operation for many years, permitting comparison and analysis of historic changes. Together with those of other Federal agencies and the States, the records provide a basis for studies of the complex system through which water moves and changes in character from the time it reaches the earth as precipitation until it reaches and passes through the lakes.

An Ocean Color Scanner (OCS) has been developed by NASA for coastal zone surveys from high altitude aircraft. The OCS is a breadboard version of the NIMBUS-G Coastal Zone Color Scanner scheduled to be flown on NIMBUS-G in late 1978. Field tests are being conducted by NASA's Goddard Space Flight Center in cooperation with the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the Corps of Engineers to evaluate this sensor in the detection, identification, quantification, and dispersal of pollutants, chlorophyll, algae blooms associated with eutrophication, and sediment from dredge and fill operations. (Also see Section 4.)

Using the LANDSAT satellites, NOAA's National Environmental Satellite Service conducts research on Great Lakes water quality through observations of algae concentrations in near-surface waters. Algae concentrations often exhibit extremely high contrast, and therefore make good tracers for surface circulation.

Remote sensing research is also supported by the EROS Program Office of the USGS, begun as part of the International Field Year for the Great Lakes. Through a contract with McMaster University, Hamilton, Ontario, scientists have analyzed groundwater and surface water distribution, lake circulation, soil moisture conditions, pollution loadings and dynamics in the Lake Ontario Basin, utilizing multispectral photography and imagery collected from NASA aircraft, and since 1972 from satellites.

A continuing study on western Lake Erie is being conducted by the Fish and Wildlife Service to determine the nature of the aquatic habitat, and measures required to preserve it.

A number of research projects on environmental studies are conducted by State groups with Federal support. EPA finances work by the Michigan Department of Natural Resources on nearshore water quality and on the biota of Lakes Superior and Huron, and by the Minnesota Pollution Control Agency on the nearshore water quality of Lake Superior. Other EPA-supported work includes studies on the chemical effects of red clays on western Lake Superior by the University of Wisconsin at Superior, and on persistent organic and heavy metal residues and red clay turbidity in western Lake Superior by the University of Minnesota. The Department of Environment, Canada has a contract with EPA to conduct Upper Great Lakes microbiological baseline studies, and to study the limnology of Lakes Superior and Huron.

The study of ecological effects of environmental pollutants in fresh water is a responsibility of EPA's National Water Quality Laboratory (NWQL) at Duluth, Minnesota. The laboratory is developing criteria to aid in the promulgation of water quality standards to protect freshwater animals and plants, and wildlife. NWQL develops the scientific information which serves as the basis for quality criteria for aquatic life. The Newtown Fish Toxicology Station, Cincinnati (Newtown), Ohio, a field station of the National Water Quality Laboratory, is working on the toxicity of complex effluents.

Interior's Office of Water Research and Technology supports projects in Illinois on the heavy metal accumulation in Lake Michigan, and in Michigan on the source of coliform organisms in northern Lake Michigan waters and the occurrence of coliform organisms from pristine streams.

Occurrence and fate of pollutants

There is considerable research being conducted on the occurrence, fate, and persistence of radioactive and heavy metal pollutants. The biogeochemical behavior of nuclear and non-nuclear energy effluents in the Great Lakes, including their pathways to man, are being studied under ERDA's Great Lakes Radioecology Program. Emphasis is placed on the long and short term behavior of plutomium and trace elements. Sedimentation, residence time of pollutants, and the distribution of plutonium in food chains

are being examined in the five lakes. Recent work in Lake Michigan has indicated that plutonium has a longer residence time than expected, suggesting that plutonium and other transuranics may be complexed by dissolved organic materials either through biological transformation or through physical-chemical mechanisms, and that the availability of transuranic elements to organisms may be modified as a result.

The Woods Hole Oceanographic Institution and ERDA's Division of Biomedical and Environmental Research are conducting a related project measuring plutonium and americum concentrations along freshwater food chains. The objective is to evaluate the significance of these elements in relation to public health and environmental quality.

The physical transport of hazardous materials and their biological-chemical transformations in the ecosystems is under study by EPA. The work includes the effect of nutrients in the growth of phytoplankton, and the rates and mechanics of exchange of chemicals between sediments and the water during the disposal of dredge spoil. Models will be developed of pollutant transport and effect.

The Department of Interior's Office of Water Research and Technology is funding a project in Ohio to investigate the transfer of heavy metal pollutants from Lake Erie bottom sediments to the overlying lake water.

Sewage pollution

The Coast Guard conducts research and development on marine sanitation devices, with particular emphasis on equipment for recreational boats, but also including Coast Guard vessels. The Maritime Administration is developing sewage treatment systems for 'lakes' ships which will meet stringent environmental standards. Several systems have been tested, including one in which sewage is put through a macerator, after which the effluent is treated with ozone and the remaining sludge is burned in the ship's boiler. The project is being carried out in conjunction with the Cleveland-Cliffs Company. Under this program, MARAD funds the fabrication of an ozone contact chamber by the Naval Ship Research and Development Center, Annapolis, Maryland, for installation on Great Lakes ore carriers.

Waste disposal systems with aeration ponds have been installed at the Grand Portage Indian Reservation (Minnesota) and are being constructed at the Red Cliff (Wisconsin) Bay Mills and L'Anse (Michigan) Indian Reservations with the advice and support of Interior's Bureau of Indian Affairs.

Pollution from power production

The rising power requirements in the Great Lakes region exert pressure to build more power plants. The effects of these on the aquatic environment may be profound, and a number of studies of their impact are being conducted. To provide a base for these, the

present environmental conditions of each of the Great Lakes is being assessed by ERDA, starting with Lake Michigan and its drainage basin and metropolitan areas. Cumulative impacts of existing uses, including power production, is measured in light of the present environmental conditions of the region, along with the effects of additional power plants. Another ERDA project examines analytical tools and data bases to assess public health and environmental problems associated with the production of energy. EPA's National Water Quality Laboratory at Duluth, Minnesota, provides guidance on the establishment of water quality criteria for effluent and receiving water and thermal discharges.

The choice of sites for power plants in relation to their effects on the environment is the subject of a study supported by NOAA's Office of Sea Grant.

A more reliable capability is being sought by ERDA for predicting the thermal fields surrounding submerged outfalls of power plants. This involves the measurement of thermal plumes from large operating plants having submerged discharges, the comparison of field measurements with examples from hydraulic model studies, and the creation of a numerical computer model capable of predicting the characteristics of such thermal plumes. The research is being conducted at two plants on Lake Michigan and three on Lake Ontario.

Interior's Fish and Wildlife Service is one of several agencies investigating the effects of cooling water and

pumped-storage water on fish and wildlife of the Great Lakes. Their activities include a measurement of the effects of nuclear plants on shallow-water nursery areas of important Great Lakes fishes, and the effects of temperature on Great Lakes fishes in relation to regulations for waste-heat discharges from power plants. ERDA supports FWS research on the effects of waste heat discharges on the local and migratory fish of Lake Michigan. Observations include the distribution and density of fish in thermal plumes under varying environmental and operational conditions, and the residence time and migratory behavior of fish relative to plume location. Body temperature changes and acclimation of fishes are being observed to assess thermoregulatory behavior and physiological performance of fish in relation to residence time in heated water.

Thermal effects on aquatic life are being studied in a semi-natural stream site built on the property of Northern States Power Company, and operated by the Monticello Field Station of EPA, in Minnesota.

Aquatic environmental effects created by coal and oil shale extraction and conversion are the focus of research efforts by EPA.

In support of the Great Lakes Extended Navigation Season Demonstration Program, the Fish and Wildlife Service is collaborating with the Corps of Engineers in a study of the biological effects of waste heat for ice suppression in Saginaw Bay.

The Fish and Wildlife Service reviews fish and wildlife aspects of applications for permits to construct and operate nuclear-fueled power plants, environmental statements relating to the number of power plants on the Great Lakes, and proposals for limiting heat input to Lake Michigan.

Pollution from land

Activities on land contribute to aquatic pollution, and are the focus of considerable study in the Great Lakes. The joint U.S.-Canada Land Use Reference Group Study, administered by the International Joint Commission, has been established in response to the Great Lakes Water Quality Agreement of 1972 to determine the extent of pollution by land drainage in boundary waters of the Great Lakes, and to recommend remedial measures. The Reference Group Study includes the assessment of impacts from land use activities on water quality, the inventory of current land use practices, population and other socio-economic characteristics, with projections to 1980 and 2020, and the survey of representative watersheds in the Great Lakes basin. The Reference Group includes participation by the EPA (Great Lakes Initiative Program) and the Department of Agriculture (Soil Conservation Service).

Task C of the Land Use Reference Group includes separate studies involving watersheds of the Great Lakes. The Menomonee River Watershed Study will determine the levels and quantities of major and trace constituents (including nutrients, pesticides and

sediments) in flow systems likely to reach Lake Michigan. It will define the sources and evaluate the behavior of pollutants associated with urbanization. The Felton-Herron Creek and Mill Creek Studies (Michigan State University) will determine the sources, forms and amounts of pollution reaching the Great Lakes due to liquid wastewater irrigation projects and fruit orchard operations. The Genessee River Pilot Watershed Study will determine quantitatively the effects of land use activities on surface water quality. The Maumee River Pilot Watershed Study will determine the effects of land use on the loss of sediment and nutrient from soils of the Maumee River Basin of Ohio, and the contribution of these to the discharge sediment and nutrients into Lake Erie. It will also determine the properties of soil colloids which affect the susceptibility of the soil to erosion and transport by streams, heavy metals concentrations, and the effects of sediment properties on phosphate absorption-desorption.

The amount and movement of groundwater pollution in a dolomite aquifer that extends lakeward beneath Lake Michigan is measured in a study by Interior's Geological Survey. Instrumentation for continuous monitoring of an increasing number of water properties and constituents at gauging stations is being improved, and these techniques are broadly applicable to studies involving wastes and waste disposal.

The National Science Foundation supports a study at Loyola University of Chicago on slag and slag-thermal effects on hatchability of Lake Michigan organisms.

Lake water is used in mining and milling operations at many places including inland sites such as the White Pine Mine south of Lake Superior, ten miles from the shore. Portions used in human consumption bear directly on the health of miners, and as a result testing of water quality constitutes part of Interior's Mining Enforcement and Safety Administration inspection and investigation activities. Work includes the analysis of Lake Superior water used in the Reserve Mining operations for human consumption, and studies of regional effects of plant wastes on public water supplies.

Pesticides and other chemicals

The effects of pesticides and other pollutants on fish and wildlife is of great concern, and much research effort is applied to these problems. Two of the Department of the Interior's Fish and Wildlife Service Laboratories in the Great Lakes region are involved in pesticide research, and a significant program is conducted by the FWS Minneapolis and Boston Regional Offices as part of the National Pesticide Monitoring Program. Activities include laboratory and field evaluation of pesticides for their effects on fish and wildlife, and collection of information required for registration of specific chemicals. The Fish Control Laboratory

of FWS at LaCrosse, Wisconsin, carries out research on registration of chemicals for fishery management, and evaluation of the hazards of pesticides to fish and the aquatic environment. Chemicals being studied include TFM (3-trifluromethyl-4-nitrophenol), Bayer 73 (2'5-dichloro-4'-nitrosalicylanilide)(a lamprey larvicide), and antimycin (a fish toxicant). The Great Lakes Fishery Laboratory at Ann Arbor, Michigan, conducts research on the amount of pesticides in Great Lakes fish, and on the evaluation of the effects of pesticides on fish.

The environmental impacts of a number of pollutants on freshwater organisms are being studied by EPA scientists. The pollutants include asbestos, chlorinated effluents, alternatives to chlorination as sewage effluent disinfectants, complex effluents, and heavy metals. Improvement of biological tests and culture techniques are being sought.

Grants to universities and other laboratories have been made by EPA for studies relating pollution to fish and the aquatic environment. These include chlorination and ozonation products of municipal sewage, and their environmental impact, analysis of the gas chromatography - mass spectometry characterizations of toxaphene in fish and water, the influence of turbidity on fish abundance in western Lake Superior, and the construction of models of plankton biomass in relation to eutrophication of the lakes.

Oil pollution

Local area surveillance systems have been created by the Coast Guard to detect spills of oil and other hazardous polluting materials in harbors and inland waters. The Coast Guard removes oil or hazardous substance discharges, or arranges for their removal, and responds to marine disasters in the navigable waters of the U.S. that create a threat of a pollution hazard due to a discharge from a vessel. A national level strike force and emergency task forces at major ports have been established.

Buoy-mounted and airborne oil surveillance systems are being developed. Studies are underway on the unique features of cold weather ice regions and changes in the characteristics of oil slicks now used for airborne detection of spills. Methods are being developed to detect and clean up oil pollution in ice conditions.

The U.S. Coast Guard and EPA are engaged in cooperative research to improve oil spill control and clean-up. The Coast Guard has developed containment booms and transfer pump systems which are air deliverable with C-130 aircraft. Recovery devices have been purchased for use by Coast Guard pollution Strike Force and other personnel. The EPA is researching beach clean-up techniques. A MARAD project is developing an oil-water separator that can be used aboard ships to make bilge and ballast discharges environmentally acceptable. Facilities for testing such oil-water

separators have been developed, and an oil-water flow loop is available for testing effectiveness of monitoring instruments for measuring oil-water discharges.

Under an agreement concluded between the United States and Canada, the U.S. Coast Guard and the Canadian Ministry of Transport maintain an international contingency plan for oil spills in the Great Lakes and elsewhere.

Dredging

Evaluations of harbor sediments to determine their suitability for open lake disposal are made by EPA, which reports on sediment quality in 115 Great Lakes harbors maintained by the Corps of Engineers. The Corps supervises and evaluates results of surveys performed on 20 critical harbors which may require diked disposal areas this year. This disposal program has provided 47 diked areas to contain polluted dredged material from the 65 Great Lakes harbors classified as polluted.

Interior's Fish and Wildlife Service reviews harbor and channel dredge projects of the Corps of Engineers, and advises the Corps on spoil and dump locations. It has a continuing project to study the channels between Lakes Huron and Erie to determine the impact of Corps of Engineers construction projects on fish and wildlife. The Service maintains a surveillance system to identify construction activities in navigable waters of the lakes that are damaging to fish and wildlife habitats. The Great Lakes Fishery Laboratory carries out research on dredging turbulence in St. Mary's River.

Air-water pollution

Methods are needed to assess atmospheric transport and dispersion climatology in the special boundary and stability conditions peculiar to offshore coastal sites for power plants. Southern Lake Michigan is being examined with regard to the turbulent dispersive properties of the lower atmosphere over open water. The information obtained can be used to describe the behavior of atmospheric pollutants moving along trajectories over the Great Lakes, and also as a model for predicting the dispersive properties in the lower atmosphere over the oceanic waters of the continental shelf. Also in the area of atmospheric transport of pollutants, EPA supports a study at Pennsylvania State University on air-to-water pollution, and Interior's Office of Water Research and Technology funds a study in Illinois on the atmosphere as a source of lead contamination in Lake Michigan.

Water quality management and data sources

The Federal Water Pollution Control Act requires a threefold thrust of water quality management planning. The coordination of these planning activities is the responsibility of EPA. A state's plan must provide a strategy for water clean-up program, implementation programs and schedules for discharges, and priorities for implementation and establishing the institutions required. The second area is metropolitan or areawide planning. Most of the urbanized areas have some form of regional planning, and by working

with the responsible agencies EPA promotes the development of population, economic and land use information on which regional water quality management plans can be used. The third area is the development of plans for construction projects. Cost effectiveness and environmental evaluation of the proposals are emphasized.

EPA's Region V has a program of Data Management which archives, analyzes, and distributes data. The major source of the data is from water quality monitoring, including intensive surveys, evaluation of water quality with respect to standards, toxic pollutant monitoring, and classification of publicly-owned freshwater lakes by eutrophic conditions.

NOAA's GLERL is developing and testing a number of simulation and prediction models that will assist in establishing a scientific basis for the development and utilization of Great Lakes resources without impairing the water quality. Tasks include a study of Maumee Bay, a phosphorus model, a lake-scale water quality model, and an atlas of Lake Ontario physical properties as defined by IFYGL. In the Maumee River Basin Level B Study, a multi-state and multi-agency program conducted through the Great Lakes Basin Commission, GLERL has the task of developing baseline conditions and trends for the Maumee Bay portion of the Lake Erie Basin, and of assessing impact of alternative management strategies on the bay and western Lake Erie.

A number of NOAA's Sea Grant-supported projects at the University of Michigan are involved with the development of an ecosystem model for Lake Michigan. This will be an important decision-making tool to guide the regulation of industrial and community activities around the Lake, enabling Federal, State, and local governments to predict the impact on water quality of alternative planning and pollution control proposals. The projects are directed toward collection of basic data for input to, and validation of model predictions and toward developing the model itself. Over forty Sea Grant-supported projects deal with the problems of environmental protection and quality in the Great Lakes, including water quality and management.

A study has been initiated by the U.S. Geological Survey in cooperation with the State of Wisconsin to develop computer models for waste-load assimilation in Wisconsin streams that receive sewage and empty into the Lakes.

Regulations and permits

Discharge of pollutants to waterways is controlled through the Refuse Act of 1899, which prohibits the discharge of refuse into U.S. navigable waters without a permit issued by the Corps of Engineers, and by the National Pollutant Discharge Elimination System (NPDES). A permit must be obtained by point source dischargers, including industrial, municipal, commercial and agricultural activities. The Federal Water Pollution Control Act (FWPCA)

requires the achievement of best practicable control technology currently available by July 1, 1977, and the achievement of best available control technology by July 1, 1983. Where regulations have not yet been designated by EPA to prevent discharges of oil and hazardous substances from vessels and transportation-related facilities, these are issued by the Coast Guard. The Coast Guard also issues regulations governing marine sanitation devices, based on the Environmental Protection Agency standards for sewage discharges from vessels.

The discharge and dumping of pollutants through outfalls is regulated by EPA through the issuance of permits specifying conditions under which such discharges may be made. This program may be operated by the States if they meet the requirements set forth in the Act, including compatible legislation and the intent to prepare NPDES permits which comply with the requirements. Thus far, Michigan, Wisconsin, Ohio and Minnesota and Indiana have been granted authority to issue NPDES permits. Illinois, Pennsylvania and New York have requested authority to operate the NPDES permit program.

The Army Corps of Engineers specifies the conditions under which discharge permits for protection of navigation and anchorages can be issued. Federal and State permits are required prior to the construction of any work in navigable waters of the United States. Federal permits are issued by the Corps of Engineers only after a

state permit or waiver thereof has been obtained. The Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) of NOAA screen discharger permit applications and recommend necessary modifications to ensure protection of aquatic resources. FSW and NMFS review environmental impact statements which impact upon fisheries resources and on the ecosystems.

The Coast Guard inspects facilities and vessels in the U.S. navigable waters for compliance with the Pollution Prevention Regulations. The Coast Guard reviews State-issued discharge permits to ensure that anchorage and navigation of navigable waters is not impaired, and that permits issued for the discharge of pollutants from a vessel are consistent with Coast Guard regulations.

Coordination

The International Joint Commission, in administering the programs developed under the United States-Canada 1972 Great Lakes Water Quality Agreement, represents the primary mechanism for the coordination of research, development and management programs related to environmental protection. This is accomplished through various committees and reference groups. The Commission established a Great Lakes Water Quality Board to act as its principal advisor with regard to these responsibilities, and a Research Advisory Board to review the research activities concerning Great Lakes water quality.

The Water Quality Board currently administers two technical studies: the International Reference Group on Land Use Activities investigates the impact of land use on the lakes' water quality, and the International Reference Group on Upper Lakes Pollution is conducting research on pollution problems specific to Lakes Huron and Superior. These responsibilities and activities of the IJC are described in Section 8 of this report.

In the United States, implementation of the Water Quality Agreement rests largely with EPA, under the authority of the Federal Water Pollution Control Act. The EPA Great Lakes program is administered through the Office of the Great Lakes Coordinator in Region V (Chicago), and assistance is provided by Regions II (Rochester) and III (Philadelphia). Program objectives are to provide a coordinated approach to understanding and solving water quality problems of the Great Lakes. The program to provide technical support to the International Joint Commission (IJC) predates the Great Lakes Water Quality Agreement.

NOAA's Great Lakes Environmental Research Laboratory (GLERL) supports EPA on the IJC Upper Lakes Pollution Reference Group by a series of physical and chemical limnology studies; e.g., (1) Lake Huron and Saginaw Bay Current Studies, (2) Lake Superior Current Studies, and (3) flux between Lake Michigan and Lake Huron. A GLERL research project on the physical-chemical properties of the Detroit River, Lake St. Clair, and the St. Clair River also supports this IJC activity.

An International Working Group on the Abatement and Control of Pollution from Dredging Activities was established as a result of the Water Quality Agreement to review existing dredging practices and regulations. The task of the Group is to develop criteria for the characterization of polluted dredged spoil, and to make recommendations governing the disposal of polluted dredged spoil in open waters.

The Army Corps of Engineers' Lake Erie Wastewater Management Study will develop a program to enhance the water quality of that lake. A preliminary feasibility report will be completed in FY'76 Contacts with Canadian authorities are maintained through the U.S. State Department and the International Joint Commission.

EPA participates in Federal and State water resources planning activities to insure that water quality, water supply, and environmental programs are incorporated into planning documents and project reports. The section represents EPA on Great Lakes Basin Commission committees, on Regional Council Task Forces, and at other special meetings which prepare and review interagency plans. EPA assists in the development of an overall coordinated monitoring program with Canada, Federal agencies and States through the auspices of the Great Lakes Water Quality Board of the IJC.

The Department of Interior's Fish and Wildlife Service cooperates with the Army Corps of Engineers in a study of the biological effects of waste heat for ice suppression in Saginaw Bay, and

Interior's Bureau of Outdoor Recreation (BOR) provides technical assistance and outdoor recreation expertise to the Corps for evaluating project proposals and preparation of feasibility reports relating to harbor and river mouth dredging projects on the Great Lakes. BOR also reviews official project proposals and environmental impact statements regarding the above projects. BOR provides planning assistance to the Corps for their use in evaluating and selecting potential locations for refuge harbors.

The National Aeronautics and Space Administration (NASA) maintains close working relationships with Federal agencies having responsibilities for the Great Lakes' coastal environment, and the regulation of man's activities there. These agencies play an active role in the planning, conduct, and evaluation of NASA's research on the development, field testing, and evaluation of remote sensors for surveying the quality of the coastal zone environment. NASA may conduct special programs at the request of other agencies, and in some instances the Congress has specifically mandated other agencies to seek assistance from NASA. For example, in the Federal Water Pollution Control Act of 1972, the Administrator of the Environmental Protection Agency is charged with establishing "national programs for the prevention, reduction and elimination of pollution, and as part of the program shall ... establish, equip, and maintain a water quality surveillance system ... conduct such surveillance by utilizing the resources of the NASA, NOAA, USCG ..."

A project being conducted by the national laboratories of the Environmental Research and Development Administration (ERDA), entitled "Planning and Development of a Coordinated Scope for an Energy-Related Regional Studies Program" is examining analytical tools and data bases to develop a coordinated Regional Studies Program.

The Office of Coastal Zone Management is responsible for insuring that States participating in coastal zone management programming consult with and consider the views of Federal agencies. This is important since the Coastal Zone Management Act of 1972 requires that Federal agencies conduct their activities in a manner consistent with approved State management programs. (Also see Section 7.)

To minimize damage caused by pollutants discharged into water, the Coast Guard has established a National Response Center to provide coordination, and has established regional response centers. The National Response Center, manned by Coast Guard personnel on a 24-hour basis at U.S. Coast Guard Headquarters, receives and coordinates information and provides advice on oil and other hazardous chemical spills. The data are fed into the Pollution Incident Reporting System, and call-out of data is available in a variety of formats. Toll free calls may be made to the Center to report spills from anywhere in the lower 48 states.

8. COORDINATING MECHANISMS

Introduction

The achievement of program objectives in the complex and many-faceted Federal activities in water-related research, development and management in the Great Lakes region requires a high degree of inter-communication among the participants. This need has been responded to by the creation of a number of formal coordinating mechanisms, by numerous less formal devices, including conferences and scientific symposia, and by frequent communication among agency planners and researchers. In this section the more important of these coordinating mechanisms are described. The agencies involved in each are listed.

International cooperation is essential in the Great Lakes region. The United States-Canadian border bisects four of the five Great Lakes, (all except Lake Michigan) so that their resources and problems, and the research to solve these problems must be shared by the two countries. The principal inter-Governmental agencies created to promote U.S.-Canadian cooperation are the International Joint Commission and the Great Lakes Fishery Commission. The Great Lakes Basin Commission represents the principal mechanism through which U.S. Federal, State, regional and local programs are coordinated. Basin Commission meetings are attended by official Canadian Federal and Provincial government representatives. The

Federal Regional Council is a principal coordinating mechanism for U.S. Federal programs.

International Joint Commission (IJC)

The International Joint Commission was established in 1912 under authority of the Boundary Waters Treaty of 1909. The Treaty gives the Commission two kinds of responsibilities. It has certain regulatory powers including approval of applications for use, obstruction or diversion of waters on either side of the boundary which would affect the natural level or flow of the boundary waters on the other side. Secondly, the Commission is responsible for investigating and making recommendations for resolving specific problems referred to it by either or both of the two governments. In studying water problems of the Great Lakes, IJC is supported by U.S. Federal agencies through participation on various boards, working groups and committees, and through direct funding of program activities under IJC administration. The organizational structure instituted by the IJC to implement its Great Lakes programs, including those developed under the 1972 Water Quality Agreement, is shown in Figures 2 and 3. Participation by U.S. Federal agencies in IJC programs is outlined below.

In response to long-standing concerns over pollution in boundary waters, in 1964 the U.S. and Canada requested the Commission to investigate the extent of pollution in Lakes Erie and Ontario, and to make recommendations for remedial action. The U.S. and Canada

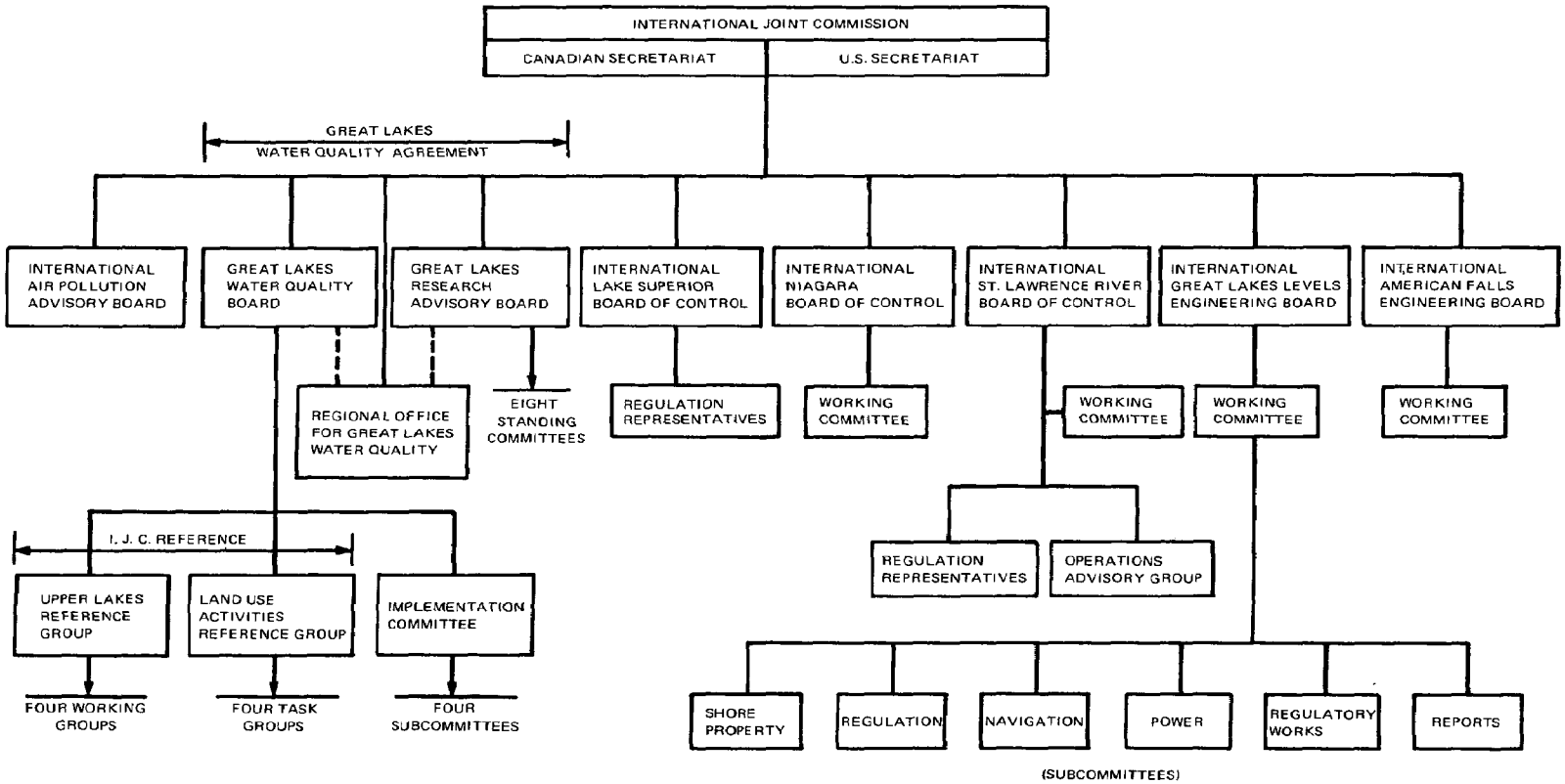

FIGURE 2: ORGANIZATIONS UNDER THE INTERNATIONAL JOINT COMMISSION

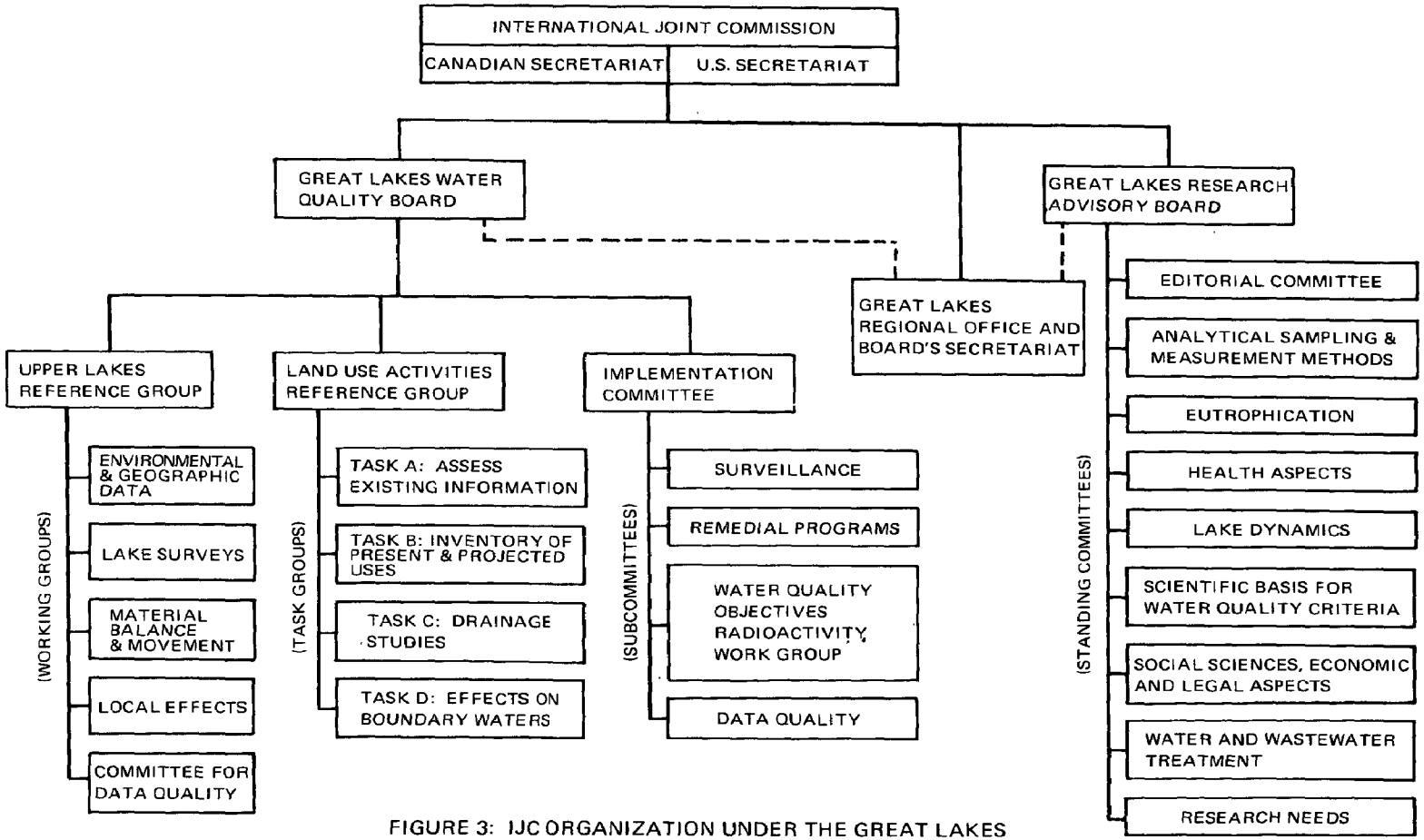

FIGURE 3: IJC ORGANIZATION UNDER THE GREAT LAKES WATER QUALITY AGREEMENT OF 1972

relied heavily on the IJC's investigation and report in negotiating the Great Lakes Water Quality Agreement signed in 1972. The Agreement largely reflects the IJC's recommendations. It sets forth water quality objectives, and outlines remedial programs designed to achieve these objectives.

Under the Water Quality Agreement the IJC is responsible for the collection, analysis and dissemination of data supplied by participating Government agencies relating to the quality of the boundary waters, and to pollution entering from the tributaries. The Commission is also responsible for advising the governments annually concerning water quality objectives, legislation, standards, regulatory requirements, programs and inter-governmental agreements. The Commission assists in coordinating joint activities. These responsibilities are carried out through the Great Lakes Water Quality Board and the Great Lakes Research Advisory Board. Coordination between the boards on pollution activities is accomplished through the IJC Regional Office for Great Lakes Water Quality.

The Great Lakes Water Quality Board is responsible for the implementation of programs initiated under the 1972 Agreement. U.S. participants include the Environmental Protection Agency (Chairman) and representatives of the eight Great Lakes States. The IJC's Regional Office for Great Lakes Water Quality provides the secretariat for the Board. The Implementation Committee assists in the preparation of the Water Quality Board's annual report, and

provides direction to four subcommittees. The U.S. section of the Implementation Committee is composed of representatives of the EPA (Region V), and several Great Lakes States.

Four subcommittees of the Implementation Committee provide technical expertise for the water quality programs. U.S. participation is as follows:

1. Surveillance Subcommittee - EPA (Surveillance and Analysis Division, Rochester Field Office and Grosse Ile Laboratory), representatives of five Great Lakes States.
2. Remedial Programs Subcommittee - EPA (Office of Great Lakes Coordinator, and the Rochester Field Office), representatives of five Great Lakes States.
3. Water Quality Objectives Subcommittee - EPA and representatives of seven Great Lakes States. The Department of Agriculture's Soil Conservation Service has ex-officio membership. The Water Quality Objectives Subcommittee has established a Radioactivity Work Group, with representatives from EPA's Criteria and Standards Division and three Great Lakes State agencies.
4. Data Quality Subcommittee - EPA (Quality Assurance Office) representatives of the eight Great Lakes States, and a representative of the IJC.

The Great Lakes Water Quality Board also administers the International Reference Group on Great Lakes Pollution from Land Use Activities, established to determine the extent of pollution by land drainage in boundary waters of the Great Lakes System, and to recommend remedial measures. U.S. participants are the Department of Agriculture (Soil Conservation Service), EPA (Surveillance and Analysis Division), and seven Great Lakes States.

The Land Use Reference Group has established four Task Group Committees, each comprised of Canadian and United States sections.

A second major program administered by the Great Lakes Water Quality Board is the Upper Lakes Pollution Reference Group which is responsible for an investigation of pollution in Lakes Superior and Huron. The U.S. Section consists of EPA (Surveillance and Analysis Division), the Departments of Commerce (NOAA - NMFS) and Interior (Fish and Wildlife Service, Great Lakes Fishery Laboratory), and four State agencies.

Administrative support for the Upper Lakes Reference Group is provided by the Coordinating Committee; the U.S. Section of the Committee is composed of representatives of the EPA (Surveillance and Analysis Division, Great Lakes Surveillance Branch and the Grosse Ile Laboratory), and the Michigan Department of Natural Resources.

Technical support for the Upper Lakes Reference Group is provided by the Committee for Data Quality, and its four Working

Groups. The committee is chaired by a representative of EPA's Central Regional Laboratory; U.S. membership is from the Department of Commerce (NOAA-GLERL), EPA's Grosse Ile Laboratory, three Great Lakes State institutions and the University of Michigan.

The four Working groups of the Committee, with U.S. section membership, are:

Working Group A - Environmental and Geographical Data Acquisition and Analysis: EPA (Surveillance and Analysis Division), the States of Minnesota, Wisconsin and Michigan.

Working Group B - Lake Surveys. EPA (Great Lakes Surveillance Branch, the Grosse Ile Laboratory, Region V) the Departments of Commerce (NOAA - GLERL), and Interior (FWS, Great Lakes Fishery Laboratory).

Working Group C - Material Balance and Movement. EPA (Grosse Ile Laboratory), five Great Lakes States agencies.

Working Group D - Local Effects. EPA (Grosse Ile Laboratory and the Surveillance and Analysis Division), and three state agencies.

The Great Lakes Research Advisory Board reviews the research activities concerning Great Lakes water quality. The Board is the principal advisor to the Commission on water quality research needs and the dissemination of research information. The U.S. Section of the Research Advisory Board is composed of representatives from the Department of Commerce (NOAA), EPA, universities and a member

of the community at large, presently a representative of the Cleveland Citizens for Clean Air and Water Inc.

The Board is supported by nine standing committees; the U.S. Federal representation on these committees consists of:

1. Editorial Committee - EPA (Grosse Ile Laboratory) - Chairman.
2. Analytical Sampling and Measurement Methods Committee - EPA (National Environmental Research Center, Cincinnati - Chairman, and the Surveillance and Analysis Division, Region V, Chicago).
3. Eutrophication Committee - EPA (Pacific Northwest Environmental Research Laboratory).
4. Health Aspects Committee - EPA (Office of Research and Development, and the National Environmental Research Center, Cincinnati).
5. Lake Dynamics Committee - no Federal representation.
6. Committee on the Scientific Basis for Water Quality Criteria - EPA, - Chairman, Department of Commerce (NOAA - GLERL).
7. Social Sciences, Economic and Legal Aspects Committee - Department of Commerce (Bureau of Economic Analysis).
8. Water and Wastewater Treatment Committee - EPA (Advanced Waste Treatment Research Laboratory).
9. Research Needs Committee - Department of Commerce (NOAA - GLERL).

A continuing program of the Research Advisory Board is the production of the Directory of Great Lakes Research Activities; this was initiated in 1975 and will be updated on an annual basis.

The International Working Group on the Abatement and Control of Pollution from Dredging Activities was established under the Great Lakes Water Quality Agreement to mitigate the effects of polluted dredge spoil. U.S. Federal participants in this Working Group include the EPA (Field Operations, and Permit Assistance and Evaluation Division), the Army Corps of Engineers (North Central Division), the Department of Interior (FWS - Division of Ecological Service), and agencies from three Great Lakes States. Their work and efforts are subject to IJC review and comment.

Through the IJC, Canada and the U.S. maintain the Advisory Sub-Group on the Objectives for Radioactivity in the Great Lakes, composed of Canadian Federal and Provincial agencies, and the Ad-Hoc Radioactivity Objectives Committee, composed of U.S. Federal, State and municipal agencies, including the EPA (Criteria and Standards Division), and ERDA. The IJC reviews and comments upon the work and the reports of these groups.

The natural fluctuations in Great Lakes water levels have resulted in extremes of stage, with adverse effects. The International Great Lakes Levels Board (IGLLB) was established by the International Joint Commission in 1964 to assist in an investigation requested by the Governments to determine the factors

affecting fluctuation of Great Lakes water levels, and to determine the feasibility of further regulation of the Lakes. U.S. Federal participants in the IGLLB include the Army Corps of Engineers, the Federal Power Commission, and the St. Lawrence Seaway Development Corporation. The study was coordinated through the Board's Working Committee and six subcommittees. The IGLLB report has been completed, and the Commission will soon make its final report to the Governments.

U.S. Federal participation in the Working Committee is by the following agencies: the Departments of Interior and Commerce (NOAA - Lake Survey Center), the Army Corps of Engineers, Federal Power Commission, and the Department of Transportation (St. Lawrence Seaway Development Corporation). The subcommittees, with U.S. membership, are:

1. Shore Property Subcommittee - Corps of Engineers, Departments of Interior (FWS) and Commerce (NOAA - NMFS), EPA.
2. Regulation Subcommittee - Corps of Engineers and Department of Commerce (NWS).
3. Navigation Subcommittee - Departments of Commerce (MARAD), and Interior (BOM), Army Corps of Engineers and Department of Transportation (St. Lawrence Seaway Development Corporation).

4. Power Subcommittee - Department of Interior, Corps of Engineers and the Federal Power Commission.

5. Regulating Works Subcommittee - Army Corps of Engineers.

6. Reports Subcommittee - Army Corps of Engineers.

The Commission maintains four other Boards of Control to administer specific projects.

The International Lake Superior Board of Control and the International St. Lawrence River Board of Control assure that the levels and outflows of Lake Superior and Lake Ontario respectively are controlled as far as possible to benefit navigation, power production and other water related interests. The Army Corps of Engineers participates in both Boards of Control; the Federal Power Commission and the St. Lawrence Seaway Development Corporation are the other U.S. Federal agencies involved.

The International American Falls Engineering Board was established to assist the Commission to investigate means of preserving the beauty of the American Falls. U.S. Federal participation was by the Army Corps of Engineers. The Commission submitted a report to the Governments in July, 1975.

The International Niagara Board of Control supervised construction, maintenance and operation of earlier remedial works. It investigates erosion at Niagara Falls, and through power diversions reports on water availability for hydro-electric production. The Army Corps of Engineers and the Federal Power Commission are the U.S. Federal agencies involved.

Great Lakes Fishery Commission (GLFC)

The Great Lakes Fishery Commission was established in 1955 to coordinate fishery management programs in the Great Lakes, including control of the parasitic sea lamprey. The functions of the Commission include formulating and coordinating fishery research programs, advising State, Provincial and Federal governments on measures to improve the fisheries, and implementing a lamprey control program.

The Commission is composed of four members each from Canada and the United States. To promote coordination of the planning and execution of research programs, the Commission has established technical committees for each of the Great Lakes, made up of senior officials from fisheries agencies in the U.S. and the Province of Ontario, with advisors from Federal agencies and local institutions.

The Commission is advised by four committees: The Scientific Advisory Committee, the Sea Lamprey Control and Research Committee, the Management and Research Committee, and the Finance and Administration Committee.

The Commission's sea lamprey control and research program is carried out under contract with the U.S. Fish and Wildlife Service and the Canadian Department of Environment. Programs are supported by joint funding from the two governments (69 percent from the United States and 31 percent from Canada).

The Commission relies on Federal, State, and Provincial agencies to provide the information on which to base recommendations for fishery management, but occasionally it awards contracts for special studies to private or university research groups.

The Commission conducts its official business, including the submission of recommendations and requests for funds, through the Department of State for the United States section.

Great Lakes - St. Lawrence Seaway Navigation Season Extension Program

Members of the U.S. Department of State, the International Joint Commission, the Great Lakes Basin Commission and the Canadian St. Lawrence Seaway Authority participate as observers on the Winter Navigation Board of the Navigation Season Extension Program, providing a degree of international coordination along with the Board's extensive coordination of Federal, State, regional and local agencies. A description of the Navigation Season Extension Program is included in Section 2. The Federal agencies involved are shown in the organization chart (Figure 4) by agency assignment. Programs initiated by the Board are coordinated through the Working Committee, which provides guidance to work group activities undertaken in support of the NSE program.

International Field Year For The Great Lakes (IFYGL)

The International Field Year for the Great Lakes (IFYGL) program is described in Section 4. This program has developed an

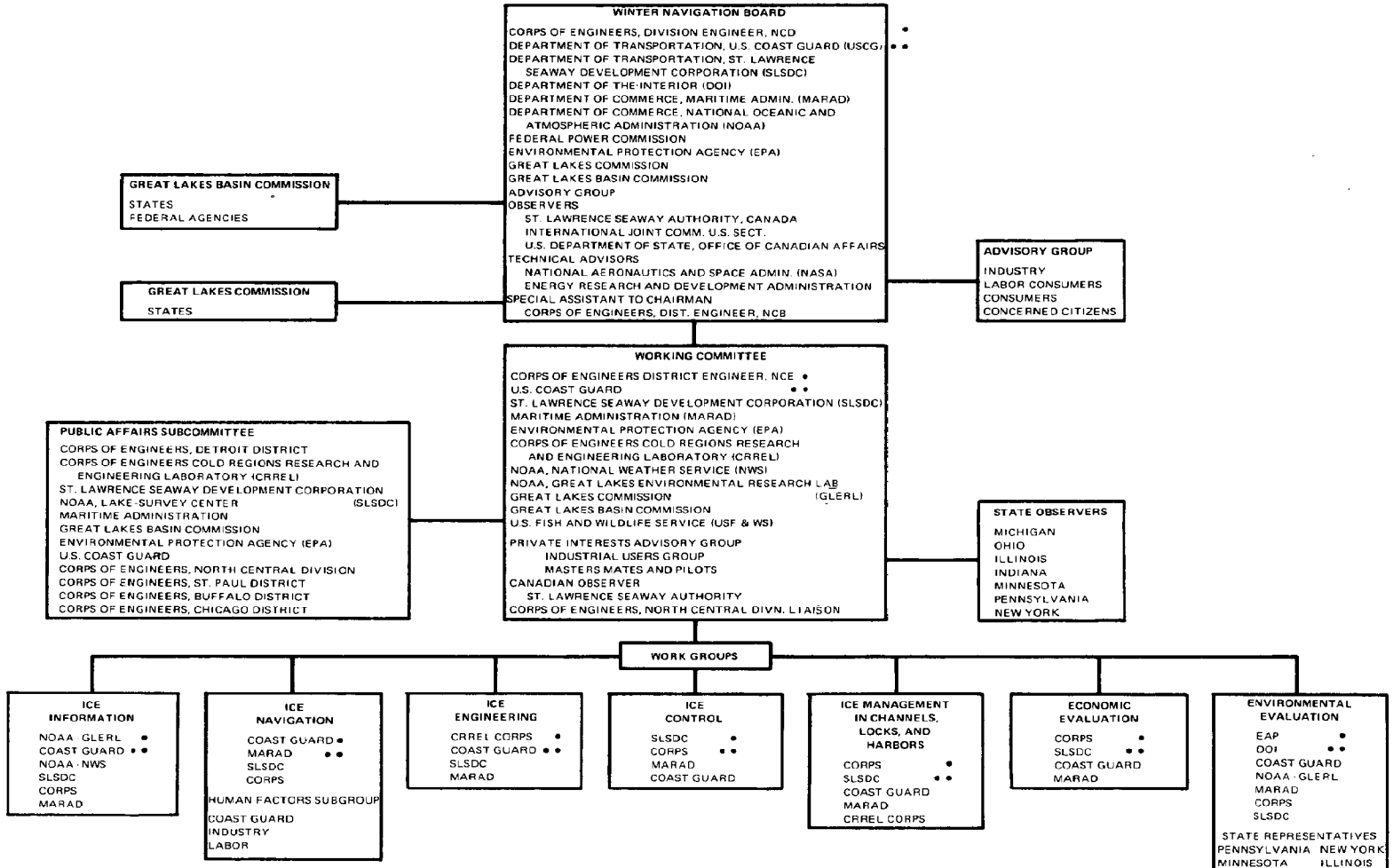

FIGURE 4. ORGANIZATION CHART — GREAT LAKES-ST. LAWRENCE SEAWAY NAVIGATION SEASON EXTENSION PROGRAM

SOURCE: Third Annual Report, Great Lakes-St. Lawrence Seaway Navigation Extension Demonstration Program, the Great Lakes-St. Lawrence Seaway Winter Navigation Board

• LEAD AGENCY OR CHAIRMAN
• • VICE CHAIRMAN

effective means of coordinating limnological research and development on Lake Ontario. Participation in IFYGL activities include both Canadian and United States agencies, with U.S. programs coordinated by NOAA's International Field Year Project Office.

Federal participation in IFYGL programs included the Army Corps of Engineers, National Aeronautics and Space Administration, Environmental Protection Agency, and several components of the Departments of Interior, Commerce, State and Transportation. Following the completion of data acquisition, the staff and programs of the Field Year Project Office were combined with the Great Lakes research program and staff of the Limnology and Computer Divisions of the Lake Survey Center (NOAA - NOS) to form the Great Lakes Environmental Research Laboratory of the National Oceanic and Atmospheric Administration (NOAA).

Under this new arrangement, IFYGL retains its Joint Steering Committee, composed of representatives of the Environmental Protection Agency (Region V) and the Department of Commerce (NOAA - GLERL), with ex-officio and liaison membership by the National Committee for the International Hydrological Decade, the Army Corps of Engineers, and the Great Lakes Basin Commission. The U.S. Coordinator for IFYGL resides in the Great Lakes Environmental Research Laboratory (NOAA), and works directly with the Joint Steering Committee.

Overall program management of the remaining IFYGL projects is through the Joint (U.S.-Canadian) Management Team, with the Department of Commerce (NOAA - GLERL, EDS) and the EPA comprising the U.S. Section. To facilitate completion of data analysis and interpretation, seven Scientific Program Panels are maintained. The agencies represented on these panels are:

Terrestrial Water Balance; Corps of Engineers, Department of the Interior (U.S. Geological Survey), Department of Commerce (NOAA - National Weather Service, Lake Survey Center), Center for the Environment and Man (CEM).

Lake Meteorology; Department of Commerce (NOAA - National Weather Service, Center for Experimental Design and Data Analysis), Center for the Environment and Man, and the University of Miami.

Water Movements; Department of Commerce (National Oceanic & Atmospheric Administration - GLERL), and the Universities of Michigan, Wisconsin, Woods Hole Oceanographic Institution, and the State University of New York at Albany.

Biology and Chemistry; Environmental Protection Agency, Department of the Interior (Great Lakes Fishery Laboratory), the New York State Department of Environmental Conservation, and the Universities of Michigan, Wisconsin and State University of New York at Buffalo.

Atmospheric Boundary Layer; Department of Commerce (NOAA - Environmental Research Laboratory, Center for Experimental Design and Data Analysis), and the Universities of Washington, Miami and Nevada.

Evaporation Synthesis; Corps of Engineers, Department of Commerce (NOAA - GLERL), ex-officio membership by chairman of other Scientific Program Panels.

Energy Balance; Department of Commerce (NOAA - Lake Survey Center), Center for the Environment and Man, and the Universities of Michigan, Wisconsin and California.

Great Lakes Basin Commission

The Great Lakes Basin Commission (GLBC) was created under the authority of the Water Resources Planning Act of 1965, Public Law 89-80. Its object is to promote cooperation among Great Lakes States and Federal Government agencies engaged in research and development on water and water related resource problems of the region. The Commission is charged by law with the coordination of planning activities for water and related land resources throughout the Great Lakes Basin, and fostering studies necessary to this activity. In addition, the Commission is responsible for the recommendation of long-range priorities for research investigations, including the collection and analysis of basic data, and for the development of projects.

Eleven Federal agencies participate in Commission activities, including the Federal Power Commission, the Army Corps of Engineers, the Environmental Protection Agency, and the Departments of Agriculture, Commerce, Health, Education and Welfare, Housing and Urban Development, Interior, Justice, State and Transportation. In addition, the eight Great Lakes States and the Great Lakes Commission are members of the GLBC.

The GLBC has established a number of committees, working groups and task forces to address specific aspects of coordinated, basin-wide resource management programs.

The Task Force on Comprehensive Coordinated Joint Plan (CCJP) fulfills the requirement of the implementing legislation that the Commission prepare a comprehensive, coordinated joint plan for public and private development of water and water-related resources. The CCJP is to include an evaluation of all reasonable alternative means of achieving optimum development of water and related land resources of the Basin, and recommendations with respect to individual development projects.

Federal representation on the CCJP are the Departments of Commerce (NOAA - GLERL), Agriculture (Soil Conservation Service), HUD (Region V), the Army Corps of Engineers (North Central Division), and the EPA (Air and Water Programs Division).

The Task Force on Organization Policy includes the Departments of Agriculture (Soil Conservation Service), Interior (North Central

Division), and State, the Army Corps of Engineers, EPA (Office of the Regional Director), and representatives from five Great Lakes States.

Standing committees maintained within the Basin Commission include:

Transportation: ERDA (Division of Transportation Systems), the Army Corps of Engineers (North Central Division), the St. Lawrence Seaway Development Corporation (Office of Comprehensive Planning), the Departments of Agriculture, Commerce (MARAD - Ports and Water Resources), and Transportation (U.S. Coast Guard and the Office of the Secretary). The eight Great Lakes States, the Great Lakes Commission, and the Lake Carriers Association participate in committee activities.

Plan and Program Formulation: The Corps of Engineers, the Great Lakes Commission, Federal Power Commission, St. Lawrence Seaway Development Corporation, Environmental Protection Agency (Water Division, and Division of Planning), the Departments of Interior (Bureau of Outdoor Recreation), Agriculture (Soil Conservation Service), Commerce (NOAA - GLERL), Justice (Land and Natural Resources Division), Housing and Urban Development, and eight Great Lakes States.

Budget and Staffing: The Army Corps of Engineers, the Departments of Agriculture and the Interior, and four State agencies.

Coastal Zone Management: EPA (Air and Water Programs Division), the Army Corps of Engineers (North Central Division), the Departments of Commerce (NOAA - GLERL) and the Interior, and eight Great Lakes States.

Framework Study Executive Committee: A principal task of the Great Lakes Basin Commission has been that of generating a framework on which to base the legally assigned "comprehensive, coordinated, joint plan." The Great Lakes Basin Framework Study identifies water and related land resource problems, and projects these for the years 1980, 2000, and 2020. The needs for water resource development are appraised and the effects of land use on projected water resources availability, management, and development are evaluated. The Framework Study is designed to reach conclusions as to the urgency of water and related land problems and recommend priorities for more detailed studies. The Framework Study includes an inventory of water and related land resources in the Basin, an analysis of projected needs for these resources for the next 50 years, and recommendations for measures to meet these requirements.

Federal participation on the Executive Committee includes representation by the Departments of Agriculture (Chairman) and Interior, the Army Corps of Engineers and the U.S. Environmental Protection Agency.

Agency participation in the Framework Study include the Army Corps of Engineers, Environmental Protection Agency (Water Supply Section, and the Air and Water Programs Division), the Great Lakes Fishery Commission, Federal Power Commission, Housing and Urban Development, (Bureau of Community Environmental Management), the Departments of Interior (U.S. Geological Survey, U.S. Bureau of Mines, Fish and Wildlife Service, Field Representative), Agriculture (Soil Conservation Service, Forest Service, Economic Research Service, North Central Resources Group), Commerce (NOAA-NWS, GLERL, NMFS, NOS; MARAD; Office of Business Economics), Transportation (U.S. Coast Guard, St. Lawrence Seaway Development Corporation), academic institutions, regional and State government agencies, and private industry.

In response to a request by the States of Ohio, Indiana, and Michigan, the GLBC has initiated the Maumee River Basin Level B Study to describe the physical parameters of Maumee Bay, to determine the interrelationship among the bay, Lake Erie and the Maumee watershed, and to develop the management alternatives for the Maumee Basin. This study will contribute to the development of a basin-wide coordinated plan by affected local, regional,

State and Federal agencies for optimum management and development of water and related land resources in the Maumee Basin.

Program coordination is accomplished through the Maumee Steering Committee, composed of representatives from the Environmental Protection Agency (Planning Branch), the Army Corps of Engineers (Planning Branch), the Departments of Agriculture (Soil Conservation Service), and Interior (North Central Region), agencies of three Great Lakes States, and the Maumee Citizens Advisory Committee.

Plan development is accomplished through the Maumee Planning Board, composed of the Corps of Engineers, Environmental Protection Agency, the Departments of Interior (Bureau of Outdoor Recreation), and Agriculture (Soil Conservation Service), and three State management agencies. Technical expertise is provided the Board through an overall Study Committee represented by seven Federal agencies: the Federal Power Commission, Corps of Engineers, Environmental Protection Agency, and the Departments of Interior (Bureau of Outdoor Recreation, Fish and Wildlife Service, U.S. Geological Survey), Agriculture (Soil Conservation Service, Economic Research Service, Forest Service), Commerce (NOAA - Great Lakes Environmental Research Laboratory) and Transportation. The Board is provided with direct input from city, State and regional management agencies.

The Maumee River Basin Level B Study Committee is responsible for implementing the policies developed by the Maumee Steering Committee. Participants on the Study Committee include six Federal

agencies, (Department of Interior, Department of Agriculture, Corps of Engineers, Department of Commerce, Environmental Protection Agency, Housing and Urban Development), the GLBC representative, and representatives of city, State and regional government agencies.

Level B Study Element leadership is provided by Federal, State, and regional government agencies. Study elements and lead agencies, are:

Outdoor Recreation - Department of the Interior (Bureau of Outdoor Recreation)

Fish and Wildlife - Department of the Interior (Fish and Wildlife Service)

Flooding and Drainage - Corps of Engineers

Land Use, Erosion and Sedimentation - Department of Agriculture (Soil Conservation Service)

Water Quality - Environmental Protection Agency

Water Supply - Department of the Interior (U.S. Geological Survey)

Baseline Reference - Urban section - regional governments; Agricultural section - state government; Environmental section - State government; Maumee Bay - Department of Commerce (NOAA - GLERL)

The Basin Commission maintains two ad hoc Committees to assist in the evaluation of ongoing programs. The Ad Hoc Review Committee on IJC's IGLLB's Report on Regulation of the Great Lakes

Water Levels is staffed by representatives of Environmental Protection Agency, Army Corps of Engineers and nine State agencies. The Ad Hoc Review Committee for the Grand River Basin Framework Report includes the Corps of Engineers, Environmental Protection Agency (Air and Water Programs Division), the Departments of Agriculture (Soil Conservation Service) and the Interior (Bureau of Outdoor Recreation), and the Michigan Department of Natural Resources.

In support of the 1975 National Water Assessment Program of the Water Resources Council, the Great Lakes Basin Commission maintains the Great Lakes National Assessment Work Group. The objective of the Work Group is to identify regional demands on water resources, and to recommend regional and Federal programs necessary to accommodate future resource demand. The Work Group is represented by each Federal agency participating in the GLBC, as well as eleven State agencies.

Interagency Committee On Marine Science And Engineering (ICMSE)

The Committee was established under the auspices of the Federal Council for Science and Technology to provide an interagency mechanism for the coordination of marine sciences and engineering. The purposes of the Committee are (1) to insure the planning and coordination of Federal marine-related activities in science and engineering, (2) to identify and foster investigations in support of national priorities for marine science and engineering programs.

The Federal agencies represented on ICMSE include the Energy Research and Development Administration, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Smithsonian Institution, and the Departments of Commerce, Defense (Army Corps of Engineers, Navy), Health, Education and Welfare, Interior, State, and Transportation. In addition, a number of Federal agencies participate as observers to committee proceedings, including the Office of Management and Budget, the Council on Environmental Quality, the National Academies of Science and Engineering, and the Office of Water Research and Technology.

In recognition of the need for closer field level coordination among Federal agencies with research programs in the Great Lakes, ICMSE organized its first Federal Conference on the Great Lakes in December 1972. Sponsored by EPA, this conference provided for exchange of information on the research programs and objectives of each of the agencies. The Proceedings of this first conference were published through the Public Information Office of the Great Lakes Basin Commission. A second conference, held in March, 1975, at the Argonne National Laboratories, Argonne, Illinois, and sponsored by ERDA, examined the current status and future needs of research related to the assessment of the impact of energy conversion upon the Great Lakes. The central theme involved the sources, transport, and ecological effects of energy

effluents in the Great Lakes. The Proceedings of this conference are now under preparation by the Great Lakes Basin Commission. ICMSE presently has under preparation a directory of U.S. and Canadian agencies with programs in the Great Lakes.

Other mechanisms

In addition to the coordinating mechanisms described above, a number of formal and informal institutions effect varying degrees of program coordination.

The Council on Environmental Quality (CEQ) assists in the coordination of programs among Federal agencies which affect environmental quality, and advises the President and Federal agencies in achieving international coordination in programs related to environmental quality. The Council is engaged in programs dealing with water quality data analysis techniques and computer information systems which have application for Great Lakes research. In administering these programs, the CEQ coordinates with the EPA, ERDA, and the Departments of Interior (USGS, FWS) and Commerce (NOAA - NMFS).

The Lake Erie Wastewater Management Study was initiated by the Army Corps of Engineers in 1972 to recommend and implement a program of improvement for wastewater management in Lake Erie, with supporting design and engineering specifications. The Study's Interagency Technical Advisory Group (ITAG) provides technical advice and assists in program coordination among Federal and State

agencies. Participation on ITAG includes the EPA, the Great Lakes Basin Commission, the Departments of Agriculture (Soil Conservation Service), Commerce (NOAA - GLERL), HEW, HUD, Interior, Justice, State (Office of Canadian Affairs), and Transportation (Coast Guard), and representatives of five Great Lakes states.

The Work Group for Federal Cooperation in Monitoring the Great Lakes was established by the Surveillance and Analysis Division of the Environmental Protection Agency in 1974 to assist in the coordination of programs within Federal agencies related to data acquisition and analysis. Agencies involved are the Army Corps of Engineers, the Energy Research and Development Administration (Argonne National Laboratory), NASA, the Departments of Interior (USGS), Commerce (NOAA) and Transportation (Coast Guard).

The Water Resources Council is an independent Federal entity which encourages the conservation and utilization of water and related land resources. The coordinating functions in the Great Lakes are accomplished principally through the Great Lakes Basin Commission in support of Great Lakes water and related programs. Federal members are the Departments of Interior, Agriculture, Army, HEW, and Transportation, and the Federal Power Commission. Other participants are the Departments of Commerce and HUD, EPA, Justice, OMB, CEQ and the River Basin Commission.

The Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data is an international organization which coordinates

hydraulic and hydrologic data and studies related to the Great Lakes and their connecting rivers, in respect to river flow, vertical control and lake level, and physical data. U.S. representatives in the Committee are the Army Corps of Engineers and NOAA (NOS -LSC and GLERL).

The Great Lakes Commission (GLC) coordinates State activities in resource conservation and environmental protection and interacts with Federal agencies in the area. Members are the Great Lakes States. There are six standing committees of the Commission: Fish and Wildlife, Seaway Navigation and Commerce, Environmental Quality Control, Water Resources, Shoreline Use and Recreation, and International Relations. While no Federal agencies are represented in the Commission, the implementation of GLC programs is coordinated with EPA and the Army Corps of Engineers in the area of discharge permit review, with the Winter Navigation Board in activities of the Navigation Season Extension Program, and the Departments of Commerce (NOAA, MARAD), Interior (FWS), and Justice (Lands and Resources Division), and with the Federal Maritime Commission and the Interstate Commerce Commission.

The International Association for Great Lakes Research (IAGLR) is a professional membership society instituted in 1967 to coordinate the annual Conference on Great Lakes Research. The objectives of IAGLR are to promote aspects of Great Lakes research and to

disseminate research information. Annual conferences provide a meeting ground for public and private agencies concerned with Great Lakes problems.

American Water Resources Association (AWRA) is a professional organization of water resource engineers and scientists. The Association provides a common ground for discussion of water resource activities. Federal agencies are represented in AWRA through the membership of their technical personnel.

The Lake Carriers Association represents the interests of the domestic maritime transportation industry in government activities in navigation, including the work of the Winter Navigation Board in the Navigation Season Extension Program. Principal Federal interaction is through the Army Corps of Engineers, the U.S. Coast Guard, NOAA, and the Maritime Administration.

The International Association of Great Lakes Ports is concerned with problems of port operations and maritime transportation. The Association consists of representatives from 22 Great Lakes ports, (including five Canadian ports) and a representative of the St. Lawrence Seaway Development Corporation. The Western Great Lakes Association and the Council of Lake Erie Ports are involved in similar activities in subregions of the Great Lakes basin.

The International Great Lakes Study Group was established in 1962 to facilitate the exchange of information on Great Lakes

research activities, and to increase the coordination among research activities. The Group is co-chaired by a representative of the Great Lakes Basin Commission, with participation by the States and all Federal agencies administering research programs or having an interest in the Great Lakes.

Interagency Committee for Marine Environmental Prediction (ICMAREP)

The Committee was formed in 1969 by a directive of the Marine Sciences Council to coordinate national efforts in Marine Environmental Prediction (MAREP) services, including those in the Great Lakes. The Federal agencies on ICMAREP include the Departments of Commerce, Defense, Interior, State and Transportation; the Army Corps of Engineers, Energy Research and Development Administration, the Environmental Protection Agency, the National Science Foundation, the National Aeronautical and Space Administration, and the Smithsonian Institution.

Summary

There are thus a considerable number of organizations and mechanisms which promote coordination and review of some aspects of Great Lakes programs, reflecting the appreciation of scientists and administrators of the need for close interaction among Federal agencies.

The International Joint Commission (IJC) considers the problems of boundary waters, focusing on joint U.S.-Canadian aspects, and in recent years concentrating on pollution problems. The IJC

Research Advisory Board has some functions of overview of research. Its coordinating activities involve primarily NOAA and EPA among the U.S. agencies.

The Great Lakes Basin Commission (GLBC) has a mandate to serve as the principal agency for the coordination of water and related land resource activities. At the request of EPA, the GLBC has recently undertaken the coordination of Federal data management as an aid to water quality surveillance and monitoring. It has maintained a continuing role in support of Great Lakes research, and its activities embrace all Federal agencies.

The duties of the Great Lakes Fishery Commission are to formulate research plans, to conduct or coordinate research which can lead to management of Great Lakes fish stocks, and to recommend management measures to the Governments. A major responsibility of the Commission has been to develop control measures for the sea lamprey.

The Commission is largely an advisory body; regulatory authority over the fisheries is vested in the Great Lakes States and the Province of Ontario.

The Great Lakes Commission is an interstate body focusing on navigation problems. It has no Federal members, but its programs are coordinated with Federal agency activities as appropriate.

The Interagency Committee on Marine Science and Engineering (ICMSE) exists to promote coordination among Federal agencies on

a nationwide basis. It has accomplished this in the Great Lakes through the sponsoring of two Federal Conferences, in 1972 and 1975.

The Federal agencies, the States, and groups of individuals frequently organize conferences or smaller meetings to address particular coordinating problems. For example in recent months the EPA Fifth District took the lead in organizing a conference to consider coordination in the monitoring of lake conditions. As another example, NOAA, FWS and EPA have established an informal series of meetings to enhance mutual support of their research on Lake Michigan limnology. This has resulted in some modifications of the plans of each agency to accommodate the needs and the proposed activities of the others.

Both IFYGL and the Extended Navigation Program represent highly focused research, development and management projects of a specified duration. This format provided effective coordination through periodic review of progress, a reappraisal of program priorities, and a definition of future research needs. IFYGL has been instrumental in identifying research programs which are necessary to avoid the potentially serious and long-term impacts arising from activities in the Great Lakes region.

9. APPENDICES

1. Letter from Senator Ernest F. Hollings, Chairman, National Ocean Policy Study, to Dr. Robert M. White, Chairman, Interagency Committee on Marine Science and Engineering.

2. Reply from Dr. White to Senator Hollings.

3. Expenditures on Great Lakes Water-Related Research, Development and Management by Certain Federal Agencies.

4. Expenditures on Great Lakes Water-Related Research, Development and Management (FY 1975), by Sub-division of Agency, and by Activity.

5. The Federal Agencies Active in Great Lakes Water-Related Programs.

6. Federal Installations in the Great Lakes Region Related to Research, Development and Management.

7. Major Legal and Statutory Authorization for Federal Agency Activity in the Great Lakes.

APPENDIX 1

C O P Y

UNITED STATES SENATE
Committee on Commerce
Washington, D.C. 20510

November 13, 1975

Dr. Robert M. White
Administrator
National Oceanic and Atmospheric Administration
Department of Commerce
Rockville, Maryland 20852

Dear Bob:

The National Ocean Policy Study, authorized by Senate Resolution 222, and supported unanimously by the chairman of the 17 standing committees, was adopted February 19, 1974. Since its formation the Study has received testimony and other information on environmental impacts of oil and gas extraction in the coastal zone, on oceanographic data requirements and sources, on oceanographic instrumentation, and on fisheries.

Part of ocean affairs of particular interest to the National Ocean Policy Study is to understand the Federal programs being carried out in the coastal zone, in order to maximize the benefits from the Federal effort. The Great Lakes is one area of concern and interest; as a unique part of the coastal zone, it is faced with special problems. A number of Federal agencies are involved in research and management activities there. It would be of considerable interest to understand better the nature of the programs in the Great Lakes area, which because of its geographic nature provides a discrete region whose character may more easily be capable of understanding.

Moreover, I hear from a number of sources that a problem exists in the Great Lakes area in respect to activities carried out and planned there on shoreline management, and other aspects of coastal research and development. The matter is apparently complex, but it seems to focus on overlapping of activities among the several Federal agencies.

The Interagency Committee on Marine Science and Engineering is, of course, an appropriate body to initiate a study of the Federal programs in the Great Lakes region, and I would be grateful if you would request the Committee to consider undertaking this task.

Among the matters the study should consider are the following:

1. The statutory and legislative responsibilities of the various Federal agencies in respect to research, development and management of the shorelines and water areas in Great Lakes region.

2. Descriptions of the aquatic programs and services of the Federal agencies in respect to research, development and management of the shorelines and water areas in Great Lakes region.

3. International and regional mechanisms, showing the Federal agency participation in each.

4. Descriptions of Federal and Federally supported installations in the area concerned with lake-related problems, including the missions and the main activities of each.

5. Federal coordinating mechanisms in the area, with the purpose of each.

Would you also please consider and advise whether ICMSE could undertake the task of obtaining State level views on their individual and regional needs and the effectiveness of the Federal response?

I would be grateful if you would indicate whether the Committee on Marine Science and Engineering can undertake this assignment and when such a study would be available to the National Ocean Policy Study.

Sincerely,

(signed by)
ERNEST F. HOLLINGS
Chairman
National Ocean Policy Study

EFH:jh

APPENDIX 2

C O P Y

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY
Interagency Committee on Marine Science and Engineering
U.S. DEPARTMENT OF COMMERCE
6010 Executive Boulevard
Rockville, Maryland 20852

December 6, 1974

Honorable Ernest F. Hollings
Chairman, National Ocean Policy Study
United States Senate
Committee on Commerce
Washington, D. C. 20510

Dear Fritz:

Your November 13, 1974 letter regarding Federal Great Lakes activities was reviewed by the Interagency Committee on Marine Science and Engineering (ICMSE) at its last meeting. As you know, ICMSE has been interested for some time in the effective application of Federal programs to the needs of the Great Lakes region. In December 1972, ICMSE convened a conference of Federal program managers concerned with Great Lakes problems in order to stimulate communication and cooperation. The Proceedings of this conference is attached hereto for your information. ICMSE is presently well along in its planning for a second conference early in 1975. This conference, being sponsored for ICMSE by the AEC, will take the form of a technical workshop on Federal programs related to the assessment of environmental impact of energy utilization in the Great Lakes Basin.

In view of ICMSE's interest in the Great Lakes, and in order to continue our assistance to the important work of the National Ocean Policy Study, I am pleased to inform you that ICMSE will undertake the study you requested on Federal research, development, and management programs for the shorelines and water areas in the Great Lakes region.

With respect to State level views on their needs and on the effectiveness of Federal response to these needs, ICMSE has agreed to defer to the National Ocean Policy Study for the acquisition of State views along the lines of our conversation in your office on November 21, 1974.

Sincerely,

(signed by)

Robert M. White
Chairman

Enclosure

APPENDIX 3

EXPENDITURES ON GREAT LAKES WATER-RELATED RESEARCH, DEVELOPMENT AND MANAGEMENT BY CERTAIN FEDERAL AGENCIES

AGENCY	TOTAL FY '75 GREAT LAKES EXPENDITURES
Department of the Interior	$ 17,456,700
Department of Commerce	9,755,856
National Science Foundation	94,050
Navy	128,000
Energy Research and Development Administration	2,403,000
National Aeronautics and Space Administration	1,015,736
Department of Transportation	39,416,000
Army Corps of Engineers	69,835,000
Department of State	2,995,500
Environmental Protection Agency	33,180,750
TOTAL	$176,280,592

APPENDIX 4

EXPENDITURES ON GREAT LAKES WATER-RELATED RESEARCH, DEVELOPMENT AND MANAGEMENT (FY 1975)

(By Sub-Divisions of Agency, and by Activity)

AGENCY	NAV. & TRANSP. ENFORCEMENT	RESOURCE MGT. & DEV.	RESEARCH	RECREATION	COASTAL DEV. & PROTECTION	ENVIRONMENTAL PROTECTION	TOTAL
DOI*		7,897,600	3,468,000	4,689,900	989,500	411,700	17,456,700
BIA		2,500[a]					2,500
BLM		25,000[a]					25,000
USBM							
BOR				2,153,000			2,153,000
FWS		5,611,100[b]	2,447,000			12,700	8,070,800
USGS		2,259,000	221,000		989,500	399,000	3,868,500[e]
NPS				2,536,900			2,536,900
OWRT			800,000				800,000
DOC/NOAA	1,409,098	1,474,162	2,489,500	1,186,630	785,223	1,531,243	8,875,856
SG	164,098	750,162		93,770	210,983	1,125,243	2,344,256
NOS	680,000		164,500	449,860	233,240		1,527,600
NWS	225,000			300,000			525,000
NMFS		380,000					380,000
EDS						55,000	55,000
ERL			2,291,000				2,291,000
NESS			34,000				34,000
OCZM	340,000	344,000		343,000	341,000	351,000	1,719,000
DOC/MARAD	440,000		440,000				880,000
NAVY			49,000			79,000	128,000[d]
NSF			94,050				94,050
ERDA			342,000			2,061,000	2,403,000
NASA	820,000					195,736[a]	1,015,736
DOT	34,397,000		1,468,000	2,270,000		1,281,000	39,416,000
USCG	34,022,000		1,468,000	2,270,000		1,281,000	39,041,000
SLSDC	375,000						375,000
COE	67,200,000	85,000		NA[a]	2,550,000[a]	NA[a]	69,835,000[c]
STATE							2,995,500[g]
IJC							767,500
GLFC							2,228,000
EPA			1,862,000			31,318,750	33,180,750[f]
TOTALS	104,266,098	9,456,762	10,212,550	8,146,530	4,324,723	36,878,429	176,280,592[g]

*See end of table for acronyms

Acronyms Used in Appendix 4 Table

BIA	Bureau of Indian Affairs, Department of the Interior
BLM	Bureau of Land Management, Department of the Interior
BOR	Bureau of Outdoor Recreation, Department of the Interior
COE	United States Army Corps of Engineers
DOC	Department of Commerce
DOI	Department of the Interior
DOT	Department of Transportation
EDS	Environmental Data Service, Department of Commerce
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERL	Environmental Research Laboratories, Department of Commerce
FWS	Fish and Wildlife Service, Department of the Interior
GLBC	Great Lakes Basin Commission
GLFC	Great Lakes Fishery Commission
IJC	International Joint Commission
MARAD	Maritime Administration, Department of Commerce
NASA	National Aeronautics and Space Administration
NESS	National Environmental Satellite Service, Department of Commerce
NMFS	National Marine Fisheries Service, Department of Commerce
NOAA	National Oceanic and Atmospheric Administration, Department of Commerce
NOS	National Ocean Survey, Department of Commerce
NPS	National Park Service, Department of the Interior
NSF	National Science Foundation
NWS	National Weather Service, Department of Commerce
OCZM	Office of Coastal Zone Management, Department of Commerce
OWRT	Office of Water Research and Technology, Department of the Interior
SG	Office of Sea Grant, Department of Commerce
SLSDC	St. Lawrence Seaway Development Corporation, Department of Transportation
USBM	United States Bureau of Mines, Department of the Interior
USCG	United States Coast Guard, Department of Transportation
USGS	United States Geological Survey, Department of the Interior

NOTES

a) Approximate; may include one or more program(s) for which no funding total was available

b) Includes $1,523,000 contributed by Department of State through GLFC

c) Agency support for coordinating organizations (GLFC, IJC, for example) not available

d) Does not include capital investments for facilities improvement (pollution control systems)

e) Including matching funds from states and other cooperators, total program funds exceed $5.5 million

f) Budget total does not include Great Lakes States Allotments through EPA's Construction Grants Program in the amount of $1,528,000,000 for construction of municipal wastewater treatment facilities

g) Vertical and horizontal totals do not match because Department of State contributions to IJC and GLBC could not be assigned to particular activities

APPENDIX 5

THE FEDERAL AGENCIES ACTIVE IN GREAT LAKES WATER-RELATED PROGRAMS

There are numerous Federal agencies active in water and water-related research, development and management programs in the Great Lakes region. Brief sketches of the overall responsibilities of the most active of these agencies are given below.

DEPARTMENT OF INTERIOR

The United States Geological Survey has responsibility for the classification of public lands, examination of their geologic structure, and measurement of mineral resources. The Survey conducts research on hydrological problems, including an assessment of physical characteristics of Great Lakes river basins and aquifer systems. The USGS is involved in the development of topographic and geological maps.

The Fish and Wildlife Service has responsibility for the living resources of the Great Lakes, the goal being to improve the quality, abundance, productivity and utilization of fish and wildlife resources. The Service examines the impact on living resources of nutrient loading, toxic contaminants, waste heat discharge, dredging, water levels, and the extension of the navigation season. The Service attempts to correct fish population imbalances by the use of fish

hatcheries and restocking, sea lamprey control, and fishery research. Aid is rendered to State agency management responsibilities through research, technical advice, and financial assistance. The Service operates 13 wildlife refuges and 8 fish hatcheries in the Great Lakes region.

The National Park Service manages two National Parks, four National Lakeshores, a National Monument and a Memorial Park in the Great Lakes region. Operation of the parks include the maintenance of special facilities such as visitor centers, marinas, docks, launching ramps, swimming beaches, lifeguard stations, patrol boats, buoys and markers, sanitary and water systems, camping and picnic areas, and nature trails. The NPS supports research through contracts and matching grant programs.

The Bureau of Outdoor Recreation is the recreation policy and planning agency for the Secretary of the Interior. The Bureau administers distribution of the Land and Water Conservation Fund, providing matching grants to States and financing acquisition of Federal recreation areas. To promote coordination of outdoor recreation programs, BOR serves Federal agencies, State and local governments, private organizations, and individuals concerned with outdoor recreation.

The Bureau of Indian Affairs provides technical assistance in Indian resource management activities. In cooperation with other

State/Federal agencies, the Bureau assists in the development of fishing conservation programs and the investigation of mineral resources in Indian lands.

The Office of Water Research and Technology supports research on water resources problems through matching grants for institute-sponsored research projects, and through direct grants and contracts to public or private organizations. OWRT disseminates technical information through its Water Resources Science Information Center.

The Bureau of Land Management has responsibility for issuing prospecting permits and leasing mineral rights, and shares responsibility with USGS for managing mineral development on Federal lands in the Great Lakes region.

The United States Bureau of Mines is the Federal focal agency for developing and assessing mining and mineral processing technology, and for the collection and interpretation of economic and statistical data on minerals and fuels essential for policy making.

The Mining Enforcement and Safety Administration implements Federal laws and programs to improve the health and safety of the working environment of miners.

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

The Great Lakes Environmental Research Laboratory conducts limnological research and collects environmental data, in order to improve environmental information concerning properties, phenomena and processes of the Great Lakes and their watersheds, to develop improved environmental service tools to support user needs in government and private organizations, and to provide an environmental advisory service.

The National Ocean Survey's Lake Survey Center conducts NOAA's mapping and charting program in the Great Lakes. It publishes the Great Lakes Pilot as a complement to the Great Lakes charts.

The National Marine Fisheries Service has two divisions directly involved in Great Lakes affairs. The Great Lakes Program Office in Ann Arbor, Michigan, provides State/industry liaison on fisheries matters in the region. The Environmental Assessment Division reviews permit applications for projects in navigable waters to reduce environmental damage. The Service administers grants-in-aid for fisheries programs in cooperation with Great Lakes States.

The National Weather Service provides regional, local, and marine forecasts which contribute to boating safety, safety and

efficiency of lake shipping and ice and anomalous lake level information for shipping and coastal facilities. The Weather Service prepares and disseminates warnings of weather hazards and floods.

The Environmental Data Service processes and disseminates Great Lakes climatological and limnological data. The Environmental Science Information Center and Great Lakes Library in Detroit, Michigan, contains an archival collection of hydrological and limnological information.

The National Environmental Satellite Service obtains oceanographic/limnological and hydrologic information through the use of remote sensors on NOAA and NASA satellites.

Two NOAA components contribute to the research and services conducted in the Great Lakes through financial and administrative support. The Office of Sea Grant provides support for approximately 130 projects at three Great Lakes area universities: Michigan, Wisconsin, and State University of New York/Cornell. The Office of Coastal Zone Management provides annual grants for the development of State coastal zone management programs, and for the acquisition and development of estuarine sanctuaries.

Maritime Administration

The Maritime Administration facilitates Great Lakes transportation and trade by improving shipboard navigation aids and ship design under ice conditions. The Administration funds research and development programs to overcome Great Lakes shipping problems. These efforts are related primarily to the extension of the winter navigation season, but also include improved communications systems, advanced marine technology, transportation market analysis, and environmental protection.

DEPARTMENT OF TRANSPORTATION

The Saint Lawrence Seaway Development Corporation, a government-owned enterprise, is responsible for the development, operation and maintenance of the seaway between Montreal and Lake Ontario within U.S. territorial limits. The Corporation conducts ice research and forecasting in conjunction with the Great Lakes-St. Lawrence Seaway Navigation Season Extension Program.

The United States Coast Guard's Ninth District, with headquarters in Cleveland, Ohio, extends for nearly 1600 km. from Duluth, Minnesota, to St. Regis, New York. In these waters the Coast Guard operates a communications service program and provides marine services, including search and rescue, aids to navigation, domestic ice navigation, marine law enforcement, merchant marine

safety, recreational boating safety, and limnological/meteorological support services. The Coast Guard is involved in the detection and cleanup of pollution, in icebreaking, and in ice research and engineering.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency plans, researches, and sets standards for the control of pollutants. In the Great Lakes the EPA Region V Office in Chicago, Illinois, coordinates the agency's activities.

The Great Lakes Initiative Program provides technical support and advice to programs of the International Joint Commission, and a coordinated approach to the analysis and resolution of water quality problems of the Great Lakes. The Grosse Ile Laboratory conducts the Large Lakes Research Program, and field, laboratory and extramural studies on the behavior and effects of pollutants on large lakes systems. These studies provide a scientific basis for water quality criteria and waste discharge control. The States have primary responsibility to control water pollution, and the EPA regional offices work closely with State agencies in such programs.

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

The Energy Research and Development Administration's research program on the Great Lakes was initiated in 1968 by its predecessor,

The Atomic Energy Commission, to evaluate the impact of the nuclear power industry in the basin. The program has been broadened under ERDA, to assess the impact of non-nuclear energy extraction, conversion, utilization and transmission. The activities in the Great Lakes include physical and biological research, environmental data acquisition and analysis, assessment of the impacts of energy conversion, and the management of pollutant discharges. ERDA programs are conducted through the Argonne National Laboratory, and through grants to academic institutions.

U.S. ARMY CORPS OF ENGINEERS

The Corps of Engineers has the responsibility for the Federal interest in navigation facilities, including feasibility studies, construction, operation, and maintenance. It administers a multi-agency program to demonstrate the practicability of extending the navigation season on the Great Lakes and the St. Lawrence Seaway. The Corps has the major Federal responsibility for flood control and protection. It is authorized to investigate the causes of floods and beach erosion, to construct protection works, and to provide emergency assistance in major disasters, hurricanes, floods and storms. Other water-related activities include stream bank erosion control, improving water-oriented recreation facilities, pollution abatement, flood plain management, waste water management, wetlands conservation, and aquatic plant control.

Research and specialized engineering for water resources in the Great Lakes is conducted for the North Central Division by the U.S. Army Coastal Engineering Research Center, the U.S. Army Engineer Waterways Experiment Station, U.S. Army Construction Engineering Research Laboratory, Corps of Engineers Hydraulic Engineering Center, and the U.S. Army Cold Regions Research and Engineering Laboratory.

DEPARTMENT OF STATE

International commissions and agreements between the United States and Canada are under the Department of State jurisdiction.

The Great Lakes Fisheries Commission has two major responsibilities: coordination of research on fish stocks of common concern to the United States and Canada, and recommendations to improve productivity, and the control of sea lamprey populations in the Great Lakes.

The International Joint Commission was created to implement the 1909 Boundary Waters Treaty. Under the terms of the Treaty the IJC's responsibilities are to evaluate applications for control works in boundary waters that would change flows or water levels, to recommend to the governments of Canada and the United States settlements on boundary disputes, and to determine the effectiveness of programs. Following the Great Lakes Water Quality Agreement of 1972, the IJC

was given the role of coordinator, to assist the two countries in developing cooperative programs and regulations for controlling polluting discharges.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration is a research and development agency whose objective is to develop and demonstrate the application of space technology in providing remotely sensed data. NASA's programs include some activities which relate to aquatic and shoreline resource management in the Great Lakes region. NASA assists other agencies when appropriate facilities, capabilities and technologies are available. Most of NASA's research and development programs related to Great Lakes problems are the result of requests for assistance received from other agencies. The Lewis Research Center, in Cleveland, Ohio, has responsibility for developing NASA activities which pertain specifically to the Great Lakes.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation supports fundamental and applied research in all scientific fields. The Foundation supports five research projects directly applicable to the Great Lakes, related to environmental data acquisition, lake dumping activities, health and sanitation, contaminants and inspection.

DEPARTMENT OF DEFENSE

The Office of Naval Research currently funds two Great Lakes limnological/meteorological research projects. The Navy maintains a personnel training installation and a Naval Research Branch Office in Great Lakes, Illinois; the latter administers contracts and reports on scientific potential in the area.

APPENDIX 6

FEDERAL INSTALLATIONS IN THE GREAT LAKES REGION RELATED TO RESEARCH, DEVELOPMENT AND MANAGEMENT

DEPARTMENT OF INTERIOR

Planning Office - Chicago, Illinois

Fish and Wildlife Service - Minneapolis and Boston Offices

Office of Water Research and Technology - Water Resources Science Information Center

Research Laboratories:

- Great Lakes Fishery Laboratory - Ann Arbor, Michigan
- Hammond Bay Biological Station - Millersburg, Michigan
- Wisconsin Biological Station - Ashland, Wisconsin
- Ohio Biological Station - Sandusky, Ohio
- Fish Control Laboratory - LaCrosse, Wisconsin
- Tunison Laboratory of Fish Nutrition - Cortland, New York
- U.S. Bureau of Mines Laboratory - Minneapolis, Minnesota
- Fish and Wildlife Service - 25 Fishery Research Units, and 20 Wildlife Research Units

Service and Management Facilities:

- National Fish Hatcheries:
  - Hiawatha Forest - Elmira, Michigan
  - Jordan River - Elmira, Michigan
  - Pendills Creek - Brimley, Michigan

National Fish Hatcheries (continued)

Hebron, Ohio

Allegheny - Warren, Pennsylvania

Genoa, Wisconsin

Lake Mills, Wisconsin

Wildlife Refuge System

Michigan - Wyandotte, Michigan Islands, Seney, Huron, and Shiawassee

Ohio - Cedar Point, Ottawa, West Sister Island

Wisconsin - Green Bay, Gravel Island

New York - Iroquois, Montezuma

Pennsylvania - Erie

Sea Lamprey Control Stations - Marquette and Ludington, Michigan

National Park System Facilities:

Apostle Island National Lakeshore, Wisconsin

Grand Portage National Monument, Minnesota

Voyageurs National Park, Minnesota

Indiana Dunes National Lakeshore, Indiana

Perry's Victory and International Peace Memorial, Ohio

Isle Royale National Park, Michigan

Pictured Rocks National Lakeshore, Michigan

Sleeping Bear National Lakeshore, Michigan

U.S. Geological Survey - 118 stream and groundwater gaging stations

DEPARTMENT OF COMMERCE

NOAA

Great Lakes Environmental Research Laboratory - Ann Arbor, Michigan

Lake Survey Center - Detroit, Michigan, Marine Facility - Monroe, Michigan

Great Lakes Library - Detroit, Michigan

National Weather Service Forecast and Service Offices - 15 offices located throughout the eight States with borders on the Great Lakes

Radar Observation Stations - three stations, Detroit, Buffalo and Neenah, Wisconsin

MARAD

Great Lakes Maritime Academy - Northwestern Michigan College, Traverse City, Michigan

DEPARTMENT OF THE NAVY

Naval Research Branch Office - Chicago, Illinois

U.S. Naval Base, Great Lakes, Illinois

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Argonne National Laboratory - Argonne, Illinois

Research Plants - Lake Michigan (2), Lake Ontario (3)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Lewis Research Center - Cleveland, Ohio

DEPARTMENT OF TRANSPORTATION

U.S. COAST GUARD

District Office - Cleveland, Ohio

Group Offices - Buffalo, Detroit, Lake Huron - St. Mary's River, Lake Michigan (2), Lake Superior

Marine Safety Offices - located in four Great Lakes (Superior, Michigan, Huron, Erie), and in the Detroit - St. Clair area

Captain of the Port Offices - Lakes Huron and Michigan

Search and Rescue Facilities - all lakes

Merchant Marine Technical Office - Cleveland, Ohio

Ice Navigation Center - Cleveland, Ohio

Numerous support and service facilities at each of the Great Lakes (aids to navigation, support vessels, etc.)

ST. LAWRENCE SEAWAY DEVELOPMENT CORPORATION

Eisenhower and Snell Locks - Massens, New York

U.S. ARMY CORPS OF ENGINEERS

North Central Division Office - Chicago, Illinois

Corps District Offices - Detroit, Michigan, St. Paul, Minnesota, Chicago, Illinois, and Buffalo, New York

ENVIRONMENTAL PROTECTION AGENCY

EPA Region V, Chicago, Illinois

EPA Region II, Rochester Field Office - Rochester, New York

Grosse Ile Laboratory, Grosse Ile, Michigan

National Water Quality Laboratory - Duluth, Minnesota

Newton Fish Toxicology Station - Cincinnati, Ohio

Monticello Field Station - Monticello, Minnesota

APPENDIX 7

MAJOR LEGAL AND STATUTORY AUTHORIZATION FOR FEDERAL AGENCY ACTIVITY IN THE GREAT LAKES

DEPARTMENT OF INTERIOR

BUREAU OF INDIAN AFFAIRS

Snyder Act of 1921 (25 USC 13)

Indian Reorganization Act (25 USC 981-902)

BUREAU OF OUTDOOR RECREATION

Land and Water Conservation Provisions (16 USC 460 L-4 to L-11)

FISH AND WILDLIFE SERVICE

Fish and Wildlife Act of 1956, as amended (16 USC 742 (a) -754)

Fish and Wildlife Coordination Act (1934), as amended (16 USC 661 - 667e)

Great Lakes Fishery Act of 1956, as amended (16 USC 931 - 939c)

Federal Aid in Fish Restoration Act (1950), as amended (16 USC 777 -777k)

Federal Aid in Wildlife Restoration Act (1937), as amended (16 USC 669 - 669i)

Endangered Species Act of 1973 (16 USC 1531 - 1543)

Migratory Bird (Acts) (1918) (16 USC 701 - 718h)

NATIONAL PARK SERVICE

Creation of (39 Stat. 535; 16 USC 1)

BUREAU OF MINES - (30 USC 107)

BUREAU OF LAND MANAGEMENT - (5 USC 133y to 133y - 16)

U.S. GEOLOGICAL SURVEY - (43 USC 31)

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Creation of (Reorganization Plan No. 4 of 1970)

Fish and Wildlife Coordination Act (48 Stat. 401, as amended)

Commercial Fisheries Research and Development Act of 1964, P.L. 88-309, as amended

Anadromous Fish Conservation Act, P.L. 89-304 as amended

Marine Protection, Research, and Sanctuaries Act of 1972, P.L. 92-532, Title II - Ocean Dumping (Sec. 201, 202), Title III - Marine Sanctuaries (Secs. 301, 302)

Coastal Zone Management Act of 1972, P.L. 92-583 (Secs. 303, 304)

National Sea Grant College and Program Act of 1966, P.L. 89-688, as amended

MARITIME ADMINISTRATION

Merchant Marine Act of 1970 (amending the 1936 Act), P.L. 91-469 (Secs. 1-36)

NATIONAL SCIENCE FOUNDATION

National Science Foundation Act of 1950

DEPARTMENT OF THE NAVY

U.S. NAVY; Compositions; Functions (10 USC 5012)

OFFICE OF NAVAL RESEARCH - (10 USC 5152)

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Energy Reorganization Act of 1974, P.L. 93-438 (Especially Secs. 103, 104)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

National Aeronautics and Space Administration Act of 1958, P.L. 85-568

Federal Water Pollution Control Act/Amendments of 1972, P.L. 92-500

DEPARTMENT OF TRANSPORTATION

U.S. COAST GUARD

Water Resources Planning Act, P.L. 89-80

Executive Order 11345, April 20, 1967, as amended (Establishment of Great Lakes Basin Commission)

River and Harbors Act of 1970, P.L. 91-611

Ports and Waterways Safety Act of 1972, P.L. 92-340

Water Ouality Improvement Act of 1970, Title I, Sec. 102, P.L. 91-224 (Control of Pollution by Oil)

Federal Boat Safety Act of 1971, P.L. 92-75

Federal Water Pollution Control Act/Amendments of 1972, Sec. 311, P.L. 92-500.

Regulation of Great Lakes Pilots and Pilotage (46 USC 216)

ST. LAWRENCE SEAWAY DEVELOPMENT CORPORATION

St. Lawrence Seaway Act, as amended, 31 USC 846, 33 USC 981-990

U.S. ARMY CORPS OF ENGINEERS

Fletcher Act, Feb. 10, 1932, Establishing Board of Engineers for Rivers and Harbors (33 USC 541)

River and Harbor Act of 1960, P.L. 86-645 as amended

River and Harbor Act of 1968, P.L. 90-483

Federal Water Project Recreation Act, P.L. 89-72

Flood Emergency Preparation, P.L. 84-99

Coastal Zone Management Act of 1972, Sec. 307c, P.L. 92-583

Federal Water Pollution Control Act/Amendments of 1972, P.L. 92-500

Marine Protection, Research and Sanctuaries Act of 1972, P.L. 92-532

River and Harbor and Flood Control Act of 1920, P.L. 91-611

Water Resources Development Act of 1974, P.L. 93-251

DEPARTMENT OF STATE

Regulation of Great Lakes Pilots and Pilotage, P.L. 86-555

Boundary Waters Treaty of 1909, 6 UST 2836, TIAS 3326

1972 Great Lakes Water Quality Agreement, 23 UST 301, TIAS F 312

Appropriations for Sundry Civil Expenses, P.L. 525

Water Resources Planning Act, P.L. 89-80

ENVIRONMENTAL PROTECTION AGENCY

Federal Water Pollution Control Act/Amendments of 1972,

P.L. 92-500

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