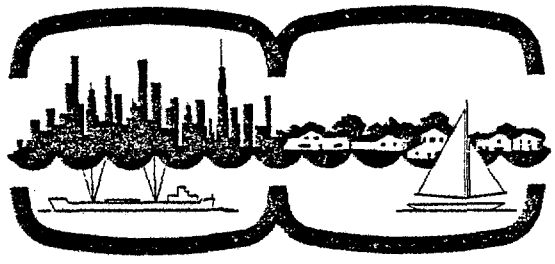
ILLINOIS COASTAL ZONE MANAGEMENT PROGRAM: COMPONENT STUDY OF BIOLOGICAL COMMUNITIES

Prepared by the

ILLINOIS NATURAL HISTORY SURVEY

for

THE ILLINOIS COASTAL ZONE MANAGEMENT PROGRAM



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PREFACE

In July 1975, the staff of the Illinois Natural History Survey began a study of the Illinois coastal zone ecosystem at the request of the Illinois Department of Transportation, Illinois Coastal Zone Management Program. Six goals were established as objectives of this study:

1) to provide historical perspective to the present state of the shore and nearshore ecosystem;

2) to provide an inventory of plant and animal species of the project;

3) to identify threatened or endangered species of the project area;

4) to identify unusual natural areas within the Illinois coastal zone;

5) to make specific recommendations and to provide general guidelines for the preservation, management, or restoration of the shore and nearshore ecosystem; and

6) to provide a bibliography of biological studies of the shore and nearshore of the Illinois portions of Lake Michigan.

The six-month time limit imposed on the study required considerable restriction in groups studied. Considered here are all vertebrate classes (mammals, breeding birds, reptiles, amphibians, and fishes), Culicidae and Chironomidae (mosquitoes and midges), Trichoptera (caddisflies), zooplankton, aquatic Oligochaeta (worms), vascular plants, and phytoplankton. Restrictions were based upon the importance of the group, the availability of historical information, and available expertise.

A team of 14 biologists participated in this study. Each was responsible for contributing to the objective stated above for one or more groups of plants or animals. Contributors and their area of responsibility are as follows (institutional affiliation Illinois Natural History Survey unless stated otherwise):

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We would like to acknowledge the assistance of Mr. Ralph Fisher and Mr. Chris Shafer, Illinois Department of Transportation, for their assistance in the administration of this project and for their continued interest and support. We especially acknowledge Dr. Elizabeth Lunn of Lake Forest for her substantial contribution to the inventory of vascular plants on the Illinois coastal zone.

Dr. Warren U. Brigham
Project Coordinator

EXECUTIVE SUMMARY

The Illinois portion of the Lake Michigan drainage basin is narrow, generally a strip of land much less than five miles in width, and the only tributary streams are the Chicago and Calumet Rivers and a few small streams draining marshes marginal to the beaches. A portion of this drainage basin and all Illinois waters of the lake have been designated as the Illinois coastal zone.

As recently as 30 years ago, many people believed that the enormous human population around Lake Michigan had altered shorelines and tributary waters, but that the lake itself was primaeval and unalterable because it was such an immense body of water. It is now known that induced eutrophication has caused changes in the communities of phytoplankton and zooplankton in Lake Michigan in the recent past. Most significant are the disappearance of some species commonly found in oligotrophic lakes and the appearance or increase in abundance of species able to tolerate more eutrophic conditions. Phytoplankton data collected over the past 33 years reveal that the average number of organisms is increasing at a rate of 13 ± 4.6 organisms per milliliter per year, with most increases coming from the blue-green algae, diatoms, and dinoflagellates.

Some problems affecting the lake, however, are the result of human activities more than 150 years ago. The construction of the Welland Canal around the Niagara Escarpment had a delayed, but devastating effect upon all the Great Lakes. Essential to this effect was the rather simple food chain basic to the natural ecology of Lake Michigan (phytoplankton to crustaceans to small fish to large predatory fish). In 1936, the sea lamprey reached Lake Michigan and selectively began to remove the large predatory species from the lake. Great increases in other small- and medium-sized fishes resulted from the removal of the predators. Apparently over-harvest of these small- and medium-sized fishes left an unfilled niche in the food chain which was occupied quickly by a second invader from the Atlantic, the alewife. This species has become notorious for its regular and massive die-offs.

Modification of the terrestrial environment has been even more extreme. As man entered the Lake Michigan coastal zone, he converted the forests and prairies into farmland and eventually into cities. This drastically reduced the suitable habitat available to many terrestrial species, which have had to adapt to man's presence, or disappear. Adequate data are available only for amphibians, reptiles, and mammals to assess extirpation among the terrestrial vertebrates. Of the 91 species once inhabiting the Illinois coastal zone, 26 are no longer present, including eight each of amphibians and reptiles and 10 mammals.

During the inventory portion of the present study, more than 1,800 species of plants, selected invertebrates, and vertebrates were recorded from the project area, as follows:

phytoplankton	320 taxa
zooplankton	150 species
aquatic worms	30 species
caddisflies	52 species
mosquitoes and midges	64 species
fishes	97 species
higher plants	735 species
amphibians	17 species
reptiles	21 species
birds	264 species
mammals	53 species

For all of these, habitat preference was determined and for most, relative abundance as well. These data are presented in a separate appendix to this final report.

Data regarding rare, threatened, or endangered species are available generally only for vertebrate animals. This does not preclude inclusion of invertebrates, especially those restricted to limited habitats. It is significant to note that the rare fishes in the lake include virtually all native species, except the yellow perch, the sculpins, the sticklebacks, trout-perch, and spottail shiner. Non-native species which have entered the lake, directly or indirectly through the activities of man, are, for the most part, the common fishes.

Among the terrestrial vertebrates, most of the less adaptable species have long been extirpated from the coastal zone. Those that remain, with few exceptions, are wide-ranging and hardy species that will probably persist as long as their habitat exists.

During the course of field studies of the Illinois coastal zone, unusual natural areas were sought out for particular study in order to recommend specific protection, management, or restoration procedures. Four such areas were located, including 1) Illinois Beach State Park and Lake Michigan shoreline north to Wisconsin boundary, 2) Lake Forest garden club ravine, 3) Wolf Lake and Powder Horn Lake, and 4) hard-substrate nearshore of Lake Michigan.

In addition to specific recommendations for unusual natural areas, general guidelines for protection, management, and restoration were developed to introduce an ecological perspective to future development in the Illinois coastal zone.

Lake Michigan is an oligotrophic lake. Oligotrophic lakes are lakes which are characterized by low concentrations of dissolved nutrients, simple food chains, high concentrations of dissolved oxygen. Lakes age as part of their natural processes. Oligotrophic lakes gradually build up a nutrient pool either through natural processes or by man-introduced pollutants. Biological communities change and often become more diverse.

Eventually, on a geological time scale, the lake basin fills in and becomes dry land. The natural enrichment process is called eutrophication. Man-introduced effluents are accelerating the eutrophication of the nearshore of Lake Michigan.

The nature of phytoplankton, zooplankton, and benthic macroinvertebrates makes it difficult to recommend preservation and shoreline management activities to affect these organisms. In order to "manage" these communities, the water quality must be closely controlled--a feat of enormous proportion in Lake Michigan. Beyond this, their importance should be recognized and their role understood.

From the standpoint of fishes and fisheries, there is little more damage that can be done to the natural environment by further development of the coastal zone of Illinois. The problems that have been pointed up in the following pages are of national importance and will not be solved soon even though many state and federal agencies are much concerned about them. While there is no simple and quick cure for the many ills of Lake Michigan and its tributary waters, awareness of what has happened in the past should encourage us to minimize further modification of the basin. The public clamor to begin cleaning up our water and air are good signs as are the efforts of many concerned agencies. The dumping of cinders and garbage in the deep water of Lake Michigan has already ceased, and the demands for more exacting standards and better waste treatment cannot be ignored.

Thermal effluents from power-generating plants are less likely to be harmful in the lake than in streams because of the enormous volume of cold water welling along the Illinois shoreline. Heat would be quickly dissipated and would have only local effects. Construction of man-made islands offshore would probably have temporary effect and do little damage unless toxic substances were thereby introduced into the water. Shoreline construction should take precautions to avoid contaminating water in the lake and tributary streams and lakes and should not be undertaken in the few remaining areas that still have natural features. The unmodified areas along the shoreline should be treasured for what they are. The greatest threat to Illinois Beach State Park is overdevelopment.

Inland, the natural lakes, marshes, and some of the streams still have large populations of a number of native fishes. These habitats are clearly worth protecting. The practice of using chemical poisons to eradicate carp in natural lakes should be stopped, and, instead of introducing non-native sport fishes, efforts should be expended to improve the habitats for such native species as lake trout, yellow perch, pickerel, sunfishes, basses, suckers, and catfishes.

The Illinois coastal zone can be broken into four terrestrial situations based on man's disturbance of the area. Approximately 66% of this area is occupied extensively by large cities which are primarily buildings

and roads and lack suitable habitat for most native organisms. In the small parks the situation is slightly better. These parks, however, are too small to be of much use in the revitalization of the fauna. If they were increased in size and allowed to maintain good grass cover and understory, they might be improved, but only the small native animals, many of which are secretive, would return, and then only to the interest of the trained observer.

The larger parks such as Jackson Park and Lincoln Park occupy approximately 10% of the Illinois coastal zone. These parks, because of their large size, are much more suitable for the existence of native fauna. It would seem pertinent to allow areas of understory and ground cover to develop in these parks. These parks have a number of buildings on them, and there is a considerable amount of human movement at this time. If allowed to go back to a semi-natural condition, these would apply ample area and habitat for many species of small- and medium-sized animals. The ponds and lagoons would also be available for colonization. To some extent both Burnham and Grant Parks might fit into this scheme although they are smaller and are affected considerably by more human disturbance.

Approximately 8% of the study area is now undergoing urban development. Within areas such as north of Fort Sheridan, around Dunes Park, and east of Kellogg Ravine, housing developments are encroaching and, in some cases, totally engulfing areas that until recently were either old field or woodland. Many of these areas are the only remaining avenues of movement of animals to and from the Lake Michigan shore.

An annotated bibliography of selected biological studies of the shore and nearshore ecosystem, intended to serve as a guide to the literature for the CZM staff and consultants, is included in this final report. References are grouped generally by principal subject.

INTRODUCTION

The Laurentian Great Lakes and their connecting waters constitute the largest body of fresh water on the surface of the earth. Of these, Lake Michigan is the third largest (sixth in the world), after Superior and Huron, with a surface area of 58,000 km^2 and a drainage basin of 175,760 km^2. Lake Michigan reaches a depth of 281 m. Along or near the lakes are large deposits of minerals and areas of productive farmland. The water mass of the lakes also tempers the climate and influences the movement of storm systems. This combination of circumstances favored the development of industries and large metropolitan areas. Ten percent of the U. S. population lives in the counties bordering the lakes. Consequently, the lakes are used for a multitude of domestic and industrial purposes, including shipping, water supply and wastewater disposal, commercial and sport fishing, and boating, bathing, and other recreation.

Lake Michigan exhibits some degree of thermal stratification during the warmer months and probably mixes deeply throughout most of the winter and spring. Solid ice sheets are limited to embayments, channels, among islands, and along shore. Although this shore ice may extend 13 to 16 km out into the lake, open-water ice usually occurs as floes. The deep water of the lake probably remains close to 4°C throughout the year.

The principal ion in the Great Lakes is bicarbonate, with the highest concentrations being found in Lake Michigan (113 mg $liter^{-1}$ as $CACO_3$). Hydrogen ion concentration (as pH) ranges from 8.0 to 8.5. Mean concentrations of other constituents, as measured by the U. S. Bureau of Commercial Fisheries, are calcium, 31.5; magnesium, 10.4; potassium, 0.9; sodium, 3.4; chloride, 6.2; sulfate, 15.5; silica, 3.1; and total phosphorus, 0.013 (all as mg $liter^{-1}$). Dissolved oxygen is near saturation, even at the greatest depths, and supersaturation is common.

Human activities have affected even this large body of water, and there is evidence of accelerated eutrophication. Although the extent of this acceleration is not as great in Lake Michigan as in Lake Erie, the standing crop of phytoplankton in the southern basin of Lake Michigan has increased significantly in the past 40 years.

Despite the widely recognized economic importance of Lake Michigan, fundamental knowledge has been available only recently. Less than 125 years ago, most of the lake's region was a wilderness and, prior to 1900, investigations were few and sketchy. From 1900 to 1950, most work concerned commercial fisheries and associated water quality. Since 1950, development of an extensive scientific literature has been phenomenal and spans a great variety of practical and fundamental aspects of large-lake limnology.

The coastal zone of the Great Lakes represents a natural ecosystem competing with man for the physical resources of the shore and nearshore.

As yet, few studies have concerned this coastal zone ecosystem. The present report is a review and synthesis of published reports and unpublished data regarding the Illinois portion of the Lake Michigan coastal zone. It is intended to provide a useful starting point for future studies and a sound ecological perspective to land-use planners and others charged with development, management, and protection of this unique resource.

HISTORICAL PERSPECTIVE

Lake Michigan is a cold, deep, oligotrophic lake that was filled to overflowing by glacial meltwater slightly more than 10,000 years ago. Known to geologists as Lake Chicago, it drained southward through the so-called Chicago Outlet down the Des Plaines and Illinois River valleys to the Mississippi, which then was a small stream above its confluence with the Illinois. After settling in its basin, drainage was reversed, and tributary streams developed that flowed into the lake. In Illinois the drainage is narrow, generally a strip of land much less than 5 km in width, and the only tributary streams are the Chicago and Calumet Rivers and a few small streams draining marshes marginal to the beaches.

Even before the opening of the man-made Illinois-Michigan Canal in 1871, there was mixing of waters during wet seasons of the Lake Michigan and Mississippi River drainages because the watershed divide between the upper Chicago and Des Plaines Rivers is low. After the construction of the canal, flow was reversed so that water from Lake Michigan coursed down the Illinois River, and there was a direct connection between the watersheds.

The spectacular growth of the City of Chicago and its suburbs, the industrialization of Cook County, and large-scale modification of the Lake Michigan shoreline are well-known. As recently as 30 years ago, many people believed that the enormous human population around Lake Michigan had altered shorelines and tributary waters, but that the lake itself was primaeval and unalterable because it was such an immense body of water. Some problems affecting the lake, however, were not recognized even though they were the result of human activities much earlier. For example, the construction more than 150 years ago of the Welland Canal around the Niagara Escarpment had a delayed, but devastating effect upon all the Great Lakes, as will be shown later.

Phytoplankton

Induced eutrophication has caused changes in the communities of phytoplankton in Lake Michigan in the recent past. Comparison with Lake Erie phytoplankton data, despite vast differences in the physical characteristics of the two lakes, has demonstrated some similar trends. The most important factor is the disappearance of some algae commonly found in oligotrophic lakes and the appearance or increase in abundance of species able to tolerate more eutrophic conditions. Although the phytoplankton of Lake Michigan has been well-documented, particularly in the southern basin, some investigations did not carry identifications to the species level. These studies are useful in determining only gross community changes, *i. e.*, shifts in dominance from one algal division to another.

The earliest comprehensive study of the deepwater phytoplankton was conducted by Ahlstrom (1936). Stoermer (1967) duplicated his study to

pin-point indications of long-term environmental changes. Ahlstrom identified 161 taxa and grouped them as euplankton (open water) or tychoplankton (inshore). Stoermer identified 257 species. Of the euplanktonic species identified by both men, 71% were considered indicators of an eutrophic environment. Thirty-seven of the euplanktonic species which Ahlstrom did not record were categorized by Stoermer as "most abundant; species often present in samples, but in small numbers; or adventitious species abundant in one or several samples." Nine species not reported by Stoermer were rated in the same way by Ahlstrom. Sampling and identification, as well as natural eutrophication of the lake could account for some of these differences, however, the appearance of species associated with eutrophic lakes followed the massive industrial and economic growth of the area surrounding the southern basin of Lake Michigan.

Stephanodiscus hantzschii Grunow, an indicator of polluted water, is a relatively recent invader of the southern basin. This alga was not reported by Ahlstrom in 1936, but Stoermer only 30 years later categorized it as an adventitious species abundant in one or several collections. In 1974, Seibel and Ayers found this species to be abundant in the vicinity of the Donald C. Cook Nuclear Plant. Vaughn (1962) found *Stephanodiscus hantzschii* and another species of *Stephanodiscus* representing more than 50% of the total phytoplankton from January to May of 1961 at a water filtration plant in the southern basin of Lake Michigan. Other indicators of eutrophication which were reported in Stoermer's (1967) study were *Cyclotella meneghiniana* Kützing and *Melosira binderana* Kützing, both of which became dominant in the phytoplankton of Lake Erie not long ago.

On a more general level, Lackey (1944) reported an increase in the number of Cyanophyta, Chrysophyta, and Pyrrophyta, however he states that he has no quantitative data to back up these observations. Thirty-three years of phytoplankton data from the water supply of the City of Chicago (Damann 1965) revealed that the average number of organisms was increasing at the rate of 13 ± 4.6 organisms per milliliter per year from 1926 to 1958.

Table 1 is expanded from Lackey's (1944) and Damann's (1945) study of phytoplankton from the southern basin of Lake Michigan. It depicts the approximate numbers of genera and species found in various studies. Stoermer's (1967) recent data have been included.

Zooplankton

The major changes in the zooplankton assemblages of Lake Michigan and the nearshore areas have resulted directly or indirectly from man-related activities. The efforts of man-related activities upon zooplankton can be assigned to three major categories: 1) effects of accelerated eutrophication, 2) effects of size-selective predation by alewife, and 3) effects of land use.

Eutrophication has resulted in changes in zooplankton assemblages especially in the littoral and bay areas. The cladoceran *Eubosmina coregoni*

Table 1. Approximate numbers of genera and species of phytoplankters found in the southern basin of Lake Michigan from 1926 through 1967.

	Eddy (1926)		Baylis and Gerstein (1929)		Ahlstrom (1936)		Daily (1938)	
	gen.	sp.	gen.	sp.	gen.	sp.	gen.	sp.
Bacillariaceae	21	26	16	17	27	90	19	26
Myxophyceae (Cyanophyta)	8	9	4	4	9	15	8	9
Chrysophyceae	3	3	3	3	4	10	3	3
Cryptophyceae	1	1	-	-	1	1	-	-
Dinophyceae (Pyrrophyta)	2	2	2	2	2	7	2	2
Euglenophyceae	3	3	-	-	-	-	-	-
Volvocales	3	3	1	1	1	2	-	-
Chlorophyceae (Chlorophyta)	15	20	12	12	20	36	11	11

	Damann (1938)		Lackey (1944)		Damann (1945)		Stoermer (1967)	
	gen.	sp.	gen.	sp.	gen.	sp.	gen.	sp.
Bacillariaceae	21	26	17	27	28	30	35	181
Myxophyceae	16	19	12	14	13	13	12	18
Chrysophyceae	2	2	7	10	-	-	4	10
Cryptophyceae	-	-	-	-	-	-	-	-
Dinophyceae	2	2	5	6	-	-	2	7
Euglenophyceae	-	-	-	-	-	-	-	-
Volvocales	-	-	9	9	-	-	-	-
Chlorophyceae	29	43	39	49	63	63	25	40

(*Bosmina longispina* in early literature citations) is usually associated with oligotrophic waters. It was the most abundant cladoceran collected in samples taken in 1887 and 1888 and in 1926 and 1927 (Eddy 1927). *Bosmina longirostris*, a species normally associated with eutrophic waters, was reported by Eddy as being rare. Wells (1970) reported *Bosmina longirostris* as the most abundant cladoceran from 1954 to the date of his publication.

Another change related to eutrophication in Lake Michigan zooplankton has been the increased abundance of calanoid copepods, especially *Diaptomus oregonensis*. This species was not reported by Eddy (1927). Wells (1960), however, reported its presence during his sampling and found it to be the dominant diaptomid during autumn 1955.

The calanoid copepod *Diaptomus siciloides* may be a useful early indicator of eutrophication in Lake Michigan (Gannon 1972). This species increased in relative abundance as Lake Erie became more eutrophic. This species has been reported only from the eutrophic waters of Green Bay and Saginaw Bay. Since this medium-sized copepod does not seem to be affected by size-selective predation, it may serve as a good indicator of eutrophication. During the present study, this species was not found in the Illinois portions of Lake Michigan.

The littoral areas have been affected by increased eutrophication more than the open lake. Gannon (1972) indicated that the relative proportions of the major zooplankton groups may be a better means of determining eutrophication than the use of indicator species. He found a higher proportion of cladocerans and rotifers than calanoid copepods in the eutrophic waters of Green Bay, whereas the oligotrohpic offshore waters of Lake Michigan contained a higher proportion of calanoid copepods.

The second major change in the zooplankton of Lake Michigan has been the effect of size-selective predation by the introduced alewife. Brooks (1968, 1969), Brooks and Dodson (1965), Gannon (1972) and Wells (1960, 1970) have addressed this subject. The zooplankton populations in Lake Michigan underwent striking size-related changes between 1954 and 1966. The species that decreased most in relative abundance were the largest species:

Cladocera-*Leptodora kindtii*
Daphnia galeata mendotae
Daphnia retrocurva
Diaphanosoma leuchtenbergianum

Copepoda- *Limnocalanus macrurus* (calanoid)
Epischura lacustris (calanoid)
Diaptomus sicilis (calanoid)
Diaptomus oregoniensis (calanoid)
Mesocyclops edax (cyclopoid)

The decline in these species was due to predation by the alewife (Wells 1970). The effects of predation were not as noticeable in Green Bay. According to

(Gannon (1974), the reduced effects of size-selective predation in Green Bay may be due to any or all of the following: 1) refuge in littoral areas, 2) recruitment from Lake Winnebago, and/or 3) high productivity in southern Green Bay.

The third major category, the effects of land development and land use on the shore of Lake Michigan, is closely allied to increased eutrophication (discussed above) and the draining, filling in, or otherwise physically altering the shoreline of Lake Michigan. As human population growth has increased on the shoreline of Lake Michigan, increased amounts of nutrients from wastewater and wastewater treatment plant effluents and certain industrial effluents have caused some localized shifts in the zooplankton assemblages. Accompanying the increased development of the shore is an increased pressure on physically changing natural areas. The extent of future development and its influence on zooplankton populations will be related to the amount of shoreline to be developed and whether areas such as inter-dune ponds and small embayments along Lake Michigan are to be left undisturbed.

Caddisflies

The earliest collections of Trichoptera, or caddisflies, from northeastern Illinois date back to 1880. In 1907 W. J. Gerhard collected additional specimens in the Chicago area along Lake Michigan. Since then several authors have published on the Illinois fauna including Ulmer (1907), Banks (1911), Betten (1934), Ross (1944), and Yamamoto and Wiggins (1964). Betten collected in ravine streams in the vicinity of Lake Forest and recorded 37 species. Ross' comprehensive work on the Illinois fauna added 146 species, bringing the total to 183. Additional species and one family (Sericostomatidae) have been added to the state list since 1944).

Since Ross' publication on the Illinois caddisflies, many of the aquatic habitats along and adjacent to the Lake Michigan shore have been modified or eliminated. These changes reflect large population increases in Lake and Cook Counties and the accompanying expansion of residential and commercial structures and facilities. Many marsh areas (*e. g.*, Skokie Marsh) have been drained, thus completely eliminating these habitats. Increased organic pollution and siltation in streams (*e. g.*, Des Plaines and Chicago Rivers) has reduced or eliminated caddisflies characteristic of clean streams while populations of species which are more tolerant of polluted conditions have increased. The ravine streams in the Lake Forest area supported a diverse caddisfly fauna when Betten collected there in the late-1920's and early-1930's. Few of these species were found during the 1975 inventory.

Several nearshore areas of the Lake Michigan coast in the Chicago area have been closed in recent years due to increases in, and at times heavy, organic pollution. A comprehensive survey of the Lake Michigan caddisfly

fauna could not be conducted in the six-months alloted for this inventory. Thus, the effect of this pollution on the caddisflies could not be determined. Benthic studies on Lake Michigan (Bartsch 1968, Beeton 1960) and the other Great Lakes (Beeton 1960, Dambach 1969, and Howmiller and Beeton 1971) have treated the caddisflies only at the genus level and, thus, have not been useful in assessing faunal changes (Resh and Unzicker 1975). Collections from the Dead River area of Illinois Beach State Park near Zion indicate that little change has taken place in this habitat since the completion of Ross' study of the Illinois caddisflies in 1944. This area has undergone little change over the intervening years, apparently due to the slower residential growth, presence of the Dead River in a state park, and inclusion of this area in the Illinois Nature Preserves system since 1964.

Fishes

If there were no record of the fishes and fishery of Lake Michigan before Chicago became a major city, the conclusion would be inescapable that it has always been an unproductive body of water. In fact, Moffett (1957) commented "Since Lake Michigan became ice-free ... there has been little time for other native fish to adapt themselves to the deep-water habitat...." While Moffett's statement about the deep water habitat may be true, a rather good record is available that shows that the shallow waters of Lake Michigan teemed with fish during the latter half of the 19th century. The Lake Michigan story is a long history of abuse of an ecosystem with a simple, but precariously balanced food chain.

Robert Kennicott (1855) prepared the first list of fishes known to inhabit the Illinois waters of Lake Michigan and cited eight species from the waters adjoining Cook County. James W. Milner collected extensively throughout the lake in 1871 and published life-history information on several important commercial species (Milner 1874). He described the large number of fish present and noted that Chicago fishermen earlier had hired Indians to scout the shoreline and report large schools of fish approaching the beaches. He lamented that sawdust from the Chicago mills was polluting the shallow waters of the lake and that the fishery had started to decline about 10 years earlier, but he believed that its real cause was over-exploitation of juvenile fish. Nevertheless, a substantial fishery existed, for he reported that in 1871 in the vicinity of Waukegan 1,989 men were employed to fish during the seven months of favorable weather. Milner also noted "... the yearly income very variable ... the investments of fishermen in their stocks are quite respectible sums, and compare favorably with the farming-communities, being all the way from $300 to $20,000, their sales reaching in some instances as high as $7,000 from their own nets." Milner's report was for all of the Great Lakes, and it is not possible to ascertain which fish records were from the Illinois portion of Lake Michigan. His extensive collections, deposited in the Chicago Academy of Sciences, were lost in the Great Chicago Fire of 1871.

A survey of the fishes in the Illinois portion of Lake Michigan was made by Edward W. Nelson (1878), and his remarkable observations have seemingly been overlooked by virtually all subsequent authors. His paper is not cited in such incomparable works as Forbes and Richardson's "Fishes of Illinois" or in Hubbs and Lagler's "Fishes of the Great Lakes Region." Nelson cited 26 species from the Lake Michigan drainage of Illinois, 23 of which were observed in the lake proper. He demonstrated that the reversal of flow in the Chicago River through the opening of the Illinois-Michigan Canal in 1871 eliminated much of the pollution entering the lake and dramatically improved fishing in the vicinity of the mouth of the Chicago River. At the same time he gave vivid descriptions of the enormous fish kills in the Chicago and Des Plaines Rivers as the polluted waters emerged from Chicago. Nelson reported that fishing in Lake Michigan was much heavier than during Milner's investigation. For example, off Chicago 100 boats and 300 men were employed in commercial fishing in 1875. Large numbers of most of the commercial and sport species were reported, including a number of species that have long been extirpated from the southern basin of Lake Michigan (freshwater drum, channel catfish, smallmouth buffalo, white bass, northern redhorse, and several others). About the white bass, he commented that so many crowded into the Chicago River to spawn that the water appeared to be filled with a compact mass of fish. Similar comments about other species long extirpated from the Illinois waters of Lake Michigan appear throughout Nelson's narrative.

A few records for Lake Michigan were cited by Nelson (1876), Jordon (1878), Forbes (1884), and Large (1903) in their respective catalogs of Illinois fishes. A number of records for both the lake and Illinois tributary waters were published by Forbes and Richardson (1908) and Meek and Hildebrand (1910). Although not contributing much in the way of distributional data, Carl L. Hubbs (1926) solved many of the zoological and nomenclatural problems that plagued earlier workers in his extremely significant checklist of fishes in the Great Lakes and their tributaries. Greene (1935) collected extensively in Wisconsin waters and summarized the earlier literature. Hubbs and Lagler (1939, 1941, and subsequent editions) produced the standard work on fishes of the Great Lakes drainage.

For many years large-scale investigations have been carried on at Ann Arbor, Michigan, by the U. S. Fish and Wildlife Service (formerly Bureau of Commercial Fisheries), Great Lakes Fishery Commission, and the University of Michigan, Great Lakes Research Division. Many of the programs of these agencies are summarized in Hile (1952) and Van Oosten (1958).

Our knowledge of the present fauna of the Illinois portion of Lake Michigan is based largely upon Smith (1965, 1971, in press), Wells (1968), Woods (1970), Lopinot (1970, 1974), Tichacek and Wight (1972), Parsons (1973), Wells and McLain (1973), and Muench (1974). The status of each of the fishes that occurs, or has been reported to occur, in the Illinois section of Lake Michigan is summarized in the following tables (Tables 2 to 4).

Table 2. Species of fishes presently occurring in Lake Michigan and adjacent waters of Illinois. Those preceded by an asterisk are not native. common names and authors are given in the appendix. INHS refers to collections of the Illinois Natural History Survey; Lit. means the documentation is based upon a published record.

Species	Tributaries	Shoreline	Open Water	Authority
Petromyzon marinus			+	INHS
Acipenser fulvescens			+	INHS
**Alosa pseudoharengus*		+	+	INHS
Dorosoma cepedianum	+	+	+	INHS
Coregonus artedii			+	INHS
Coregonus clupeaformis			+	Lit.
Coregonus hoyi			+	INHS
**Oncorhynchus kisutch*		+	+	INHS
**Oncorhynchus tshawytscha*		+	+	INHS
**Salmo gairdneri*		+	+	Lit.
**Salmo trutta*		+	+	Lit.
Salvelinus fontinalis		+	+	INHS
Salvalinus namaycush			+	INHS
**Osmerus mordax*		+	+	INHS
Umbra limi	+	+		INHS
Esox americanus	+			INHS
Esox lucius		+	+	INHS
**Carassius auratus*	+	+		INHS
Couesius plumbeus		+	+	INHS
**Cyprinus carpio*	+	+	+	INHS
Notemigonus crysoleucas	+	+		INHS
Notropis atherinoides		+		INHS
Notropis cornutus	+	+		INHS
Notropis heterodon	+			INHS
Notropis hudsonius	+	+	+	INHS
Notropis stramineus	+	+		INHS
Pimephales notatus	+	+		INHS
Pimephales promelas	+	+		INHS
Rhinichthys cataractae		+		INHS
Semotilus atromaculatus	+	+		INHS
Catostomus catostomus			+	INHS
Catostomus commersoni	+	+	+	INHS
Erimyzon sucetta	+			INHS
Ictalurus melas	+	+		INHS
Ictalurus natalis	+	+		INHS
Ictalurus nebulosus	+			INHS
Noturus gyrinus	+	+		INHS
Fundulus diaphanus	+			INHS
Fundulus notti	+			INHS
Percopsis omiscomaycus		+	+	INHS
Lota lota			+	INHS
Culaea inconstans	+	+		INHS
Pungitius pungitius		+	+	INHS

Table 2. Continued.

Species	Tributaries	Shoreline	Open Water	Authority
Ambloplites rupestris	+	+		INHS
Lepomis cyanellus	+			INHS
Lepomis gibbosus	+	+		INHS
Lepomis gulosus	+	+		Lit.
Lepomis macrochirus	+	+		INHS
Micropterus salmoides	+	+		Lit.
Pomoxis annularis	+	+		INHS
Pomoxis nigromaculatus		+		Lit.
Etheostoma exile	+			INHS
Etheostoma microperca	+	+		INHS
Etheostoma nigrum	+	+	+	INHS
Perca flavescens	+	+	+	INHS
Stizostedion vitreum		+		Lit.
Cottus baridi		+		INHS
Cottus cognatus		+	+	INHS
Cottus ricei		+	+	Lit.
Myoxocephalus quadricornis			+	INHS

Table 3. Species recorded, but whose present occurrence in the Illinois portion of Lake Michigan is problematical (extirpated or initial record probably in error). Those preceded by an asterisk are not native.

Species	Lake	Drainage	Comment
Lampetra lamottei	+		?Extirpated
Ichthyomyzon unicuspis	+	+	"
*Polyodon spathula***		+	Probably in error
Lepisosteus osseus	+	+	?Extirpated
Amia calva		+	"
Anguilla rostrata	+	+	"
**Alosa sapidissima*		+	Extirpated
Coregonus alpenae (as *prognathus*)	+		?Extirpated
Coregonus nigripinnis	+		"
Prosopium cylindraceum	+		"
Esox masquinongy	+		"
**Carassius carassius*		+	"
Hybognathus nuchalis		+	Probably in error
Hybopsis storeriana	+		?Extirpated
Notropis blennius		+	Probably in error
Notropis dorsalis		+	?Extirpated
Notropis emiliae		+	"
Notropis heterolepis		+	"
Notropis spilopterus		+	"
Clinostomus elongatus	+		Probably in error
Carpiodes velifer		+	"
Ictiobus bubalus	+	+	?Extirpated
Ictiobus niger		+	"
Moxostoma erythrurum		+	"
Moxostoma macrolepidotum		+	"
Ictalurus punctatus	+	+	"
Noturus flavus		+	"
Labidesthes sicculus		+	"
Morone chrysops	+	+	"
Morone mississippiensis		+	"
Lepomis megalotis		+	"
Etheostoma caeruleum		+	"
Etheostoma chlorosomum		+	"
Percina caprodes		+	"
Aplodinotus grunniens	+	+	"

**Believed a stray by way of the Illinois-Michigan Canal.

Table 4. Species not yet reported from Illinois waters of Lake Michigan, but reported elsewhere in the lake, and species reported, but in need of confirmation and documentation. (* = not native)

Species	Authority	Comment
Ichthyomyzon castaneus	G. C. Becker, pers. comm.	Wisconsin (Drainage)
Coregonus kiyi	Wells (1968)	SE Lake Michigan
Coregonus johannae	Greene (1935)	Wisconsin (Lake)
Coregonus reighardi	Wells (1968)	SE Lake Michigan
Coregonus zenithicus	Greene (1935)	Wisconsin (Lake)
**Oncorhynchus nerka*	Verbal report	Status unknown
**Salmo clarki*	G. C. Becker, pers. comm.	"
**Salmo salar*[1]	Verbal report	"
Carpiodes cyprinus	Wells (1968)	SE Lake Michigan

[1]Hubbs and Lagler (1964) note that it is difficult to distinguish adults of *Salmo salar* and *Salmo trutta*.

By the early 1900's, the Chicago and Calumet Rivers were so polluted that few fish ascended them and, if they did, soon perished. During very high water stages, occasional fish would find their way from Lake Michigan into the Illinois River, but in recent years the pollution has formed an effective barrier between the lake and river faunas. Other Illinois tributaries are too small to be significant, and many of them are too modified to support aquatic life. Some of the native species persist in small lakes and marshes.

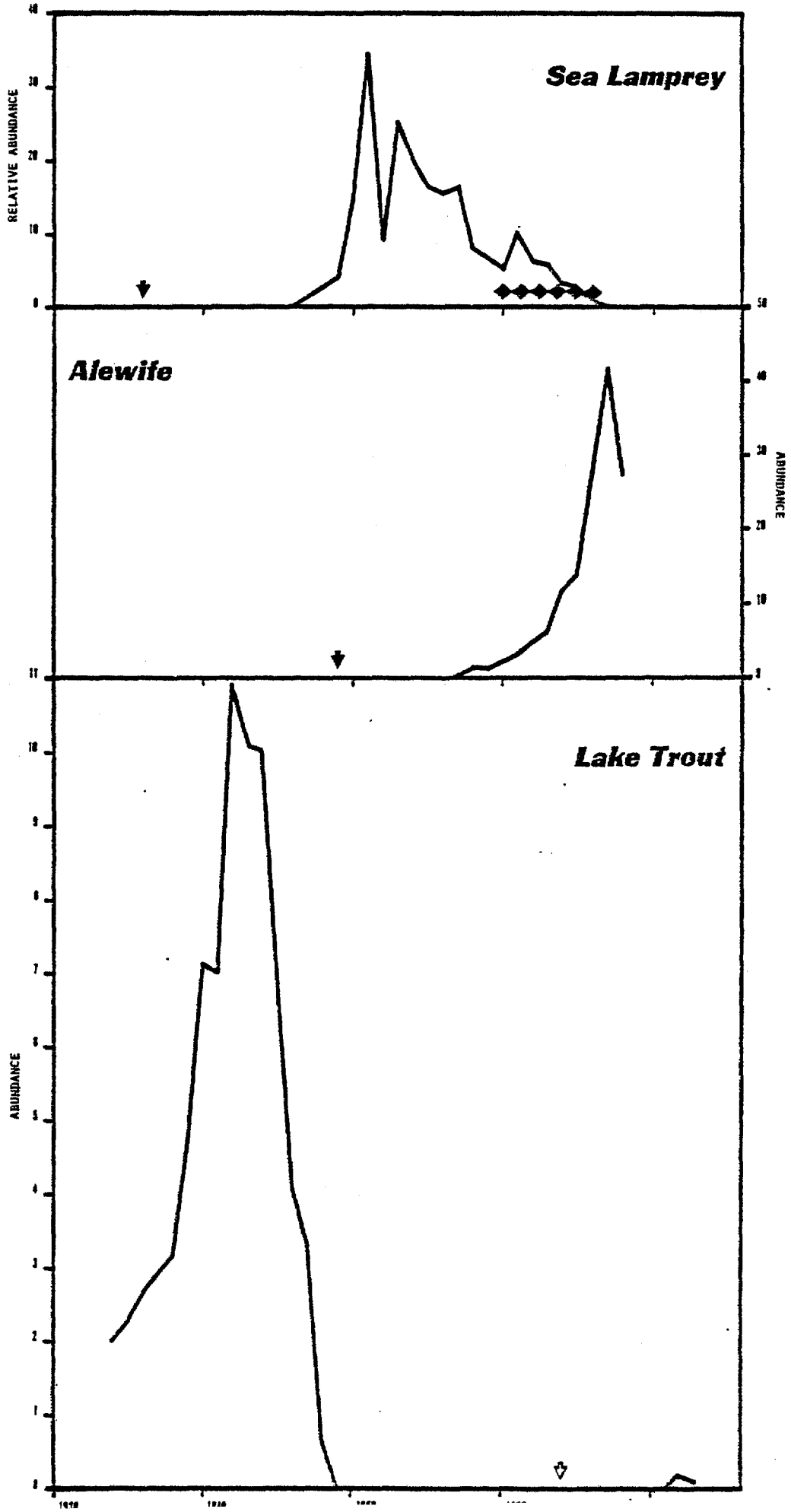
Throughout the first half of this century, water quality gradually deteriorated, and the shoreline became increasingly modified. Because of the immense size and depth of Lake Michigan, it supported a fishery for lake trout, ciscos, and whitefish until about 1950. In 1936, a specimen of the sea lamprey was found in southern Lake Michigan and reported by Hubbs and Pope (1937), who warned that its presence posed a serious threat to the Great Lakes fishery. Native to the Atlantic Ocean, but with a landlocked form in Lake Ontario, the species had been unable to surmount the Niagara Falls barrier until the Welland Canal was constructed in the mid-1820's. Its dispersal into southern Lake Michigan required more than 100 years, possibly because predation on them by native fishes kept their numbers low. The sea lamprey's effect upon large species of native fishes was quick and devastating. In a few years the large fishes and commercially important species succumbed to the combination of lamprey predation and commercial over-exploitation (Moffett 1957).

By 1960, a selective lamprey larvicide, called TFM, was found that gradually brought the lamprey population under control (Applegate, *et al.* 1961), but the natural ecology of Lake Michigan was destroyed. Prior to the arrival of the sea lamprey, the food chain consisted of large species (lake trout, burbot) feeding upon small fish (sculpins, small coregonid species, etc.), which in turn fed almost exclusively upon crustaceans. According to Moffett (1957), the removal of a large predatory fish from the food pyramid resulted in great increases in smaller species such as sculpines and the bloater. Commercial fishermen either went out of business or harvested the small, slow-growing, and less desirable bloater, many of which were too small to be marketable.

Apparently over-harvest of the bloater and other small and medium-sized coregonids left an unfilled niche in the food chain which was quickly occupied by a second invader from the Atlantic Coast via the Welland Canal: the alewife. First reported in Lake Michigan in 1949, the alewife was a serious problem throughout the 1960's. It was so abundant and prone to regular and massive dieoffs that water intake valves had to be screened and crews of men hired to scoop up the windrows of dead fish along the shoreline. Beaches were closed during the summers, and fishing vessels were contracted to catch and remove live fish. Tons of alewives were used for fertilizer and pet food.

In the middle 1960's, the Michigan Department of Conservation began experimenting with releasing coho and other salmon species from the Pacific

Figure 1. Abundance of lake trout (units=100,000 lbs), alewife (units= 1,000,000 lbs), and sea lamprey (relative units based upon counts in spawning runs) in Lake Michigan from 1930 through 1976, based upon harvest and other data. Solid arrows indicate the first year a species was detected in the lake. The open arrow indicates the year salmonid stocking began. Solid diamonds indicate the period during which chemical control of larval lampreys was underway.


Sea Lamprey
RELATIVE ABUNDANCE
Alewife
ABUNDANCE
Lake Trout
ABUNDANCE

Northwest into Lake Michigan. Since numerous attempts had been made in the late-19th century to stock Atlantic salmon and Atlantic shad into the Great Lakes without success, Michigan's program was viewed with initial skepticism. However, the rationale for the experiment was that the alewife provided an abundant food supply not being utilized and that Michigan had suitable tributaries for spawning salmon. The coho and later the chinook salmon cooperated and grew at fantastic rates, providing Michigan with an immensely popular sport fishery. Soon the salmon fishery rivaled that of the American smelt, which had been successfully stocked in the inland Great Lakes about 1912. Whether the salmon populations will be permanent is as yet unknown, but they may have alleviated somewhat the alewife problem and have provided an exciting fishery for almost 10 years in Lake Michigan. Unfortunately there are too few tributaries with suitable spawning habitats to accomodate the large numbers of hatchery-reared smolt each year. Although expensive, the practice is justified by the money fishermen expend in fishing for salmon and trout.

Other states adjoining Lake Michigan have developed programs not only to introduce exotic species of salmon and the steelhead (rainbow) and brown trouts, but also to reintroduce stocks of native brook and lake trout.

While the trouts and salmons are the most sought-after species, the yellow perch remains the most abundant sport fish along the Illinois shore of Lake Michigan. However, its numbers have declined in the last 10 years. The catch of American smelt has vascillated over the years, but the species is still important in the fishery of southern Lake Michigan. The chub, *Coregonus hoyi*, is the most commonly taken commercial species. It has been said that 90 to 95% of the fish present in Lake Michigan are alewives (Woods 1970). Yet, the annual harvest of commercial species during the early 1970's was three times that of the early 1960's in terms of total pounds, but far below the annual harvest in the 1930's and 1940's (Lopinot 1974). Both sport and commercial fishing are more intensive now even though there are far fewer desirable fish to be taken (Table 5).

In addition to the problems created by the ecological imbalance, Lake Michigan has recently undergone severe eutrophication in the shallow waters, bays, and harbors. Nitrogen and phosphorus from wastewater, detergents, and field runoff have added nutrients that stimulate massive growths of the filamentous alga *Cladophora*. Early in this decade, rising levels of DDT in the flesh of fish caused great concern. After the ban on the use of DDT in Illinois, the residues have been diminishing gradually, but the residues of other pesticides such as Aldrin, Dieldrin, and Lindane remain high. Equally serious is the buildup of another chlorinated hydrocarbon, the polychlorinated biphenyls, or PCB's, which are almost indestructable. The presence of mercury in the fish flesh is still another health hazard that has appeared in Lake Michigan in the 1970's. An excellent account of these problems is to be found in Woods (1970).

Although the future may appear ominous, Lake Michigan is an immense body of water, and the deeper parts of the lake have not changed so dramatically as the shoreline waters. The land area has been tremendously

Table 5. Average numbers per year of licensed commercial fishermen, native[1] and non-native or restocked[2] fish caught, and total pounds for the Illinois portion of Lake Michigan, 1934 through 1973. Data calculated from Lopinot (1974).

Years	Commercial Fishermen	Native Fish	Introduced or Restocked Fish	Total Pounds
1934-35	....	930,102	....	930,162
1936-40	....	1,189,572	....	1,347,267
1941-45	....	1,797,923	....	1,659,390
1946-50	39.4	1,596,418	....	1,595,907
1951-55	29.4	1,373,560	5,914	1,379,015
1956-60	21.4	803,403	5,807	809,210
1961-65	20.0	342,870	8,457	346,486
1966-70	25.8	377,843	....	377,740
1971-73	51.3	677,163	8,122	693,147

[1]Principally yellow perch, coregonid fishes, and in early years lake trout; in later years, some suckers.

[2]Principally smelt and, in later years, also introduced trouts, salmons, stocked lake and brook trouts.

modified, but still contains some habitats of great value. During the 1975 investigations, three species of fishes, long assumed to have been extirpated in the basin, were found to be present in Wolf Lake and Powder Horn Lake near the Indiana state line. They were the brown bullhead, banded killifish, and Iowa darter.

Terrestrial Vegetation

Warne (1870) and Babcock (1872, 1873) were among the first to publish information concerning the terrestrial plant species in the Illinois Coastal Zone. Cowles (1901) published an ecological study that concerned the entire Chicago area and included plant habitats and communities of the north shore. Van Hook (1905) listed the ferns found near Lake Michigan. Then followed studies that were restricted to more specific habitats. Gates (1912) studied the associations of the beach area from Waukegan, Illinois, to Kenosha, Wisconsin, and included a list of species. Schmoll (1920) surveyed the forests in the vicinity of Glencoe. Doubtless many other students visited the various habitats and perhaps wrote "term papers" which are no longer extant. Recently Dr. Elizabeth Lunn of Lake Forest has carried out extensive research at Illinois Beach State Park and her list contributed the majority of species listed in this paper for that area. The publication of Gates (1912), and Swink (1969) and the collections in the herbarium of the Illinois Natural History Survey supplied others.

The true beach and the generally flat sand land extending to the bluff presents a number of habitats for vascular plants. These are the middle beach, the foredunes, rear dunes, stable dunes, sand ridges (dunic in character), moist prairies and swales, marsh, pond, and flood plain. Since the arrival of European man, numerous distrubance habitats, *i. e.*, dumps, old sand pits, parking lots, and roadsides, have appeared and must be included. In the list of species presented in the appendix, these habitats have been recorded under the title "Urban."

The habitats enumerated above lie mostly from Waukegan to the state line. South of Waukegan, to Evanston, the beach is narrow and vascular plants occupy the middle beach portion that reaches the base of the bluffs.

The lake bluffs are composed of moranic clays and are easily eroded by wave action and slumping. No other habitat in our climatic area imposes such severe conditions upon vegetation as an eroding clay bluff (Cowles 1901). Vegetation is scarce or lacking on the eroding surface. Where erosion has ceased and the bluffs are not steep, trees such as quaking aspen, large-toothed aspen, cottonwood, hop hornbeam, red cedar, and red oak became established as did a number of shrubs and herbs (Cowles 1901; Fuller 1917). Later, exotics were introduced by residents and some of these introductions, as common buckthorn, have become abundant. Exotic species of pines and spruces have also been introduced. One of the rare native species in this habitat was the buffalo-berry. It grew on the bluff at Glencoe (17 May 1954, Evers #42282) and a few plants may still survive there (Swink 1969).

The ravines are an intersting feature of the lake bluffs. Most of them occur between Winnetka and the Great Lakes Naval Training Center, although several are found northward to Winthrop Harbor. Some of the ravines are small, extending only a short distance from the lake front into the bluff. Others are larger, some of these having several branches that are eroding into the upland. Warne (1870), Cowles (1901, 1926), Fuller (1917), Schmoll (1920), and Pepoon (1927) were a few to mention or describe the ravines. The ravines are subjected to tremendous erosion as they presently serve as conductors of storm water from the upland to the lake. The moranic clay permits lateral erosion by storm water and slumping from ground water; the habitat is a very unstable one for vascular plants. On the exposed slopes, the vegetation resembles that of the lake bluffs, on more protected sites it resembles the mesophytic and flood plain forest. Local residents have introduced a number of exotic trees, shrubs, and herbs, some of which have spread.

Beech (*Fagus grandifolia* Ehrh) once grew along Pettybone Creek, at the Naval Training Center, and also at Highland Park (Jensen 1929). Swink (1969) stated that beech trees may be in ravines at Highland Park and Fort Sheridan, but there are no recent collections or observations.

Most of the upland forest, occupying the bluff-top and the upland beyond, has been modified by urbanization. Much of the land serves as estate grounds. Fuller (1917) listed 49 species of vascular plants for these uplands. Some of the original forest tree species remain, but the number of native shrubs and herbs has been reduced by cultivation and introduction of exotics.

Amphibians and Reptiles

Natural habitats for amphibians and reptiles in the Illinois portion of the Lake Michigan basin originally consisted of forest, steep ravines cutting through wooded bluffs, bogs, prairies, extensive marshes, and sand hills and beach along the edge of the lake. Virtually all of these habitats have been altered in the area by urbanization and industrialization except for a narrow strip near the lake, which includes Illinois Beach State Park. The amphibian and reptile fauna was never rich, but is of interest because of the intergradation of forest and prairie species and because a surprisingly large number of species have managed to persist in the area despite the impact of human modification of most of the natural features in the basin.

The amphibian and reptile fauna has been studied thoroughly over the years, particularly by herpetologists and students associated with the Field Museum of Natural History and the Chicago Academy of Sciences. The earliest publication was that of Robert Kennicott (1855), who listed 12 species of amphibians and 23 species of reptiles as occurring in Cook County, Illinois, but not necessarily in the Lake Michigan basin. Many of the species he cited still occur in the Mississippi River drainage of north-

Table 6. Species of amphibians and reptiles presently occurring in the Illinois portion of the Lake Michigan basin (see appendix for common names).

Amphibians	Reptiles
Ambystoma laterale	*Chelydra serpentina*
Ambystoma tigrinum tigrinum	*Sternotherus odoratus*
Bufo americanus americanus	*Kinosternon flavescens spooneri*
Bufo woodhousei fowleri	*Emydoidea blandingi*
Acris crepitans blanchardi	*Chrysemys picta marginata*
Pseudacris triseriata triseriata	*Heretodon platyrhinos*
Hyla crucifer crucifer	*Opheodrys vernalis blanchardi*
Rana clamitans melanota	*Elaphe vulpina vulpina*
Rana pipiens pipiens	*Lampropeltis triangulum triangulum*
	Thamnophis radix radix
	Thamnophis sirtalis semifasciata
	Storeria dekayi wrightorum
	Natrix sipedon sipedon

Table 7. Species of amphibians and reptiles presently occurring near the Illinois portion of the Lake Michigan basin that may yet be found there. Some of them were known to occur there formerly.

Amphibians	Reptiles
Ambystoma maculatum	*Graptemys geographica*
Notophthalmus viridescens louisianensis	*Trionyx spinifer spinifer*
Plethodon cinereus cinereus	*Ophisaurus attenuatus attenuatus*
Hyla versicolor versicolor	*Cnemidophorus sexlineatus sexlineatus*
Rana catesbeiana	*Coluber constrictor foxi*
Rana sylvatica	*Thamnophis proximus proximus*
	Storeria occipitomaculata occipitomaculata
	Natrix grahami
	Natrix kirtlandi
	Natrix septemvitatta
	Sistrurus catenatus catenatus

Table 8. Species of amphibians and reptiles known to be extirpated from the Illinois portion of the Lake Michigan basin.

Amphibians	Reptiles
Hemidactylium scutatum	*Clemmys guttata*
Necturus maculosus maculosus	*Eumeces fasciatus*
	Elaphe obsoleta obsoleta

eastern Illinois; many others have long been extirpated, and others probably never occurred in Cook County as we know it today, for it may have been much larger geographically in the early 19th century. Other 19th century studies were a list of Illinois amphibians and reptiles by N. S. Davis and F. L. Rice (1883), who listed the mudpuppy, *Necturus maculosus*, as "exceedingly abundant in Lake Michigan" where it is probably now extirpated, and a much more complete synopsis of Illinois species by Harrison Garman (1892), who cited a few records from the Lake Michigan basin.

The first modern studies of the herpetofauna of the area were those of K. P. Schmidt (1929, 1930, 1935 - with Necker, 1938) of the Field Museum of Natural History and the younger herpetologists, whom Dr. Schmidt encouraged to conduct field work. The most prolific of these workers was W. L. Necker (1933, 1938, 1939a, 1939b). Using these publications as baseline data, G. S. Pearsall (1940) compiled lists of the fauna and flora of the Forest Preserve District of Cook County, and C. H. Pope (1944) produced an excellent handbook of amphibians and reptiles of the Chicago area. In the late 1940's, H. K. Gloyd of the Chicago Academy of Sciences assumed Schmidt's role in encouraging local herpetological investigations and is, in part, responsible for the researches of R. A. Edgren and W. T. Stille (1948), Stille and Edgren (1948), and A. G. Smith (1951). Two early and important papers on population dynamics of vacant-lot snakes were published by H. C. Seibert and C. W. Hagen (1947) and Seibert (1950) based upon a study conducted in the Lake Calumet region of southeast Chicago.

The next era began with P. W. Smith (1956, 1961) and continues today with the Chicago Herpetological Society, which publishes papers by members on the local fauna in its Bulletin series. During this period, R. D. Gustafson (1966) prepared, but never published, a list of amphibians and reptiles observed in Illinois Beach State Park. A great number of systematic revisions in recent years have cited records based upon museum specimens collected in northeastern Illinois.

Birds

The retreat of the Wisconsin glaciation left a rich belt of aquatic and marsh habitats at the southern perimeter of Lake Michigan, which supported a distinctive, mainly northern avi-fauna largely intact into recent times. The richest area in terms of marsh or wet prairie species was probably the Calumet River area and adjacent Indiana, which supported the southeasternmost breeding populations of such marsh indicators as the horned grebe, pintail, green-winged teal, American wigeon, redhead, lesser scaup, ruddy duck, sandhill crane (*Grus canadensis tabida*), Wilson's snipe, and Wilson's phalarope. Kennicott's (1855), and Nelson's (1876-1877) papers on the birds of Cook County and northeastern Illinois attest to the richness of the area and the bird population it supported. In addition to the northern marsh species, forest habitat which had developed on ridges and along rivers behind the beaches and marsh areas, supported a large fauna with species of both northern and southern origins.

These faunas probably survived in essentially a pristine state into the 19th century, but began to change with the ingress and expansion of the non-native human population. Chicago, which had a population of about 30,000 human inhabitants in 1850, grew enormously in the next 30 years to over 500,000. Deterioration of wildlife populations was already underway when Kennicott (1855) made his observations, and the trend showed signs of accelerating by the time Nelson made his observations about 20 years later. Game species and those intolerant of humans were showing population declines or disappearing--including the wild turkey, prairie chicken, sharp-tailed grouse, sandhill crane, bald eagle, and raven. Most of the change, however, was yet to come.

Chicago's (metropolitan district) population doubled, to over a million people in the decade 1880 to 1890, doubled again by 1910, reached over 5 million by 1950, and nearly 7 million by 1970. In the face of this human expansion, it was almost inevitable that a certain sensitive segment of the fauna would disappear, especially in view of the fact that what was happening in the Chicago area was happening more or less generally. In the Midwest declines apparent in the 19th century accelerated to the point of extirpation for (especially breeding populations) the eagle, all of the grouse (ruffed, sharp-tailed, prairie chicken), turkey, crane, and raven, plus greatly reduced populations of many species. Most surprising was the passenger pigeon, which was still plentiful in the area in the 1870's but completely extinct by 1914. A few Wilson's phalaropes continued nesting attempts until 1969, but the Illinois breeding population is probably now extirpated.

Song birds, in general, with less extensive territory requirements continue to survive, but we can expect faunal deterioration to involve these smaller species more and more as natural habitats continue to be reduced both in quantity and quality.

Mammals

The mammalian fauna presently surviving within the Illinois coastal zone is in serious trouble. When the area is compared with what existed before European man's arrival, it is obvious what has happened to this once rich and wild area. The ease of travel on the Great Lakes accelerated the development of eastern Lake and Cook Counties into large cities. The spreading cities devoured land, moving in all directions away from the city of Chicago, spreading with it a habitat of concrete and steel. The prairies and woodlands receded as agricultural land was needed to supply food to these cities and the rest of the nation. With this, many mammals including man himself, in the form of the American Indian, receded. One must go into the western portion of Lake County to find areas of suitable woodland for the existence of many forest-dwelling mammals, and sufficient prairie regions no longer exist for even the smallest of prairie-dwelling mammals. The mammals have had to adapt to man's presence or disappear, as did the bison.

At the time of European man's arrival in the area now called the State of Illinois, 63 species of mammals existed within the state and 51 of these thrived in the Lake Michigan area. Thirty-eight different species are still doing relatively well within this area, 11 species have been extirpated, one has been reintroduced successfully, two or three might be reintroduced if the proper habitat could be increased and maintained, and three species have been successfully, though accidently, introduced.

Prior to the arrival of European man in the Lake Michigan area, a number of large mammals roamed the forests and prairies and could be found along the shores of the Great Lakes and the rivers and streams draining into and from Lake Michigan. Large herbivores such as elk and bison were present, as well as the white-tailed deer. Carnivores were also found in reasonable numbers. The mountain lion, wolf, wolverine, pine martin, fisher and black bear thrived prior to white man's appearance and his relentless alteration of the habitat around Lake Michigan.

By the middle 1800's, the elk, bison and mountain lion were extirpated from all of Illinois. The other previously mentioned species held on for a considerably longer period of time, but by the early 1900's, the black bear, wolf, and wolverine were extirpated from the coastal zone. The fisher and pine martin could be found until the middle 1940's.

The major contributor to the extirpation of these species of mammals was their relative intolerance of man. As man entered the Lake Michigan area, he converted the forests and prairies into farmland and eventually into cities. This drastically reduced the suitable habitat available to many of these species. Although a few somewhat natural areas still exist, these are too few and too small in area to allow the maintenance of a healthy, breeding mammal population. Exceptions include the pine martin and fisher, which have recently been successfully reintroduced into areas of suitable habitat in Wisconsin.

A few additional mammals, in all probability, no longer exist within the Illinois portion of the coastal zone. The river otter is exceedingly rare throughout Illinois, as is the red squirrel. The coyote, although still found in low numbers in southern Illinois, should be considered extirpated from the study area. Of these three species, only the red squirrel has a chance for successful reintroduction. Its requirement for large stands of conifers and mixed conifer forests make its chance for survival slim.

The house mouse, black rat, and Norway rat were introduced by European man and are thriving, much to the disgust of most citizens. These three species do well in the presence of man. They inhabit buildings, garbage dumps, and almost anything associated with man. While they survive well around man, they do not do so in the open fields or woods away from man's dwellings.

The white-tailed deer was extirpated from the Lake Michigan area of Illinois during the 1930's, but was successfully reintroduced soon after. Deer can now be found in the northern portion of the study area along the Lake Michigan shoreline.

RARE, THREATENED, OR ENDANGERED SPECIES

Federal law establishes two categories of endangerment: 1) those species in danger of extinction through all or a significant portion of their range, *i. e., endangered* species; and 2) those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, *i. e., threatened* species. In addition to these categories, it is useful to consider as *rare*, species which exist in extremely low numbers or in a very restricted habitat. Species so classified are indicated in the appendix. Emphasis is given to certain of these below.

Of the aquatic invertebrate groups studied, only the Trichoptera are sufficiently well-known to permit discussion. Fifty-nine species of caddisflies are known to occur in the nearshore of Lake Michigan and adjacent shore areas in northeastern Illinois. Four of these are classified in Illinois as rare. They are *Fabria inornata* (Banks), *Leptophylax gracilis* Banks, *Polycentropus remotus* Banks, and *Triaenodes baris* Ross. All four species are northern in distribution and occur in states farther north in the U. S. and in southern Canada. In Illinois, *F. inornata* and *P. remotus* have been collected only in the Dead River area of Illinois Beach State Park, while *T. baris* has been collected in the Dead River and in the Kankakee River at Momence. *Leptophylax gracilis* only has been collected from Lake Michigan in the Chicago area. None of these species were taken during the 1975 sampling.

Many fish species have become extirpated and nearly all of the remaining native fishes face some sort of threat. The 1973 edition of the Department of the Interior's "Red Book" entitled *Threatened Wildlife of the United States* lists the lake sturgeon, langjaw cisco, deepwater cicso, and blackfin cisco and notes that neither of the latter two species have been seen since 1955. Lopinot and Smith (1973) cited the lake sturgeon, cisco, lake whitefish, blackfin cisco, round whitefish, blackchin shiner, and banded killifish (all native to the Great Lakes drainage) as rare and endangered in Illinois. The rare fishes in Lake Michigan include virtually all native species, except the yellow perch, the sculpins, the sticklebacks, trout-perch, and spottail shiner. Smith (in press) cited as threatened the lake trout and blackchin shiner as rare and restricted in distribution in the lake, chub (*Couesius*) and longnose sucker, although neither of the latter is believed to be threatened or endangered at the moment.

The common fishes in Lake Michigan are, for the most part, the non-native species. The common fishes in the tributaries tend to be those that are wide-ranging in the Great Lakes and Mississippi drainages.

Among the terrestrial vertebrates, most of the less adaptable species have long been extirpated from the highly modified basin. Those that remain, with few exceptions, are wide-ranging and hardy species that will probably persist as long as their habitat exists. A number of prairie species have

adapted to living in vacant lots and trash dumps in the suburbs and maintain large populations where there is an abundance of food and cover. Several forest species can live in the forest preserves and in wooded areas remote from the cities and villages. Marsh species still have relatively abundant habitat in Lake County and the Calumet-Wolf Lake area of Cook County.

Lake Michigan proper does not provide suitable habitat for amphibians and reptiles any longer, and the reasons are unknown. Being a cold lake, it may have never harbored these animals except for the mudpuppy and an occasional turtle.

There is meager evidence that a population of melanistic plains garter snakes may occur in the basin. At this time only one specimen is known, a subadult from Winthrop Harbor. It is the first recorded case of melanism in this species. Melanistic colonies of another species, the eastern garter snake, are well-known in the Lake Erie marshes of northern Ohio (Conant 1951), but have never been reported from Illinois.

Two nearly unique animals in this area are the Illinois mud turtle and Chicago garter snake. The Illinois mud turtle, *Kinosternon flavescens spooneri*, was described and named by P. W. Smith (1951) from ponds and floodplain sloughs along the middle Illinois River and along the Mississippi River in northwestern Illinois. By the time of publication of the latest edition of *A field guide to reptiles and amphibians of eastern and central North America* (Conant 1975), the total known range of this species was sand areas in central and northwestern Illinois and one locality each for the states of Iowa and Missouri, both adjacent to the Illinois border along the Mississippi River. The subspecies is thus virtually endemic to the State of Illinois, hence its common name.

In the summer of 1966, Roger D. Gustafson, then Naturalist of Illinois Beach State Park in Lake County, found a half-grown mud turtle killed on the highway near the entrance to the park and submitted it to the Illinois Natural History Survey for identification. Mr. Gustafson noted that the turtle was found near a small pond, but also suggested the possibility that the turtle had been transported to the park by a visitor. The specimen had been assumed to be the eastern mud turtle, *Kinosternon subrubrum*, because this species was known to be present in a few relict colonies in sandy areas in northeastern Indiana up until about 20 years ago. However, the specimen from Illinois Beach State Park was unmistakably *Kinosternon flavescens spooneri*.

At the urging of Smith, several biologists tried unsuccessfully to confirm the presence of a breeding population of the Illinois mud turtle in the park and, in the absence of additional specimens, it was assumed that the specimen had been brought in from elsewhere. However, in the summer of 1972, Dr. L. M. Page of the Illinois Natural History Survey captured a very large specimen in a pond near park headquarters, confirmed its identification, and released it in the pond. The size of the turtle precluded any other kinosternid turtle, for the Illinois mud turtle is the largest

member of the genus in Illinois. Thus, at long last there was little reason to doubt the provenance of the specimen found in 1966, that this unusual turtle does indeed exist, and that it has eluded collectors because of its rarity and secretive habits.

The population in Illinois Beach State Park is the northernmost and easternmost known for the turtle. Since its habitat is protected in the State Park, its future may be more secure here than elsewhere in its limited range. The greatest threat to its continued existence lies in overdevelopment of park facilities and consequent modification of the ponds along the lake front and the taking of specimens by collectors and pet fanciers once they learn that this highly prized species is available so near the city of Chicago. It is recommended that measures be implemented to reduce these threats.

Investigations during 1975 failed to reveal additional specimens, but it was ascertained that suitable habitat is still plentiful in the park and there is every reason to believe that the species, while rare, will persist in the area. Its discovery in Illinois Beach State Park is one of the most exciting herpetological discoveries in Illinois in many years.

Relict populations such as those of the Illinois mud turtle serve as valuable "outdoor" laboratories for scientists interested in unraveling the mysteries of past dispersals of reptiles and other animals, and they have contributed substantially to an understanding of the postglacial climatic history of the Midwest.

In the course of the field work and research for the report *The amphibians and reptiles of Illinois*, P. W. Smith noted that specimens of eastern garter snakes from the greater Chicago area differed markedly from other garter snakes in having the lateral stripes on the anterior part of the body interrupted regularly by black crossbars. Further study revealed that this pattern difference is rather constant and that the population of garter snakes in extreme northeastern Illinois should be recognized as a distinct subspecies. A search of the literature resulted in the discovery that E. D. Cope had reached the same conclusion in the late 19th century and had proposed the name *Eutaenia sirtalis semifasciata* for the population. However, A. Ruthven (1908) published a revision of all species of garter snakes and concluded that Cope's name *semifasciata* should be synonymized because not all individuals of the garter snakes in northeastern Illinois possessed the distinctive pattern.

Based on a thorough study of museum specimens then available, Smith resurrected the name *semifasciata* from the synonymy for the population and demonstrated that nearly all specimens (90%) are immediately recognizable by the pattern difference. The Common Names Committee of the American Society of Ichthyologists and Herpetologists concurred with Smith that the snake should have a name and it proposed as a common name for the subspecies, Chicago garter snake. Chicago has the dubious distinction of having a snake named for it.

The Chicago garter snake is virtually confined to the greater Chicago area, but also occurs in Lake and Porter counties, Indiana, and in a few counties in extreme southeastern Wisconsin. Presumably the population differentiated in place, possibly during glacial times, and has thrived in the area since. It is not a threatened or endangered species. In fact, it is still common throughout northeastern Illinois and occupies meadows, forest preserves, and even vacant lots. Its abundance and the presence of suitable habitat for it were corroborated during investigations conducted during the summer of 1975.

Natural populations such as this are of inestimable value to scientists interested in variability of living things, speciation and evolution, and the mechanisms of genetics.

The coastal zone includes certain bird habitats that are seriously threatened not only in Illinois, but on a global scale. Every effort should be made to preserve these habitats where the remnants survive. Included here particularly are the beach itself, and the grassland, and the marsh and pool areas behind the dunes. These habitats are rich in very specialized faunal associations.

Because individual birds require sizable areas of essential habitats for survival, it is important, in order to preserve sustaining populations and integrated fuanas, to save habitats in as large blocks as possible. While one-acre tracts may sustain some plant and invertebrate populations, birds and other vertebrate animals in general, require much larger areas for survival.

Beyond the space requirements, some minimal, but largely unknown, quality of habitat is essential. As the coastal zone is narrow, it is particularly susceptible to degradation from various human activities. For bird and other animal populations in the zone, human traffic creates serious problems through both harrassment and physical destruction of habitats. Human traffic favors only a few species, notably introduced pest species such as the starling, house sparrow, and rock dove, which are, themselves, indicators of ecological degradation and are already dominants of the coastal zone.

The native species have varying tolerances, from species to species, for human traffic, and it is axiomatic in the preservation of faunas, that management plans must be geared to the most sensitive, fragile, or vulnerable populations, or important segments of the fauna will be lost.

Each species has its own unique problems and potentials, and it is impracticable, even impossible in view of the state of our present knowledge, to consider them all here (see avifaunal list in the appendix). The following are merely examples, using two bird species, of the kinds of problems that coastal zone management involves.

Perhaps the single bird species most characteristic of the Lake Michigan beach is the piping plover. A nesting population of this species probably existed in the Illinois Beach State Park shore area until at least 1955, and on the Indiana beach until the early 1960's (Russell 1973). An isolated nesting of piping plovers occurred near Waukegan in 1973 (Kleen 1973). Transient piping plovers still occur in both states during migration. The extirpation of the nesting population came probably as a direct result of human distrubance with increased recreational use of the Lake Michigan beach. The human traffic on the beach in spring and summer is now probably far in excess of what the species can tolerate. What has happened to the species in Illinois and Indiana has also been happening elsewhere on the Great Lakes' beaches, proportional to the size of the local human populace. Nesting populations now survive only on the more isolated (from humans) beaches.

The piper's habitat is large unvegetated areas of sand beach. No population measurements of piping plovers were ever made in Illinois, but in New York, populations as high as 20 pairs per two lineal miles of beach have been studied (Wilcox 1959). The minimal habitat acreage requirement is unknown, but there would probably be little point in setting aside sanctuaries of less than a lineal mile of beach, plus adjacent dunes and cushion area to a depth of one-half mile or more, to support any sustaining population of nesting pipers. Perhaps the best sanctuary site would be the southernmost mile of Illinois Beach State Park, including the areas behind the dunes back to the tree-growth line.

A problem of a different sort is suggested by the recent nesting of ring-billed gulls in what could be called marginal habitat at Lake Calumet (Kleen 1973). The record is pertinent in the consideration of coastal zone management because it shows the adaptability of this species, whose populations are presently increasing. The projected construction of coastal isalnds by the city of Chicago might, depending again upon human disturbance, greatly increase gull populations in the area. While such populations are probably desirable as beach gleavers, it should be remembered that they are incompatible with local aircraft operations, such as those at Meigs Field, because of the hazard of aircraft-bird collisions.

Several species of mammals are presently in danger of extirpation within the Lake Michigan coastal zone of Illinois. These are the badger, gray fox, bobcat, and the southern flying squirrel. The badger is an inhabitant of the open prairie and, although it is able to survive in the fencerows in farming areas, it is intolerant of the housing industry and of the clean fencerows now used extensively by man. The gray fox, bobcat, and southern flying squirrel are inhabitants of the forested areas which are steadily losing ground. None of these three species survives well in areas set aside for recreational purposes and all need good stands of timber that have been set aside as conservation areas or as preserves that are not frequented by man.

A number of species of mammals such as the masked shrew, pigmy shrew, least weasel, long-tailed weasel, and jumping mouse are rare and not generally observed, but this is generally true throughout their entire range. These species should be of some concern as they may now be on the verge of being extirpated from the study area. Old field, field edge, and woodland situations are needed by the weasels, and in large quantities, as they maintain large home ranges. If these habitats are maintained, the two shrews also ought to survive. The moist grasslands and marshy areas of the northern portion of the study area ought to supply the needed habitat for the jumping mouse.

The prairie vole is having some difficulty and is observed in low numbers. Although the voles in general are cyclic in abundance and one would expect to observe periods of low density to alternate with periods of high density, the prairie vole has a particular problem. It requires large areas of natural prairie or old field situations which are not cropped or burned over, as compared with the meadow vole, which can thrive along the edges of fields, drainage ditches, and roadsides having a moderate stand of grass. The problem facing the prairie vole is that when areas of natural prairie are burned over to maintain the natural prairie botanical species, or when old fields are hayed, the prairie vole must seek refuge in areas already occupied by the meadow vole. In these temporary refuges, the meadow vole outcompetes the prairie vole, and when the fields and prairies are again suitable for inhabitation, only the meadow vole is available to recolonize them. From the standpoint of mammals, the prairie vole should be a good indicator species as to the amount of disturbance present in old fields and prairie situations.

UNUSUAL NATURAL AREAS & SPECIFIC RECOMMENDATIONS FOR PROTECTION, MANAGEMENT, OR RESTORATION

One of the objectives of this component study of the Illinois Coastal Zone was the identification of unusual natural areas within that zone. Criteria used during this selection process included ecological uniqueness, critical habitat for threatened and endangered species, pristine state, and/or "restorability" potential of the area. Two areas have been designated as Geographical Areas of Particular Concern by the Illinois Office of Coastal Zone Management. The nominations of these areas included brief descriptions of the areas, located them on maps, and discussed the particular sensitivity of each. The following account considers four areas recognized by us as unusual natural areas.

1) *Illinois Beach State Park and Lake Michigan Shoreline north to Wisconsin boundary.*
Illinois Beach State Park and adjacent areas represent the largest stand of relatively undisturbed land in the Illinois Coastal Zone. Faunal and floral diversity of the area, including many rare species, results from habitat diversity (large lake, pond, marsh, stream, beach, dune, sand prairie, and forest). Presently the southern portion of the park is designated a nature preserve.

This area extends from the southern boundary of Illinois Beach State Park north to the Wisconsin State line. The eastern boundary is Lake Michigan. The area extends westward to the western edge of Illinois Beach State Park and, north of the park, to the Chicago and Northwestern railway. The area is approximately one mile wide east-to-west.

The area is considered here because it represents unique, fragile and relatively undisturbed natural habitat. It provides essential habitat for many rare organisms, including the Illinois mud turtle--designated as threatened and endangered. The area has high potential as a recreational resource, but development and utilization may conflict with the preservation of pristine habitat.

Illinois Beach State Park is ecologically very unusual for Illinois and at the same time vulnerable to overdevelopment because of its proximity to Chicago. The proposed addition northward from the existing park boundary provides an opportunity to increase substantially protection to the natural area. As we understand it, new parkland is to be created north of the Zion Nuclear Power Station. A roadway through the power station land is to connect the existing park to the new area to the north.

New parkland should be restored to a natural condition by removal of structures and exotic vegetation. It would seem feasible to all

area uses to transfer most daily use and most or all overnight camping to the new section of the park. The existing parkland would still provide lodge facilities and nature trails to park visitors. A public roadway connecting the "two" parks is not recommended. A maintenance road could be provided but should be closed to the public.

The purpose of these recommendations is to restrict access to the nature preserve and essential habitat surrounding the preserve not by regulations and gates but by concentrating recreation centers elsewhere. A nature preserve is more than a set of physical and chemical conditions and an abundance of plants and animals. It includes also the presence of rare organisms quite intolerant of man's intrusion. Solitude for these organisms is a prerequisite for continued existence.

As an alternative, a sanctuary should be established, perhaps from the southernmost mile of the State Park, including the beach and dunes from the lake back to the tree growth. From this area virtually all human traffic would have to be eliminated from March through October. Especially benefited would be approximately 20 species of shorebirds, including the piping plover. Private owners of beach area could be encouraged to join in the sanctuary program by reducing human traffic to an absolute minimum.

2) *Lake Forest Garden Club Ravine*

Unique to the northern portion of the Illinois shore of Lake Michigan is a series of deep ravines cutting through the bluffs to the lake. Most are heavily wooded and have permanent or intermittant streams at their bottoms. In many cases some exotic vegetation has been introduced, usually dating from when these ravines were part of large lakefront estates. While the following discussion is limited to one ravine maintained by the Lake Forest Garden Club as a nature trail, its problems and possible cures are common to most of the other ravines.

The Garden Club ravine is located in southern Lake Forest, north of Westleigh Road and generally east of Sheridan Road. Its watershed divide is, of course, more extensive. The ravine presently represents a fine nature trail--mainly through the restoration work of the Garden Club. Further restoration is needed to develop fully the ecological potential of the area.

Four problems have been identified on site visits: 1) excessive erosion due to storm water diversion, 2) absence of natural revegetation of slumped banks, 3) poor water quality in the streams, and 4) presence of exotic vegetation. Present traffic by visitors is considered compatible with the designation of a nature trail.

The ravine ecosystem is a fragile one due to the erosive potential of the ravine slopes. The principal threat to this ecosystem is stormwater diversion, either through storm sewers or via surface runoff,

into the ravines. Originally, the ravines were steep-sided, heavily wooded, and had heavy water-retaining ground cover. Streams at the bottoms of the ravines were small and intermittant. Stormwater diversion has increased stream flow and depth to a point where it is undercutting and toppling streamside trees. Meandering further aggravates this situation. In most cases, toppling of a streamside tree is followed shortly by slumping of the entire ravine slope above the tree. Conditions are such that revegetation of this denuded area does not take place (perhaps because urbanization of the surrounding highlands has affected shallow groundwater hydrology to a point where slumping continues creating unstable soil conditions for bare-ground invaders).

Gutter drainage and storm sewer discharge should not be permitted to flow into ravine surface channels. This stormwater should be conducted to its ultimate disposal site in pipes. In one ravine in Lake Forest, this piping was placed in the ravine bed. Habitat destruction during this operation was excessive and similar action is not recommended.

Absence of natural revegetation on slumped banks remains a problem. Shading is such that traditional bank stabilization plants would not survive. A proposal for additional study of this problem is appended to this report.

Poor water quality in the ravine streams is also attributed to stormwater diversion. Site inspection revealed an invertebrate community of organisms tolerant of low dissolved oxygen. Stormwater runoff commonly contains large amounts of degradable organic matter whose subsequent decomposition exerts a high oxygen demand upon the water. Petroleum derivatives and road salt further aggravate the water quality of the streams. Diversion of stormwater from these streams would improve greatly water quality.

Most of the ravines contain exotic vegetation planted when the ravines were part of large estates. This vegetation adversely effects the aesthetic value of the ravines as nature preserves and trails. Removal of this vegetation should include ample provision for revegetation and erosion control.

3) *Wolf Lake and Powder Horn Lake.*
Wolf and Powder Horn Lakes near Calumet City represent marsh and lake habitat unusual in Illinois and support species having limited distributions in Illinois.

The area considered here is north and east of Brainard and Burnham Avenues, respectively, and west of the Indiana state line. The area extends northward to the northern edge of Wolf Lake.

This area is considered here because it represents scarce habitat for threatened or rare fauna which is particularly vulnerable to the adverse effects of development of adjacent areas. Management and

protection will be especially difficult as Wolf Lake is located, in part, in Indiana, beyond the jurisdiction of Illinois Coastal Zone Management.

Although presently part of the area is designated as a forest preserve, the danger of overdevelopment is evident. Intense use of the Wm. Powers Conservation Area and attendant littering are threatening remaining natural habitats. Further development for recreational activities should not be permitted. Regulations should be formulated to cover land use in these portions of the area in private ownership in order to protect environmental quality. Particular emphasis should be given to coordinating activities with the State of Indiana concerning potential heavy industrial use of the eastern portion of the Wolf Lake Basin.

4) *Hard-Substrate Nearshore of Lake Michigan.*
Hard-substrate areas in the nearshore portions of Lake Michigan represent potential spawning sites for desirable fish species. As such they are considered potential areas of high natural productivity for fishes and critical to the re-establishment of salmonid fishes and a balanced trophic web in the lake.

It is not possible yet to locate these areas precisely, but the Illinois State Geological Survey is in the process of mapping the lake bed and will identify hard-substrate areas on the maps. Because of the present imprecise nature of locating these sites it is possible only to recommend that proposed activities such as the disposal of harbor dredging and/or maining of sand deposits be excluded from areas known to have nearby hard substrates. Any proposed mining or disposal activities should include bottom reconnaissance to determine the nature of the substrate to be affected.

As stated above, the food chain in Lake Michigan is simple, having no more than four levels. Salmonid fishes represent the top level carnivores. Lake trout once represented the apex of this chain. Sea lampreys and over-harvest depleted the lake trout population. Lamprey control and harvest regulations have made it feasible to re-introduce salmonid fishes. In the middle 1960's, the Michigan Department of Conservation began experimenting with releasing coho and other salmon species from the Pacific Northwest into Lake Michigan. The rationale for the experiment was that the alewife provided an abundant food supply not being utilized and that Michigan had suitable tributaries for spawning salmon. Although growth rates have been fantastic and an immensely popular sport fishery has been developed, the permanence of the salmon population is as yet unknown. Unfortunately, there are too few tributaries with suitable spawning habitats to accomodate the large number of salmon in Lake Michigan and it is necessary to stock large numbers of hatchery-reared smolt each year. There is, in fact, a danger that spawning salmon will affect adversely native trout populations in the spawning streams.

In our opinion it is more desirable to reintroduce stocks of native lake trout than to introduce only exotic species of trout and salmon. Lake

trout would provide the sport fishery and alewife control presently obtained from the salmon and would have the additional advantage of spawning in hard-substrate areas of the lake, thereby reducing competition with stream fishes.

GENERAL GUIDELINES FOR PROTECTION, MANAGEMENT, AND RESTORATION

In addition to specific recommendations for specific sites, it is desirable to set forth a set of general guidelines to introduce an ecological perspective to future development in the Illinois Coastal Zone. The following discussion considers these matters.

Lake Michigan is an oligotrophic lake. Oligotrophic lakes are lakes which are characterized by low concentrations of dissolved nutrients, simple food chains, high concentrations of dissolved oxygen. Simply, oligotrophic lakes bring to mind "pure, clean, and cold" as opposed to "enriched, possibly turbid, and warm." Lakes age as part of their natural processes. Oligotrophic lakes gradually build up a nutrient pool, either through natural processes or by man-introduced pollutants. Biological communities change and often become more diverse. Eventually, on a geological time scale, the lake basin fills in and becomes dry land.

The natural enrichment process is called eutrophication. Man-introduced effluents are accelerating the eutrophication of the nearshore of Lake Michigan. Because of their role of converters of inorganic nutrients to organic matter, the phytoplankton community perhaps best characterizes these early signs of eutrophication.

The nature of phytoplankton makes it difficult to recommend preservation and shoreline management activities to affect these organisms. In order to "manage" the phytoplankton communities, the water quality must be closely controlled--a feat of enormous proportion in Lake Michigan. Beyond this, their importance should be recognized and their importance understood.

The algae are a relatively minor portion of the diet of adult fishes in Lake Michigan. Table 9 lists the algal food of three fishes found in Lake Michigan, as determined from analysis of stomach contents (Rolan 1972). Algal production is consumed primarily by the zooplankton, zoobenthos, and fish fry. As detritis it is available to the fungi and bacteria. What is not consumed by these organisms is made available to bacteria and other organisms in soluble form. Relative to their abundance, blue-green algae and dinoflagellates are seldom included in the diets of most fish (Rolan 1972). Due to the toxic substances produced by some of these algae, the fish may avoid them. A usual consequence of eutrophication is an increase in the abundance of blue-green algae, and a decrease in the abundance of diatom and green algal communities, creating a deficiency in food available to fish. The blue-greens may also cause drinking water to take on particular odors and taste, and even colors. These problems are expensive and difficult to correct during water treatment.

Extensive growths of *Cladophora* sp. and other filamentous algae along the shoreline are commonly the result of eutrophication. The decomposition of these algae detract from the appeal of water-based recreational areas.

Table 9. Algal Food of Fishes of the Great Lakes
(exerpted from Rolan 1972)

	Stizostedium viterum (Walleye)	*Perca flavesceus* (Yellow perch)	*Micropterus salmoides* (Largemouth bass)
CHRYSOPHYTA			
Amphora ovalis	X		
Cocconeis placentual	X		
Coscinodiscus radiatus	X		
Cyclotella meneghiniana	X		
Cymatopleura solea	X		
Diatoma elongatum	X		
Fragilaria capucina	X		
Fragilaria crotonensis	X		
Fragilaria vaucheriae	X		
Melosira ambigua	X		
Melosira binderana	X		
Melosira granulata	X		
Nitzschia gracilis	X		
Nitzschia sigmoidea	X		
Stephanodiscus astraea	X		
Surirella angustata	X		
Synedra acus	X		
Synedra ulna	X		
Tabellaria fenestrata	X		
PYRROPHYTA			
Ceratium hirundinella	X		
CYANOPHYTA			
Gomphosphaeria lacustris	X		
Oscillatoria sp.		X	
CHLOROPHYTA			
Pediastrum boryanum	X		
Pediastrum duplex	X		
Pediastrum simplex	X		
Scenedesmus acuminatus	X		
Spirogyra sp.	X	X	
Staurastrum sebaldi	X		
Ulothrix sp.		X	X

Management Recommendations

From the standpoint of fishes and fisheries, there is little more damage that can be done to the natural environment by further development of the coastal zone of Illinois. The problems that have been pointed up in the preceding pages are of national importance and will not be solved soon even though many state and federal agencies are much concerned about them. While there is no simple and quick cure for the many ills of Lake Michigan and its tributary waters, awareness of what has happened in the past should encourage us to minimize further modification of the basin. The public clamor to begin cleaning up our water and air are good signs as are the efforts of many concerned agencies. The dumping of cinders and garbage in the deep water of Lake Michigan has already ceased, and the demands for more exacting standards and better waste treatment cannot be ignored.

Thermal effluents from power-generating plants are less likely to be harmful in the lake than in streams because of the enormous volume of cold water welling along the Illinois shoreline. Heat would be quickly dissipated and would have only local effects. Construction of man-made islands offshore would probably have temporary effect and do little damage unless toxic substances are thereby introduced into the water. Shoreline construction should take precautions to avoid contaminating water in the lake and tributary streams and lakes and should not be undertaken in the few remaining areas that still have natural features. The unmodified areas along the shoreline should be treasured for what they are. The greatest threat to Illinois Beach State Park is overdevelopment.

Inland the natural lakes, marshes, and some of the streams still have large populations of a number of native fishes. These habitats are clearly worth protecting. The practice of using chemical poisons to eradicate carp in natural lakes should be stopped and, instead of introducing non-native sport fishes, efforts should be expended to improve the habitats for such native species as lake trout, yellow perch, pickerel, sunfishes, basses, suckers, and catfishes.

The Illinois coastal zone can be broken into four terrestrial situations based on man's disturbance of the area. Approximately 66% of this area is occupied extensively by large cities which are primarily buildings and roads and lack suitable habitat for most native organisms. In the small parks such as Lloyd, Gillson, Elliot, Rogers, and Jarvis Avenue Parks, which are approximately 17 in number and are found almost entirely within Cook County, the situation is slightly better. Among the mammals gray squirrels, thirteen-lined ground squirrels, and, occasionally, chipmunks can be seen during the day and there is the possibility that a few endemic small rodents, such as the white-footed mouse and the meadow vole, might be present although only the house mouse was observed in these areas. No sign of other nondomesticated mammals was seen in the form of specimens, scat, or tracks although it is possible that an occasional raccoon, oppossum, or rabbit might be able to temporarily inhabit these small parks, but they

would have to be considered accidental. These parks, however, are too small to be of much use in the revitalization of the fauna. If they were increased in size and allowed to maintain good grass cover and understory they might be improved, but only the small native animals, many of which are secretive, would return, and then only to the interest of the trained observer. This area would include most of Chicago, with the exception of Jackson Park, the stretch of shoreline from North Avenue to Foster Avenue, and it would include Evanston, Wilmette, Kenilworth, Winnetka, Glencoe, Ravinia, Highland Park, Highwood, Lake Forest, Lake Bluff, North Chicago, Waukegan, Zion, and Winthrop Harbor.

The larger parks such as Jackson Park and Lincoln Park occupy approximately 10% of the Illinois coastal zone. These parks, because of their large size (Lincoln Park is approximately 2.8 miles long and averages a little more than 0.25 miles wide while Jackson Park is approximately 1.15 miles long and 0.67 miles wide) are much more suitable for the existence of native fauna. Appropriate restoration would allow areas of understory and ground cover to develop in these parks. These parks have a number of buildings on them and there is a considerable amount of human movement at this time. If allowed to go back to a semi-natural condition these would supply ample area and habitat for many species of small- and medium-sized animals. The ponds and lagoons would also be available for colonization. To some extent both Burnham and Grant Parks might fit into this scheme although they are smaller and are affected considerably by more human disturbance.

Site visits to Park District lagoons revealed that lagoons connected to Lake Michigan via yacht harbors, canals, etc., generally had higher water quality than lagoons in closed basins. Our conclusions regarding the lagoons were that the water quality was good and apparently not limiting to aquatic life. The physical setting of the lagoons, with trash in and around the water, gave the appearance of poor conditions, but the biota did not bear this out.

The principal problem observed stems from sediment, probably from bank erosion. Many of the attributes of "clean" water are associated with hard substrates such as sand, gravel, or rock. If these ever existed in the lagoons, they have been smothered by soft sediments. The effects of these sediments are not apparent in free swimming forms such as the plankton, but are apparent in sedentary forms such as periphyton (nearly absent) and benthos (many forms absent).

Restoration by dredging might be feasible, but it must be accompanied by some form of bank stabilization program. Some high-erosion areas may require rock rip-rap, but stabilization by vegetation could prove sufficient. An emergent plant having a dense root mat such as the water willow has been used successfully in other parts of Illinois and should be considered for use here.

Approximately 8% of the study area is now undergoing urban development. Within areas such as north of Fort Sheridan, around Dunes Park, and east of Kellogg Ravine, housing developments are encroaching and, in some

cases, totally engulfing areas that until recently were either old field or woodland. Many of these areas are the only remaining avenues of movement of animals to and from the Lake Michigan shore.

Mink, muskrat, raccoon, opossum, long-tailed weasel, skunk, badger, and red fox are the fur bearers found throughout this region and should be managed properly. The most accurate method of management would be to allow only a specific number of trappers onto the area so as they have an accurate census of the annual harvest of furbearers. The same method should be used to mange the deer, eastern cottontail, fox squirrel, gray squirrel, and woodchuck populations. Management in the form of an annual harvest is particularly necessary in this area due to its small size and reduced avenues of immigration. Life tables can be constructed by the collection of skulls and long bones used in aging and identification of species. From these tables population levels can be monitored and the amount of trapping or hunting controlled accordingly. This would be an expensive and continuous, but worthwhile project if game and furbearing mammals are to be managed properly.

In addition to protection of ecologically unique areas, coastal zone management should include provisions for the management of invertebrate pest species such as mosquitoes and midge flies. These two groups are discussed briefly below.

The literature and collection of the Illinois Natural History Survey indicate that 29 species of mosquitoes occur in and around the Lake Michigan shoreline in Illinois. Not all of these species are attracted to humans, but two groups could become a severe nuisance or health hazard to local inhabitants. The species of *Aedes* and *Psorophora* are floodplain mosquitoes. Their eggs are laid outside of water but they hatch and develop rapidly when the eggs are flooded. During periods of heavy rainfall or flooding, these species may occur in large numbers and have a severe bite to humans. Little can be done to remove the breeding habitat of these mosquitoes, but larval and adult control is managed and controlled in the Chicago area by a variety of local mosquito control districts and private operators.

The current mosquito problem in the Lake Michigan area is related to *Culex pipiens*, a species directly associated with the transmission of St. Louis encephalitis to humans. *Culex pipiens* breeds and develops in standing water which contains high amounts of organic sewage. Any development of the Lake Michigan shoreline that involves the installation of sewage lagoons or oxidation ponds for the treatment of local sewage might present a viable breeding area for *C. pipiens* and a potential health hazard to local residences. Such lagoons are not recommended unless accompanied by a rigorous mosquito control program.

Although numerous species of midge flies, or chironomids have been reported from the Lake Michigan area of Illinois, their principal concern to the local inhabitants is their nuisance value when they occur in large numbers. Chironomids breed in a variety of aquatic habitats, although they can develop in large numbers in areas containing organic enrichment. The principal management proposal again is in the area of sewage treatment. Chironomids breed abundantly in sewage lagoons and oxidation ponds and considerable thought to these ramifications should be given before these types of facilities are installed.

PROPOSALS

During the course of data acquisition and preparation of this report, and based upon information provided or questions asked by others concerning the ecology of the Illinois coastal zone, it became apparent that a need exists to conduct special studies of three additional subjects. Recommended scopes of work for each may be found below. The order in which the studies appear is not based upon intentional prioritization.

1. VEGETATION MAP OF THE LAKE FOREST GARDEN CLUB RAVINE

Objective: To provide a current and accurate map of vegetative cover of the Lake Forest garden club ravine.

Study Area: The garden club ravine is located in southern Lake Forest, north of Westleigh Road and generally east of Sheridan Road.

Purpose: Unique to the northern portion of the Illinois shore of Lake Michigan is a series of deep ravines cutting through the bluffs to the lake. Most are heavily wooded and have permanent or intermittant streams at their bottoms. In many cases some exotic vegetation has been introduced, usually dating from when those ravines were part of large lakefront estates. The garden club ravine may represent the finest example of this unique biological habitat remaining in Illinois.

Four problems were identified on site visits to this ravine: 1) excessive erosion due to storm water diversion, 2) absence of natural revegetation on slumped banks, 3) poor water quality in the streams, and 4) presence of exotic vegetation.

It is anticipated and recommended that a management/restoration plan be prepared for this ravine. The ravine ecosystem, however, is a fragile one due to the erosive potential of the ravine slopes. Existing vegetation retards erosion, thereby protecting undisturbed slopes. Any management plan for the ravine must include and be based upon a detailed topographic and vegetative map of the area. A topographic map of suitable scale is available. This work element would add the necessary botanical information to the data base of the planning study.

Method: It is anticipated that aerial photography would supplement field reconnaissance of the project area. Standard mapping procedures would be followed.

End Product: A vegetation map would be prepared having sufficient detail to show clearly all significant vegetation components while retaining perspective to the overall ravine ecosystem. This map would include appropriate topographic and geographic features to facilitate its use. A narrative would accompany the map and would include a discussion of purpose, methods, floral components identified, and other relevant subjects.

Budget: Project funds (estimated) $2,500.00 plus appropriate services-in-kind provided by the Natural History Survey.

Schedule: Tentative submission of draft report 3 months from beginning date. Final report to be submitted 1 month from receipt of written comments and approval of the draft report.

2. VEGETATION MAP OF ILLINOIS BEACH STATE PARK AND LAKE MICHIGAN SHORELINE NORTH TO WISCONSIN BORDER

Objective: To provide a current and accurate map of vegetative cover of the study area defined below.

Study Area: The study area is understood to include Illinois Beach State Park, including the Dead River Nature Preserve, plus newly-acquired and/or potential parkland contiguous to and north of existing parkland north along the Lake Michigan shoreline to the Wisconsin border.

Purpose: Illinois Beach State Park is a popular recreational facility in northeastern Illinois. Much of the popularity of this park is due to its location in the coastal zone of Lake Michigan and to its unusual biological community. Proposed expansion of this park is northward within the study area described above. Present and recent-past land use of this area was residential. Maximum utilization of this additional parkland calls for the removal of exotic vegetation and, presumably, revegetation with species native to the area. Sound planning will require vegetation mapping of existing undisturbed areas to determine the extent of the revegetation required.

Method: It is anticipated that aerial photography would supplement field reconnaissance of the project area. Standard mapping procedures would be followed.

End Product: A vegetation map would be prepared having sufficient detail to show clearly all significant vegetation components while retaining perspective to the overall parkland ecosystem. This map would include appropriate topographic and geographic features to facilitate its use. A narrative would accompany the map and would include a discussion of purpose, methods, floral components identified, and other relevant subjects.

Budget: Project funds (estimated) $3,500.00 plus appropriate services in kind provided by the Natural History Survey.

Schedule: Tentative submission of draft report 4 months from beginning date. Final report to be submitted one month from receipt of written comments and approval of the draft report.

3. USE OF VEGETATION FOR BLUFF AND RAVINE SLOPE STABILIZATION

Objective: To prepare a layman-oriented document outlining the use of vegetation to stabilize bluffs and ravine slopes in the Illinois coastal zone.

Study Area: In general, the entire Illinois coastal zone will be considered, but preliminary studies indicate that the focus of this problem is in the northern Cook County and Lake County portions of the coastal zone.

Purpose: The erosive potential of the Lake Michigan bluffs and of the ravine slopes in the northern portion of the Lake Michigan coastal zone is great. Erosion generally starts with the action of high water, either as storm waves on Lake Michigan or as storm discharge in the ravine streams, breaking existing vegetative cover and exposing the easily erodable soil beneath. Subsequent slumping and erosion generally produces a slope unsuitable for natural revegetation because of steepness, shade, and soil stability. This work element would provide information to the landowner experiencing erosion regarding techniques of soil stabilization by means of vegetation. This revegetation is prerequisite to erosion control.

Method: Field study of eroded bluffs and ravine slopes would familiarize the investigators with the specific requirements of erosion control in the Illinois coastal zone. Recent and old examples of eroded banks would serve to document natural and some artificial means of control. Existing literature and acknowledged experts would round out the data acquisition/interpretation phases of this study.

End Product: A pamphlet or booklet would be prepared, written in layman terms, describing recognized types of erosion related to lakeshore bluffs and ravine banks, identifying the causes of each, and detailing specific techniques for controlling this erosion by revegetation techniques. Prevention of erosion through vegetation protection and management would be discussed.

Budget: Project funds (estimated) $12,000.00.

Schedule: Tentative submission of draft report 9 months from beginning date. Final report to be submitted 2 months from receipt of written comments and approval of the draft report.

BIOLOGICAL INVENTORY

One of the objectives of this study of the Illinois coastal zone was to provide an inventory of plant and animal species. The time restrictions imposed upon the study required considerable restriction in groups studied. Restrictions were based upon the importance of the group, the availability of historical information, and available expertise. Considered here were all vertebrate classes (mammals, breeding birds, reptiles, amphibians, and fishes), Culicidae and Chironomidae (mosquitoes and midges), Trichoptera (caddisflies), zooplankton, aquatic Oligochaeta (worms), vascular plants and plytoplankton.

Four sources contributed to this biological inventory: published data, faunistic and herbarium specimens in the collections of the Illinois Natural History Survey, unpublished data obtained from local experts, and field observations conducted as a part of this study. These sources appear as footnotes to species listed in the separate appendix to this report. Superscript "2" denotes species whose presence was verified during this inventory. Superscript "1" denotes species known to occur based upon literature records or museum specimens from the Illinois coastal zone. No superscript number denotes species whose general distribution is such that they are likely to occur in the Illinois coastal zone despite the absence of voucher material.

Nearly 1,800 species of plants and animals are included in the inventory. The majority of these species are plants, with 735 vascular and 320 planktonic species. Aquatic invertebrates listed in the inventory include 150 species of zooplankters, 30 species of aquatic oligochaetes, 52 species of caddisflies and 64 species of midges and mosquitoes. Among the vertebrates, birds predominate, with 264 species. Next in abundance of species are the fishes, with 97 species being listed. Mammals, reptiles, and amphibians make up the remainder of the inventory with 53, 21, and 17 species, respectively.

After all project participants had visited the project area, it was mutually agreed that all of the microhabitats of the Illinois coastal zone could be grouped under 16 major habitat types. These major habitat types have been incorporated into the biological inventory so that relative abundance (common, uncommon, or rare) and habitat preference of each species could be portrayed.

GLOSSARY

Benthos: The community of medium-sized to minute plants and animals which live on and in the bottoms of lakes, ponds, rivers, and streams.

Biota: A collective noun referring to all living things, plant and animal, in an area.

Calanoid Copepod: Microscopic animals belonging to the crustacean suborder Calanoida which are free-swimming in the water of lakes and ponds.

Cladoceran: Water fleas; microscopic animals belonging to the crustacean order Cladocera which are free-swimming in the water of lakes and ponds.

Coregonid: Fishes of the genus *Coregonus*, including bloater, cisco, and whitefish, which inhabit the open-lake portions of large lakes such as Lake Michigan.

Diaptomid: Microscopic animals belonging to the crustacean family Diaptomidae which are free-swimming in the water of lakes and ponds.

Diatom: Microscopic plants belonging to the division Chrysophyta (Bacillariophyceae) which are either suspended in the water of lakes and ponds or attached to submerged surfaces in standing or flowing water.

Dinoflagellate: Microscopic plants belonging to the division Pyrrophyta which are suspended in the water of lakes and ponds.

Ecosystem: A distinct biological community consisting of plants and animals interacting with each other and with their physical environment.

Endemic: A species of plant or animal which lives only in a relatively restricted geographical area.

Eutrophic: A type of lake characterized by high concentrations of dissolved nutrients, sediments rich in organic matter, and a large number of species of aquatic organisms.

Eutrophication: The natural maturation process of lakes in which nutrient-poor (oligotrophic) lakes become enriched (eutrophic). This process may be accelerated by man's introduction of wastewater effluents.

Exotic: A species of plant or animal not native to a region, but which gained access directly or indirectly as the result of man's activities.

Extant: A species which still occurs in the study area.

Extirpated: A species which formerly occurred in the study area, but which no longer occurs there. It may not be extinct, because it may still occur in other parts of its range.

Food chain: Green plants utilize solar energy to combine inorganic substances into organic compounds and store certain of these to be used as an energy source. Herbivorous animals consume these plants and are, in turn, consumed by carnivorous animals. All organic waste products and dead plants and animals are decomposed by bacteria and fungi to the inorganic state or back to simple organic compounds. This entire cycle of energy flow is called the food chain or trophic web.

Ion: An electrically charged atom or group of atoms formed by dissolving a salt in a solvent, typically water.

Kinosternid: A turtle belonging to the reptile family Kinosternidae.

Limnology: The science which studies physical, chemical, and biological processes occurring in fresh water, typically lakes, ponds, and marshes rather than rivers and streams.

Littoral: Pertaining to near-shore portions of lakes and ponds, typically shallow and with submerged, floating, or emergent aquatic vegetation.

Macroinvertebrate: An invertebrate animal large enough to be retained by a sieve having, typically, 30 meshes per inch.

Melanistic: A condition of pigmentation in which an individual or local population of a species exhibits a large amount of dark or black pigment not typical to the species as a whole.

Mesophytic: Vegetation growing under well-balanced moisture conditions.

Niche: A specific set of physical, chemical, and biological conditions which an organism requires for its existence. Niche differs from habitat in that a niche includes the organism and a habitat does not.

Oligotrophic: A type of lake characterized by low concentrations of dissolved nutrients, few organic sediments, and few species of aquatic organisms. Lake Michigan is the only oligotrophic lake in the Illinois coastal zone.

Periphyton: A community of plants or of plants and animals which form an encrusting layer on submerged objects. Slime on rocks is periphyton predominated by filamentous microscopic plants (algae).

Phytoplankton: Microscopic plants which live suspended in the water of lakes and ponds.

Scat: Solid wastes, specifically those expelled by mammals. Each species produces characteristic scats (size, shape, color, location) and may be identified from the study of scats alone.

Smolt: A young salmon, typically the age during which the fish migrate from the spawning streams to the larger body of water where the adult feeds.

Trophic web: This term is defined under "food chain."

Vascular plants: Plants characterized by a complex structure differentiated into tissues specialized for conducting water and food materials throughout the plant.

Zoobenthos: Medium-sized to microscopic animals which live on or in the bottoms of lakes and ponds.

Zooplankton: Microscopic animals which swim feebly or are suspended in the water of lakes and ponds.

ANNOTATED BIBLIOGRAPHY OF VERTEBRATE AND SELECTED INVERTEBRATE FAUNA AND FLORA OF THE LAKE MICHIGAN SHORE IN ILLINOIS (SELECTED REFERENCES)

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Authorship for the various sections is as follows:

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Emphasis is placed on Lakes Erie and Ontario, but studies concerning Lake Michigan are briefly discussed.

Ward, H.B.
1896. A biological examination of Lake Michigan in the Traverse Bay region. Bull. Michigan Fish. Comm. No. 6, 100pp.

This study is of historical interest.

ZOOPLANKTON (CLADOCERA, COPEPODA, ROTIFERA)

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1934. A quantitative study of Rotatoria in Terwilliger's Pond, Put-in-Bay, Ohio. Bull. Ohio Biol. Survey. 6:1-36.

Lists species of Rotifera from Lake Michgan.

1936. The deep-water plankton of Lake Michigan, exclusive of the Crustacea. Trans. Amer. Microscop. Soc. 55:286-299.

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1940. A revision of the rotatorian genera *Brachionus* and *Platyias* with descriptions of one new species and two new varieties. Bull. Amer. Mus. Nat. Hist. 77:143-184.

Important taxonomic work for the identification of the genera *Brachionus* and *Platyias* (Rotifera).

1943. A revision of the rotatorian genus *Keratella* with descriptions of three species and of five new varieties. Bull. Amer. Mus. Nat. Hist. 80:411-457.

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Ayers, J.C.

1970. Lake Michigan environmental survey. Univ. Michigan Great Lakes Res. Div., Spec. Rept. No. 49.

Radioactivity levels of Lake Michigan zooplankton.

Balch, R.F., K.M. Mackenthun, W.M. Van Horn, and T.F. Wisniewski.

1956. Biological studies of the Fox River and Green Bay from cooperative state-industry surveys of the lower Fox River and Green Bay made in 1955-1956. Bull. Wisconsin Comm. Water Poll., WP102. 74p.

Zooplankton Crustacea collected from lower Fox River and extreme southern Green Bay. Data presented as numbers/liter of Cladocera, Copepoda and nauplii.

Baylis, J.R. and H.H. Gerstein.

1929. Micro-organisms in the Lake Michigan water at Chicago. Municipal News and Water Works. 76:291-296.

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Beeton, A.M.

1965. Eutrophication of the St. Lawrence Great Lakes. Limnol. Oceanogr. 10:240-254.

Reports changes in the species composition and abundance of the zooplankton crustaceans in Lake Michigan.

1966. Indices of Great Lakes eutrophication. Univ. Michigan, Great Lakes Res. Div. Pub. No. 15. 8pp.

Includes a review of changes in zooplankton species composition in Lake Michigan.

1969. Changes in the environment and biota of the Great Lakes. pp. 150-187. *In* Eutrophication: causes, consequences, correctives. Proc. Internat. Symposium on Eutrophication. Washington, D.C.

Reviews literature on some major changes in species composition and abundance of zooplankton.

Birge, E. A.

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Brooks, J.L.

1957. The systematics of North American *Daphnia*. Mem. Connecticut Acad. Arts Sci. 13:1-180.

Important taxonomic work that includes a key, species descriptions, and distribution records of *Daphnia*. Includes records from the Great Lakes.

1968. The effects of prey-size selection by lake planktivores. Syst. Zool. 17:273-291.

Pertinent to zooplankton species changes (Crustacea) in Lake Michigan due to size selective predators.

1969. Eutrophication and changes in the composition of the zooplankton, pp. 236-255. *In* Eutrophication: causes, consequences, correctives. Proc. Internat. Symposium on Eutrophication. Washington, D.C.

Discusses shift in Lake Michigan toward larger zooplankton (Crustacea) after the large decline in the coregonids, and the presence of *Bosmina* as an indicator of enrichment.

Brooks, J.L. and S.I. Dodson.

1965. Predation, body size, and composition of plankton. Science 150:28-35.

Pertinent to zooplankton species changes (Crustacea) in Lake Michigan due to size selective predators.

Chandler, D.C.
1964. The St. Lawrence Great Lakes. Verh. Internat. Verein. Limnol. 15:59-75.

General limnological characteristics of the Great Lakes including a generic level discussion of the zooplankton.

Czaika, S.C.
1974. Aids to the identification of the Great Lakes Harpacticoids *Canthocamptus robertcookeri* and *Canthocamptus staphylinoides*. Internat. Assoc. Great Lakes Res., Proc. 17th Conf. Great Lakes Res. pp. 587-588.

Gives identification aids for the two most common Harpacticoids in the Great Lakes, including Lake Michigan.

1974. Crustacean zooplankton of southwestern Lake Ontario in 1972 during the international field year for the Great Lakes. Internat. Assoc. Great Lakes Res. Proc.,17th Conf. Great Lakes Res. pp. 1-16.

Crustacean zooplankton population trends in Lake Ontario (1972). Also species identification, relative abundance, and seasonal similarities of zooplankton populations from Lake Ontario and Lake Michigan.

Czaika, S.C. and A. Robertson.
1968. Identification of the copepodids of the Great Lakes species of *Diaptomus* (Calanoida, Copepoda). Internat. Assoc. Great Lakes Res., Proc. 11th Conf. Great Lakes Res. pp. 39-60.

An important taxonomic work which includes a key for the identification of the six Great Lakes species of *Diaptomus* to stage, species, and sex of diaptomid copepodids in the Great Lakes. Illustrated.

Damann, K.E.
1945. Plankton studies of Lake Michigan. 1. Seventeen years of plankton data collected at Chicago, Illinois. Amer. Midl. Nat. 34:769-796.

Lists of genera of Rotifera, Cladocera, and Copepoda collected at Chicago water intake in Lake Michigan over 17 years.

1960. Plankton studies of Lake Michigan. 11. Thirty-three years of continuous plankton and coliform bacteria data collected from Lake Michigan at Chicago, Illinois. Trans. Amer. Microscop. Soc. 79:397-404.

Discusses relationship of total plankton and pollution (coliform bacteria) in the Chicago area of Lake Michigan (1926-1958).

Damann, K.E.
1966. Plankton studies of Lake Michigan. 111. Seasonal periodicity of total plankton. Univ. Michigan. Great Lakes Res. Div. Pub. No. 15. pp. 9-17.

Seasonal trends of total plankton (phytoplankton and zooplankton) from 1926-1958 in Lake Michigan near Milwaukee are compared with similar data from the Chicago area. Discussion of total numbers only.

Davis, C.C.
1954. A preliminary study of the plankton of the Cleveland Harbor area, Ohio. 111. The zooplankton, and general ecological considerations of phytoplankton and zooplankton production. Ohio J. Sci. 54:388-408.

Contains records from literature of Cladocera, Copepoda, and Rotifera species occurring in Lake Michigan with relative abundance.

1966. Plankton studies in the largest great lakes of the world with special reference to the St. Lawrence Great Lakes of North America. Univ. Michigan Great Lakes Res. Div. Pub. No. 14. pp. 1-36.

A review of the major zooplankton studies of the Great Lakes.

Deevey, E.S., Jr., and G.B. Deevey.
1971. The American species of *Eubosmina* Seligo (Crustacea, Cladocera). Limnol. Oceanogr. 16:201-218.

Distinguishes between the genera *Bosmina* and *Eubosmina*: species descriptions, key. Includes records from Lake Michigan.

Eddy, S.
1927. The plankton of Lake Michigan. Illinois Nat. Hist. Surv. Bull. 17:203-232.

Lists species of Rotifera, Cladocera, and Copepoda found in southern Lake Michigan from inshore and surface collections. Also relative abundance of each species.

1934. A study of fresh-water plankton communities. Illinois Biol. Monogr. 12:1-93.

Species and relative abundance of zooplankton (Cladocera, Copepoda, Rotifera) of various rivers and streams in Illinois. Also species and abundance of plankton predominants in Lake Michigan and in beach ponds on shore of Lake Michigan near Gary, Indiana (May 1927-1929).

Edmondson, W.T. (ed).
1959. Fresh-water biology, 2nd ed. John Wiley and Sons, New York. 1248 pp.

Standard taxonomic work applicable to the zooplankton fauna of the Great Lakes region.

Faber, D.J., and E.G. Jermolajev.
1966. A new copepod genus in the plankton of the Great Lakes. Limnol. Oceanogr. 11:301-303.

New copepod (Calanoida:*Eurytemora affinis* Poppe) reported from Lakes Erie, Huron and Ontario. Possible introduction by bilge water of boats. (This species now in Lake Michigan).

Fetterolf, C.M., and D.J. Seeburger.
1971. Radioactivity in Lake Michigan water and biota, vicinity of Big Rock Point Nuclear Reactor, 1960-1969. Internat. Assoc. Great Lakes Res., Proc. 14th Conf. Great Lakes Res. pp. 211-218.

Has radioactivity readings for the aquatic biota (including plankton) for gross *B* radioactivity in vicinity of Big Rock Point Nuclear Reactor on Lake Michigan.

Forbes, E.B.
1897. A contribution to a knowledge of North American fresh-water Cyclopidae. Bull. Illinois State Lab. Nat. Hist. 5:27-82.

Species descriptions. Records from Lake Michigan included.

Forbes, S.A.
1882. On some Entomostraca of Lake Michigan and adjacent waters. Amer. Nat. 16:537-543; 640-650.

Gives information on species of Cladocera and Copepoda found in Lake Michigan- some near Chicago water supply.

1883. The food of the smaller fresh-water fishes. Bull. Illinois State Lab. Nat. Hist. 1:65-94.

Includes genera and species of zooplankton (Crustacea) used as food by various species of fish. Several fish from Lake Michigan included.

1883. The first food of the common whitefish (*Coregonus clupeaformis* Mitchill). Bull. Illinois State Lab. Nat. Hist. 1:95-109.

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1888. Notes on the first food of the whitefish. Trans. Amer. Fish. Soc. 17:59-66.

Laboratory experiments using zooplankton collected from Lake Michigan.

Gannon, J.E.
1969. Great Lakes plankton investigations; a bibliography. Univ. Wisconsin-Milwaukee, Center for Great Lakes Studies. Spec. Rep. No. 7. 65pp.

Important annotated bibliography on zooplankton, phytoplankton, and miscellaneous groups found in the plankton of the Great Lakes.

Gannon, J.E.
1970. An artificial key to the common zooplankton Crustacea of Lake Michigan, exclusive of Green Bay. Industrial BIOTEST Laboratories, Inc., Northbrook, Illinois. 30 pp.

Key for the Cladocera and Copepoda of Lake Michigan. Notes on relative abundance.

1972. Effects of eutrophication and fish predation on recent changes in zooplankton species composition in Lake Michigan. Trans. Amer. Microscop. Soc. 91:82-84.

Discussion of effects of size-selective predation and eutrophication and whether certain species of micro-crustacea would be good indicators of advancing eutrophication in Lake Michigan.

1974. The crustacean zooplankton of Green Bay, Lake Michigan. Internat. Assoc. Great Lakes Res., Proc. 17th Conf. Great Lakes Res. pp. 28-51.

Important list of Cladocera and Copepoda found in Green Bay, Lake Michigan with population estimates.

Gannon, J.E., and A.M. Beeton.
1969. Studies on the effects of dredged materials from selected Great Lakes harbors on plankton and benthos. Center for Great Lakes Studies. Univ. Wisconsin-Milwaukee, Wisconsin. Spec. Rep. No. 8. 82 pp.

The effect on zooplankton and *Daphnia pulex* of sediments from various harbors within the Great Lakes, including Calumet, Illinois; Green Bay, Wisconsin; and Indiana Harbor, Indiana. Bioassay methods.

Gerstein, H.H.
1965. Lake Michigan pollution and Chicago's water supply. J.Amer Water Works Assoc. 57:841-857.

Total plankton counts.

Gullens, O.
1953. Common plankton organisms in Lake Michigan water- their effect on filtration. Pure Water 5: 64-66.

General article on plankton and water filtration at Chicago.

Hoy, P.R.
1872. Deepwater fauna of Lake Michigan. Trans. Wisconsin Acad. Sci., Arts, Lett. 1: 98-101.
1873. Ann. Mag. Nat. Hist. 11:319-320.

Examination of stomach contents of Whitefish.

Industrial BIO-TEST Laboratories, Inc.

1971. Zooplankton study, Project V111 (IBT No. W8961). *In* Evaluation of thermal effects in southwestern Lake Michigan. Waukegan and Zion Generating Stations. May 1970-March 1971. Prepared by Industrial BIO-TEST Laboratories, Inc. for Commonwealth Edison Company, Chicago, Illinois.

Documents zooplankton crustacean species composition and seasonal changes of the zooplankton populations in the Waukegan-Zion vicinity of Lake Michigan. Also evaluates the effects of the thermal effluent from the Waukegan Generating Station on the species composition and abundance of zooplankton in the vicinity of the plant.

Jennings, H.S.

1894. A list of the Rotatoria of the Great Lakes and some of the inland lakes of Michigan . Bull. Michigan Fish. Comm. 3: 3-34.

Littoral and pelagic rotifers collected primarily from Lake St. Clair during the summer 1893. Lists 122 species, relative abundance and local distribution. Includes many species probably found in littoral areas of Lake Michigan.

1896. Report on the Rotatoria. Appendix 3. Biological examination of Lake Michigan. Bull. Michigan Fish. Comm. 6:85-93.

Lists species of Rotifera found in Lake Michigan in the summer of 1893. Notes on habitat.

1900 Rotatoria of the United States, with especial reference to those of the Great Lakes. Bull. U.S. Fish. Comm. 1900:67-104.

Taxonomic study with many specimens from Lake Erie. Records from Lake Michigan also included.

1903. Rotatoria of the United States. 11. A monograph of the Rattulidae. Bull. U.S. Fish Comm. 22:273-352.

Species descriptions, key, and relative abundance of the rotifer genus *Trichocerca*. Records from Lake Michigan included.

Lane, P.A., and D.C. McNaught.

1970. A mathematical analysis of the niches of Lake Michigan zooplankton. Internat. Assoc. Great Lakes Res., Proc. 13th Conf. Great Lakes Res. pp. 47-57.

Discusses factors influencing niche assignments in Lake Michigan, such as available food, vertical migration, for selected species of Cladocera and Copepoda.

Marsh, C.D.
1895 On the Cyclopidae and Calanidae of Lake St. Clair, Lake Michigan, and central island lakes of Michigan. Bull. Michigan Fish. Comm. 5:1-24.

Lists species of copepods from Lake Michigan.

1929. Distribution and key of the North American copepods of the genus *Diaptomus*, with a description of a new species. Proc. U.S. Nat. Mus. 75:1-27.

Includes Great Lakes species.

McNaught, D.C.
1966. Depth control by planktonic Crustacea in Lake Michgan. Univ. Michigan. Great Lakes Res. Div. Pub. No. 15:98-108.

Quantitative data on abundance and vertical distribution of Lake Michigan cladoceran species in relation to light quality and depth.

1968. Acoustical determination of zooplankton distributions. Internat. Assoc. Great Lakes Res. Proc. 11th Conf. Great Lakes Res. pp. 76-84.

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1969. Developments in acoustic plankton sampling. Internat. Assoc. Great Lakes Res. Proc. 12th Conf. Great Lakes Res. pp. 61-68.

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McNaught, D.C., and A.D. Hasler.
1966. Photo-environments of planktonic Crustacea in Lake Michigan. Verh. Internat. Verein. Limnol. 16:194-203.

Quantitative data on vertical distribution of *Daphnia retrocurva* and *Limnocalanus macrurus* in Lake Michigan in relation to light quality and depth.

Marsell, J.W.,and C.R. Norden.
1968. Food habits of the alewife, *Alosa pseudoharengus* (Wilson), in Lake Michigan. Internat. Assoc. Great Lakes Res., Proc. 11th Conf. Great Lakes Res. pp. 96-102.

Stomach analysis of alewives taken from Green Bay and Milwaukee Harbor, Lake Michigan, showed zooplankton (especially copepods) predominated in stomaches of fish taken from shore zones. Most zooplankton identified to species. Seasonal and depth information included.

Norden, C.R.
1968. Morphology and food habits of the larval alewife, *Alosa pseudoharengus* (Wilson), in Lake Michigan. Internat. Assoc. Great Lakes Res., Proc. 11th Conf. Great Lakes Res. pp. 103-110.

Zooplankton (Crustacea) from Milwaukee, Lake Michigan, eaten by alewife larvae (5.3-67.1 mm TL) identified to genus.

Patalas, K.
1972. Crustacean plankton and the eutrophication of the St. Lawrence Great Lakes. J. Fish. Res. Bd. Canada 29:1451-1462.

Copepod and cladoceran species in the summer plankton of the Great Lakes (Lake Michigan omitted) are discussed as to relative abundance and species associated with oligotrophic and eutrophic lakes. Good paper for comparison with Lake Michigan.

Pearse, A.S.
1910. A preliminary list of the Crustacea of Michigan. Michigan Acad. Sci., Arts, Lett. 12:68-76.

Zooplankton from Lake Michigan included.

Powers, C.F., and A. Robertson.
1968. Biological exploration in Lake Michigan from a research submarine. Internat. Assoc. Great Lakes Res., Proc. 11th Conf. Great Lakes Res. pp. 117-123.

Includes observations of Copepods in Lake Michigan.

Powers, C.F., A. Robertson, S.A. Czaika, and W.P. Alley.
1967. Lake Michigan biological data, 1964-1966, pp. 179-227. *In* Studies on the environment and eutrophication of Lake Michigan. Univ. Michigan. Great Lakes Res. Div., Spec. Rep. No. 30.

Data collected on organic matter in zooplankton from 35 stations in Lake Michigan twice monthly (April-Nov. 1964, 1965; March-June 1966). No treatment of data.

Reinghard, J.E.
1893. Some plankton estimates in the Great Lakes. Trans. Amer. Fish. Soc. 22:112-122.

Net plankton volumes from Lake Michigan.

Rigler, F.H., and R.R. Langford.
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Includes discussion of zooplnakton from Lake Michigan.

Robertson, A.
1966. The distribution of calanoid copepods in the Great Lakes. Univ. Michigan. Great Lakes Res. Div. Pub. No. 15. pp. 129-39.

Geographical and seasonal distribution of calanoid copepods in the Great Lakes.

1968. The abundance, distribution, and biology of plankton in Lake Michigan with the addition of a research ships of opportunity project. Univ. Michigan. Great Lakes Res. Div. Spec. Rep. No. 35. 43pp.

Application of the Hardy continuous plankton recorder to plankton studies in Lake Michigan.

Rolan, R.G.
1972. The zooplankton,zoobenthos and periphytic invertebrates of the Great Lakes, pp. 4•690-4•806. *In* Limnology of lakes and embayments. Draft No.2., Vol.2. Great Lakes Basin Framework Study.

Review of crustacean zooplankton changes in Lake Michigan, seasonal abundance, distribution within the Great Lakes. Also zooplankton species important as food source for fish.

Roth, J.C., and J.A. Stewart.
1973. Nearshore zooplankton of southeastern Lake Michigan, 1972. Internat. Assoc. Great Lakes Res., Proc. 16th Conf. Great Lakes Res. pp. 132-142.

Seasonal abundance of Copepoda and Cladocera collected in the coastal zone of southeastern Lake Michigan monthly from April to November 1972. Species identification. Distinct inshore and offshore fauna discussed.

Schacht, F.W.
1897. The North American species of *Diaptomus*. Bull. Illinois State Lab. Nat. Hist. 5:97-208.

Has key and describes species of *Diaptomus*. Records from the Great Lakes included.

1898. The North American Centrepagidae belonging to the genera *Osphrantium, Limnocalanus,* and *Epischura*. Bull. Illinois State Lab. Nat. Hist. 5:225-270.

Includes records from Lake Michigan.

Schelske, C.L., and J.C. Roth.
1973. Limnological survey of Lakes Michigan, Superior, Huron, and Erie. Univ. Michigan. Great Lakes Res. Div. Pub. No. 17. 108 pp.

Biological aspects limited to generic data from Lake Michigan. Comparison of zooplankton populations of all Great Lakes.

Stemberger, Richard S.
1974. Temporal and spatial distributions of planktonic rotifers in Milwaukee Harbor and adjacent Lake Michigan. Internat. Assoc. Great Lakes Res., Proc. 17th Conf. Great Lakes Res. pp. 120-134.

Discusses seasonal, horizontal, and vertical distribution of 29 species of rotifers found inshore and offshore at Milwaukee Harbor in Lake Michigan. Relative abundance also included.

Stewart, J.A.
1974. Lake Michigan zooplankton communities in the area of the Cook Nuclear Power Plant, pp. 211-332. E. Seibel and J.C. Ayers, eds. The biological, chemical, and physical character of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Power Plant. Univ. Michigan. Great Lakes Res. Div. Spec. Rep. No. 51.

Zooplankton population trends samples during 1973-1974 in vicinity of Donald C. Cook Nuclear Plant on Lake Michigan. Species identification (Copepod, Cladocera, Rotifera), population estimates and yearly trends included.

Stimpson, W.
1870. On the deepwater fauna of Lake Michigan. Amer. Nat. 4:403-405.

Records of Crustacea in deep water of Lake Michigan.

Underwood, L.M.
1886. List of the described species of fresh-water Crustacea from America, North of Mexico. Bull. Illinois State Lab. Nat. Hist. 2: 323-385.

Includes records from Lake Michigan.

Van Oosten, J.
1957. Great Lakes fauna, flora and their environment- a bibliography. Great Lakes Comm. Ann Arbor, Michigan. 86 pp.

A bibliography on major biological and environmental studies conducted on Lake Michigan prior to 1957.

Voigt, M.
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Most recent comprehensive taxonomic study of the Rotifera.

Ward, H.B.
1896. A biological examination of Lake Michigan in the Traverse Bay Region. Bull. Michigan Fish. Comm. 6:1-71.

Appendix by Jenning (1896) on Rotifera of Lake Michigan.

Watson, N.H.F.
1974. Zooplankton of the St. Lawrence Great Lakes- species composition, distribution, and abundance. J. Fish. Res. Bd. Canada. 31:783-794.

Species list of Cladocera and Copepoda found in each of the Great Lakes. Summarizes literature on long-term changes in zooplankton populations.

Wells, L.
1960. Seasonal abundance and vertical movements of planktonic Crustacea in Lake Michigan. U.S. Fish and Wildl. Serv., Fish. Bull. 60:342-369.

Reports species of Copepoda and Cladocera from collections made in Lake Michigan (1954-1955). Also discusses relative abundance of each species and vertical migration.

1970. Effects of alewife predation on zooplankton populations in Lake Michigan. Limnol. Oceanogr. 15:556-565.

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Wells, L., and A.M. Beeton.
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Reports on species of Copepoda and Cladocera important as food to the bloater in Lake Michigan.

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1966. Dominant planktonic rotifers of major waterways of the United States. Limnol. Oceanogr. 11:83-91.

Genera of rotifers at Milwaukee, Wisconsin and Gary, Indiana in Lake Michigan.

Yaguchi, E.M., B.J. Waller, and J.S. Marshall.
1974. Plutonium distribution in Lake Michigan biota. Internat. Assoc. Great Lakes Res., Proc 17th Conf. Great Lakes Res. pp. 150-157.

Reports plutonium levels in mixed plankton and zooplankton samples from Lake Michigan during 1972-1973.

Yeatman, H.C.
1944. American cyclopoid copopods of the *viridis-vernalis* including a description of *Cyclops carolinianus* n. sp. Amer. Midl. Nat. 32:1-90.

Includes taxonomic discussion of the Great Lakes species, *Cyclops bicuspidatus* and *C. vernalis*.

AQUATIC WORMS (OLIGOCHAETA)

Alley, W. P., and R. F. Anderson.
1968. Small scale patterns of spatial distribution of Lake Michigan macrobenthos. Proc. 11th Conf. Great Lakes Res. pp. 1-10.

The biological implications of the distributional patterns of *Pontoporeia*, sphaeriids, chironomids, and oligochaetes, and the statistical inferences of the sampling techniques used in this study are discussed.

Alley, W. P., and C. Powers.
1970. Dry weight of the macrobenthos as an indicator of eutrophication in the Great Lakes. Proc. 13th Conf. Great Lakes Res. pp. 595-600.

This article concerns the eutrophication of Lake Michigan and its effect upon the benthos.

Bartsch, A. F.
1968. Eutrophication is beginning in Lake Michigan. Water Waste Eng. 5:84-87.

Examination of eutrophication and changes in densities of benthos.

Beddard, F. E.
1895. A monograph of the order of Oligochaeta. Clarendon Press, Oxford. xii + 5 pls + 769 pp.

This monograph contains many original descriptions, keys, and an excellent bibliography concerning earlier work on the Oligochaeta.

Beer, L. P., and W. O. Pipes.
1969. A practical approach to the environmental effects of thermal discharges. Proc. Indust. Waste Conf. 24:727-744.

Effects of thermal discharges upon benthic communities are discussed.

Beeton, A. M.
1965. Eutrophication of the St. Lawrence Great Lakes. Limnol. Oceanogr. 10:240-254.

This article refers to the Tubificidae population changes in Lake Michigan.

1969. Changes in environment and biota of the Great Lakes, pp. 150-187. *In* G. A. Rohlich, Chairman. Eutrophication: causes, consequences, correctives. Nat. Acad. Sci., Washington, D. C.

Limited distributional data of oligochaete genera and species.

1970. Statement on pollution and eutrophication of the Great Lakes.

Univ. Wisconsin Center for Great Lakes Studies, Spec. Rept. No. 11. 35 pp.

A review of the most important aspects involved in biophysical and chemical changes that have occurred in the Great Lakes since settlement.

Brinkhurst, R. O.
1962. A re-description of *Peloscolex variegatus* (Leidy) (Oligochaeta, Tubificidae) with a consideration of the diagnosis of the genus *Peloscolex*. Int. Rev. ges. Hydrobiol. 47:301-306.

Lake Michigan locality listed.

1964. Studies on the North American aquatic Oligochaeta. I. Naididae and Opistocystidae. Proc. Acad. Nat. Sci. Philadelphia 116: 195-230.

Occurrence, distribution and key for identification of these families of Oligochaeta.

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1966. Studies on the North American aquatic Oligochaeta. III. Lumbriculidae and additional notes and records of other families. Proc. Acad. Nat. Sci. Philadelphia 118:1-33.

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1967. The distribution of aquatic oligochaetes in Saginaw Bay, Lake Huron. Limnol. Oceanogr. 12:137-143.

Some species of Oligochaeta from Lake Michigan are discussed.

Brinkhurst, R. O., and B. G. M. Jamieson.
1971. Aquatic Oligochaeta of the world. Univ. Toronto Press, Toronto. xi + 860 pp.

Species occurring in Lake Michigan described and discussed.

Cook, D. G., and M. G. Johnson.
1974. Benthic macroinvertebrates of the St. Lawrence Great Lakes. J. Fish. Res. Bd. Canada 31:763-782.

History of Great Lakes benthos studies from 1870 to the present, as well as a discussion of the existing benthic community.

Cook, G. W., and R. E. Powers.
1964. The benthic fauna of Lake Michigan as affected by the St. Joseph River. Univ. Michigan Great Lakes Res. Div. Publ.

No. 11.

Effects of dissolved and volatile liquids and organic deposits transported by the St. Joseph River upon the benthic fauna are discussed.

Coutant, C. C., and A. J. Brook.
1970. Biological aspects of thermal pollution. I: Entrainment and discharge canal effects. Critical Reviews in Env. Control 1:341-381.

Evaluation of thermal pollution in Lake Michigan and its effects upon benthic communities.

Eggleton, F. E.
1936. The deep-water bottom fauna of Lake Michigan. Papers Michigan Acad. Sci. Arts Letters 21:599-612.

Methods and equipment used for collection, temporal and geographical distribution of sampling, and general biological features of deep-water benthos are discussed.

1937. Productivity of the profundal benthic zone in Lake Michigan. Papers Michigan Acad. Sci. Arts Letters 22:593-611.

Abundance, depth distribution, seasonal variation, and general ecology of the profundal benthos are discussed.

Goodnight, C. J.
1940. The Branchiobdellidae (Oligochaeta) of North American crayfishes. Illinois Biol. Monogr. 17:5-75.

Biological and morphological characteristics and key for identification of branchiobdellid worms associated with crayfishes.

1959. Oligochaeta, pp. 522-539. *In* W. T. Edmondson, ed. Fresh-water biology, 2nd ed. John Wiley & Sons, New York.

Key for identification and limited distributional data.

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1973. A laboratory guide. Keys to the tubificid and naidid Oligochaeta of the Great Lakes region. Great Lakes Fish. Res. Lab., Ann Arbor.

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1971. Biological evaluation of environmental quality, Green Bay, Wisconsin. J. Water Poll. Contr. Fed. 43:123-133.

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Report based upon collections between 1893 and 1899.

Mozley, S. C.
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A study of physico-chemical and biological components during a 4-week period during summer 1970.

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Good discussion of sediment analysis.

Stephenson, J.
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Stimpson, W.
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Van Oosten, J.
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Excellent up to the mid-1950's.

TRICHOPTERA

Banks, N.
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Describes species from Lake Michigan.

Bartsch, A. F.
1968. Eutrophication is beginning in Lake Michigan. Water Waste Eng. 5:84-87.

Examination of eutrophication and changes in densities of benthos.

Betten, C. B.
1934. The caddis flies or Trichoptera of New York State. Bull. N. Y. State Mus. No. 292:1-576.

List species from Lake Michigan.

Beeton, A. M.
1960. Great Lakes Limnological investigations. Univ. Mich. Great Lakes Res. Div. Publ. 4:123-218.

Accelerating eutrophication and the effect on benthos.

Dambach, C. A.
1969. Changes in the biology of the lower Great Lakes. Bull. Buffalo Soc. Nat. Sci. 25:1-17.

Changes in Trichoptera populations and densities with increasing eutrophication.

Dendy, J. S.
1944. The fate of animals in streamdrift when carried into lakes. Ecol. Monogr. 14:333-357.

Fate of Trichoptera in drift when carried into lakes.

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Changes in Trichoptera community because of eutrophication.

Leonard, J. W., and F. A. Leonard.
1949. An annotated list of Michigan Trichoptera. Occas. Papers Mus. Zool., Univ. Mich. 522:1-35.

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1951. Pest Trichoptera at Fort Erie, Ontario. Can. Entomol. 83:69-72.

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Nimmo, A. P.
1966. The arrival pattern of Trichoptera at artifical light near Montreal, Quebec. Quaest. Entomol. 2:217-242.

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Resh, V. H., and J. D. Unzicker.
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1944. The caddis flies, or Trichoptera, of Illinois. Bull. Ill. Nat. Hist. Survey, 23:1-326.

Lists species of Trichoptera from Lake Michigan and the Dead River.

Selgeby, J. H.
1974. Immature insects (Plecoptera, Trichoptera, and Ephemeroptera) collected from deep water in western Lake Superior. J. Fish Res. Bd. Canada. 3:109-111.

Species of Trichoptera collected in deep water.

Smith, L. L., and J. B. Moule.
1944. A biological survey and fishery management plan for the streams of the Lake Superior north shore watershed. Minn. Dept. Conserv., Div. Game & Fish., Tech. Bull. 1:1-228.

Relationship between benthos and stream management for streams of Lake Superior north shore watershed.

Vorhies, C. T.
1909. Studies of the Trichoptera of Wisconsin. Trans. Wisc. Acad. Sci., Arts and Lett. 16:647-739.

Lists species from Lake Michigan.

Yamaoto, T., and G. B. Wiggins.
1964. A comparative study of North American species of the caddisfly genus *Mystacides* (Trichoptera: Leptoceridae). Can. J. Zool. 42:1105-1126.

Lists species which occur in Lake Michigan.

Ulmer, G.
1907. Trichopteren. *In* Genera insectorum, Fasc. 60. 259 pp.

CHIRONOMIDS AND MOSQUITOES

Alley, W. P., and C. F. Powers.
1970. Dry weight of the macrobenthos as an indicator of eutrophication of the Great Lakes. Internat. Assoc. Great Lakes Res., Proc. 13th. Conf. Great Lakes Res., Part 2:595-600.

Eutrophication of Lake Michigan and effect on benthos.

Bartsch, A. F.
1968. Eutrophication is beginning in Lake Michigan. Water Waste Eng. 5:84-87.

Examination of eutrophication and changes in densities of chironomids.

Beer, L. P., and W. O. Pipes.
1969. A practical approach to the environmental effects of thermal discharges. Proc. Ind. Waste Conf. 24:727-744.

Effects of thermal discharge on benthic communities.

Carpenter, S. J., and W. J. La Casse.
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Distribution of Mosquitoes.

Christensen, G. R., and F. C. Harmston.
1944. A preliminary list of the mosquitoes of Indiana. J. Econ. Entomol. 37:110-111.

Distribution of mosquitoes in northwest Indiana.

Coutant, C. C., and A. J. Brook.
1970. Biological aspects of thermal pollution. I: Entrainment and discharge canal effects. Critical Reviews in Env. Control. 1:341-381.

Evaluation of thermal pollution in Lake Michigan on benthic communities.

Dembach, C. A.
1969. Changes in the biology of the Lower Great Lakes. Bull. Buffalo Soc. Nat. Sci. 25:1-17.

Changes in chironomid population and densities with increasing eutrophication.

Dickinson, W. E.
1944. The mosquitoes of Wisconsin. Milwaukee Pub. Mus. Bull. 8: 269-365.

Distribution of mosquitoes in southeastern Wisconsin.

Gerhard, W. J.
1910. A list of the mosquitoes in the vicinity of Chicago, Illinois. Entomol. News. 21:293-300.

First list of mosquitoes of the Chicago area.

Hart, J. W.
1944. A preliminary list of the mosquitoes of Indiana. Amer. Midl. Nat. 31:414-416.

Distribution of mosquitoes in northwestern Indiana.

Hart, J. W.
1969. A checklist of the mosquitoes of Indiana with a record of the occurrence of *Aedes infirmatus* Dyar and Knab. Indiana Acad. Sci. Proc. 78:257-259.

Distribution of mosquitoes in northwestern Indiana.

Howmiller, R. P., and A. M. Beeton.
1971. Biological evaluation of environmental quality, Green Bay, Lake Michigan. J. Water Poll. Contr. Fed. 43:123-133.

Changes in chironomid community because of eutrophication.

Malloch, J. R.
1915. The Chironomidae, or midges, of Illinois, with particular reference to the species occurring in the Illinois River. Bull. Illinois State Lab. Nat. Hist. 10:217-542.

Distribution of chironomids in northeastern Illinois.

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1970. The Adults of the subfamily Tanypodinae (= Pelopiinae) in North America (Diptera: Chironomidae). Acad. Nat. Sci. Philadelphia Monog. 17:1-410.

Distribution of chironomids in northeastern Illinois.

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1947. The mosquitoes of Illinois (Diptera, Culicidae). Bull. Illinois Nat. Hist. Surv. 24:1-96.

Distribution of mosquitoes in northeastern Illinois.

Saether, O. A.
1973. Taxonomy and ecology of three new species of *Monodiamesa* (Kieffer) with keys to Nearctic and Palaearctic species of the genus (Diptera: Chironomidae). J. Fish. Res. Bd. Canada. 30:665-679.

Distribution of *Monodiamesa* in Lake Michigan.

Siverly, R. E.
1966. Occurrence of *Culiseta melanura* (Coquillett) in Illinois. Mosq. News. 26:95-96.

Distribution of *Culiseta* in northeastern Illinois.

Townes, H. K., Jr.
1945. The Nearctic species of Tendipedini (Diptera, Tendipedidae (= Chironomidae)). Amer. Midl. Nat. 34:1-206.

Distribution of chironomids in northeastern Illinois.

FISHES AND FISHERIES

Downs, W.
1975. Fish of Lake Michigan. Univeristy of Wisconsin Sea Grant College Program Wis-SG-74-121. 32 p.

An uncritical and popular account of fish species in Lake Michigan. Greatest value lies in its list of species in Green Bay that do not occur in Illinois portion of Lake Michigan.

Forbes, S. A.
1884. A catalogue of the native fishes of Illinois. Illinois State Fish Commissioner's Report for 1884. p. 60-89.

Third comprehensive report on Illinois fishes with numerous records cited for the Chicago area. Of interest chiefly as a record of fishes and habitats present in the late 19th century.

Forbes, S. A., and R. E. Richardson.
[1908.] The fishes of Illinois. Illinois Natural History Survey Division, Urbana cxxxi + 357;. + separate atlas containing 102. maps.

The classic report on Illinois fishes, summarizing the ichthyofauna up to approximately 1905.

Greene, C. W.
1935. The distribution of Wisconsin fishes. State of Wisconsin Conservation Commission, Madison. 235 p.

Of interest because of data on fishes in Lake Michigan in waters adjacent to the Illinois portion of the Lake.

Hile, R.
1952. 25 years of federal fishery research on the Great Lakes. U. S. Fish. Wild. Serv. Spec. Sci. Rep. Fish. No. 85. 48 p.

Excellent summary of the history of the trout and whitefish fishery of the Great Lakes.

Hubbs, C. L.
1926. A Check-list of the fishes of the Great Lakes and tributary waters, with nomenclatorial notes and analytical keys. Uni. Mich. Mus. Zool. Misc. Publ. No. 15. 77 p.

Important work providing foundation for proper understanding of systematics and nomenclature of Great Lakes basin fishes.

Hubbs, C. L., and K. F. Lagler.
1939. Keys for the identification of the fishes of the Great Lakes and tributary waters. Privately published, Ann Arbor. 37 p.

The classic study of fishes in the Great Lakes drainage.

Hubbs, C. L., and K. F. Lagler.
1941. Guide to the fishes of the Great Lakes and tributary waters. Cranbrook Inst. Sci. Bull. No. 18. 100 p. (and revised editions).

Revised editions updating knowldege of fishes in Great Lakes.

Jordan, D. S.
1878. A catalogue of the fishes of Illinois. Bull. Illinois State Lab. Nat. Hist. 1:37-70.

Second comprehensive report on Illinois fishes with many records for Chicago area. Excellent description of fishes and habitats during the 1870's.

Kennicott, R.
1855. Catalogue of animals observed in Cook County, Illinois. Illinois State Agric. Soc. Trans. 1:577-595.

Earliest account of vertebrate animals in the Chicago area. Of great historical value.

Large, T.
1903. A list of native fishes of Illinois, with keys. Appendix to the Illinois State Board of Fish Commissioners for 1900-1902. 30 p.

Fourth catalogue of Illinois fishes. Important becuase it establishes the systematic relationships and much of the nomenclature used later by Forbes and Richardson.

Lopinot, A. C.
1970. 1969 creel survey of the Illinois portion of Lake Michigan. Illinois Dep. Cons. Spec. Fish. Rep. No. 32. 46 p.

Fishery statistics and list of sport fishes taken in the year 1969.

Lopinot, A. C.
1974. Illinois fishery of Lake Michigan. Illinois Department of Conservation Division of Fisheries, Springfield. 47 p.

Excellent summary of fishery statistics in Illinois waters of Lake Michigan over the years.

Meek, S. E., and S. F. Hildebrand.
1910. A synoptic list of the fishes known to occur within 50 miles of Chicago. Publ. Field Mus. Nat. Hist., Zool. Serv. 7:223-338.

Early list of fishes of Chicago area. A technical but uncritical treatment based largely upon the Forbes and Richardson records for northeastern Illinois.

Milner, J. W.
1874. Report on the fisheries of the Great Lakes; the results of inquiries prosecuted in 1871 and 1872. In Part II. Report of the Commissioner of Fish and Fisheries for 1871 and 1873. Appendix A. The Fisheries of the Great Lakes. p. 1-75.

First detailed report on the fishery of Lake Michigan with statistics and life-history data for many commercial and sport species.

Moffett, J. W.
1957. Recent changes in the deep-water fish populations of Lake Michigan. Trans. Amer. Fish. Soc. 86:393-408.

Important paper detailing the decline of fishes and fishery of Lake Michigan and citing reasons for the changes.

Muench, B.
1974. Unpublished report to Commonwealth Edison Company by Industrial Bio-Test, Inc. on Lake Michigan: Zion and Waukegan.

Report on extensive collections of fishes made at two sites along shoreline of Lake Michigan in early 1970's.

Nelson, E. W.
1876. A partial catalogue of the fishes of Illinois. Bull. Illinois Mus. of Nat. Hist. 1:33-52.

First list of Illinois fishes with many new species described. Excellent description of fauna of the period.

Nelson, E. W.
1878. Fisheries of Chicago and vicinity. Report of the U. S. Commissioner of Fish and Fisheries, Part 4, for 1875-1876. Appendix B, p. 783-800.

Superb description of fishes and fishery of Lake Michigan near mouth of Chicago River and of the Chicago, Calumet, and upper Kankakee rivers. An obscure but extremely valuable account of the biology of the area before construction of canals between Lake Michigan and the Illinois River.

Parsons, J. W.
1973. History of salmon in the Great Lakes, 1850-1970. U. S. Bureau Sport Fish. Wildl. Tech. Papers 68. 80 p.

History of attempts to stock salmons and trouts in Lake Michigan over the past 80 years with a realistic analysis of future transplantings.

Smith, P. W.
1965. A preliminary annotated list of the lampreys and fishes of Illinois. Illinois Nat. Hist. Surv. Biol. Notes No. 54. 12 p.

Account of fishes of Illinois in the 1960's with annotations of species new to the state and those extirpated.

Smith, P. W.
1971. Illinois streams: A classification based on their fishes and an analysis of factors responsible for disappearance of native species. Illinois Nat. Hist. Surv. Biol. Notes No. 76. 14 p.

Analysis of changes in fishes and their habitats throughout Illinois with factors responsible for changes identified. Streams rated and unusual species and their habitats cited.

Smith, P. W.
The fishes of Illinois. Unpublished Ms.

Monographic treatment of fishes of Illinois that reviews previous literature and describes present distributions of species. State report based on 15 years of intensive research.

Tichacek, G. and H. Wight
1973. Lake County surface water resources. Illinois Department of Conservation Division of Fisheries. 162 p.

Mimeographed report detailing fishery statistics for Lake County surface waters.

Van Oosten, J.
1958. Great Lakes fauna flora and their environment. A bibliography. Great Lakes Commission, Ann Arbor. x + 86 p.

Excellent extensive bibliography of papers on Lake Michigan fauna published up to the mid-1950's.

Wells, L.
1968. Seasonal depth distribtuion of fish in southeastern Lake Michigan. Fish Bull. 67:1-15.

Important paper on depth distribtuion of principal species of fishes in Lake Michigan in relation to season of year.

Wells, L. and A. L. McLain.
1973. Lake Michigan. Man's effect on native fish stocks and other biota. Great Lakes Fishery Commission Technical Report 20. v + 55 p.

Superb account of changes in Lake Michigan and its fishes.

Woods, L. P.
1970. The changing Great Lakes. Field Mus. Nat. Hist. Bull. 49:6-10, 8:6-11.

Popular but well written account of the history of the fish fauna in Lake Michigan.

VEGETATION

Allen, J. A.
1870. The flora of the prairies. Amer. Nat. 4:577-585.

The region under study was northern Illinois and western and central Iowa. Seasonal aspects of the prairies well described.

Anderson, R. C.
1970. Prairies in the prairie state. Trans. Illinois Acad. Sci. 63:214-221.

Map based upon original land survey records in presented and compared with earlier maps of Gerhard (1857) and Vestal (1931).

Atwell, C. B.
1932. Three dune associations compared. Torreya 32:109-115.

Gives characteristic plants of upper beach, forest association, and a table with species of high beach and foredunes, and dune crests at Beach, Illinois (pp. 110-111).

Babcock, H. H.
1872. The flora of Chicago and vicinity. The Lens 1:20-26, 65-71, 144-150, 218-222.

Treats the plants of the lake shore within 40 miles of Chicago.

1873. The flora of Chicago and vicinity. The Lens 2:33-34, 96-98, 248-250.

A continuation of Babcock (1872).

Baker, F. C.
1910. The ecology of the Skokie Marsh area, with special reference to the Mollusca. Bull. Illinois State Lab. Nat. Hist. 8:441-498.

Some reference to plants of the area, especially as they are associated with the Mollusca.

Benninghoff, W. S.
1964. The prairie peninsula as a filter barrier to post-glacial migration. Proc. Indiana Acad. Sci. 73:116-124.

Prairie peninsula established shortly after glacial retreat. It is older than the pine stage in central Indiana.

Buhl, C. A.
1934. Supplement to an annotated flora of the Chicago area by H. S. Pepoon. Bull. Chicago Acad. Sci. 5:5-12.

Many species added, some deleted, from Pepoon (1927).

Clute, W. N.
1911. The flora of the Chicago plain. Amer. Bot. 17:65-70.

Mostly about the City of Chicago area, a flat stretch of land, 10 to 15 miles wide, bounded on the west and south by the Valparaiso moraine. A species list is given for 6 mos of 1911.

1912. The summer flora of the Chicago plain. Amer. Bot. 18:97-100.

Contains a species list.

Cowles, H. C.

1899. The ecological relations of the vegetation on the sand dunes of Lake Michigan. Bot. Gaz. 27:95-117, 167-202, 281-308, 361-391.

Data chiefly from the study of dunes in northwestern Indiana and in the vicinity of Chicago.

1901. The physiographic ecology of Chicago and vicinity; a study of the origin, development, and classification of plant societies. Bot. Gaz. 31:73-108, 145-182. Also Geogr. Soc. Chicago Bull. No. 2. 76 pp.

Includes photos of bluffs at Glencoe.

1926. North shore ravines, p. 473. *In* Ecological Society of America. Naturalist's guide to the Americas. Williams & Wilkins Co, Baltimore.

Ravines between Winnetka and Waukegan contain a rich mesophytic flora and are notable as almost the only sites for beach in northern Illinois.

Cowles, H. C., and W. C. Allee.

1926. Waukegan flats, p. 475. *In* Ecological Society of America. Naturalist's guide to the Americas. Williams & Wilkins Co, Baltimore.

The flora was considered to be rich and representative. The water in Dead River was unpolluted and contained a good fauna.

Fuller, G. D.

1912. The cottonwood dune association. Trans. Illinois Acad. Sci. 5:137-143.

The Calumet area.

1917. The vegetation of the Chicago region. Published privately, Chicago. 28 pp.

An outline of some of the principal plant associations together with lists of their principal species.

1925. The vegetation of the Chicago region. An outline of some of the principal plant associations, together with lists of their principal species, Univ. Chicago Press, Chicago. 27 pp.

An outline of some of the principal plant associations together with lists of their principal species.

Gates, F. C.

1910. The plant associations of the recent and fossil beaches of Lake Michigan, between Kenosha, Wisconsin and Waukegan, Illinois. Unpub. BA thesis, Univ. Illinois, Urbana. 96 pp.

Discusses the associations of the sand land along Lake Michigan and provides a list of species observed in the area of study. Photographs and maps are included.

1912. The vegetation of the beach area in northeastern Illinois and southeastern Wisconsin. Bull. Illinois State Lab. Nat. Hist. 9:255-272.

A thorough study of the physiography, climate, edaphic factors, and the plant associations of that area. Species list and bibliography included.

Gleason, H. A.

1901. The flora of the prairies. Unpubl. B. S. thesis, Univ. Illinois, Urbana.

Cites early writers on prairies and gives an annotated list of species, geographical distributions, and statistical analysis of some.

1910. The vegetation of inland sand deposits of Illinois. Bull. Illinois State Lab. Nat. Hist. 9:23-174.

Based upon studies of sand areas near Havana, Hanover, Amboy, Dixon, Oquawka, Kankankee, and Winnebago County. Climate and vegetation discussed and an annotated list of species is included. The study did not include the sand deposit of northeastern Illinois.

Hall, R. C., and C. D. Ingall.

1911. Forest conditions in Illinois. Bull. Illinois State Lab. Nat. Hist. 9:175-253.

Northwestern Illinois not included in this study.

Higley, W. K., and C. S. Raddin.

1891. The flora of Cook County, Illinois, and a part of Lake County, Indiana. Bull. Chicago Acad. Sci. 2:23-191.

Emphasis upon heavily timbered country extending through central and northern portions of Cook County, the Calumet Region of Illinois and Lake County, Indiana. Cites localities of uncommon species.

Hill, E. J.

1892. Notes on the flora of Chicago and vicinity. I. Bot. Gaz. 17:246-252.

Notes on native and introduced plants of the neighborhood of Chicago and northwestern Indiana (e.g. *Salsoli kali* at Evanston).

1899. Notes on plants of the Chicago district. Bull. Torrey Bot. Club. 26:303-311.

Concerns plants of the Chicago area and the dune areas at the southern end of Lake Michigan.

1915. Notes on the plants of the Chicago region. Torreya 15:21-28.

Discusses some species he located in the Chicago area.

Jenses, J.

1929. The native beeches in the Chicago region. Trans. Illinois Acad. Sci. 21:69-71.

One colony along Pettibone Creek south of Waukegan (now Great Lakes Training Station) and another at Highland Park.

Pepoon, H. S.

1927. An annotated flora of the Chicago region. Chicago Acad. Aci. Nat. Hist. Bull. No. 8. 554 pp.

Includes material on the flora of the Waukegan "moorlands" and ravines, woodland, and littoral areas of the North Shore.

Sampson, H. C.

1921. An ecological survey of the prairie vegetation of Illinois. Ill. Nat. Hist. Surv. Bull. 13:523-577.

Lists 27 counties that contained prairie. One was Cook with 5000 acres, 200 of which were in the vicinity of Ashburn within the city limits of Chicago.

Schmoll, H. M.

1920. Ecological survey of forests in the vicinity of Glencoe, Illinois. Illinois State Acad. Sci. Trans. 12:208-233.

Listed are four bluff and three ravine floral associations. Photographs are included showing changes between 1900 and 1918.

Shelford, V. E., and G. S. Winterringer.

1959. The disappearence of an area of prairie in the Cook County, Illinois, Forest Preserve District. Amer. Midl. Nat. 61:84-94.

Area located east of Chicago Zoological Park between First Ave. and the Des Plaines River, and south of Thirty-first St.

Sherff, E. E.

1912. The vegetation of the Skokie Marsh, with special reference to the subterranean organs and their relationships. Bot. Gaz. 53:415-435.

Title a good summary.

1913. Vegetation of the Skokie Marsh. Bull. Illinois State Lab. Nat. Hist. 9:575-614.

Description of the marsh, general features of the vegetation, certain ecological conditions, subterranean organs and their relationships, summary, and an annotated list of species.

Simmons, L. M.
1921. Forest distribution at the ends of the Lake Chicago beaches. Trans. Illinois Acad. Sci. 13:226-239.

Considers the Upland Oak-Hickory, Xerophytic Sand Ridge Type, and Morainic Swamp Forest associations of the north part of Evanston, all of Wilmette and Kenilworth, and the east part of Winnetka.

Stearns, F., and N. Kobriger.
1975. Environmental status of the Lake Michigan Region, vol. 10. Vegetation of the Lake Michigan drainage basin. Argonne Nat. Lab. 113 pp.

A report on the entire basin discussing natural communities, present-day communities, forest communities, and plant succession. A good bibliography is provided.

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Craigmile, E. A.
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