Biological Services Program

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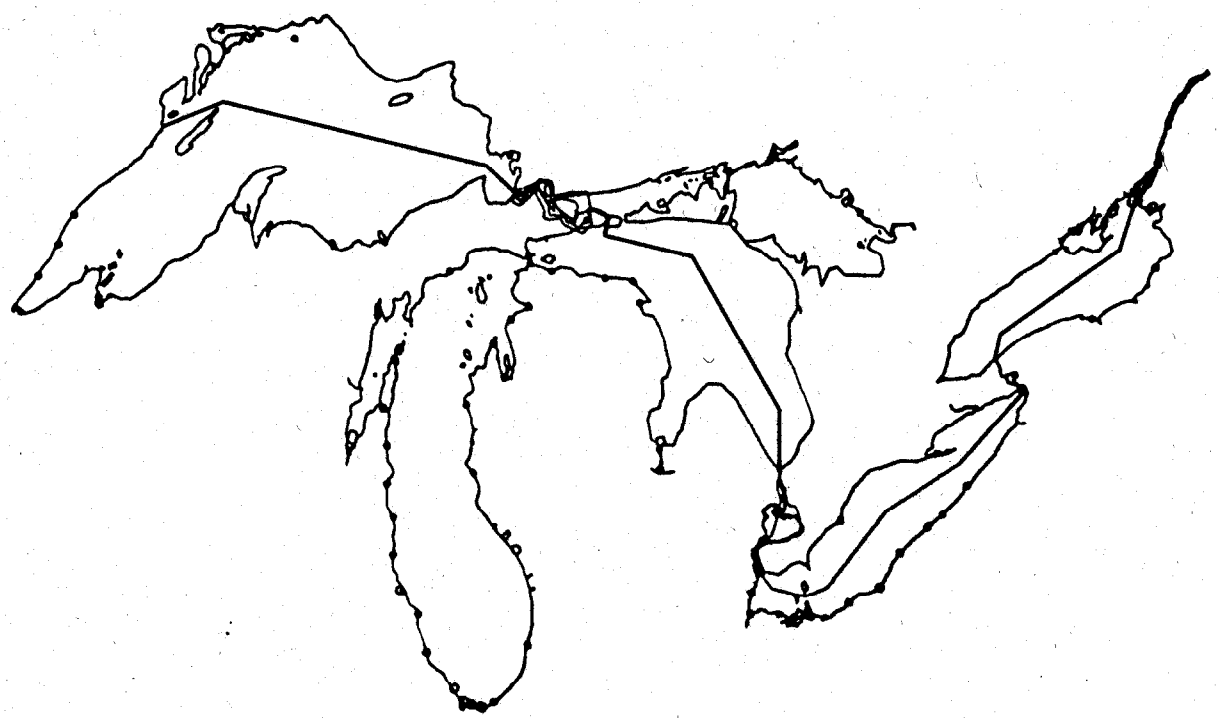
ATLAS OF THE SPAWNING AND NURSERY AREAS OF GREAT LAKES FISHES

Volume IV--Lake Michigan

Great Lakes-St. Lawrence Seaway
Navigation Season Extension Program



Fish and Wildlife Service
U.S. Department of the Interior

Corps of Engineers
U.S. Department of the Army

The Biological Services Program was established within the U.S. Fish and Wildllfe Service to supply scientific information and methodologies on key environmental issues that Impact fish and wildlife resources and their supporting ecosystems. The mission of the program is as follows:

- To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.
- To gather, analyze, and present information that will aid decisionmnakers in the identification and resolution of problems associated with major changes in land and water use.
- To provide better ecological information and evaluation for Department of the Interior development programs, such as those relatfng to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decisionmaking process to prevent or minimize the impact of development on fish and wildlife. Research activities and technlcal assistance services are based on an analysis of the issues, a determination of the decisionmakers involved and their informatlon needs, and an evaluation of the state of the art to identify information gaps and to determine priorities. This is a strategy that will ensure that the products produced and disseminated are timely and useful.

Projects have been initiated in the following areas: coal extraction and conversion; power plants; geothermal, mineral and oil shale development; water resource analysis, including stream alterations and western water allocation; coastal ecosystems and Outer Continental Shelf development; and systems, inventory, including National Wetland Inventory, habitat classification and analysis, and information transfer.

The Biological Services Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning-and management; Natlonal Teams, which provide the Program's central scientific and technical expertise and arrange for contracting biological services studies with states, universities, consulting firms, and others; Regional Staffs, who provide a link to problems at theoperating level; and staffs at certain Fish and Wildlife Service research facilities, who conduct in-house research studies.

FWS/OBS-82/52
September 1982

ATLAS OF THE SPAWNING AND NURSERY AREAS OF GREAT LAKES FISHES

VOLUME IV
Lake Michigan

by

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PREFACE

The fish resources of the Great Lakes have changed markedly since the settlement of the Great Lakes Basin began in the late 1700s-early 1800s. Local declines in the abundance of some highly valued species that supported early fisheries were reported in the 1800s. By the late 1950s-early 1960s, a number of important native species had disappeared from the catch, most once-productive stocks were depleted, and the fisheries that persisted were supported mainly by species of low value and utility. These undesirable changes have been attributed to the overharvest of desirable species, the invasion and introduction of undesirable exotic species, lowered water quality, and the destruction of portions of the physical habitat, including spawning grounds, vital to the maintenance of the resource base.

Since the 1950s, intensive efforts have been mounted to reestablish stable, self-sustaining fish communities, mainly by reducing sea lamprey abundance, limiting the harvest of remnant native stocks, and stocking desirable native or exotic species to replace or supplement depleted populations. Many of the native species and some of the desirable, introduced species have responded-favorably and are now supporting valuable, productive fisheries. These successes suggest that continued judicious exercise of established management strategies will result in further significant improvements in the fish resources and the fisheries. An emerging perspective suggests, however, that enduring, major improvements in the fish resources and the fisheries will require greater emphasis on rehabilitation efforts directed more specifically at safeguarding and improving the quality of the fish habitat in general, and on ensuring fuller utilization of the specialized habitat required by sensitive, embryonic- juvenile life stages of species that are to be included in any future, self-sustaining resource base. We prepared this atlas to provide a comprehensive information base against which past changes in the condition and use of spawning and nursery habitat of Great Lakes fishes could be viewed and evaluated and the needs of the future, self-sustaining resource base could be projected.

The atlas is composed of the following 14 volumes:

I. Spawning and Nursery Areas of Great Lakes Fishes: A Summary by Geographic Area

II. Lake Superior

III. St. Marys River

IV. Lake Michigan

V. Lake Huron

VI. St. Clair River

VII. Lake St.Clair

VIII. Detroit River

IX. Lake Erie

X. Niagara River

XI. Lake Ontario

XII. St. Lawrence River

XIII. Reproductive Characteristics of Great Lakes Fishes

XIV. Literature Cited

Volume I is designed to permit the reader to determine quickly whether a particular geographic area of interest contains fish spawning or nursery areas that are described in volumes II-XII. Volumes II-XII consolidate existing information describing spawning and nursery areas used by stocks of fish, including anadromous stocks, considered to be residents of the Great Lakes and their connecting waters. The information presented for each spawning or nursery area identified in volumes II-XII includes, when known, the area's precise location, history of use, season of use, water temperatures during the season of use, major substrate type, and water depth. Pre- and post-spawning migrations of mature fish and movements of young fish are also described, insofar as this information serves to better delineate spawning or nursery areas. Volume XIII contains concise descriptions of the reproductive characteristics of species included in volumes I-XII.

In the preparation of the atlas we found that considerable information was available for most of the species that support (or supported) major recreational or commercial fishes, or that are or were major components of the forage base; conversely, relatively little information was available for many other species not included in these general categories. For most species, spawning areas were more completely described than were nursery areas. The historical information in particular provided more extensive descriptions of spawning areas than of nursery areas, because much of this information was obtained from records of fisheries that had been conducted for spawning fish. Thus, although the information available to us for compilation was relatively extensive, it was nonetheless incomplete for the reasons given above. Users of the atlas are therefore cautioned not to view the lack of explicit reference to a given area as conclusive evidence that the area is or was not used as a spawning or nursery area by Great Lakes fishes.

Sources of the information incorporated in the atlas are described in volume I. Acknowledgements are also given in volume I.

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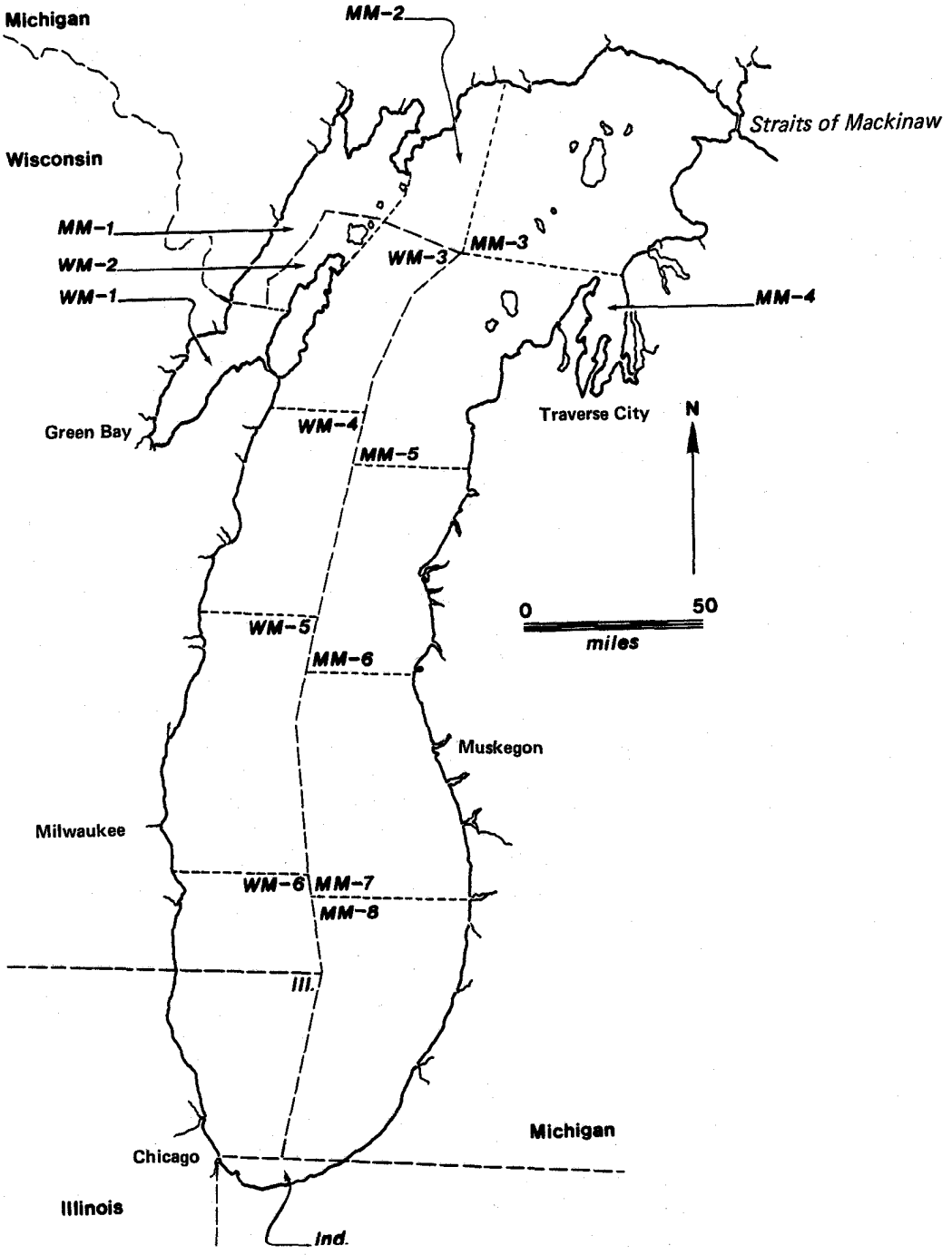
Volume IV. LAKE MICHIGAN

INTRODUCTION



Historically, large amounts of fish spawning habitat in Lake Michigan was destroyed or degraded by sawmill wastes, which covered spawning grounds in tributaries and near stream mouths, and by the construction of dams, which blocked spawning migrations into tributaries (Wells and McLain 1973). By the late 1800s, spawning grounds in Grand Traverse Bay and the Muskegon River had been degraded by sawdust (Milner 1874a; Smith and Snell 1891). By the early 1900s, the Fox River was unsuitable for spawning because of the large numbers of dams and bottom deposits of silt and paper fiber (Turner 1927).

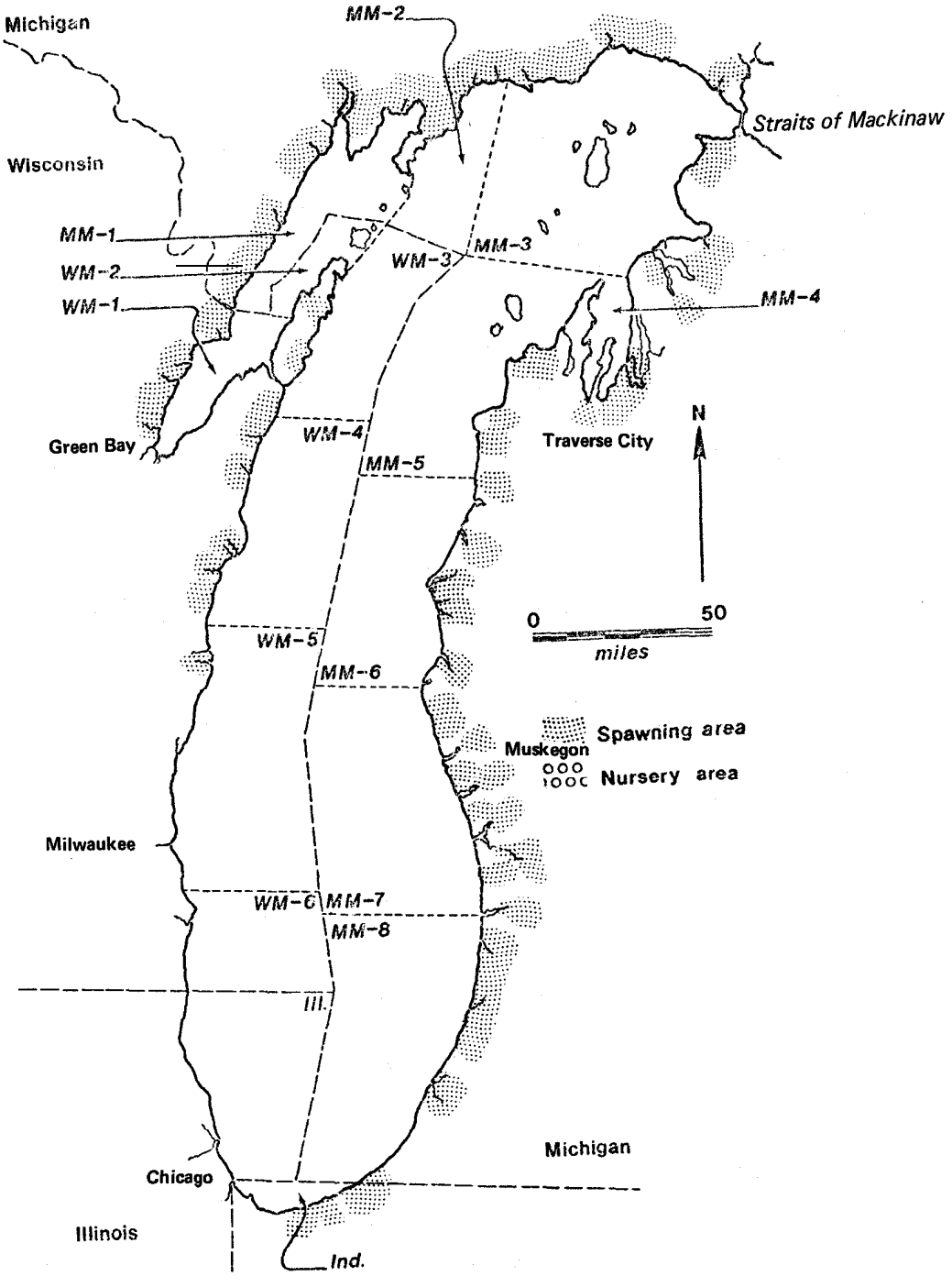
Almost 100 species of fish have been recorded as residents in Lake Michigan (Emery 1976; Koch, pers. comm. 1979; MWRC 1975; Wells, pers. comm. 1979) l This volume describes the reproductive habitat used by the 64 species for which information was available. Fifty-two species treated in this volume were native to the lake. Most of these 52 native species spawned (or spawn) in tributaries, reef area, or in shallow, protected waters of the lake. Only the lake trout, seven species of ciscoes, and the fourhorn sculpin, utilized the deep offshore waters for spawning. Six of these deepwater spawners, the blackfin cisco, longjaw cisco, shortjaw cisco, shortnose cisco, deepwater cisco, and kiyi are now believed to be extinct in Lake Michigan. Only the lake trout spawned in the shallow nearshore waters and also the deeper offshore waters.

The 12 exotic species treated in this volume were introduced by man or immigrated to the lake during the period of record, from populations established elsewhere in the Great Lakes drainage. Six of these are salmonids which spawn in tributaries; the other six exotic species spawn in tributaries and also in protected nearshore waters in some areas.

Information on nursery areas used by the 64 species treated in this volume is fragmentary, but as would be expected, it suggests that tributaries and nearshore waters are important as nursery areas, at least for the earliest life stages. Dispersal from spawning areas is rapid for some species which have small, pelagic larvae, whereas the juveniles of some salmonids that spawn in tributaries may remain in or near spawning areas in those tributaries for as many as three years before entering the lake and dispersing.

The information in this volume is presented in narrative form, by species. A map accompanies each species narrative when there was sufficient information to warrant graphic summarization. Each species narrative presents the available information systematically by statistical fishing district (Smith et al. 1961) beginning with district WM-1 and ending with district MM-8. Within each district the presentation proceeds systematically from one end of the district to the other, by shoreline segmen and adjacent littoral and offshore water areas. For each referenced location within a district, the narrative first presents the available information for spawning areas and then for nursery areas. Historical information is presented before the more current information.

SEA LAMPREY


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Green Bay
WM-4
MM-5
Traverse City
N
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
Ill.
Michigan
Chicago
Illinois
Ind.

The first reported capture of a sea lamprey in Lake Michigan occurred near Milwaukee in March 1936. In June 1936, a male apparently on a spawning run was captured at Elk Rapids, and later that year two immature adults were captured. The sea lamprey may have been established in the lake since about 1932 (Hubbs and Pope 1937).

Many Lake Michigan tributaries are ideal for reproduction; ammocoetes have been found in at least 112 of these tributaries (Dees 1980) and also in bays and in the lake off river mouths (Hansen and Hayne 1962; Morman 1979; Wagner and Stauffer 1962). Spawning runs usually peak in late May or early June (Fisherman 1947; Morman 1979). Spawning runs are rare or absent along the west shore of the lake south of Green Bay (Morman et al. 1980). Sea lamprey populations are also small in tributaries of southern Lake Michigan where pollution, unstable steam flow, substrate, and water temperature limit or prevent reproduction. Spawning runs are extensive in the northern part of the lake (Morman 1979).

The tributaries listed below are classified as spawning-streams based on the presence of ammocoetes, spawning adults, or both.

Wisconsin

The following streams have spawning runs (Applegate et al. 1952; FWS 1979b,c; GLFC 1973b; Torblaa and Westman 1980, unless otherwise noted).

WM-1

Menominee River (45°06', 87°35'), Little River (45°03', 87°38'), Peshtigo River (44°58', 87°39'), Oconto River (44°54', 87°50'), Pensaukee River (44°49', 87°54'), Little Suamico River (44°42', 87°59'), and Big Suamico River (44°38', 88°00').

WM-2

Ephraim River (45°09', 87°10').

WM-3

Hibbard Creek (44°59', 87°10'), Whitefish Bay Creek (44°55', 87°13'), Shivering Sands Creek (44°52', 87°14'), Lilly Bay Creek (44°51', 87°16'), and Bear Creek (44°42', 87°21').

WM-4

stony Creek (44°40', 87°23'), Ahnapee River (44°36', 87°26'), Three Mile Creek (44°34', 87°27'), Kewaunee River (44°28', 87°30'), and East Twin River (44°09', 87°34').

Manitowoc River (44°05', 87°39') (Norden, pers. comm. 1980).

Pine Creek (43°59', 87°42') and Fischer Creek (43°56', 87°43').

WM-5

Sheboygan River (43°45', 87°42').

Indiana

Spawning occurs in the following tributaries (FWS 1979b; GLFC 1975; Morman 1979; Torblaa and Westman 1980).

Burns Waterway (41°38', 87°10'), Donns Creek (41°40', 87°04'), Trail Creek (41°44', 86°54'), and State Creek (41°46', 86'49').

Michigan

The following tributaries have spawning runs (Applegate 1950; Bails et al. 1971; Braem and Rugen 1976; Erkkila et al. 1956; FWS 1979b,c; GLFC 1973b, 1975; Morman 1979; North Woods Call 1979g; Price and Kelly 1976; smith 1971; Smith and Braem 1976; Smith and McLain 1962; Stauffer 1961; Torblaa and Westman 1980; Wagner and Stauffer 1962).

M-1

springer Creek (45°11', 87°34'), Beattie Creek (45°14', 87°31'), Bailey Creek (45°15', 87°29'), Johnson Creek (45°16', 87°28'), Rochereau Creek (45°18', 87°26'), Arthur Bay Creek (45°79', 87°26'), Sugar Creek (45°22', 87°23'), Cedar River (45°24', 87°21'), Bark River (45°34', 87°14'), Sunny Brook (45°40', 87°10'), Ford River (45°40', 87°80'), Portage Creek (45°42', 87°06'), Days River (45°54', 86°59'), Tacoosh River (45°55', 86°58'), Rapid River (45°55', 86°58'), Whitefish River (45°55', 86°57'), Black George (Hock) Creek (45°53', 86°57'), Squaw Creek (45°48', 86°59'), Ogontz River (45°52', 86°46'), Sturgeon River (45°50', 86°40'), Fishdam River (45°54', 86°35'), Little Fishdam River (45°54', 86°34'), and valentine Creek (45°50', 86°32').

MM-2

Poodle Pete Creek (45°47', 86°26'), Parent Creek (45°48', 86°25'), Bursaw Creek (45°50', 86°20'), Deadhorse and Snyder Creeks (45°52*, 86°20'), Johnson Creek (45°53', 86°20'), Thompson Creek (45°54', 86°19'), Southtown Creek (45°56', 86°16'), Manistique River (45°57', 86°15'), Marblehead Creek (45°58', 86°07'), and Gulliver Lake Outlet (45°58', 86°03).

MM-3

Bulldog Creek (45°57*, 85°55'), Milakokia River (45°58', 85°54'), Swan Creek (45°59', 85°49*), Hudson Creek (45°58', 85°42'), Point Patterson Creek (45°58', 85°39'), Catarac River (45°59', 85°39'), Crow

River (46°02', 85°36'), Rock River (46°05', 85°32'), Mille Coquins River (46°06', 85°29'), Mile Creek (46°06', 85°26'), Black River (46°06', 80°21'), Sucker Creek (46°05', 85°19'), Hog Island Creek (46°04', 85°17'), Davenport Creek (46°04', 85°16'), Paquin Creek (46°04', 85°13'), Brevoort River (45°57', 84°56'), Carp Lake River (45°45', 84°50'), Big Stone Creek (45°45', 84°54'), Big Sucker Creek (45°44', 84°56'), Wycamp creek (45°39', 85°01), Bear River (45°23', 84°58'), Boyne River (45°13', 85°01'), Porter Creek (45°13', 85°04'), Jordan River (45°09', 85°08'), Horton creek (45°17', 85°05'), Monroe Creek (45°11', 85°10'), Loeb Creek (45°17', 85°14'), and McGeach Creek (45°18', 85°19').

MM-4

Antrim Creek (45°10', 85°23'), Elk River (44°54', 85°25'), Yuba Creek (44°49', 85°28'), Acme Creek (44°46', 85°30'), Mitchell Creek (44°45', 85°34'), and Boardman River (44°46', 85°37).

MM-5

Shalda Creek (44°57', 85°53'), Crystal River (44°55', 85°58'), Platte River (44°44', 86°09'), Betsie River (44°37', 86°13'), and Bar (Bowens) Creek (44°29', 86°14').

MM-6

Big (44°15', 86°18') and Little (44°13', 86°16') Manistee Rivers, Gurney Creek (44°08', 86°25'), Big sable River (44°02', 86°30'), Lincoln River (43°59', 86°28'), Pere Marquette River (43°56', 86°26'), Bass Lake Outlet (43°50', 86°26'), and Pentwater River (43°46', 86°24').

MM-7

Stony Creek (43°34', 86°30'), Flower Creek (43°28', 86°28')' White River (43°25', 86°21'), Duck Creek (43°21', 86°25'), Big Bear Creek (43°15', 86°18'), Muskegon River (43°15', 86°15'), Black Creek (43°08', 86°17'), Grand River (43°03, 86°15'), Pigeon River (42°54', 86°12'). and Pine Creek (42°48', 86°09').

MM-8

Gibson Creek (42°43', 86°13'), Kalamazoo River (42°40', 86°13'), Allegan 3 Creek (42°36', 86°13'), Allegan 4 Creek (42°35', 86°13'), Allegan 5 Creek (42°34', 86°14'), Black River (42°24', 86°17'), Brandywine Creek (42°19', 86°19'), Rogers Creek (42°15', 86°21'), St. Joseph River (42°07', 86°29'), and Paw Paw Rivers (42°07, 86°28'), and Galien River (41°48', 86°45').

LAKE STURGEON

Historically, lake sturgeon spawned in many tributaries of Lake Michigan. Populations were reduced by the degradation of spawning grounds in these rivers and near river mouths (Wells and McLain 1973). In Green Bay (45°05', 87°25'), spawning runs generally occur in April and May immediately after the walleye runs (Copes, pers. comm. 1979). For many years, most streams in Green Bay were too polluted to support runs (Bertrand et al. 1976).

Wisconsin

WM-1

Menominee River (45°06', 87°35'). This river, which forms the boundary between Wisconsin and Michigan, supported large sturgeon spawning runs prior to the 1900s (Belonger, pers. comm. 1979; Binkowski, pers. comm. 1979) and now may be a potential spawning site (Kernen, pers. comm. 1979). Lake sturgeon now migrate up the Menominee River (Copes, pers. comm. 1979).

Peshtigo (44°58', 87°39') and Oconto (44°54', 87°50') Rivers. These are potential spawning grounds (Kernen, pers. comm. 1979). The removal of dams on the rivers would increase access to prime spawning grounds (GLFC 1979b).

Long Tail Point (44°35', 87°59')--Grassy Island (44°33', 87°59'). A commercial fisherman reported that this is a spawning area for lake sturgeon (Coberly and Horrall 1980b).

Fox River (44°32', 88°00'). This is an historical spawning ground (Copes, pers. comm. 1979; Kernen, pers. comm. 1979). Lake sturgeon are presently found in the river (Kernen, pers. comm. 1979), and spawning occurs there (Copes, pers. comm. 1979).

Illinois

In southern Lake Michigan, lake sturgeon congregated at river mouths and near shore in June to spawn (Kirsch and Fordice 1889; Milner 1874a).

south Chicago (41°46', 87°33'--41°41', 87°29'). Lake spawning historically occurred here (Harkness and Dymond 1961). In 1871, many spent fish and one gravid individual were taken at the mouth of the Calumet River (41°44', 87°32') in a single seine haul on July 1 (Milner 1874a).

MM-3

Fox Island (probably South Fox Island, 45°25', 85°51'). In 1890, ripe male and female lake sturgeon were collected at Fox Island between May 26 and June 14 (Leach and Borodin 1920).

MM-4

Grand Traverse Bay (45°05', 85°30'). Spawning runs formerly entered many of the spring-fed streams and rivers in this area; dams built in the mid-1800s at Elk Rapids (44°54', 85°25') and on Kid's Creek (44°46', 85°38') blocked spawning runs on those streams (Price and Kelly 1976).

MM-6

Ludington (43°57', 86°28'). Spawning was observed at Point Sable (probably Big Sable Point, 44°03, 86°31') (Harkness and Dymond 1961). Lake sturgeon spawned in the lake proper on clay banks approximately 8 mi N of Pentwater (43°47', 86°26') (MSBFC 1890).

MM-8

Saugatuck (42°40', 86°12'). Lake spawning occurred here (Harkness and Dymond 1961). The Kalamazoo River (42°40', 86°13') upstream to the first dam was a favorite spawning ground (Milner 1874a).

Ganges (42°35', 86°13'). Since 1934, spawning has occurred along 2 mi of shoreline (42°36', 86°14'--42°34', 86°14') here; in 1978, spawning occurred over gravel bottom in June (Organ et al. 1978).

South Haven (42°24', 86°17'). In the late 1800s, lake sturgeon "favored" the area near here, and the spawning grounds were believed to be not far away (Smith and Snell 1891).

St. Joseph (42°07', 86°29') and Galien (41°48', 86°45') rivers. Lake sturgeon spawned in these rivers, but it is not known if these were lake-run fish (Organ et al. 1978). Historically the St. Joseph River was a favorite spawning ground (MSBFC 1893).

New Buffalo (41°48*, 86°45'). Since 1934, lake sturgeon have spawned in an area (41°49', 86°43'), approximately 1-2 mi N of New Buffalo over a sandy bottom with some rock, at water depths of 6 ft or less (Organ et al. 1978).

Pier Cove (location unknown). In 1871, schools of sturgeon, presumably seeking a river in which to spawn, were present in shallow water here on June 11 (Milner 1874a).

BOWFIN

Bowfins are residents of the protected bays, river mouths, and marshes of Lake Michigan and also spawn in these areas. Green Bay (45°05', 87°25') is a major spawning area for bowfins. The following locations in Lake Michigan support self-sustaining populations and are probably both spawning and nursery areas.

Wisconsin

WM-1

Menominee River (45°06', 87°35'). The mouth of the river is a spawning area (Belonger, pers. comm. 1979).

Peshtigo River (44°58', 87°39') and Oconto River (44°54', 87°50'). The lower areas of both rivers are probably spawning and nursery areas (Belonger, pers. comm. 1979).

Little Sturgeon Bay (44°50', 87°33') (Kernen, pers. comm. 1979).

Sturgeon Bay (44°53', 87°24')--Sawyer Harbor (44°53', 87°26') (Kernen 1972, pers. comm. 1979).

WM-3

Rowley Bay (45°13', 87°01')--Mink River (45°14', 87°02'). Spawning has been observed in the marshy portions of the Mink River estuary (Kernen, pers. comm. 1979).

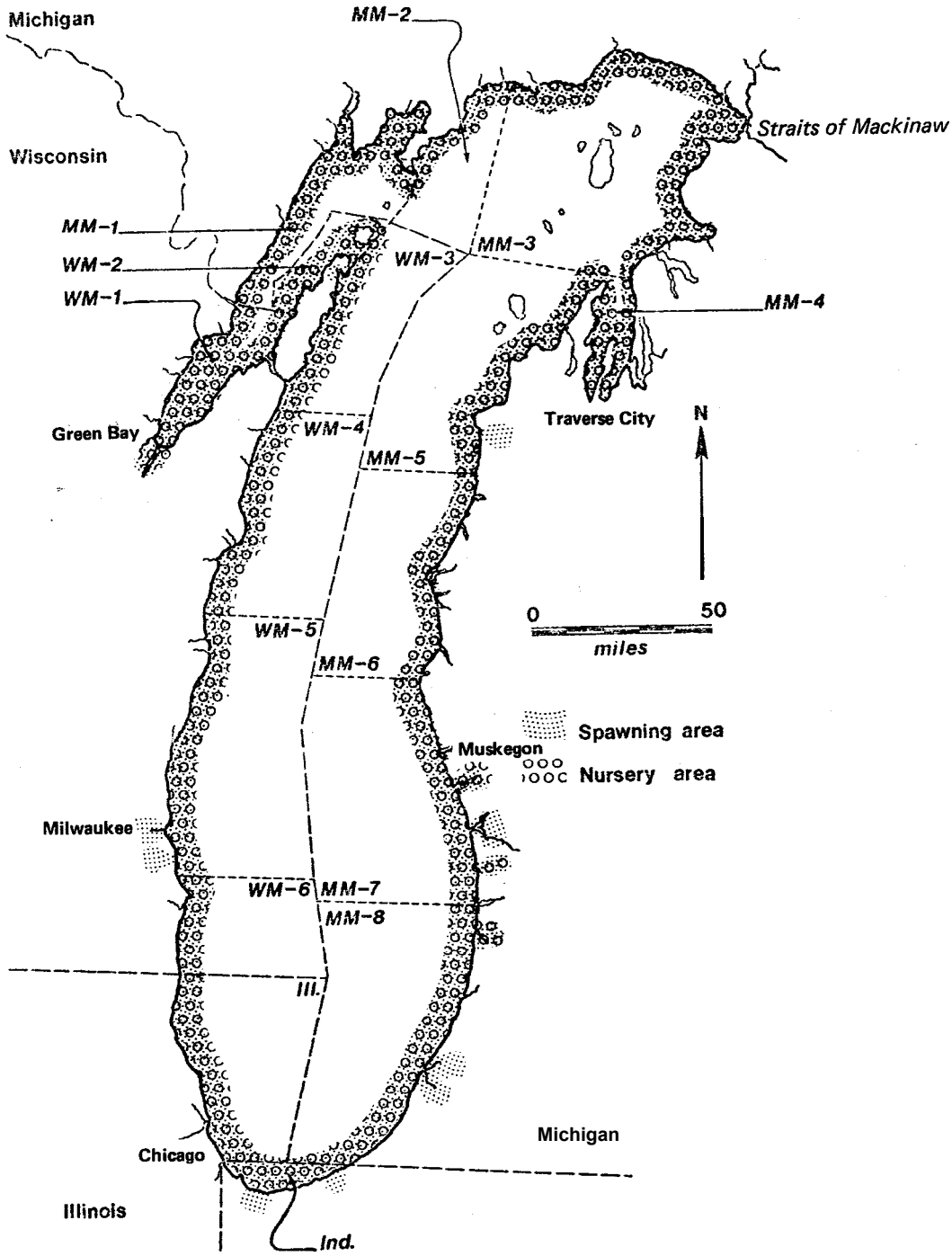
Michigan

MM-6

Pere Marquette River (43°56', 86°26')--Pentwater River (43°46', 86°24'). Self-sustaining populations are believed to exist in the lower reaches of these rivers (Brazo, pers. comm. 1979), and spawning probably occurs here. A few ripe adults were collected in June at the Ludington Pumped Storage Plant (43°54', 86°27'), but these were believed to be strays moving between the river mouths (Brazo, pers. comm. 1979).

MM-7

Port Sheldon (42°54', 86°13'). Bowfin larvae, about 0.2-1.0 in. long, were collected in Pigeon Lake (42°54', 86°12') in early June, indicating that spawning probably took place there during May. The collection of a spent female in July and a ripe male in October suggests that spawning may occur over an extended period (Jude et al. 1979a).


Michigan
Wisconsin
MM-2
Straits of Mackinaw
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Green Bay
WM-4
MM-5
Traverse City
N
0
50
miles
WM-5
MM-6
Spawning area
Nursery area
Muskegon
Milwaukee
WM-6
MM-7
MM-8
Ill.
Chicago
Michigan
Illinois
Ind.

The alewife presumably entered Lake Michigan from Lake Huron. The first recorded capture of an alewife in Lake Michigan occurred near South Manitou Island, Michigan, on May 5, 1949 (Miller 1957). Schools of young-of-the-year (YOY) found in southern Green Bay in 1953 presented the first indication of successful spawning; the first substantial spawning run occurred in Green Bay in 1956 (Joeris and Karvelis 1962; Miller 1957).

Alewives migrate in large schools from deeper water to inshore areas beginning about the second week in April. The migration begins earlier in the southern portion of the lake than in the northern portion and earlier along the west shore than along the east shore. Spawning has been reported from mid-May into August (Brown 1972; Buss and Warner 1972; Hlavek and Norden 1978; Organ et al. 1978; Reigle 1969a, 1969c; Wagner 1972; Walburg 1973), with a peak in July (Hlavek and Norden 1978; Walburg 1973).

Alewives may spawn along the entire shoreline of Lake Michigan (Brown, pers. comm. 1979; Moore, pers. comm. 1979; Wells 1979). They spawn inshore, mainly in stream mouths and protected areas, including harbors and bays, and tend to concentrate near breakwalls (Brown 1972, pers. comm. 1979; Buss and Warner 1972; USBCF 1965; USDI 1966; Walburg 1973). Alewives also enter tributaries, especially in the southern part of the lake (Edsall 1964, Moffett 1966a), and spawning can occur far upstream in rivers not blocked by dams (Brown, pers. comm. 1979).

Alewives spawn in the northwest portion of Lake Michigan from late spring to late July in 6-20 ft of water over sand and rock (Organ et al. 1978). Spawning is common in tributary streams and in nearshore sheltered areas of Green Bay; when the water is warm enough, spawning occasionally occurs along unprotected shoreline (CDM/Limnetics 1976c; GLFL 1970; Walburg 1973). Most, if not all, of the inshore waters of Green Bay are potential spawning areas (Brown, pers. comm. 1979; Moore, pers. comm. 1979; Wells, pers. comm. 1979). Spawning begins in June or early July and continues through early August based on seasonal trends in the commercial catch. Alewives reach peak abundance in Green Bay during early-mid July (Bertrand et al. 1976; Brown, pers. comm. 1979; GLFC 1976; Joeris and Karvelis 1962; Reigle 1969b). After spawning, adults leave Green Bay (Joeris and Karvelis 1962); many that have apparently returned to the lake are often found off Sturgeon Bay (44°53', 87°24') at depths of 60-420 ft (Brown, pers. comm. 1980). Spawning also occurs everywhere along the shoreline in the northeastern portion of the lake in 15-30 ft of water, wherever there is sand (Organ et al. 1978). Alewives spawn successfully along the entire shoreline in the southern two-thirds of the lake (CDM/Limnetics 1976c). Generally, most sources agree that spawning takes place along the entire shoreline of the lake over sand, rock, and gravel in waters 2-30 ft deep at water temperatures of 55-70°F (Moffett 1966a; Organ et al. 1978; Reigle 1969c).

The entire nearshore area inside the 30 ft depth contour along the east shore of Lake Michigan is heavily used as a nursery ground, at least as far north as Frankfort (44°38', 86°14'). Alewife nursery areas are

much less abundant on the western shore. The abundance of adults on-the western shoreline suggests that heavy spawning occurs there, but fry may be swept away from shore during upwellings. In Green Bay, YOY are first collected in trawls in early August, and they remain in Green Bay at least until the ice forms (Joeris and Karvelis 1962). In general, nursery grounds include all nearshore areas of the lake for early stages and all pelagic waters for later YOY stages (Wells 1973, pers. comm. 1979).

Alewife larvae tend to concentrate in the upper 6-10 ft of the water column but occur as deep as 30 ft (Wells 1974). In late August 1965, YOY were observed in the epilimnion of southern Lake Michigan at temperatures of about 68°F (Wells 1980). Eggs and young have been known to thrive in warm bays and rivers, even those that are heavily contaminated with wastes (Smith 1968). Roth YOY and adults move to deeper water in fall (Brown 1972; USDI 1966; Walburg 1973).

Wisconsin

WM-1

Marinette (45°05', 87°36') Oconto (44°53', 87°52'), and Suamico (44°38', 88°03). In 1978, YOY were found here in late August and September (Belonger 1979).

Duck Creek (44°34', 88°02'). Schools of YOY found in carp-holding ponds near here in October 1953 were the first evidence of spawning success in Lake Michigan (Joeris and Karvelis 1962; Miller 1957).

Fox River (44°32', 88°00). In 1975-76, impingement of adults at the Pulliam Power Plant (44°32', 88°00') peaked in June as adults migrated inshore. Eggs were found in the river and in the bay off the plant during June to August. Larvae were first collected July 2 in the river and July 30 in Green Bay (NALCO, undated a).

WM-2

Gills Rock (45°17', 87°02'). Alewives spawn over sand, rubble, or large boulders in water 2-30 ft deep (Joeris and Karvelis 1962).

WM-3

Door Peninsula (45°05', 87°10'). Spawning occurs primarily in June in the waters along the northern portion of the peninsula. Alewives spawn in all the bays at the northern tip of the peninsula, including North Bay (45°09', 87°04'), Moonlight Bay (45°05', 87°05'), Baileys Harbor (45°03', 87°07'), Rowley Bay (45°13', 87°01'), and in the marshy areas of the Mink River estuary (45'14', 87°02') (Frederick, pers. comm. 1979).

Sturgeon Bay Ship Canal (44°48', 87°19'). Alewives probably move up the Ship Canal to spawn in June and July. During the 1960s and early 1970s, large concentrations of adults were observed in the lake proper off the mouth of the canal in late May (Brown, pers. comm. 1979).

WM-4

Kewaunee Power Plant (44°21', 87°32'). Alewives spawn along much of the beach near the plant (USAEC 1972e). The substrate at the intake area and 1 mi N of the plant is rock and rubble over sand or clay (Ind. Bio-Test 1972). Alewives in spawning condition have been collected in large numbers during June and July at the intake and north and south of the intake at the 10 and 20 ft depth contours when the water temperature was about 49-50°F (LaJeone 1976). Adults moved inshore in spring, and the maximum impingement of adults occurred in June. After spawning, adults gradually disperse to deep water in late summer and early fall (NALCO, undated b). Eggs were entrained at the plant from late June to mid-August with peak entrainment in mid-July; alewife eggs were about 70% of the total number of eggs entrained (NALCO, undated a). Alewife eggs were also collected at all sampling stations located within 1/2 mi N and 2 mi S of the plant at the 10 and 20 ft depth contours; the largest number of eggs were collected near the plant water intake (LaJeone 1976). Larvae about 0.3-0.8 in. long have been entrained in mid-July and August (NALCO, undated a). In September 1975, many YOY were collected with minnow seines 2 mi S of the plant offshore of Two Creeks (44°18', 87°33') (LaJeone 1976).

Point Beach Power Plant (44°17', 87°32'). Alewife eggs and larvae are more abundant here than those of most other species (Wis. Elec. Power, undated). Alewives migrate inshore to spawn during April, May, and June (Limnetics 1974; Prepejchal, Romberg, and Spigarelli 1974; Wis. Elec. Power 1975a; Wis. Elec. Power and Wis.-Mich. Power, undated a,c). During June, hundreds of thousands of alewives move into the intake and discharge areas of the plant; by the end of July few remain in the area (Limnetics 1974; Reed 1972; Romberg and Spigarelli 1973; Wis. Elec. Power, undated). Ripe adults are impinged from June through mid-August (Wis. Elec. Power 1976c). Alewife eggs are present in the vicinity of the power plant during March to August. Eggs are collected in the discharge and intake areas as early as June 3, and peak abundance occurred in July when the water temperature reached 45-48°F (Limnetics 1974; Wis. Elec. Power 1975a, 1976c; Wis. Elec. Power and Wis.-Mich. Power, undated a,b,c). Fry were collected in several areas surrounding the power plant during August through October over hard clay, scattered rock, silt, and shifting sand (Limnetics 1974; Wis. Elec. Power 1975a). Young-of-the-year were collected in shore seines, and schools were observed moving into the discharge area in September and October (Romberg and Spigarelli 1973; Wis. Elec. Power, undated). Fry migrated from the nearshore zone by October (Wis. Elec. Power and Wis.-Mich. Power, undated b).

East Twin River (44°09', 87°34'). Alewives are abundant in the lower river during the spawning season (Weber, Desparte, and Threinen 1968).

Manitowoc (44°05', 87°39'). Alewife eggs were collected at the Manitowoc Generating Plant (44°05', 87°39') from mid-June to early September. The majority of entrained eggs were taken in July. No larvae were collected in the area, but juveniles were observed swarming near shore in late summer (CDM/Limnetics 1976a).

WM-5

Haven (43°51′, 87°44′). In 1973-74, ripe adults were collected in the area from May through September (Ind. Bio-Test 1977; Wis. Elec. Power et al. 1979b). Based on observations made in July and August, adults appeared to be spawning; by September, many adults were spent (Ind. Bio-Test 1977; Wis. Elec. Power et al. 1979b). Spawning occurs near shore over hard clay, cobble-size rock, and scattered boulders (LaJeone, pers. comm. 1979). Eggs were collected from early July through August when water temperatures were about 46-55°F (Ind. Bio-Test 1977; Wis. Elec. Power et al. 1979a). Eggs were collected at the surface, the 15 ft depth stratum, and on the bottom at the 20 ft contour' throughout an area that extended 2 mi N and 2 mi S of the plant (Ind. Bio-Test 1977); the greatest number of eggs were collected nearshore at the 10 ft depth contour (Wis. Elec. Power et al. 1979a, 1979b). Alewife larvae were collected during July to September (Wis. Elec. Power et al. 1979a,b).

sheboygan (43°45', 87°42'). Alewives spawned successfully in the vicinity of the Edgewater Power Plant 143°43', 87°42'). In 1975-78, ripe or ripening fish were impinged at the plant during June and July; peak impingement occurred in mid-June. Eggs were collected in the lake and entrained from June to Auqust; the first eggs were taken when the water temperature reached about 44°F. Larvae were found beginning in late August (Swanson Environ. 1976, 1979).

Port Washington (43°23', 87°52'). In 1975, adults were impinged at the Port Washington Power Plant (43°23', 87°52'), from early March to June; almost 60% of the total impingement occurred between late May and early June. Eggs and larvae were entrained at the plant during July to Auqust and July to September respectively (Wis. Elec. Power 1976e).

Milwaukee (43°02', 87°54'). Alewives migrate into shallow waters in the Milwaukee area during late April and early May and begin to leave at the end of August after spawning (Binkowski, pers. comm. 1979; Janssen, pers. comm. 1979; Limnetics 1974; Norden 1967a; Shaefer 1975; Wis. Elec. Power 1975b). In 1979, adults were observed near shore in May, ripe adults were collected in July, and spawning occurred from mid-July to mid-August. Spawning usually occurs in the area from June 1 through August. Alewives spawn over a period of 4-6 weeks, when temperatures are about 59-64°F (Binkowski, pers. comm. 1979). Alewives spawn in large numbers in the Milwaukee Harbor area (Binkowski, pers. comm. 1979; Janssen, pers. comm. 1979; Norden, pers. comm. 1979). Gravid females, newly fertilized eggs, and newly hatched larvae were collected in the harbor in late July and August when water temperatures were about 63-70°F (Hlavek and Norden 1978; Norden, pers. comm. 1979). In 1965, spawning peaked during the first 2 weeks of July. The collection of larvae

indicated that spawning may have occurred from late June to August in 1965 and from late June to October in 1966 and 1967 (Norden 1967a, 1968). Heavy concentrations of spawning alewives were observed along the breakwalls at the Inner Harbor (43°01', 87°53'), the Milwaukee Yacht Club (43°03', 87°53'), and at McKinley Beach (43°03', 87°53') (Binkowski, pers. comm. 1979). In 1965, eggs were found in the harbor area consistently from the end of July to the end of August (Norden 1967a). Eggs and larvae were collected along the edge of the seawall and at the surface as far as 1 mi offshore. Most larvae more than 0.8 in. long were seined about 1 mi N of the harbor at the water purification plant (43°04', 87°52') (Norden 1967b).

Runs enter the Milwaukee River (43°02', 87°54') from late May to early August (Binkowski, pers. comm. 1979; Poff and Threinen 1964; Wis. Elec. Power 1976b). Ripe alewives were impinged at the Commerce Street Power Plant (43°02', 87°54') from early June to early August, and eggs were collected in the area in June (Wis. Elec. Power 1976b). Ripe adults were found in the area and were impinged at the Lakeside Power Plant (42°58', 87°51') from late May to mid-August; peak abundance occurred in late June. Eggs were entrained during July (Limnetics 1974; Wis. Elec. Power 1976a).

Young-of-the-year may be distributed all along the shore in the Milwaukee area; they were found in large numbers at the South Shore Yacht Club boat launch (43°00', 87°53') (Binkowski, pers. comm. 1979). In the Milwaukee Harbor area, newly hatched larvae were collected at the end of July and August when water temperatures were about 64-70°F; YOY were taken as late as October, if the water temperature remained high enough (Norden, pers. comm. 1979; Norden 1967a). Young-of-the-year were found off the Lakeside Power Plant, often in less than 18 ft of water, from July to October (Limnetics 1974; Wis. Elec. Power 1975c). In 1968, YOY alewives were collected in shore seines to depths of 3-4 ft in September and October (Brown and Norden 1970). In late June, fry were common in the nearshore zone from Waukegan (42°22', 87°50') to Milwaukee, but were scarce north of Milwaukee (Harris and Eschmeyer 1975). Young-of-the-year alewives stayed inshore in the beach zone, and concentrated around jetties and breakwaters, except when upwellings lowered the inshore temperatures; then they were often found offshore in the epilimnion at depths of 30-100 ft (Binkowski, pers. comm. 1979). Young-of-the-year were common at the surface, when temperatures were greater than about 70°F (Harris and Eschmeyer). Young-of-the-year alewives were collected at Bradford Beach (43°04', 87°52'), McKinley Beach, McKinley Beach jetties, and the South Shore Yacht Club marina. Temperatures at the South Shore Yacht Club when YOY were collected were about 59-72°F; the site has a sand and gravel bottom with submergent vascular plants (Binkowski, pers. comm. 1979).

Oak Creek (42°54', 87°51'). Alewives enter Oak Creek in the spring (Binkowski, pers. comm. 1979; Janssen, pers. comm. 1979). The intake channel of the Oak Creek Power Plant (42°51', 87°50'), which has a substrate of sand and coarse detritus, is a favorable spawning area. In 1972-76, inshore movement began in March, and adults were impinged from April to July. Eggs were collected in June and July, and larvae and YOY

were taken from July to September (Limnetics 1974; Wis. Elec. Power 1975b, 1976d).

WM-6

Racine County (42°49', 87°49'--42°40', 87°48'). Many alewives enter shallow water and streams to spawn (Poff and Threinen 1961a).

Illinois

Alewives spawn along the entire Illinois shoreline (42°29', 87°48'--41°43', 87°32′) out to a depth of 50 ft, from mid-May to mid-July (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). This entire area appears to be a spawning and nursery ground (Commonw. Edison 1976; Ind. Bio-Test 1975b; Raney 1972). Adults in spawning condition moved inshore from March to June when the water temperature reached about 43-50°F. Maximum impingement of adults at the Zion (42°27', 87°48') and Waukegan (42°23′, 87°49') generating stations occurred in May and June (CMD/Limnetics 1977; Cima 1977; Cima et al. 1976; Cochran undated, 1975, 1976; Cochran and Kitchel 1976; Johnson and Muench undated; Kitchel and Otto 1974, 1976; Orpet and Cochran 1976; Otto 1975; Prepejchal, Romberg, and Spigarelli 1974). Spawning begins in June, peaks in July when the water temperature reaches about 56-64°F, and continues through the end of August (Cima 1977; Cima et al. 1976; Cochran undated; Cochran and Cima 1974; Ind. Rio-Test 1975a,b; Otto 1975). Eggs were entrained from May to August at the stations. Egg densities increase rapidly in late June and peak in July. Eggs have been collected throughout the entire area; most eggs were collected at depths of 40 ft or less, but some were found at depths as great as 60 ft. (CDM/Limnetics 1977; Cima 1977; Cima et al. 1976; Cochran undated; Cochran and Cima 1974; Ind. Bio-Test 1975b; Muench, pers. comm. 1979; Otto 1975). Spawning was observed in Waukegan Harbor (42°22', 87°49') (Brown, pers. comm. 1979) and in the intake bay of the Waukegan Generating Station (Otto 1975). Larvae were entrained at the Zion and Waukegan generating stations and were abundant throughout the area during June to October (Cochran and Cima 1974). Larvae were collected in water 10 to 60 ft deep, but most were taken at depths of 30 ft or less (CDM/Limnetics 1977; Cima and Cochran undated; Cima et al. 1976; Cochran undated; Ind. Bio-Test 1975b; Otto 1975). Generally, larvae were collected from June to August; peak abundance occurred in July (Cima et al. 1976; Cochran and Cima 1974, Otto 1975). Many YOY were seined from the intake pond and discharge canal of the Waukegan Generating Station (Otto et al. 1976).

Chicago (41°53', 87°37'). In 1966, adults were collected from May 26 to June 13 during the spawning run (Brown 1968). Spawning was observed along shore from Evanston (42°03, 87°40') to Chicago during mid- to late July and sometimes into August. Fry remained in the area about 2 weeks (Janssen, pers. comm. 1979).

Indiana

Alewives spawn all along the Indiana shoreline (41°43', 87°32'--41°46', 86°49'), including harbor areas, to water depths of about 35 ft (Koch, pers. comm. 1979; McComish, pers. comm. 1979). The spawninq migration beqins in March and April (CDM/Limnetics 1977; Koch, pers. comm. 1979; Krueger 1976; McComish, pers. comm. 1979; Morgan 1978a; NALCO 1976a,c; Tex. Instrum. 1975b). Eggs were collected from May through July; egg densities were highest in nearshore waters, usually at depths of about 30 ft or less (McComish, pers. comm. 1979). Spawning is usually completed by July; adults begin moving offshore in late July and August (Morgan 1978a; Koch, pers. comm. 1979; McComish, pers. comm. 1979). Young-of-the-year were collected all along the Indiana shoreline, usually out to a depth of about 33 ft, from July to September. Young-of-the-year were concentrated nearshore in July and August, and the entire shore zone is a nursery area (McComish, pers. comm. 1979). When the water cools in September, YOY move offshore (Koch, pers. comm. 1979; McComish, pers. comm. 1979).

Hammond (41°40', 87°30'). Alewives are believed to spawn successfully near the Stateline Generating Station (41°42', 87°31'). In 1975-76, alewife eggs and larvae were 99% and 90% respectively of the total number of fish and larvae entrained at the plant and collected in the area from May to August. eggs were generally most abundant inshore in late June, and larvae were most abundant in late June and early July (NALCO 1976c).

Gary (41°37', 87°20'). Adults move inshore and enter streams in the area in April. At the Mitchell Power Station (41°37', 87°22'), most adults were collected and impinged in May and June. Eggs were entrained at the plant from May to August and larvae from May to September. Spawning may have occurred in the intake and discharge canals of the plant (CDM/Limnetics 1977, Krueger 1976, NALCO 1976a).

Bailly Generating Station (41°39', 87°07'). Spawning occurs in the area from May to mid-August, and reaches a peak during June and July, when most adults are found in the area and impingement at the plant is highest. Spawning was observed in late May and early June in the discharge canal. Eggs were collected throughout the area from May to September, and the highest densities occurred near the plant discharge. Prolarvae and postlarvae were present from May to October (Tex. Instrum. 1975b, 1976a,c, 1977b,c, 1979a).

Michigan City (41°43', 86°54'). Adults are most abundant in the area during April to June, during the spawning period. The inshore movement begins in March; adults move offshore in July (Morgan 1978a). Spawning was observed in the discharge canal of the Michigan City Generating Station (41°43', 86°54') (Morgan 1978a,b), in Michigan City Harbor, and at the mouth of Trail Creek (41°44', 86°54') (Brown, pers. comm. 1979). The area from Michigan City east to the Michigan state line (41°46', 86°49')

is an important nursery area; the densities of YOY are higher here than farther west (McComish, pers. comm. 1979).

Michigan

MM-1

Little Bay de Noc (45°45', 87°00'). Adults enter the bay by the end of May and are abundant in late spring and summer (FWS 1979d; Wagner 1971, 1973; Wagner and Stauffer 1969). Spawning has occurred since the 1950s from Gladstone (45°51', 87°00') south along the shore for 2-3 mi over a rocky substrate to a depth of about 6 ft (Organ et al. 1978). Spawning has also been observed at Escanaba (45°45', 87°04') in a slightly protected area near shore, over mud, sand, and organic debris in water 2-4 ft deep (Joeris and Karvelis 1962). Hatching probably occurs in the bay from early June through late July. Alewife larvae have been observed in dense schools on the surface of the bay. Prolarvae and postlarvae have been taken from mid-June through September with a peak in mid-August. Larvae were distributed throughout the surface waters of the bay in July and August, but greater numbers were collected at stations nearest shore (Wagner 1971, 1973; Wagner and Stauffer 1969). Young-of-the-year, 0.2-2.8 in. long, are abundant from July through September (Peck 1974, Wagner 1972).

Ford River (45°40', 87°08')--Bark River (45°34', 87°14'). In 1978-79, alewife eggs were collected from mid-June to mid-August along shore at the 5 and 10 ft depth contours. Larvae were collected with shore seines and trawls from June to October (Wis. Elec. Power, unpubl. data).

Arthur Bay (45°19', 87°26'). Since 1963, alewives have spawned over rock in 6-18 ft of water and over sand and rock to depths of 36 ft. The spawning area (45°20', 87°24'--45°17', 87°27') extends about 2 mi N and S of the town of Arthur Bay (Organ et al. 1978).

MM-2

Manistique (45°57', 86°15'). In 1978, adults in spawning condition were observed at the mouth of Manistique Harbor near the surface in mid- to late June (Owens, pers. comm. 1981). From 1973-80, YOY were collected off Manistique in September to November (FWS, unpubl. data).

MM-3

Brevort (46°01', 85°02'). From 1966-76, spawning was observed in an area (46°01', 85°02') over sand to depths of about 18 ft (Organ et al. 1978).

Big Rock Point (45°22', 85°12'). In 1974-75, two larvae were collected at the Big Rock Power Plant (45°22', 85°12') in late August (Consumers Power 1976e).

MM-5

Frankfort (44°38', 86°14'). Spawning was observed in Betsie Lake (44°38', 86°14') (Brown, pers. comm. 1979).

MM-6

Ludington (43°57', 86°28'). Adults are abundant during the summer in Pere Marquette Lake (43°56', 86°16') (FWS 1979d). The shore area near the Ludington Pumped Storage Plant (43°54', 86°27'), primarily at depths of 15 ft or less, is a spawning and nursery area for alewives. Onshore migration begins in late May or early June, and ripe adults are taken in late June. Ripe and spent fish were collected through August (Brazo, pers. comm. 1979; Liston and Tack 1973). The bottom in this area is composed of sand, gravel, and clay outcroppings with some large rocks (Brazo, pers. comm. 1979). Larvae are collected near the plant from late June to early fall (Brazo, pers. comm. 1979; Liston and Tack 1973; Liston et al. 1978). Swarms of newly hatched larvae were observed at the intake in early August (Liston and Tack 1973). Many YOY are collected at all depths out to 30 ft (Brazo, pers. comm. 1979).

MM-7

Muskegon (43°13', 86°17'). During the 1960s, spawning occurred in an area (43°12', 86°20') 1 mi S of the mouth of Muskegon Lake, from shore out to a depth of about 20 ft over a sandy substrate (Organ et al. 1978). Most adults were impinged at the Cobb Power Plant (43°15', 86°15') on Muskegon Lake during mid-July, and eggs (possibly released by impinged, ripe fish) were entrained in late May and early June. Clupeid larvae were first entrained in mid-July and were 88% of the total larvae entrained (Consumers Power 1976f).

Grand River (43°03, 86°15'). Spawning was observed at the river mouth (Brown, pers. comm. 1979). Young-of-the-year were found off Grand Haven in September (Brandt 1978).

Port Sheldon (42°54', 86°13'). A massive inshore migration to the beach zone occurs; the migration may begin in April, but the main movement occurs in May and June (Jude et al. 1978, 1979a; Heufelder and Klinger, pers. comm. 1979). The number of adult alewives impinged at the Campbell Power Plant (42°55', 86°12') increased dramatically in June and remained high in July; the greatest numbers of adults were also present in the area in late June and early July (Consumers Power 1976b; Jude 1978; Jude et al. 1978). Spawning begins by the first week of June (Jude et al. 1978). Spawning was observed in Pigeon Lake (42°54', 86°12'), in the power plant discharge and intake canals, and almost everywhere along the Lake Michigan shore (Heufelder and Klinger pers. comm. 1979; Jude 1978; Jude et al. 1979a). Spawning is completed by August or September. Adults move out of Pigeon Lake by August and leave the nearshore zone by October (Heufelder and Klinger, pers. comm. 1979; Jude et al. 1978, 1979a). There is extensive egg deposition in the nearshore zone (Jude et al. 1979a). In 197'7, densities as high as 512,000 eggs per 1,000m^3 of water were found at

beach stations through late July (Jude et al. 1978). In 1974, eggs were entrained from Pigeon Lake during late May to late June (Consumers Power 1976b). Larvae were first collected in early June when water temperatures reached about 55°F, and peak abundance was reached in early July (Consumers Power 1977, Heufelder and Klinger, pers. comm. 1979; Jude 1978; Jude et al. 1978, 1979a). In 1977, densities as high as 9,000 larvae per 1,000m^3 were found at beach stations (Jude et al. 1978). Many were also found in August, and larvae were collected and entrained until October (Consumers Power 1977; Jude et al. 1978, 1979a; Wapora 1979a). The entrainment of larvae 0.2-0.3 in. long in early May suggests that spawning occurs in late April in Pigeon Lake. The larvae that were entrained in large numbers in June may have been spawned in late May in-the major rivers in the area (Jude et al. 1979a). Many YOY were collected in seines in the beach zone out to the 10 ft depth contour during July to September. An offshore movement occurs in September and October (Jude et al. 1978, 1979a).

MM-8

Kalamazoo River (42°40', 86°13′). Spawning runs first enter the river in April when water temperatures are below 50°F. Spawning generally occurs from late May through early August and peaks in June and July (Brown 1968, 1970b, 1972; Edsall 1964, 1970a; Wells 1968). In 1963, spawning was observed 2 mi upstream in 10 ft of water in an area with light current (Edsall 1964). Young-of-the-year alewives hatch mainly in June and July and are found off the mouth of the river at mid-level depths until late summer or fall (Wells 1968).

Palisades Power Plant (42°19', 86°19'). Spawning was observed near the plant in 3 ft of water (Wapora 1979c). Peak numbers of adults generally have been impinged or collected in April and May as they moved inshore to spawn (Consumers Power 1975, 1972b; Patriarche 1971a; Wapora 1979c,d). Ripe adults have been found in the area in June (Consumers Power 1972b; Patriarche 1972; Wapora 1979c). Eggs have been found at the power plant from June to August; the maximum numbers are collected in June (Consumers Power 1972b; Patriarche 1972; Wapora 1979c). In 1978, alewife eggs were 92% of the estimated total eggs entrained; alewife eggs were collected from early June to early August, and density peaked in early June (Wapora 1979c). Alewife fry were collected in large numbers near the power plant in water as shallow as 4 ft. Young-of-the-year were present in the area in July and August, and thousands were seined in the area and impinged at the plant as late as October (Consumers Power 1973a, 1974, 1975; Patriarche 197la,b, 1973b, 1974; Wapora 7979).

St. Joseph River (42°07', 86°29'). Spawning migrations were observed into the St. Joseph and Paw Paw (42°07', 86°28') rivers, and ripe males and females were collected there (Brown 1970b, 1972; Brown, pers. comm. 1979).

Bridgman (41°56′, 86°35′) Spawning was observed in the beach zone from the Cook Power Plant (41°59', 86°34') south to the Warren Dunes State Park (41°54′, 86°37'), from the shoreline out to about the 30 ft depth

contour (Jude 1976a; Jude, Dorr, and Tesar, pers. comm. 1979). The substrate in the area is sand and scattered rocks out to about the 84 ft depth contour; from Benton Harbor (42°06', 86°27') southward it is silt mixed with sand beyond the 72 ft depth contour (Wells 1972). Adults migrate inshore from March to May. Most adults are usually found in June; ripe, running, and spent adults are taken in June and July (Indiana and Mich. Power 1975; Jude et al. 1975, 1979b). Spawning generally occurs during June and July; however, in some years spawning is observed as early as late May and as late as early August. Peak spawning usually occurs in late June and early July. Spawning was observed, and large numbers of ripe-running adults, eggs, and 1-day-old larvae were collected here from June through August (Brown, pers. comm. 1979; Indiana and Mich. Power 1975; Jude et al. 1975, 1979b; Jude, Dorr, and Tesar, pers. comm. 1979). The Bridgman area is also an important nursery ground. Alewife larvae are collected along the shore throughout the area and are more abundant than larvae of other species. Alewife larvae are found in the epilimnion out to the 70 ft depth contour but are more concentrated in the beach zone. They have been collected in large numbers at about the 20- and 30 ft depth contours during the summer months. Alewife larvae first appear in collections in late May and early June and are generally encountered in the beach zone area from June to August. Peak abundance of larvae varies from year to year, but it often occurs in late June and early July (Indiana and Mich. Power 1975; Jude 1976a, 1977; Jude et al. 1975, 1979b; Jude, Dorr and Tesar, pers. comm. 1979). Very large numbers of YOY are found in the beach zone from July to October (Indiana and Mich. Power 1975; Jude et al. 1973, 1975, 1979b). Young-of-the-year have been observed in large schools at depths of 30 ft or less near the intake and discharge structures during July to September (Dorr 1976, 1977). Young-of-the-year appear to move away from the beach zone to deeper waters in November (Indiana and Mich. Power 1975).

GIZZARD SHAD

The gizzard shad presumably entered Lake Michigan via the Chicago River Canal (41°53', 87°37'), Illinois. The first recorded capture of gizzard shad in Lake Michigan occurred near Muskegon, Michigan, and Gary, Indiana, in 1953 (Miller 1957). Populations of gizzard shad are generally concentrated near and in rivers (Belonger, pers. comm. 1979).

Wisconsin

All of Green Bay (45°05', 87°25') is potentially a reproductive site for gizzard shad (Kernen, pers. comm. 1979).

WM-1

Fox River (44°32', 88°00'). In 1975, eggs tentatively identified as those of gizzard shad were collected in June at the Pulliam Power Plant (44°32', 88°00'), and a few young-of-the-year (YOY) were subsequently

collected in July from both Green Bay and the Fox River. Young-of-the-year may be attracted to the heated discharge from the plant in the winter; many were impinged at the plant in December (NALCO, undated a). Gizzard shad were collected in the lower Fox River, suggesting that spawning occurs in the river (Becker 1976).

Indiana

Bailly Generating Station (41°39', 87°07'). In 1976, spawning occurred here. Eggs were entrained at the station during the last week in June (Tex. Instrum. 1976b, as cited in Tex. Instrum. 1977b, 1976c); eggs were also collected in August east of the station (Tex. Instrum. 1977b). Egg densities were highest in the discharge plume. In 1974, gravid adults were collected in the area (Tex. Instrum. 1974b).

Michigan

MM-6

Pere Marquette (43°56', 86°26') and Pentwater (43°46', 86°24') Rivers. Spawning is suspected to occur in the river mouths because YOY about 4 in. long were collected, although not commonly, in late fall at the Ludington Pumped Storage Plant (43°54', 86°27') (Brazo, pers. comm. 1979).

MM-7

Grand River (43°03, 86°15'). Significant reproduction probably occurs in the river. Young-of-the-year have been seen in the river (Jude, pers. comm. 1979), and in 1977, thousands of young about 1 in. long were observed along the docks in Grand Haven (43°04', 86°13') during the summer (Jude et al. 1978).

Port Sheldon (42°54', 86°13'). No ripe adults were collected here, but the discharge canal of the Campbell Power Plant (42°55', 86°12′) is considered to be prime spawning habitat (Jude et al. 1978). Larvae were found offshore in August (Wapora 1979a), and YOY were collected at beach stations north and south of the plant in July (Jude, pers. comm. 1979).

MM-8

Kalamazoo River (42°40, 86°13'). Gizzard shad were collected in the lower river, suggesting that spawning may occur in the river (Becker 1976).

LONGJAW CISCO

This species is believed to be extinct in the Great Lakes (Todd, pers. comm. 1981). The last recorded capture of the longjaw cisco in Lake Michigan occurred in Grand Traverse Hay, Michigan, in 1967 (Todd 1978). The longjaw cisco is now considered to be taxonomically synonymous with the shortjaw cisco (Todd and Smith, unpubl. data). The longjaw cisco generally spawned in October and November in Lake Michigan (Hile, pers. comm. 1979; Jobes 1946; Koelz 1929).

Wisconsin

WM-5

Sheboygan (43°45', 87°42'). In the early 1930s, spent females were taken here in 228-300 ft of water in mid-October (Jobes 1946).

Port Washington (43°23', 87°52'). In the early 1930s, one ripe female was collected here in about 450 ft of water in mid-September (Jobes 1946).

Milwaukee (43°02', 87°54'). In the early 1930s, one ripe male was collected here in 192-216 ft of water in late October (Jobes 1946).

WM-6

Racine (42°44', 87°47'). In the early 1930s, spent females were taken in 252 ft of water in early November (Jobes 1946).

Illinois

Waukegan (44°22', 87°50'). In the early 1930s, spent females were taken here in 204-270 ft of water in early November (Jobes 1946).

Michigan

MM-2

Manistique (45°57', 86°15'). In the early 1930s, one ripe female was taken here in 384-408 ft of water in early July (Jobes 1946).

MM-3

Beaver Island (45°40', 85°33'). In 1929, spawning occurred off the east shore of the island over substrate of mud, clay, and rock (Koelz 1929).

Little Traverse Bay (45°24', 85°00'). In 1929, spawning occurred over mud, clay, and rock substrate (Koelz 1929).

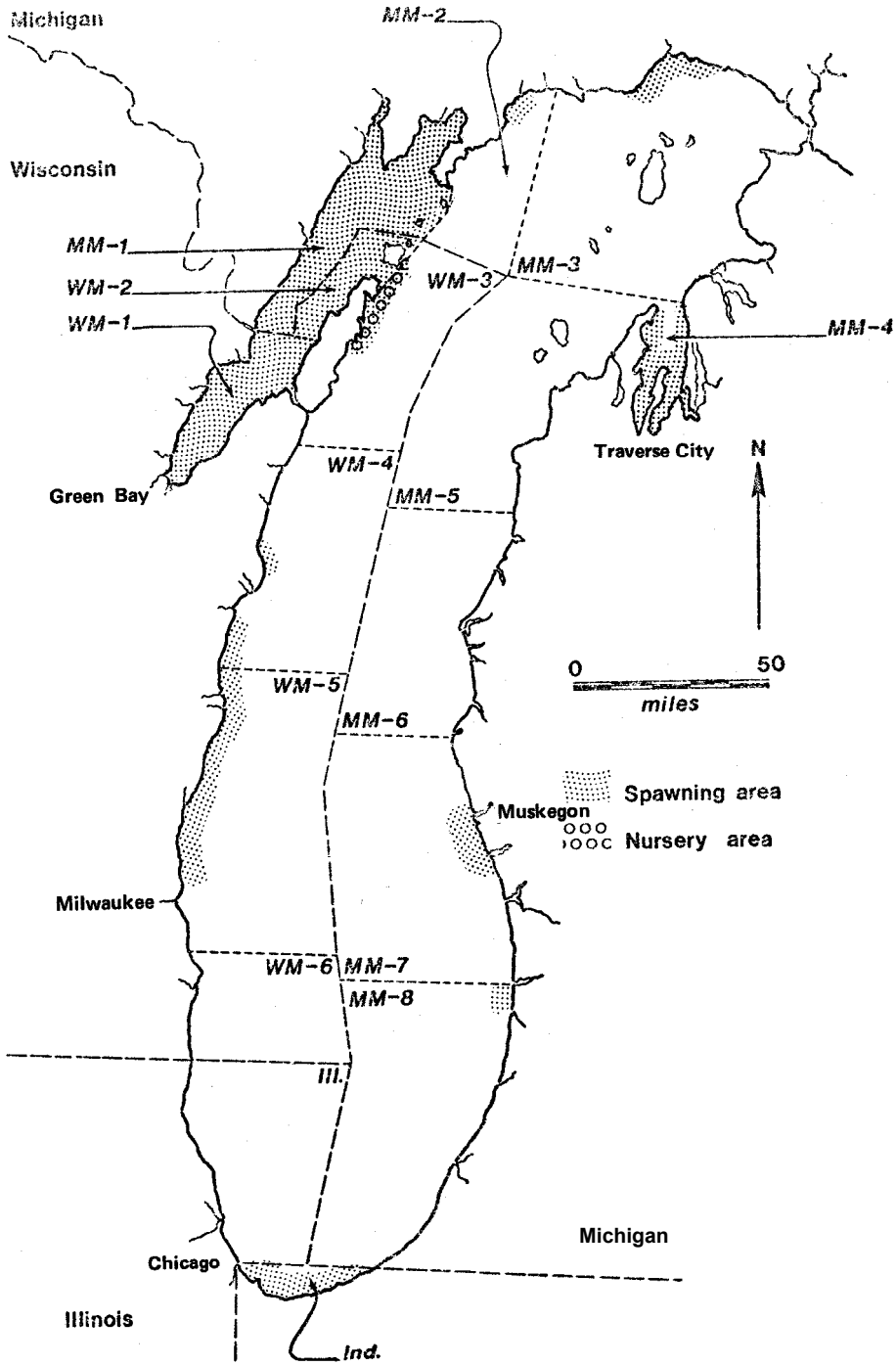
MM-4 l

Grand Traverse Bay (45°05', 85°30'). In 1929, spawning occurred over mud, clay, and rock substrate (Koelz 1929).

MM-6

Ludington (43°57', 86°28'). In the early 1930s, one ripe female was collected here in about 156 ft of water in early August (Jobes 1946).

LAKE HERRING



Lake herring are much less abundant now than they formerly were in Lake Michigan. The major decline in lake herring abundance, which began in 1957, has been attributed to the resurgence of rainbow smelt to considerable abundance by the 1950s and the explosive increase in alewives which began in the mid-1950s (Wells and McLain 1972, 1973). Presently, lake herring stocks in general are continuing to decline; local populations are either abundant or depleted (Todd, pers. comm. 1981). In Lake Michigan, lake herring spawn in November to mid-December (Hile, pers. comm. 1979; Koelz 1929; Milner 1874a; Smith 1954, 1956). Commercial fisheries were carried out in Green Bay for lake herring when they moved inshore to spawn (Koelz 1929). Lake herring moved in large numbers to inshore areas of the bay in early November prior to spawning (Milner 1874a). Lake herring in Green Bay remained in schools during the spawning period; all of the schools did not spawn at the same time nor did they necessarily finish spawning at the same place they started. Lake herring appeared to spawn pelagically over all depths in all parts of Green Bay but preferred inshore areas and were concentrated in 10-60 ft of water. Spawning also may have occurred in deeper water, because both ripe and spent fish were collected at depths to 140 ft. Lake herring spawned over boulders, sand, and mud and exhibited no preference for a particular substrate (Smith 7954, 1956).

Wisconsin

In southern Green Bay, the run began approximately October 25, reached Marinette (45°05', 87°36') approximately November 11-12, and ended approximately December 10. Lake herring were also fished along the east shore during the fall spawning season, but the run was not as heavy as the one on the western shore (Coberly and Horrall 1980b).

WM-1

Green Island (45°03, 87°30'). Lake herring were fished here during the spawning season (Coberly and Horrall 1980b).

Peshtigo Reef (44°58', 87°36'). This was once a heavily used spawning area; few fish now use the area (Copes, pers. comm. 1979).

Oconto Shoal (44°51', 87°47'). In the 1920s, this was a heavily used spawning area. In 1920, a few fish were found spawning off Oconto (44°53', 87°52') on November 17. Peak spawning usually occurred over sand bottom in 10-25 ft of water in late November (Koelz 1929).

Larsens Reef (44°53', 87°29'). Fishermen caught spawning lake herring here (Coberly and Horrall 1980b).

WM-2

Door Peninsula (45°05', 87°10'). Fishermen caught spawning lake herring at Egg Harbor (45°03', 87°17')--Fish Creek (45°08', 87°15'), Eagle

Bluff (45°10', 87°14'), Ellison Bay (45°15', 87°05')--Table Bluff (45°18', 87°01'), and the nearshore area east of Table Bluff--Waverly Shoal (45°17', 86°57') (Coberly and Horrall 1980b). In 1951, despite intensive sampling in Green Bay, only 2 young-of-the-year (YOY) were found; these were found off Gills Rock (45°17', 87°02') in 102 ft of water in December (Smith 1954, 1956).

Washington Island (45°23', 86°54'). Spawning areas include Detroit Harbor (45°21', 86°55'), Hog Island (45°21', 86°51'), and from Washington Harbor (45°25', 86°55') to Rock Island (45°25', 86°49') (Coberly and Horrall 1980b).

WM-3

Rowley Bay (45°13', 87°01')--Baileys Harbor (45°03, 87°07'). The entire Lake Michigan shore of the peninsula from Baileys Harbor north may be a spawning and nursery area for lake herring. Larvae, presumed to be lake herring, were found in Baileys Harbor, Moonlight Bay (45°05', 87°05'), and North Bay (45°09', 87°04'). In 1979, larvae about 0.2 in. long were found in Rowley Bay in April (Leary, Booke, Copes, and Ebener, pers. comm. 1979). Fishermen caught spawning lake herring in North Bay and Rowley Bay (Coberly and Horrall 1980b).

WM-4

Rawley Point (44°13', 87°30'). Fishermen caught spawning lake herring here (Coberly and Horrall 1980b).

WM-5

Port Washington (43°23', 87°52'). In this area, spawning occurred over sand along shore in 10-25 ft of water; peak spawning occurred about November 20, and the fish remained on the spawning grounds until December (Koelz 1929). In 1975, one larva was entrained at the Port Washington Power Plant (43°23', 87°52') on April 15 (Wis. Elec. Power 1976e). The shoreline extending north from Port Washington to 5 mi S of Manitowoc (44°01', 87°38') and south to Milwaukee Bay (43°02', 87°52') is a spawning ground (Coberly and Horrall 1980b).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In 1972, one ripe-running female lake herring was collected in this area in late November. The substrate in the area is fine sand with a few rocks (Cochran, undated; LaJeone, pers. comm. 1979).

Indiana

Lake herring spawned anywhere along shore in 25-40 ft of water.

Miller Beach (location unknown). In the late 1930s ripe-running adults were collected here in late November (Westerman, pers. comm. 1979).

Michigan

MM-1

Menominee (45°07', 87°37')--Escanaba (45°45', 87°04). During the 1800s, one of the principal fishing grounds extended from Menominee north, approximately to Escanaba, where the most abundant species found was the "shoal" herring (MSBFC 1897, 1899). A spawning run occurred at Escanaba in late fall and early winter (Smith and Snell 1891). Until the 1940s, lake herring spawned off the mouth of No-See-Urn Creek (45°39', 87°11') over sand and rock at depths of 12-40 ft; during the 1920s to 1950s, spawning occurred at Arthur Bay (45°19', 87°26') over sand in 18-24 ft of water (Organ et al. 1978). Fishermen have recently reported that ripe lake herring were caught almost everywhere in the northern half of Green Bay during the spawning season, and that the west shore was the major spawning ground. Spawning occurred over a varied substrate of mud, clay, sand, or fine gravel in water as shallow as 5-10 ft (Coberly and Horrall 1980b).

Big Bay de Noc (45°45', 86°45'). During the 1940s, lake herring spawned in an area (45°41', 86°46'--45°35', 86°50') extending from about 4 mi SE of Chippewa Point (45°43', 86°50') toward Wilsey Bay Point (45°42', 86°55') over rock, sand, and mud at depths of 45-60 ft. Spawning also occurred in an area extending from Chippewa Point southward toward Eleven Foot Shoal (45°38', 86°59') over sand, gravel, and mud in water 40-60 ft deep (Organ et al. 1978).

MM-2

Manistique (45°57', 86°15'). Until the 1950s, lake herring spawned in an area (45°56', 86°17') SW of Manistique; spawning occurred near shore over sand and gravel in water about 12-18 ft deep (Organ et al. 1978).

MM-3

Scott Point (45°58', 85°42')-- Davenport Creek (46°04', 85°16'). From the 1950s to 1972, lake herring spawned in an area from Scott Point to 46°02', 85°16', near the mouth of Davenport Creek; spawning occurred over rock and gravel at depths of 5-30 ft in November (Organ et al. 1978).

MM-4

Grand Traverse Bay (45°05', 85°30'). Spawning apparently occurred along the shores of the bay over sand in 10-25 ft of water. Spawning peaked around November 20, and adults remained on the spawning grounds until December (Koelz 1929).

MM-7

Muskegon (43°13', 86°17'). "Greenback herring" spawned along about 5-6 mi of the shoreline from Mona Lake (43°10', 86°18') to White Lake (43°23', 86°26'). During 1932-70, spawning occurred over sandy bottom in less than 10 ft of water (Organ et al. 1978).

MM-8

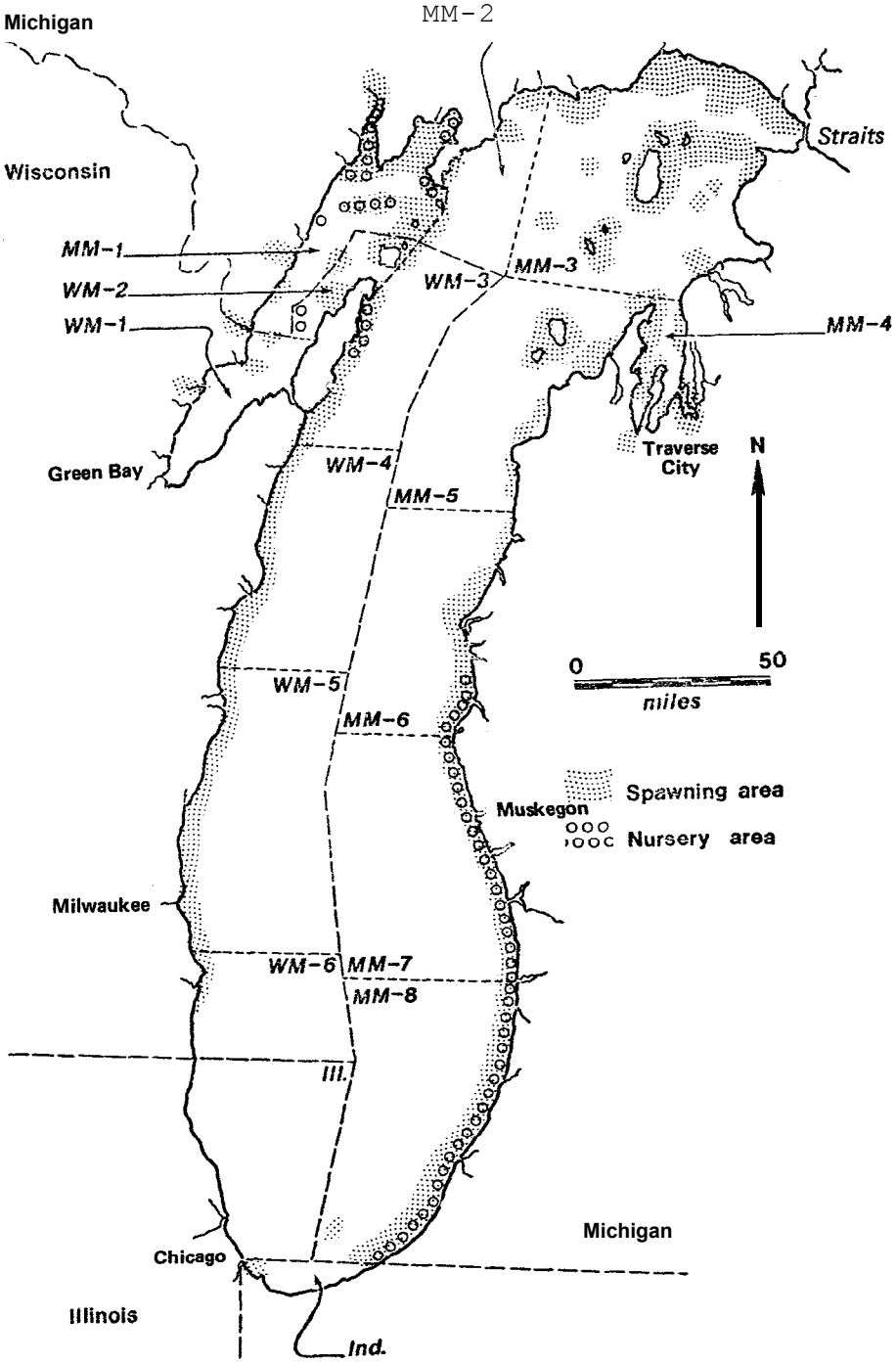
Spawning could occur anywhere near shore in the southeast portion of the lake from approximately Saugatuck (42°40', 86°12') to New Buffalo (41°48', 86°45'), but would be light due to the low abundance of adults (Wells 1972).

Saugatuck (42°40', 86°12'). In the 1940s to 1950s, greenback herring spawned in an area (42°42', 86°17'--42°45', 86°17') 3-4 mi off the mouth of the Kalamazoo River (42°40', 86°13') and north for about 3 mi. Spawning occurred over mud bottom in 90-108 ft of water from November to January (Organ et al. 1978).

Bridgman (41°56', 86°35'). In 1972, seven YOY smaller than 1 in. long were captured off the Cook Power Plant (41°59', 86°34') in August through October (Jude et al. 1973). In 1974, a spent female was captured near the plant in late December (Jude et al. 1979b).

LAKE WHITEFISH

MM-2



Records of the fishery conducted for lake whitefish in Lake Michigan during the spawning season indicate that spawning occurs in shallow shoreline waters of the entire lake in times of high abundance, and that spawning may be restricted to a few local areas when abundance is low. Adults begin concentrating in the shallow areas in October (Smith 1909), and generally spawn during a 2-4 week period in late November and December when the water temperature falls to about 40-46°F (Daly et al. 1975; GLFL 1970; Koelz 1929; Price and Kelly 1976; Smith 1909). Spawning occurs over gravel, stone, or honeycombed rock, swept clean by currents, at depths of 6-60 ft (Davidson 1937; Grosse Ile Lab. 1972; Koelz 1929; Price and Kelly 1976; Walburg 1973). Spawning also occurred over "round-heads," (areas of boulder rock on sand bottom) (Smith 1909). After spawning, adults return to the deeper offshore waters (Davidson 1937). Wisconsin fishermen reported that lake whitefish enter sandy bays to spawn in as little as *10* ft of water, in contrast to lake trout which spawn on rock shoals farther offshore (Coberly and Horrall 1980b).

Historically, lake whitefish spawned in tributaries and near river mouths (Wells and McLain 1972). In the 1800s, the principal spawning grounds along the west shore of Green Bay were in the tributaries emptying into the bay (Geare 1884; Smiley 1882). Lake whitefish were taken in qreat numbers in these rivers durinq the spawning season (Milner 1874a; Smiley 1882). Prior to 1897, spawn was collected from ripe fish taken on the west and north shores of the bay (Nevin 1899). The tributary runs ceased when sawmill wastes polluted the rivers (Milner 1874a; Smiley 1882).

In the 1870s, lake whitefish spawned in an area beginning south of Racine (42°44', 87°47'), Wisconsin, and continuing north along the entire shore. No known spawninq grounds were recorded for Chicago (41°53', 87°37') and Illinois waters (Milner 1874a; Smith and Snell 1891). No spawning qrounds were reported in the area from St. Joseph (42°06', 86°29'), Michigan, south to Michigan City (41°44', 86°54'), Indiana. Spawning grounds south of Frankfort (44°38', 86°14'), Michigan, were few and unimportant (MSBFC 1897).

Lake whitefish larvae are usually most abundant near the surface. They frequent shallow inshore areas and bays not more than 10 ft deep. When the larvae are about 0.8 in. long, they begin to seek the bottom in deeper waters (Hoagman 1973; Hogman 1971).

Wisconsin

WM-1

Menominee River (45°06', 87°35'). Historically, spawning runs entered the river (Ebener and Copes, pers. comm. 1979; Imhof, pers. comm. 1979). The river, which forms the boundary between Wisconsin and Michigan, supported an important fishery; thousands of lake whitefish were taken here as they returned to the lake after spawning (Geare 1884; True 1887). However, no whitefish were taken in the river after 1870 (Smiley

1882), and by the late 1800s spawninq grounds in Green Bay at a considerable distance from the river mouth had been completely ruined by wastes from sawmills located on the river (Smiley 1882; True 1887).

Green Island (45°03, 87°30'). A commercial fisherman reported that spawning occurred here (Coberly and Horrall 1980b).

Peshtiqo Reef (44°58', 87°36'). Lake whitefish spawned here historically, and in the 1970s, ripe fish were collected on the reef (Ebener and Copes, pers. comm. 1979). Tagging studies indicate that lake whitefish also move from the reef to North (45°09', 87°04') and Moonlights (45°05', 87°05') bays to spawn and then return to the reef (Gunderson 1978).

Oconto River (44°54', 87°50'). In 1845, lake whitefish ran 20 mi upstream to the falls to spawn; by the late 1800s the river bottom and shoals in Green Bay at a considerable distance from the river mouth were covered by wastes from sawmills located on the river (Smiley 1882).

WM-2

chambers Island (45°11', 87°21'). Spawning does not appear to occur here, but lake whitefish larvae are found regularly at the island, especially off the east shore in water less than 10 ft deep (Hoagman 1973; Hogman 1971). Lake currents may transport these larvae to the site from a spawninq qround in Big Bay de Noc (45°45', 86°45') (Frederick, pers. comm. 1979; Hoagman 1973; Hogman 1971). In 1970, hatching in areas contributing larvae to the nursery grounds at the island peaked in late April; yolk-sac larvae captured at the island by May 2 were more than 7 days old. The nursery area on the east side of the island has a rocky bottom with patches of sand; the water depth is about 1-6 ft; there is no vegetation in this area, and a large rock shelf reduces water currents. Larvae inhabit these nearshore waters until mid-May, after which they move to deeper water and become difficult to capture (Hoagman 1973; Hoqman 1971). In the late 1970s, tagged adult whitefish moved from Chambers Island to spawn in North (45°09', 87°04') and Moonlight (45°05', 87°05') bays and then returned to the island (Gunderson 1978).

Horseshoe Island (45°11', 87°13') (Coberly and Horrall 1980b).

Horseshoe Reefs (45°13', 87°12') (Imhof, pers. comm. 1979). Recently spent fish with spawning tubercles were captured here in February, indicating that spawning may have occurred in late January **and February** (Ebener and Copes, pers. comm. 1979).

Sister Islands (45°13', 87°09') and Sister Shoals (45°12', 87°10') (Imhof, pers. comm. 1979).

Washington Island (45°23', 86°54'). Prior to 1868, some of the most important spawning grounds for lake whitefish **were** located north and west of Washinqton Island; these grounds extended to St. Martin Island (45°30', 86°46') (Smiley 1882). Spawn was collected from ripe fish taken near

Detroit Harbor (45°21′, 86°55′) (Nevin 1901b). Lake whitefish spawn off the east shore of Washington Island from 45°24', 86°49'--45°20', 86°49' (Coberly and Horrall 1980b; Imhof, pers. comm. 1979).

Fish Island (45°24', 85°46') and Fisherman Shoal (45°22', 85°47'). Spawning occurs here (Coberly and Horrall 1980b; Imhof, pers. comm. 1979).

Waverly Shoal (45°17', 86°57'), Nine Foot Shoal (45°17′, 86°57′), and Europe Bay (45°16', 86°59'). Spawninq occurs here (Coberly and Horrall 1980b).

WM-3

The major lake whitefish spawning grounds in Wisconsin waters of Lake Michigan are located along the eastern shore of the Door Peninsula from Europe Bay (45°16', 86°59') south to Cave Point (44°56', 87°10') in water as shallow as 10 ft (Coberly and Horrall 1980b).

Europe Bay (45°16', 86°59')--Four Foot Shoal (45°10', 87°00') (Imhof, pers. comm. 1979). Spider Island (45°13', 86°59') is an especially important spawning area (Coberly and Horrall 1980b).

Rowley Bay (45°13′, 87°01′). This is an important spawning area (Coberly and Horrall 1980b). Ripe lake whitefish are present in Rowley Bay during the last week in October (Ebener and Copes, pers. comm. 1979). Larvae have been collected at the head of the bay over rock bottom with patches of sand (Frederick, pers. comm. 1979).

North Bay (45°09', 87°04')--Baileys Harbor (45°03, 87°07'). This entire area, including Moonlight Bay (45°05', 87°05'), is a major spawning ground for lake whitefish (Ebener and Copes, pers. comm. 1979; Imhof, pers. comm. 1979), Especially important sites are Cana Island (45°05', 87°03) (Coberly and Horrall 1980b) and North Bay, where spawning occurs at the mouth of the bay and along shore toward Cana Island over honeycombed rock (Binkowski, pers. comm. 1979; FWS 1979d; Hoagman 1973; Hogman 1971; Imhof 1977, pers. comm. 1979). It was estimated that 75% of the lake whitefish caught in the Wisconsin waters of Lake Michigan in 1976 were produced from spawnings in North and Moonlight bays (Humphreys 1978). Tagqing studies indicate that homing occurs to specific bays in the area (Humphreys 1978; Imhof 1978); fish move into the bays from Lake Michigan proper and from Green Bay, especially Peshtigo Reef (44°58', 87°36') and Chambers Island (45°11′, 87°21'), to spawn (Ebener and Copes, pers. comm. 1979; Frederick, pers. comm. 1979; Gunderson 1978; Hoagman 1973; Hogman 1971; Humphreys 1978; Moore, pers. comm. 1979). Large concentrations of ripe fish are found along the entire shore from North Bay to Baileys Harbor in water 40 ft deep or less from mid-October through November (Frederick, pers. comm. 1979); the greatest numbers are found near North Bay in October (Hoagman 1973; Hogman 1971). Substrate in the area to water depths of 30 ft is shelf rock containing many crevices; at depths of 30-60 ft the substrate is honeycombed rock (Frederick, pers. comm. 1979). In 1970, lake whitefish arrived at North Bay on about November 1; peak spawning activity occurred on about November 10 (Hoagman 1973; Hogman

1971). Eggs hatch in early to mid-April, as soon as the ice cover breaks up (Frederick, pers. comm. 1979). North Bay, Moonlight Bay, Baileys Harbor, and the surrounding nearshore waters are nursery areas (Frederick, pers. comm. 1979; Moore, pers. comm. 1979). Many newly hatched larvae are present in North Bay in April and May; most are found at depths of less than 3 ft (Hoagman 1973; Hogman 1971). Young-of-the-year (YOY) remain in the bays until late May; they are collected along shore at depths of less than 80 ft until September or October (Frederick, pers. comm. 1979).

Whitefish Point (44°52', 87°12'). Commercial fishermen have recently identified this area as a spawning ground (Coberly and Horrall 1980b).

WM-4

Kewaunee Power Plant (44°21', 87°32'). An occasional ripe lake whitefish is collected in waters off the plant. The substrate in the area is generally hard clay with cobble-size rock (LaJeone, pers. comm. 1979).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In the 1970s, no evidence of spawning was found here (Commonw. Edison 1976; USAEC 1972c); however, young lake whitefish (possibly YOY and yearlings) were collected in the area over a substrate of fine sand and rock (LaJeone, pers. comm. 1979).

Indiana

Whiting (41°41', 87°30'). Historically, large numbers of lake whitefish spawned a short distance offshore at "South Chicago" (Nelson 1878), which was approximately at the present location of Whiting.

Bailly Generating Station (41°39', 87°07'). In 1974, one ripe lake whitefish was collected about 3 mi N of the station at the 15 ft depth contour during the spawning season (Tex. Instrum. 1975b).

Michigan City (41°43', 86°54'). During 1945-68, lake whitefish spawned in an area (41°44', 86°55') about 3 mi offshore in 55-60 ft of water (Organ et al. 1978).

Michigan

MM-1

Whaleback Shoal (45°21', 87°11'). Spawning occurs here (Imhof, pers.

Arthur Bay (45°19', 87°26'). During the 1920s to 1940s, spawning occurred here over sand in water about 20 ft deep (Organ et al. 1978).

Cedar River (45°24', 87°21'). Historically, lake whitefish entered this river to spawn (Imhof, pers. comm. 1979).

Bark River (45°34', 87°14'). In 1978, larvae were collected off the river mouth from late April to late May (Wis. Elec. Power, unpubl. data).

Minneapolis Shoal (45°35', 87°00'), Drisco Shoal (45°34', 86°57'), and North Drisco Shoal (45°33', 86°57'). Since 1915, spawning has occurred on these shoals over rock (Imhof, pers. comm. 1979; Organ et al. 1978). The shoals are also nursery areas for YOY and yearling lake whitefish (Ebener and Copes, pers. comm. 1979).

Little Bay de Noc (45°45', 87°00'). The portion of the bay north of portage Point (45°42', 87°04') is a spawning and nursery area for lake whitefish. Running-ripe fish were collected in this area (Ebner, Copes, and Leary, pers. comm. 1979).

Ford River (45°40', 87°08'). In 1978, a few eggs were found just off the mouth of the Ford River at the 5 and 10 ft depth contours in mid-April; larvae were found from late April to late May (Wis. Elec. Power, unpubl. data).

Stonington (45°45', 86°59'). Since the 1920s, spawning has occurred off Stonington over rock in about 6-12 ft of water (Organ et al. 1978).

Whitefish River (45°55', 86°57'). Before paper mills were constructed in the area, spawning runs of lake whitefish entered the river (Ebener, Copes, and Leary, pers. comm. 1979).

Big Bay de Noc (45°45', 86°45'). Spawning occurs in the bay (Ebener and Copes, pers. comm. 1979; FWS 1979d; Hile, pers. comm. 1979; Hoagman 1973; Hogman 1971), mostly in the inner bay north of the tip of Big Bay de Noc Shoal (45°45', 86°42') (Ebener and Copes, pers. comm. 1979). In the early 1890s, lake whitefish were more abundant in the bay in the fall, during the spawning season, than in the spring (Smith and Snell 1891). A tagging study conducted in 1954 and 1955 indicates that lake whitefish in the bay are not migratory (Gunderson 1978; Roelofs 1958); however, WDNR records show that some fish tagged in central Green Bay migrated to Big Bay de Noc to spawn (Hoagman 1973; Hogman 1971). In the 1920s, lake whitefish spawned at the north end of the bay near Isabella (45°53', 86°36') and at "humps" (location unknown) in the bay in November (Van Oosten 1927a). According to commercial fishermen, the primary spawning grounds occur along the eastern shore of the bay, just north of Garden (45°46', 86°33'); this area receives strong currents from Lake Michigan proper (Hoagman 1973; Hogman 1971). Since 1915, lake whitefish have spawned along the entire shoreline from Garden Bluff (45°47', 86°37')--Peninsula Point (45°40', 86°58'), at the 12 ft depth contour over rock, gravel, and sand (Organ et al. **1978).** Lake whitefish **larvae that are**

spawned in Big Bay de Noc probably disperse to the Chambers Island (45°11', 87°21') area (Hoagman 1973; Hogman 1971).

Round Island (45°45', 86°46'). Since 1915, lake whitefish have spawned on the shoals around the island over rock and gravel (Organ et al. 1978). This is probably the same area, 5 mi WNW of Fayette (45°43', 86°40'), where spawning occurred in 1937 at depths as shallow as 4 ft (Van Oosten 1938b).

Big Bay de Noc Shoal (45°45', 86°42'). Since 1920, lake whitefish have spawned here over rock, gravel, and sand. Spawning also occurs (no dates given) on the adjacent shoal (45°47', 86°40') at depths of about 18-20 ft, over sand and rock (Organ et al. 1978).

Valentine Bay (45°50', 86°33'). In 1970, many larvae were collected here in early May (Hoagman 1973; Hogman 1971).

Kates Bay (45°49', 86°34'). Spawning occurs here, and in 1970 many lake whitefish larvae were collected in the bay in early May (Hoagman 1973; Hogman 1971).

Burnt Bluff (45°41', 86°42'). Since 1915, spawning has occurred here over sand and gravel (Organ et al. 1978).

St. Martin Island (45°30', 86°46') and St. Martin Island Shoals (45°27', 86°46'). Prior to 1868, some of the best spawning grounds for lake whitefish were south and west of St. Martin Island; these grounds extended to Washington Island (43°23', 86°54') (Smiley 1882). Since 1915, spawning has occurred on the shoals and along the south shore of the island (Organ et al. 1978).

Poverty Island Shoal (45°33', 86°42'), Gravelly Island Shoals (45°32', 86°44'), Gravelly Island (45°31', 86°44'), Gull Island (45°31*, 86°43'), and Little Gull Island (45°30', 86°43'). Since 1915, lake whitefish have spawned here over rock and gravel (Organ et al. 1978).

Poverty Island (45°32', 86°40') and south shore of Summer Island (45°34', 86°38'). Spawning occurs (no dates given) on the shoals here (Organ et al. 1978).

Rocky Island (45°37', 86°43') and Little Summer Island Shoal (45°35', 86°43'). since 1915, spawning has occurred here over rock (Organ et al. 1978).

Sac Bay (45°39', 86°42'). In 1915-78, lake whitefish spawned here over sand and gravel (Organ et al. 1978).

Point Detour (45°36', 86°37') and Fairport (45°37', 86°40'). In 1970, small numbers of larvae were caught here (Hoagman 1973; Hogman 1971).

MM-2

In the early 1890s, spawning lake whitefish were caught along the shores of Schoolcraft County (Smith and Snell 1891).

Kregg Bay (45°42', 86°34'). From 1915 to 1978, lake whitefish spawned on the rock shoal (45°41', 86°31'), about 2 mi E of the bay (Organ et al. 1978).

Portage Bay (45°45', 86°31')--Point aux Barques (45°48', 86°21'). According to fishermen, lake whitefish probably spawn on the rocky shoals in this area (Ebener and Copes, pers. comm. 1979); spawning sites in this area include:

> Portage Bay. Since 1915, spawning has occurred on the rock and gravel shoal areas of this bay; the bay is probably a nursery area for lake whitefish (Ebener and Copes, pers. comm. 1979).
>
> A rock area (45°44', 86°28'), between Portage Bay and Parent Bay. From 1915 to 1978, spawning occurred here at depths of 6-24 ft (Organ et al. 1978).
>
> Parent Bay (45°47', 86°25'). From the 1920s to 1978, spawning occurred here over rock and gravel (Organ et al. 1978).
>
> Point aux Barques. From 1940 to 1978, spawning occurred over rock and gravel in water 12-30 ft deep (Organ et al. 1978).

Higgins Point Shoal (45°51', 86°18'). From 1915 to 1978, spawning occurred here over rock and gravel at depths of less than 30 ft (Organ et al. 1978).

Dutch Johns Point (45°57', 86°08'). From the 1920s to 1978, lake whitefish spawned here over gravel from the shoreline to depths of 25 ft (Organ et al. 1978).

MM-3

The north shore of Lake Michigan, especially the reefs around the islands, was historically one of the most productive lake whitefish spawning grounds. By the 1890s, sawdust pollution entering the lake from the Manistique River (45°57', 86°15') had fouled spawning grounds and reduced the catch of lake whitefish in this area (Koelz 1929; MSBFC 1887, 1893, 1895, 1897).

Seul Choix Point (45°55', 85°55'). In 1975 and 1976, lake whitefish were captured here during the spawning season (Imhof 1977); fishermen presently catch ripe fish here (Leary and Copes, pers. comm. 1979).

Boulder Reef (45°36', 85°58'). Historically, this reef was one of the largest spawning areas in the lake (Koelz 1929); spawning occurred here in November and December (Van Oosten 1927a). Until 1948, spawning occurred here over rock in less than 30 ft of water (Organ et al. 1978).

Gull Island (45°42', 85°50'). Spawning occurred here (MSBFC 1890).

Scott Point (45°58', 85°42')--Pointe aux Chenes (45°56', 84°54'). Spawning occurs along shore in this area (Organ et al. 1978). In the early 1890s, many spawning lake whitefish were caught along the shores of Mackinac County in late November (Smith and Snell 1891).

Scott Point (45°58', 85°42')--Rock River (46°05', 85°32'). From the 1940s to 1978, spawning occurred here along shore over sand, rock, and gravel at depths of 6-24 ft (Organ et al. 1978).

Rock River (46°05', 85°32')--Biddle Point (46°05', 85°23'). From 1967 to 1969, spawning occurred along shore here over rock, sand, and gravel (Organ et al. 1978). Naubinway (46°00', 85°27') was a base for spawn collection (Clark 1886), and spawning occurred during November (Van Oosten 1927a). Lake whitefish spawned at Naubinway Island (46°04', 85°27') over sand and rock at depths of 30 ft or less (Organ et al. 1978), and in Mille Coguins Bay (46°05', 85°29') from October 25 to November 25 (Van Oosten 1927a).

Biddle Point (46°05', 85°23')--Davenport Creek (46°04', 85°16'). From the 1940s to 1978, spawning occurred here over rock and gravel (Organ et al. 1978). Spawning occurred on an unnamed reef south of Little Hog Island (46°04', 85°18') from October 20 to November 10 and on a reef (precise location unknown) 6 mi E of Naubinway (46°06', 85°27'), which would be just west of Little Hog Island, from November 5 to 25 (Van Oosten 1927a).

Davenport Creek (46°04', 85°16')--Epoufette (46°03, 85°10'). Epoufette was a base for spawn collection (Clark 1886). From 1967 to 1969, spawning occurred in this area over rock, sand, and gravel. From 1961 to 1978, spawning occurred at Pelkie Reef (46°02′, 85°15′) over rock at depths of 11-30 ft (Organ et al. 1978).

Brevoort River (45°57', 84°56')--Pointe aux Chenes Bay (45°55', 84°53′). From 1961 to 1978, spawning has occurred here over rock and gravel substrate, from the shore out to a depth of about 30 ft (Organ et al. 1978).

South Tarp Island (location unknown). Spawning occurred here on December 10-20 (Van Oosten 1927a).

Beaver Island (45°40', 85°33'). Historically, spawning occurred here during a 3 week period in November to December (Strang 1855). In the 1920s, spawning occurred during November 12-25 at the north end of the island and during November 15-30 at Kelty Point (45°37', 85°29') (Van oosten 1927a). In 1970, ripe fish were captured at the north end of the island (GLFC 1970b). Spawning has occurred over sand and rock since 1963 at Kelty Point, Indian Point (45°46', 85°34'), and Stony Point (45°44', 85°30'), and since the 1930s in Sandy Bay (45°41', 85°30') (Organ et al, 1978).

Garden Island (45°48', 85°30'). Since 1961, spawning has occurred over rock on all the shoals around Garden Island, including Garden Island Shoal (45°52', 85°29'), Whiskey (45°49', 85°37'), Squaw (45°50', 85°35'), Pismire (45°46', 85°27'), and Grape (45°47', 85°25') islands and their shoal areas (Organ et al. 1978).

Hog Island (45°47', 85°22'). Since the 1920s, spawning has occurred over rock and gravel on all the shoals around Hog Island, including Hog Island Reef (45°44', 85°21') and Hat Island (45°49', 85°18') (Organ et al. 1978). Spawning usually occurred in this area from late November to late December (Van Oosten 1927a), but some times spawning began in late October (Koelz 1929). In 1970, ripe fish were collected from reefs (45°50', 85°23') on the north side of Hog Island (GLFC 1970b).

Mille Coquins Reefs (46°00', 85°27'), Outer Reef (45°58', 85°27'), and Potter Reef (46°00', 85°32'). Lake whitefish spawned here over rock and gravel in November (Organ et al. 1978; Van Oosten 1927a).

Fagan Reef (45°57', 85°18'). Spawning occurred here during November (Organ et al. 1978; Van Oosten 1927a).

Five Mile Reef, Metty's Point Grounds, and Metty Outer Reef (locations unknown). Spawning occurred here in November (Van Oosten 1927a).

Grays Reef (45°47', 85°14'). Since 1961, spawning has occurred here over rock and gravel (Organ et al. 1978).

Simmons Reef (45°55', 85°12'). Lake whitefish spawned here (no dates given) over rock (Organ et al. 1978).

Manitou Paymen Shoal (45°58', 85°04'). In 1935-36, lake whitefish spawned here over rock substrate at depths of 6 to 30 ft (Organ et al. 1978).

Sturgeon Bay (45°43', 84°58'). As early as 1927-30, spawning occurred in the bay, mainly over rock, gravel, and sand in 6-60 ft of water (Organ et al. 1978).

Cross Village (45°39', 85°03). In 1866, a large catch of lake whitefish was made in November in an area (precise location unknown) 1 mi S of the village in 20 ft of water (Smith and Snell 1891).

Ile aux Galets (45°41', 85°10'). Spawning occurs here over rocky substrate at depths of 6-30 ft (Organ et al. 1978).

Dahlia Shoal (45°38', 85°12'). Spawning occurs over honeycombed limestone in water as deep as 30 ft (Organ et al. 1978).

St. Helena Shoal (45°52', 84°55'). Lake whitefish spawn over rocky substrate here in water about 6-30 ft deep in November and December. Spawning was reported here as early as the mid-1920s, and again in the 1960s and 1970s (Organ et al. 1978; Van Oosten 1927a).

Charlevoix (45°19', 85°15'). Lake whitefish larvae hatched in this area in the spring (Ward 1896).

Fox Islands (45°27', 85°50'). Spawning occurred on the large area of reefs and shoals around the islands (Koelz 1929, MSBFC 1890) during a 2-week period in mid-November to January (Van Oosten 1927a, 1936c). Lake whitefish spawned during the 1930s over rock around North Fox Island (45°29', 85°47'), from 1915 to the 1970s over gravel around South Fox Island (45°25', 85°51'), and from 1915 to the 1960s over gravel on the south Fox Island Shoals (45°18', 85°51') (Organ et al. 1978).

MM-4

Grand Traverse Bay (45°05', 85°30'). The west arm of the bay was a favorite spawning ground for lake whitefish (MSBFC 1895), but the beds became covered by sawdust and sawmill waste, and the fish were driven away (MSBFC 1888, 1895). In 1897, spawn of whitefish or lake trout, or both, were collected from a tributary (location unknown) of the bay (Ravenel 1898).

Antrim Creek (45°10', 85°23'). Until 1950, spawning occurred at the creek mouth (Organ et al. 1978).

Grand Traverse Shoal (45°08', 85°26') (Price and Kelly 1976). In the 1920s, spawning occurred here from November 25 to December 10 (Van Oosten 1927a).

Elk River (44°54', 85°25'). Historically, a spawning run of lake whitefish entered the river; in 1851, a sawmill and dam was built which blocked the run (Price and Kelly 1976).

Old Mission Point (45°00', 85°29'). Historically, spawning occurred on the extensive shoal area at the point over coarse gravel and porous rock (MSBFC 1895; Koelz 1929). Spawning occurred on Old Mission Point Shoal (45°01', 85°29') from November 25 to December 10 and on Old Mission Point Reef (45°02', 85°29') during December 1 to 15 (Organ et al. 1978; Van Oosten 1927a); spawning in the area occurred about 2 weeks later than at Lighthouse Point (45°13', 85°33') (Koelz 1929).

Deepwater Point (44°47', 85°31'). Spawning occurs on the rocky shoreline north of the point (Price and Kelly 1976).

Merril Point (44°58', 85°31'). Since 1935, spawning has occurred here over rock (Organ et al. 1978).

Tucker Point (44°54', 85°34'). Spawning occurred later here than at Mission Point (45°00', 85°29') (Koelz 1929).

Traverse City (44°46', 85°37'). A spawning run of lake whitefish entered Kid's Creek (44°46', 85°38'); in 1847, a dam was erected on the creek which blocked the run (Price and Kelly 1976).

Lee's Reef (44°54', 85°37'). Since 1936, spawning has occurred here over honeycombed rock and moss (Organ et al. 1978; Price and Kelly 1976).

Suttons Point (45°00', 85°36')--Lee Point (44°56', 85°36'). Spawning occurs at Suttons Point over rock. During 1935-68, spawning occurred over sand and gravel along shore from Suttons Point to Lee Point (Organ et al. 1978).

New Mission Bay (45°02', 85°35'). Since 1958, spawning has occurred at 45°02', 85°35' over sand and rock (Organ et al. 1978).

Northport Bay (45°07', 85°35'). Since 1958, spawning has occurred over rock and sand along shore in an area (45°05', 85°35') about 1 mi S of Timber Shores Resort (45°06', 85°36') (Organ et al. 1978).

Bellow Island (45°06', 85°34'). Since 1935, spawning has occurred over rock around the island and over the reefs (45°07', 85°34') north of the island (Organ et al. 1978).

Lighthouse Point (45°13', 85°33'). This was historically one of the greatest lake whitefish spawning grounds in Lake Michigan (Koelz 1929; Kumlein and True 1887), spawning occurred over the reef and shoals from November 25 to December 15 (Van Oosten 1927a). Since 1958, spawning has occurred over rock and sand at the point and in an area (45°11', 85°28'--45°14', 85°29') about 4 mi E of the point; since 1935, lake whitefish have spawned over rock, moss, and mud on a reef (45°11', 85°31') about half-way to Northport Point (Organ et al. 1978).

Raft's Camp (location unknown). Spawning occurs here on rocky reefs (Price and Kelly 1976).

MM-5

Cat Head Point (45°11', 85°37'). In the 1920s, spawning occurred here from November 25 to December 10 (Van Oosten 1927a).

Leland (45°01', 85°46'). Historically, spawning occurred off Leland (MSBFC 1890); the specific location was not given.

Good Harbor Bay (44°58', 85°50'). Since 1954, lake whitefish have spawned over rock and sand at Pyramid Point (44°58', 85°56'); from 1925 to 1940, spawning also occurred over the rock reef (44°59', 85°49') in the bay (Organ et al. 1978).

North Manitou Shoals (45°02', 85°58'). In the 1930s spawning occurred here over gravel (Organ et al. 1978).

North Manitou Island (45°07', 86°01'). From 1925 to 1940, spawning occurred around the entire island over gravel and rock substrate (Organ et

al. 1978). During the 1920s, spawning occurred here from November 25 to December 15 (Van Oosten 1927a).

South Manitou Island (45°01', 86°08'). Historically, spawning occurred on the rocky reef (45°03, 86°09') off the northwest corner of the island (MSBFC 1890). From 1915 to the 1960s, spawning occurred all around the island (Organ et al. 1978). During the 1920s, spawning occurred here from November 15 to December 16 (Van Oosten 1927a).

Platte Bay (44°45', 86°07'). Lake whitefish spawned (no dates given) over the rock reef (44°44', 86°09') at the mouth of the Platte River (Organ et al. 1978) and over rocks (precise location unknown) off Empire (44°49', 86°04') (MSBFC 1890). In the 1920s, spawning at Empire occurred from November 25 to December 15 (Van Oosten 1927a).

Frankfort (44°38', 86°14'). Historically, spawning occurred off Frankfort (MSBFC 1890); the specific location was not given.

MM-6

Arcadia (44°30', 86°14'). Since the 1930s spawning has occurred on a rock reef (44°28', 86°16') along shore south of Arcadia (Organ et al. 1978).

Portage Lake (44°22', 86°14'). Since the 1930s spawning has occurred on a small rock reef (44°22', 86°17') in 30 ft of water (Organ et al. 1978).

Bar Lake (44°18', 86°18'). Since the 1930s lake whitefish have spawned in an area extending about 2 mi S from Bar Lake over rock (Organ et al. 1978).

Manistee (44°15', 86°20')--Little Sable Point (43°39', 86°33'). From the 1930s to 1978, lake whitefish spawned along this entire shoreline over rock, gravel, and clay, usually at water depths less than 60 ft (Organ et al. 1978).

Manistee. Historically, whitefish were driven away from the Manistee area by sawdust and other sawmill waste (MSBFC 1888).

Ludington (43°57', 86°28'). In 1890, spawning was believed to occur on clay banks (precise location unknown) in the Ludington area about 8 mi N of Pentwater (43°47', 86°26') (MSBFC 1890). At this time, lake whitefish were reportedly being driven away from the area by sawdust and other sawmill wastes (MSBFC 1888, 1893, 1895). In the 1920s, lake whitefish spawned on small rock patches (precise location unknown) 6 mi S of Ludington and on the "Ludington Clay Banks" (precise location unknown) from mid-November to mid-December (Van Oosten 1927a). Spawning lake whitefish appear at the Ludington Pumped Storage Plant (43°54', 86°27') beginning about the last week of October; abundance peaks during the second and third week of November and remains high until early December. Spawning occurs in an area (43°52', 86°27' --43°55', 86°27') surrounding the intake of the plant, at

depths less than 30 ft (Brazo, pers. comm. 1979). Many lake whitefish spawn along the rock jetties of the plant, especially along the west breakwall. Large numbers of ripe adults have been collected in the area (Brazo, pers. comm. 1979; Brazo and Liston 1977). In 1971, many ripe fish were collected about 2 mi offshore from the plant intake in mid-November (Consumers Power 1972). Lake whitefish larvae are collected near the plant from mid-April to early May (Brazo, pers. comm. 1979; Liston et al. 1978); large numbers of larvae are found between the shoreline and the 5 ft depth contour. Young-of-the-year are found between the 5 and 15 ft depth contours, mainly just north of the plant (Brazo, per-s. comm. 1979).

MM-7

Stony Lake (43°34', 86°30')--Duck Lake (43°20', 86°24'). In the late 1800s and early 1900s, lake whitefish were being driven away from the White Lake area (43°23', 86°26') by sawdust and paper mill waste (MSBFC 1888, 1895). Commercial fishermen report that lake whitefish spawned from the 1920s to 1978 in most areas along the shoreline from about 4 mi N of Stony Lake to 2 mi S of Duck Lake over rock, gravel, clay, and sand (Organ et al. 1978). A rather isolated population of lake whitefish exists in the east-central part of Lake Michigan proper, and at least one fisherman believes that this population spawns on a clay bottom area near White Lake. The nursery area for this population probably extends from saugatuck (42°40', 86°12') to Pentwater (43°47', 86°26') (Wells, pers. comm. 1979).

Muskegon (43°13', 86°17'). By the late 1800s, lake whitefish were reported to have been driven away from the Muskegon area by the great quantities of sawdust and edging wastes from the sawmills on the Muskegon River (43°14', 86°15') (MSBFC 1887, 1888, 1893, 1895). From 1932 to 1978, lake whitefish spawned in an area (43°14', 86°21'--43°11', 86°19') extending south from the mouth of the Muskegon River for about 3 mi; spawning occurred over sand in water about 12-30 ft deep (Organ et al. 1978).

Little Black Lake (43°07', 86°17')--Lake Macatawa (42°46', 86°13'). From 1930 to 1975, lake whitefish spawned in this area over sand in water about 12-70 ft deep (Organ et al. 1978).

Grand Haven (43°04', 86°13'). Lake whitefish spawned about 4 mi S of the mouth of the Grand River (43°03, 86°15'); a single catch of 1,100 lbs of lake whitefish was made there on November 9, 1893 (MSBFC 1895). In the late 1800s, lake whitefish were reportedly being driven away from the Grand Haven area by sawdust and sawmill waste (MSBFC 1888).

Little Pigeon (Pine) Creek (42°58', 86°13'), In 1980, lake whitefish fry were collected at the creek mouth in March (Gulvas, pers. comm. 1980).

Port Sheldon (42°54', 86°13'). In 1978 and 1980, a few larvae, believed to be lake whitefish, were present in samples collected at the Campbell Power Plant (45°55', 86°12') in April and May (Jude et al. 1979a; Jude and Auer, pers. comm. 1980).

MM-8

Lake whitefish probably spawn in small numbers in suitable areas all along the southeast shore (Wells et al. 1971), and presumably the entire shoreline (41°46', 86°49'--42°46', 86°12') bordering Allegan, Van Buren, and Berrien counties is a nursery ground (Wells 1972).

Lake Macatawa (42°46', 86°13')--Kalamazoo River (42°40', 86°13'). In 1946-75, spawning occurred throughout the area, over rock and sand, from the shoreline out to a water depth of 50 ft (Organ et al. 1978).

Saugatuck (42°40', 86°12'). In the 1880s, Honey Comb Reef (42°39', 86°15'--42°36', 86°15'), about 1 mi SW of the mouth of the Kalamazoo River (42°40', 86°13'), was a good spawning ground for lake whitefish (Smith and Snell 1891). Spawning also occurred on a larger area of gravel and porous rock (precise location unknown) 4-6 mi SW of Saugatuck (MSBFC 1893). By 1890, no spawning had occurred at Saugatuck for 3-4 years (MSBFC 1890). In 1971, a few ripe adults were captured at Saugatuck Reef (Honey Comb Reef) in the fall (Wells 1972; Wells et al. 1971). Commercial fishermen reported that spawning occurred on the reef from 1934 to 1977 (Organ et al. 1978). The area near Saugatuck Reef may be one of the more important nursery areas along the southeast shore of Lake Michigan (Wells 1972).

Glenn (42°31*, 86°14'). Lake whitefish spawn in an offshore area (42°29', 86°20') about 2 mi S of Glenn over rock at depths of about 75-100 ft (Organ et al. 1978).

South Haven (42°24', 86°17'). Historically, lake whitefish did not spawn near South Haven (MSBFC 1890). Presently, spawning occurs along shore from the Palisades Power Plant (42°19', 86°19') north to South Haven over sand and rock at depths of about 18-70 ft (Organ et al. 1978).

St. Joseph (42°06', 86°29'). Prior to 1890, spawning occurred 8 mi sw of St. Joseph (MSBFC 1890). It was reported earlier that lake whitefish were being driven away from the area by sawdust and sawmill waste (MSBFC 1888).

Warren Dunes State Park (41°54', 86°37')--Grand Beach (41°46', 86°49') . Lake whitefish spawn along this shoreline to depths of about 40 ft. During 1945-68, they also spawned in an area (41°49', 86°51') off Grand Beach at depths of about 50-60 ft (Organ et al. 1978). In the late 1930s ripe-running fish were captured in late fall in a reef area (41°48', 86°59') about 10 mi W of Grand Beach at depths greater than 80 ft (Westerman, pers. comm. 1979). Spawning also occurs on the clay reef (41°52', 86°42') off Lakeside (41°51', 86°40'), and the area near the reef may be one of the more important nursery grounds along the southeast shore of Lake Michigan (Wells 1972).

BLOATER

In recent years, the chub population in Lake Michigan has been composed mainly of bloaters (Becker 1976). The bloater is generally common in Lake Michigan but is declining in some areas (Todd, pers. comm. 1981). The bloater spawns pelagically in the open lake at depths of about 198-396 ft, but usually at depths greater than about 240 ft; spawning occurs from January to March, and usually peaks in February (Brown, pers. comm. 1979; Daly et al. 1975; Emery and Brown 1978; Hile, pers. comm. 1979; Jobes 1949b; Koelz 1929; Lagler 1948; Walburg 1973; Wells 1980). A few spent adults have been collected as early as August (Jobes 1949b; WDNR 1974); most females are spent by April (Daly et al. 1975). The bloater probably spawned in deep water throughout the lake off most of the shipping ports (Koelz 1929) and used the entire pelagic zone of the lake as a nursery ground (Wells, pers. comm. 1979); most young-of-the-year (YOY) are found at mid-water (Brown and Wells 1976).

Wisconsin

WM-3

North Bay (45°09' 87°04'), Moonlight Bay (45°05', 87°05'), and Baileys Harbor (45°03', 87°07'). 'Larvae were seen here just after ice break-up in 1978 and 1979 (Copes, pers. comm. 1979).

WM-4

Kewaunee Power Plant (44°21', 87°32'). Coregonine larvae, presumed to be bloaters, were entrained at the plant (CDM/Limnetics 1977).

WM-5

Pigeon River (43°47', 87°43'). A few YOY about 3 in. long were collected just north of the mouth of the Pigeon River over clay substrate with cobbles and a few boulders to a depth of about 24 ft (LaJeone, pers. comm. 1979).

Port Washington (43°23', 87°52'). Spawning occurred off this port, and many ripe bloaters were caught in shallow water (Koelz 1929). Coregonine larvae, presumed to be bloaters, were entrained at the Port Washington Power Plant (43°23', 87°52') (CMD/Limnetics 1977).

Milwaukee (43°02', 87°54'). In 1919, spawning occurred off Milwaukee; spent and ripe fish were caught here in 300 ft of water in late March (Koelz 1929). In *1974-75,* eggs were collected during the winter in about *190* ft of water at approximately 43°00', 87°40' (Norden, pers. comm. *1979).* In *1976,* larvae were hatched from eggs stripped from ripe adults taken on Milwaukee Reef (42°59', 87°05'--43°11', 87°20') in early March (Janssen, pers. comm. 1979).

MM-8

Along the southeast shoreline of Lake Michigan, spawning or nursery grounds are rarely found in water less than 120 ft deep (Wells 1972).

Holland (42°47', 86°07')--South Haven (42°24', 86°17'). A commercial fisherman reported that spawning occurred in an area extending from the MM-7 district boundary at Holland to 4 mi W of South Haven. Spawning occurs over mud, sand, and clay at depths of 120-360 ft in late December to March (Organ et al. 1978). In 1964, bloaters began hatching in the Saugatuck area (42°40', 86°12') in early April, and peak hatching occurred in mid-June. Maximum numbers of larvae were collected in late June and early July, and densities rapidly declined to zero in mid-October. Most larvae were found near bottom in deep water. The highest densities were in 300-360 ft of water; 83% of all larvae were found at depths of 240-360 ft, and 96% of the bloater larvae were taken in water where the temperature did not exceed about 41°F (Wells 1966).

Bridgman (41°56', 86°35'). In 1921, spawning and nearly ripe fish were collected approximately 21 mi W (41°55', 87°00') and 30 mi W (41°59', 87°08') of Bridgman, in 168 and 180 ft of water respectively, in early March (Koelz 1929). Spawning is believed to occur in the winter (Jude, pers. comm. 1979) in deep water at unknown locations (Jude et al. 1975). Young-of-the-year were collected at depths of 20 and 30 ft in late fall (Jude et al. 1979b). Unidentified coregonine larvae, presumed to be bloaters, have been collected during April and May at depths of 70 ft. Since 1977, many YOY have been collected here; this is probably a nursery area for larger YOY (Jude and Thurber, pers. comm. 1979).

DEEPWATER CISCO

The deepwater cisco is believed to be extinct in Lake Michigan (Todd, pers. comm. 1981). The last recorded capture in Lake Michigan occurred in Grand Traverse Bay, Michigan, in June 1951 (Todd 1978). This species spawned in August and September in Lake Michigan (Koelz 1929).

Wisconsin

WM-2

Rock Island (45°25', 86°49'). In 1920, mature males with pearl organs were taken at depths of 420-546 ft off Rock Island in mid-August (Koelz 1929).

WM-6

Kenosha (42°35', 87°49'). Spawning occurred off Kenosha (Brown 1970a), and in 1969 eggs were collected from ripe adults captured 4 mi E of Kenosha in February (Edsall, Rottiers, and Brown 1970).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In August and September 1978, many YOY were found near the Waukegan Generating Station (42°23', 87°49') over a substrate of fine sand with a few rocks at depths of 30 ft or less; YOY were particularly abundant at the Wisconsin-Illinois border (42°29', 87°48') (LaJeone, pers. comm. 1979).

Michigan

MM-2

Point Aux Bargues (45°48', 86°21'). Spawning occurred in the spring, over mud, in water 300-360 ft deep about 15 mi SSE of Point Aux Bargues (Organ et al. 1978).

MM-3

Big Rock Point (45°22', 85°12'). Coregonine larvae, presumed to be bloaters, were entrained at the Big Rock Power Plant (45°22', 85°12') (CDM/Limnetics 1977).

MM-7

Duck Lake (43°20', 86°24')--Holland (42°47', 86°07'). A commercial fisherman reported that spawning occurred in an area extending from about 8 mi W of Duck Lake south to the MM-8 district boundary at Holland. Spawning occurs over mud, sand, and clay at depths of 120-360 ft in late December to March (Organ et al. 1978). In 1919, spent and ripe fish were caught at a location 12 mi W of Grand Haven (43°04', 86°13') in 300-330 ft of water on March 20 (Koelz 1929). Bloaters probably spawn in the deeper waters off Port Sheldon (42°54', 86°13') (Jude et al. 1978, 1979a; Jude, pers. comm. 1979). Collections of YOY in the fall indicated that significant spawning had occurred somewhere in the area earlier in the year (Jude et al. 1978, 1979a). Three ripe females and one ripe male were collected in June and July in shallow water. One larva was found on June 18 in 50 ft of water about 2 mi S of Port Sheldon (Jude et al. 1978). A few larvae, believed to be bloaters, were collected in June 1977 and 1978 and in July and August 1980 (Jude and Auer, pers. comm. 1980).

KIYI

The kiyi is believed to be extinct in Lake Michigan (Todd, pers. comm. 1981). The last reported capture of kiyi in Lake Michigan occurred near Milwaukee, Wisconsin, on September 11, 1974 (Todd 1978). In Lake Michigan, kiyi spawned from late September through at least mid-November, and peak spawning usually occurred from mid-October to early November (Hile and Deason 1947; Lagler 1948). Kiyi spawned at depths of approximately 300-540 ft (Hile, pers. comm. 1979; Hile and Deason 1947). Spawning may have occurred in all areas of the lake at suitable depths (Hile and Deason 1947). The spawning substrate was typically mud (Hile, pers. comm. 1979). The following locations were identified as spawning grounds based on collections of ripe and spent fish.

Wisconsin

WM-4

Kewaunee (44°27', 87°30'). Spawning occurred here in October (Deason and Hile 1947). In 1931, spawning occurred at a location (44°25', 87°15') 7-12 mi off Kewaunee in 438-558 ft of water, from at least October 15 to November 5 (Hile and Deason 1947).

WM-5

Sheboygan (43°45', 87°42'). In 1931, spawning fish were collected at a location (43°40', 87°28') about 13 mi off Sheboygan, in 426 ft of water from late October to mid-November (Hile and Deason 1947).

WM-6

Racine (42°44', 87°47'). A spawning run occurred here in October (Deason and Hile 1947). In 1931, ripe and spent fish were collected at a location about 22 mi off Racine at a depth of 360 ft, from late September to late October (Hile and Deason 1947).

Indiana

Michigan City (41°43', 86°54'). In 1920, two pearled males were caught here on October 11, and a spent female and many fish that had not yet spawned were collected on November 8 (Koelz 1929).

Michigan

MM-5

Frankfort (44°38', 86°14'). In 1929, spawning kiyi were taken in October on the "northwest shoal" (44°45', 86°26') about 12 mi NW of Frankfort, at a depth of 420 ft (Koelz 1929). Large numbers of fish were also caught during the spawning season in an area (44°35', 86°20') about 5 mi off Frankfort at a depth of about 474 ft (Hile and Deason 1947).

MM-6

Ludington (43°57', 86°28'). Many fish were caught during the spawning season (about October 1) at a location (43°56', 86°40') off Ludington at a depth of 366 ft; although the gonads of the fish were not examined, the large catch indicated that this was probably a spawning ground (Hile and Deason 1947).

MM-7

Muskegon (43°13', 86°17'). In 1931, ripe and spent fish were collected about 11 mi WSW of Muskegon at approximately 43°10', 86°34' in 348 ft of water on September 29 (Hile and Deason 1947).

BLACKFIN CISCO

The blackfin cisco is believed to be extinct in all the Great Lakes (Todd, pers. comm. 1981). The last recorded capture of blackfin cisco in Lake Michigan occurred at Marinette, Wisconsin, on May 26, 1969 (Todd 1978). The blackfin cisco spawned on stony substrate (Smith and Snell 1891) between October and March, primarily in December and January (Koelz 1929; MSBFC 1887; Smith and Snell 1891). he blackfin cisco did not move to shoal water to spawn (MSBFC 1887).

Wisconsin

WM-6

Racine (42°44', 87°47'). Spawning occurred at an unnamed location (42°43', 87°10') about 30 mi E of Racine, in 360-540 ft of water, from late December to early January (Koelz 1929).

Michigan

MM-1

Escanaba (45°45', 87°04'). A run evidently occurred in Little Bay de Noc (45°45', 87°00'); fish generally were not found in the bay until

mid-October, after which they constituted a large part of the catch (Smith and Snell 1891).

MM-4

Grand Traverse Bay (45°05', 85°30'). Many blackfin ciscoes spawned here over mud and clay bottom in 90-180 ft of water in late fall and winter (Smith and Snell 1891).

MM-6

Manistee (44°15', 86°20'). Spawning occurred at an unnamed area (44°14', 86°30'--44°14', 86°27') 5-8 mi W of Manistee on clay in 240-480 ft of water from late December to early January (Koelz 1929). They first appeared in the area on about November 1 and increased to peak abundance in December. Most fishing was carried out at depths of 360-480 ft. In the spring, the fish moved back to water 600-660 ft deep (Smith and Snell 1891).

MM-8

Saugatuck (42°40', 86°12'). Spawning occurred at an unnamed area (42°42', 86°44'--42°42', 86°50') 25-30 mi W of Saugatuck over mud in 360-480 ft of water (Organ et al. 1978).

SHORTNOSE CISCO

This species is believed to be extinct in Lake Michigan (Todd, pers. comm. 1981). The last recorded capture of the shortnose cisco in Lake Michigan occurred near Ludington, Michigan, on May 18, 1972 (Todd 1978). In Lake Michigan, the shortnose cisco generally spawned from April through June, but some spawning did not occur until September (Brown, pers. comm. 1979; Jobes 1943; Koelz 1929; Lagler 1948). Two ripe adults were collected in May during the late 1960s (Brown, pers. comm. 1979). The location of spawning grounds was deduced from catches of ripe and spent adults. During the spawning season, the shortnose cisco was found at depths of 72-582 ft, but usually at 120-474 ft in lower Lake Michigan, 180-354 ft in the upper lake, and less than 150 ft in Green Bay (45°05', 87°25') (Jobes 1943). Spawning occurred at water temperatures of 39-40°F over a -wide variety of substrates, including clay, silt, sand, and muddy sand (Jobes 1943; Koelz 1929). The following areas were spawning grounds.

Wisconsin

WM-1

Sturgeon Bay (44°53', 87°24') (Koelz 1929).

WM-2

Washington Island (45°23', 86°54'). East of the island (Jobes 1943).

WM-4

Algoma (44°37', 87°26') (Koelz 1949).

WM-5

Sheboygan (43°45', 87°42'). In 1931, a spawning run occurred in early May at depths of 330-390 ft (Jobes 1943).

Port Washington (43°23', 87°52'). In 1921, a heavy run was reported 3-4 mi ENE of Port Washington (43°24', 87°46') over muddy sand at depths of 84-210 ft; spawning began in the last week of April and continued until mid-June (Koelz 1929).

Milwaukee (43°02', 87°54') (Koelz 1929).

WM-6

Racine (42°44', 87°47'). In 1931, a run occurred at depths of 216-240 ft in late May (Jobes 1943).

Indiana

Michigan City (41°43', 86°54') (Koelz 1929).

Michigan

MM-2

Manistique (45°57', 86°15') (Jobes 1943).

MM-3

Charlevoix (45°19', 85°15') (Jobes 1943).

MM-4

Northport (45°08', 85°37') (Koelz 1929).

MM-6

Ludington (43°57', 86°28'). In 1931, runs occurred at depths of 180-204 ft and 450-480 ft from mid-may to late June (Jobes 1943). In 1972, a few spent males with spawning tubercles were collected at Ludington on May 18 (Brown, pers. comm. 1979; Todd, pers. corn. 1981).

MM-7

Grand Haven (43°04', 86°13'). In 1931, runs occurred at depths of 168-192 ft and 300-342 ft in late May and early June (Jobes 1943).

MM-8

St. Joseph (42°06', 86°29'). In 1931, runs occurred at depths of 180-198 ft and 282-288 ft in mid- to late May (Jobes 1943).

SHORTJAW CISCO

This species is believed to be extinct in Lake Michigan (Todd, pers. comm. 1981). The last recorded capture in Lake Michigan occurred at Racine, Wisconsin, on September 23, 1975 (Todd 1978). The shortjaw cisco is now considered to be taxonomically synonymous with the longjaw cisco (Todd and Smith, unpubl. data). In Lake Michigan, the shortjaw cisco spawned over a period of about 2 weeks in October or November (Koelz 1929). All of the known spawning grounds were in 60-180 ft of water and had sand and clay substrate (Koelz 1929). Fishermen reported that the depth of spawning varied with weather conditions; in calm weather, the fish spawned in shallower water. The entire area between Port Washington (43°23', 87°52') and Grand Haven (43°04', 86°13') was believed to have been a spawning area (Koelz 1929). Spawning occurred off the following ports.

Wisconsin

WM-5

Port Washington (43°23', 87°52') and Milwaukee (43°02', 87°54*) (Koelz 1929).

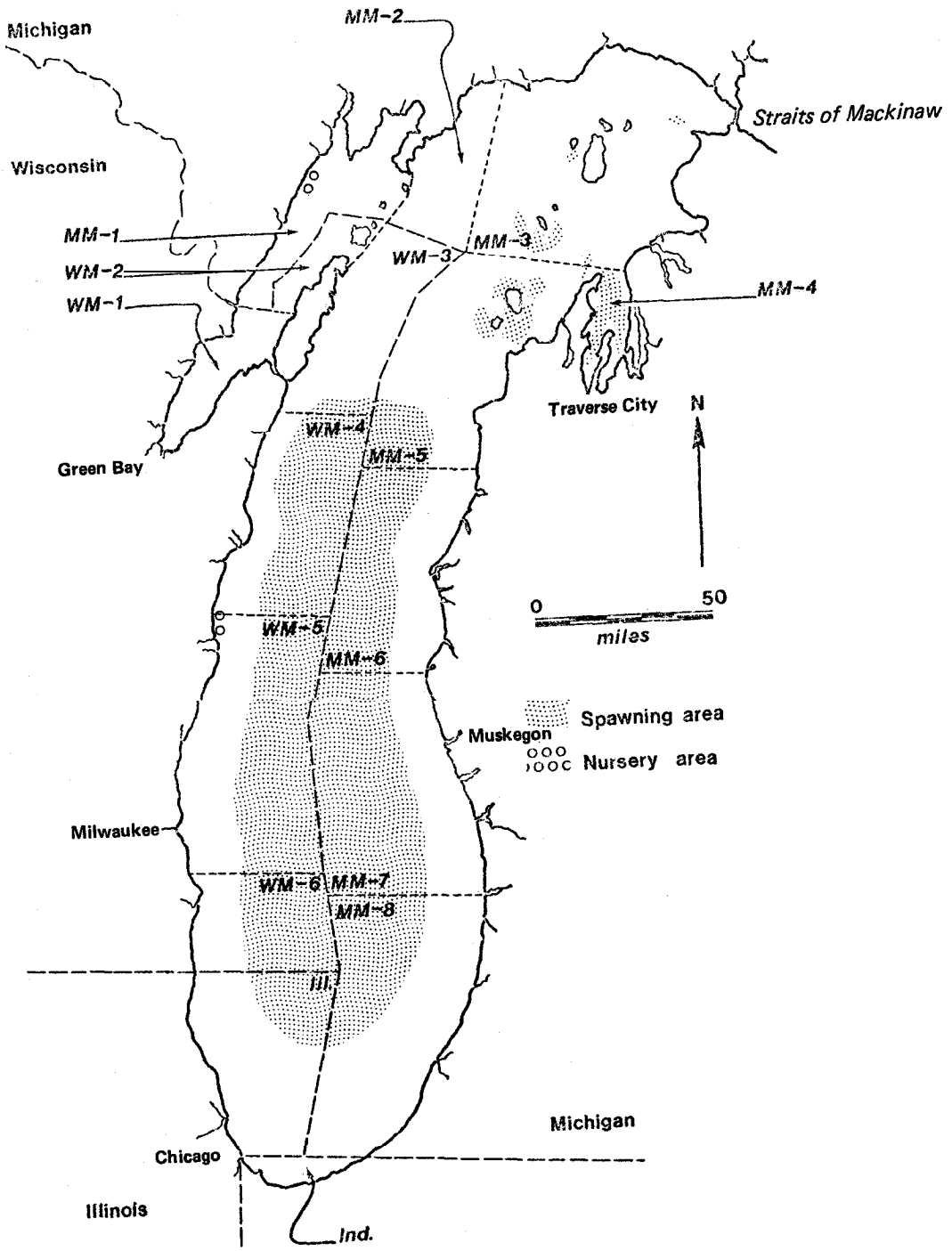
Indiana

Michigan City (41°43', 86°54') (Koelz 1929).

Michigan

MM-7

Grand Haven (43°04', 86°13') (Koelz 1929).


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Traverse City
N
WM-4
MM-5
Green Bay
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
Ill.
Michigan
Chicago
Illinois
Ind.

Most commercial fishermen do not distinguish among the several species of chubs found in their nets. Areas used by chubs for spawning are difficult to identify precisely because the fishermen often describe large general areas that include a wide range of depths. One fisherman identified the chub spawning areas as being any locations with pea-sized gravel, usually where the waters are 180-300 ft deep (Organ et al. 1978).

Wisconsin

WM-5

Pigeon River (43°47', 87°43'). A few young-of-the-year about 3 in. long were collected near the mouth of the river. These were either lake herring or bloater. The substrate in the area is hard clay and cobble with a few boulders (LaJeone, pers. comm. *1979).*

Sheboygan (43°45', 87°42'). In 1977, one early postlarva of an unidentified coregonine was captured near the Edgewater Power Plant (43°43', 87°42') in late July (Swanson Environ. 1979).

Milwaukee Reef (42°59', 87°05'--43°11', 87°20')--Sheboygan Reef (43°14', 87°10'--43°27', 87°10'). Until about 1958, this area supported chub spawning. The substrate was clay, mud, some rock, honeycombed rock, and "clinkers" (combusted coal waste) at depths of 252-480 ft (Organ et al. 1978).

Michigan

MM-1

Bark River (45°34', 87°14'). Larvae of an unidentified coregonine were collected off the mouth of the river in late April to late May (Wis. Elec. Power, unpubl. data).

MM-3

South Fox Island Shoals (45°18', 85°51'). In 1954-78, spawning occurred over mud bottom in an area (45°20', 85°48'--45°15', 85°50') about 2 mi off the east side of the shoals; in a V-shaped area (45°15', 85°54'-- 45°13', 85°52' and 45°15', 85°50'--45°13', 85°52') extending south: in a V-shaped area (45°17', 85°59') about 6 mi to the west, and in a strip about 15 mi W of the shoals (Organ et al. 1978).

High Island (45°44', 85°40'). Spawning occurs in an area (45°43', 85°45'--45°39', 85°45') between High Island, Gull Island Reef (45°38', 85°48'), and Beaver Island (45°40', 85°33'); spawning takes place over clay, mud, and rock in November and December (Organ et al. 1978).

Simmons Reef (45°55', 85°12'). Spawning occurs just south of the reef (Organ et al. 1978).

Cat Head Reef (45°18', 85°33'). Fishermen have identified the area (45°17', 85°35'--45°14', 85°35') southwest of the reef as a spawning area (Organ et al. 1978).

MM-4

Grand Traverse Bay (45°05', 85°30'). In about 1869, an unidentified chub spawned along the shores of the bay in November (Koelz 1929). Between 1935 and 1968, spawning occurred in most of the bay over mud, at depths of 240-600 ft, in November and December. Fishermen have identified the central portions of both the east and west arms of the bay as spawning areas (Organ et al. 1978).

MM-5

Manitou Islands (45°04', 86°03'). As early as 1916, spawning occurred in many areas around the islands over mud and sand, at depths of about 100-600 ft, from November to February. Areas identified include an area (45°09', 85°57') east of North Manitou Island at depths of 210-360 ft; an area (45°06', 85°48') 9 mi E of North Manitou at depths of 500-600 ft; an area (45°01', 85°55'--45°05', 85°51') over mud north of Pyramid Point Shoal (44°59', 85°55') a mud and sand strip (45°06', 86°06'--45°11', 86°02') about 1 mi off the northwest shore of North Manitou (45°07', 86°01'); a mud and sand area (45°03, 86°03'--44°59', 86°03) about 2 mi off the east shore of South Manitou Island; a large mud and sand area (44°57', 86°02') about 7 mi in diameter between South Manitou Island and Sleeping Bear Bay (44°55', 86°00'); and a mud strip (45°06', 86°16'--44°55', 86°18') about 12 mi long running north to south about 6 mi W of South Manitou Island (45°01', 86°08') at depths of 300-600 ft (Organ et al. 1978). In 1952, fry of either bloater or shortnose cisco were caught by dip net in open water at an unidentified location near North Manitou Island in late July (Smith 1954, 1956).

MM-6

Point Betsie (44°42', 86°15')--Stony Lake (43°34', 86°30'). Spawning occurred throughout this entire area, over mud at depths greater than 190 ft, in January to mid-February (Organ et al. 1978).

MM-7

Stony Lake (43°34', 86°30')--Holland (42°47', 86°07'). From the 1940s to 1970s, spawning occurred along this entire shoreline at depths greater than 180 ft, over mud, silt, sand, and clay, mainly in October and November (Organ et al. 1978).

MM-8

Holland (42°47', 86°07')--South Haven (42°24', 86°17'). From the 1940s to 1970s, spawning occurred along this entire shoreline at depths greater than 180 ft, over mud, silt, sand, and clay, mainly in October and November (Organ et al. 1978).

South Haven (42°24', 86°17')--Indiana state line (41°46', 86°49'). From the 1930s to 1960s, chubs spawned 10 mi offshore in waters deeper than 180 ft, over clay, mud, and silt during October and November (Organ et al. 1978).

PINK SALMON

Pink salmon were introduced into Lake Superior in 1956 (Parsons 1973). In 1973, the first pink salmon appeared in northern Lake Michigan, and spawning runs have since been observed in odd-numbered years (North Woods Call 1979l). Adults usually spawn in streams at the first suitable gravel area upstream from the mouth, during September (Wagner 1974a, 1976b). Relatively small spawning runs have entered the following tributaries to Green Bay (45°05', 87°25') and northern Lake Michigan.

Wisconsin

WM-1

Menominee River (45°06' , 87°35'). Spawning runs occur (North Woods Call 1979j).

MM-1

Cedar River (45°24', 87°21'). In 1977 and 1979 (North Woods Call 1979j; Wagner 1977, 1979).

Pord River (45°40', 87°08'). One adult was caught in 1973 (Wagner 1974a).

MM-2

Thompson Creek (45°54', 86°19'). In 1973 and 1977 (Wagner 1974a, 1977).

Manistique River (45°57', 86°15'). In 1973 (Wagner 1974a).

MM-3

Point Patterson Creek (45°58', 85°40'). In 1975 (Wagner 1976a,b).

Crow River (46°02', 85°36'). In 1975 and 1979 (Wagner 1976a,b, 1979).

Rock River (46°05', 85°32'). In 1975 and 1977 (Wagner 1976a,b, 1977).

Black River (46°06', 85°21'). In 1973, 1975, 1977, and 1979 (Wagner 1974a, 1976a,b, 1977, 1979).

Cut River (46°03', 85°07') and Hog Island Creek (46°04', 85°17'). In 1975 (Wagner 1976a,b).

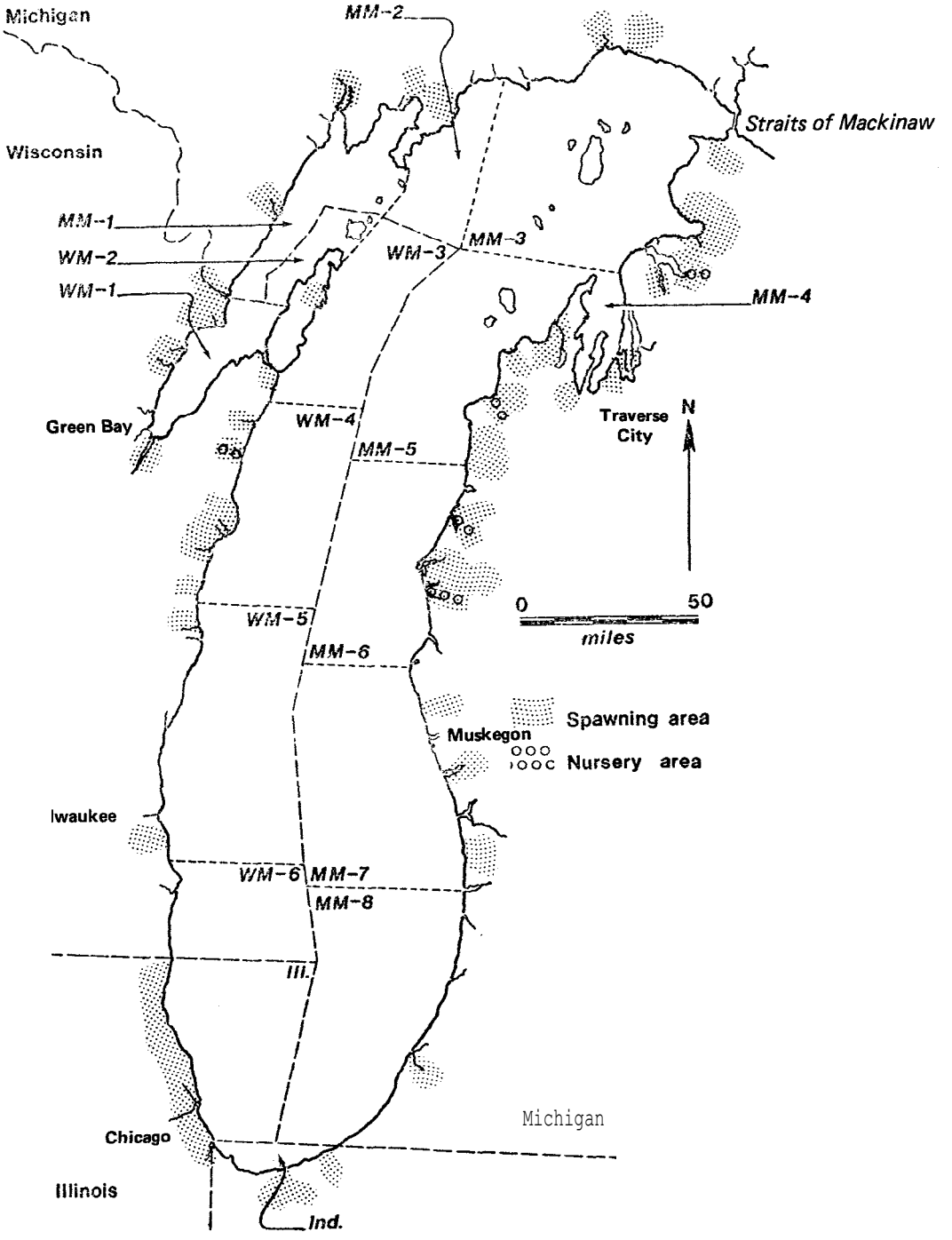
Big Sucker Creek (45°44', 84°57'), Little Sucker Creek (45°44', 84°57'), and Wycamp Creek (45°39', 85°01). In 1975 (Richey 1976).

Emmet County (45°47', 84*44'--45°22', 85°06'). Many streams in the county are believed to have pink salmon spawning runs (North Woods Call 1979j).

MM-5

Crystal River (44°55', 85°58'). In 1977, pink salmon were caught near the mouth of the river (Wagner 1978a).

COHO SALMON


Michigan
Wisconsin
MM-2
Straits of Mackinaw
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Green Bay
WM-4
MM-5
Traverse City
N
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
lwaukee
WM-6
MM-7
MM-8
III.
Michigan
Chicago
Illinois
Ind.

Annual plantings of coho salmon in Lake Michigan since 1966 (Daly et al. 1975; GLFC 1973a,b, 1975, 1976, 1978; Parsons 1973; Wells and McLain 1973; WDNR, unpubl. data) have produced fall spawning runs in a number of Lake Michigan tributaries, and self-sustaining populations are established in some areas (Becker 1976; MDNR 1970; Taube 1974a). The first reported spawning runs of coho salmon from Lake Michigan occurred in the Big Manistee (44°15′, 86°18') and Platte (44°44', 86°09') rivers in 1966 (MDNR 1970). Adults generally concentrate off stream mouths in late summer and early fall before entering streams to spawn; average bottom temperatures in the beach zones range from about 69°F in August to 58°F in September (GLFL 1970). Generally, spawning runs peak in September and October (Walburg 1973). Many Lake Michigan streams are not suitable for reproduction because of heavy siltation, a lack of gravel substrate, and poor water quality. About 2-8% of stocked fish are recovered in spawning migrations, and 95% of these are recovered in the streams in which they were released (Hasler et al. 1978).

Wisconsin

In Wisconsin tributaries of Lake Michigan, the most important factor restricting natural reproduction is the lack of suitable spawning substrate. Other limiting factors include prolonged cold water temperatures, unstable stream discharges, and superimposition of redds (Avery 1974).

WM-1

Coho salmon spawn in Green Bay (45°05', 87°25') tributaries in October and December (Belonger and Kernen, pers. comm. 1979). Stocked coho salmon spawn in the following tributaries.

Menominee River (45°06', 87°35'). Fall runs of stray fish occur (Belonqer and Kernen, pers. comm. 1979).

Little River (45°03', 87°38') (Belonger and Kernen, pers. comm. 1979).

Peshtigo River (44°58', 87°39'). Fall runs of stray fish occur (Belonger and Kernen, pers. comm. 1979).

Oconto River (44°54', 87°50'). Fall runs of stray fish occur (Belonger and Kernen, pers comm. 1979; Carlson et al. 1977).

Pensaukee River (44°49', 87°54') and Fox River (44°32', 88°00). Fall runs of stray fish occur (Belonger and Kernen, pers. comm. 1979).

Sturgeon Bay (44°53', 87°24'). In 1973, fish tagged at Point Beach (44°17′, 87°32') on October 24 were recaptured in Sturgeon Bay on October 30 (Spigarelli, unpubl. data). Coho salmon stocked as juveniles return to spawn in Strawberry Creek (44°49', 87°22') (Belonger and Kernen, pers. comm. 1979; MDNR 1970).

WM-3

Three Springs Creek (45°09', 87°04'). Spawning runs, redd building, and egg laying have been observed in this creek, which empties into North Bay (45°09', 87°04'). The stream bottom is sand, which silts over in the winter, and it is doubtful that successful natural reproduction occurs (Frederick, pers. comm. 1979).

Reiboldt Creek (45°06', 87°05') (MDNR 1970).

Woodard Creek (44°45', 87°20'). In 1974, fish tagged at Point Beach (44°17', 87°32') on October 16 were recaptured in Woodard Creek on November 26 (Spigarelli, unpubl. data).

WM-4

Ahnapee River (44°36', 87°26'). Stocked fish return to spawn here from October through December (Kernen, pers. comm. 1979).

Kewaunee River (44°28', 87°30'). Stocked fish return to spawn in the river from October through December (Kernen, pers. comm. 1979). Migrations of maturing coho salmon occur near the Kewaunee Power Plant (44°21', 87°32') (Spigarelli and Thommes 1976; Wis. Public Serv. Corp. 1971). A few ripe adults have been collected in the area near the plant when they congregate around river mouths. The substrate in this area is hard clay and cobble-size rock (LaJeone, pers. comm. 1979). Natural reproduction occurs in Little Scarboro Creek, a tributary of the Kewaunee River (Kernen, pers. comm. 1979). Spawning fish were observed in this creek in late October; many were present by the first week in November. The bottom type is mostly sand and gravel, and natural reproduction is severely limited by the high amount of fine substrate (Cloern 1973, 1976). Studies of Little Scarboro Creek from July 1971 to April 1973 revealed that mature coho salmon began to migrate into the creek in late October and spawning peaked in November. Water temperatures during the winter varied from 32 to 36°F, and eggs hatched in 145-150 days in early April. Young-of-the-year (YOY) averaged 3.6 in. in length by early September and began migrating downstream in August (Avery 1974; Cloern 1976).

Point Beach Power Plant (44°17', 87°32'). In 1971, large numbers of adult coho salmon appeared in the vicinity of the plant during the first week of September (Reed 1972). In 1976, the largest numbers of adults were caught in September and October (Spigarelli and Thommes 1976; Wis. Elec. Power and Wis.-Mich. Power, undated c).

East and West Twin Rivers (44°09, 87°34'). Stocked coho salmon return to spawn in both rivers from October to December (Hanson and Kernen, pers. comm. 1979). Catches in Two Rivers Harbor (44°09', 87°34') peaked in September prior to major fall spawning runs (Spigarelli and Thommes 1976).

Manitowoc (44°05', 87°39'). Both the Manitowoc (44°05', 87°39') and Little Manitowoc (44°06', 87°39') rivers have runs of stocked coho salmon from October to December (Hanson and Kernen, pers. comm. 1979).

Fischer Creek (43°56', 87°43'). Natural reproduction has occurred in this stream.(Belonger and Kernen, pers. comm. 1979). Spawning runs begin in late October, and spawning peaks in November. In 1972, redds were observed on November 9. Water temperatures during the winter ranged from 30 to 35°F. Eggs collected from redds have hatched in 145-150 days in early April (Avery 1974, Cloern 1973, 1976). Substrate in the creek is muck and silt near' the mouth and clay, rubble, and gravel in the upper reaches (Cloern 1973, 1976).

WM-5

Haven (43°51', 87°44'). Ripe adults moving inshore were collected over a hard clay and cobble rock substrate with scattered boulders. Adults congregate around the mouths of rivers and in rivers during October (LaJeone, pers. comm. 1979).

Sheboygan River (43°45', 87°42'). Coho salmon are found in the river into early winter (Swanson Environ. 1979).

Oak Creek (42°54', 87°51'). Spawning runs enter Oak Creek; fish also congregate in the area of the Oak Creek Power Plant (42°51', 87°50') during the fall (Limnetics 1974; Schultz et al. 1973; Wis. Elec. Power 1975b).

Illinois

Runs of stocked coho salmon enter all of the harbors along the shore (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°20', 87°50'). Ripe adults were collected in this area over a fine sand substrate with a few scattered rocks (LaJeone, pers. comm. 1979).

Indiana

Gary (41°37', 87°20'). In 1975, coho salmon collected at the Mitchell Power Station (41°38', 87°22') in November were in spawning condition (NALCO 1976a).

Burns Waterway (41°38', 87°10'). Stocked fish migrate into the Little Calumet River (41°37', 87°10') via the waterway to spawn during September to November (Koch, pers. comm. 1979). In 1969, natural reproduction was observed in the Little Calumet River in October and November (GLFC 1970b).

Bailly Generating Station (41°39', 87°07'). In *1974*, two ripe males were collected in the immediate vicinity of the plant in September and October (Tex. Instrum. 1975b).

Trail Creek (41°44', 86°54'). Coho salmon spawn in Trail Creek from October to December (Koch, pers. comm. 1979). In 1969, natural reproduction was observed in Trail Creek in October and November (GLFC 1970b).

Michigan

By 1970, coho salmon had strayed extensively from the original planting sites, and relatively large spawning runs entered most of the Michigan tributaries of Lake Michigan (MDNR 1970; Parsons 1973).

MM-1

Cedar River (45°24', 87°21') (MDNR 1970).

Whitefish River (45°55', 86°57') (Parsons 1973). Some successful natural reproduction occurs (Beeker 1976).

Fishdam River (45°54', 86°35'). Some successful natural reproduction occurs (Becker 1976).

MM-2

Bursaw Creek (45°50', 86°20') (MDNR 1970).

Thompson Creek (45°54', 86°19') (MDNR 1970; North Woods Call 1980a; Parsons 1973).

MM-3

Rock River (46°05', 85°32') (FWS 1979c).

Black River (46°06', 85°21'). Some natural reproduction occurs (Becker 1976).

Carp Lake River (45°45', 84°50'). In 1967, spawning runs entered the Carp Lake River (MDNR 1970).

Little Traverse Bay (45°24', 85°00'). Spawning runs enter the Bear River (45°23', 84°58'), Tannery Creek (45°23', 84°55'), Roaring Brook Creek (45°25', 84°56'), and Fivemile Creek (45°26', 85°02') (GLFC 1970b; MDNR 1970).

Lake Charlevoix (45°17', 85°10'). Spawning runs enter Porter (45°13', 85°04'), Page (Charlevoix County), Dyer (45°13', 85°04'), Horton (45°17', 85°05'), and Woods (45°19', 85°12') creeks and the Boyne River (45°13', 85°01') (MDNR 1970). A run also proceeds to the upper reaches of the Jordan River (45°09', 85°80') (Quick 1971). In 1978, fingerlings were found in the Boyne River (Galbraith 1978).

MM-4

Grand Traverse Bay (45°05', 85°30'). In 1967, Elk River (44°54', 85°25') and Yuba Creek (44°49', 85°28') had spawning runs (MDNR 1970). In 1968, spawning occurred in Brewery Creek (44°48', 85°38') (Parsons 1973).

MM-5

Leland (Carp) River (45°01', 85°46'), Good Harbor Creek (44°57', 85°49'), Shalda (Sucker) Creek (44°57', 85°53'), Crystal River (44°55', 85°58'), and Otter Creek (44°46', 86°04') (MDNR 1970).

Platte River (44°44', 86°09'). Stocked coho salmon returned to the Platte River to spawn (Hildebrand 1971; MDNR 1970; Parsons 1973, 1975; Reinert and Bergman 1974; Rybicki 1973; Rybicki and Keller 1976; Rybicki et al. 1975; Stauffer 1970, 1971, 1973; Taube 1969, 1971a,b, 1972, 1973, 1974a,c, 1975; Tody 1970). Spawning runs begin as early as mid-October and end as late as the end of January; runs peak anytime from October 25 to November 5 (Hildebrand 1971; MDNR 1970; Parsons 1975). In 1979, coho salmon schooled in Platte Bay (44°45', 86°07') in late August (Crowe 1979a). In 1970, coho salmon were collected on November 3 during the spawning run at a water temperature of 40-50°F (Stauffer 1971a). Successful natural reproduction has occurred every year since 1967 (Taube 1971b, 1972, 1973). Young remain in the Platte River for about one year and then migrate to the lake. Most return in about 18 months to spawn (Taube 1974a,c, 1975).

Betsie River (44°37', 86°13') (MDNR 1970). In 1979, coho salmon schooled off the mouth of the river in late‘ August (Crowe 1979a).

Herrinq Creek (44°34', 86°13') and Arcadia Creek (44°29', 86°15') (MDNR 1970).

MM-6

Manistee (44°15', 86°20'). Stocked fish return to the Big Manistee (44°15', 86°18') and Little Manistee (44°13', 86°16') rivers to spawn (MDNR 1970; Parsons 1973; Rybicki 1973; Rybicki and Keller 1976; Tody 1970). Extensive spawning runs proceed up the Big Manistee River and enter Pine Creek; choice spawning areas here are used repeatedly throughout the spawning period that lasts at least 90 days (Merna 1979). In 1977-79, YOY were found in Pine Creek during early May to early June (Carl 1977, 1978, 1979). Runs peak in Bear Creek, a stocked tributary of the Big Manistee River, from late September to mid-October (MDNR 1970; Taube 1975). In 1979, coho salmon schooled in Lake Michigan off Manistee in August (Crowe 1979a).

Big Sable River (44°02', 86°30'). A spawning run enters this river (Rybicki 1973).

Ludington (43°57′, 86°28′). In 1979, coho salmon schooled off Ludington in late August (Crowe 1979a). Peak collections near the rock jetties of the Ludington Pumped Storage Plant {43°54', 86°27') are made from mid-September through October during spawning runs (Brazo, pers. comm. 1979; Brazo and Liston 1977). Natural reproduction occurs in most of the streams in the vicinity, especially in the Pere Marquette River (43°56′, 86°26') and the Lincoln River (43°59', 86°28') (Brazo, pers. comm. 1979; FWS 1979d). Most of the streams in Mason County have good concentrations of naturally spawned YOY (Brazo, pers. comm. 1979). Runs have been reported in the Pere Marquette River and its tributaries, including Sanborn Creek, Baldwin Creek, and Big South Branch (MDNR 1970).

Pentwater (43°47', 86°26'). In 1979, coho salmon schooled off Pentwater in late August (Crowe 1979a), and runs may enter the Pentwater River (43°46', 86°24′) (Brazo, pers. comm. 1979).

MM-7

Stony Creek (43°34', 86°30'). Runs occur (Borgeson 1967).

Muskegon (43°13', 86°17'). Coho salmon enter and spawn successfully in the Muskegon River (43°15′, 86°15') in October (Consumers Power 1976f; Crowe 1979a; FWS 1979d; MDNR 1970). Extensive spawning runs proceed up the river and enter Bigelow Creek, Newaygo County; choice spawning areas in the creek are used repeatedly throughout the spawning season, which lasts at least 90 days (Merna 1979).

Port Sheldon (42°54', 86°13′), Adults migrate into the discharge canal of the Campbell Power Plant (42°55', 86°12') in October and November. Smolts or yearlings were collected with beach seines approximately 1 mi N and S of the Pigeon River (42°54', 86°12') and at the former discharge canal of the plant; most of these were probably stocked fish (Heufelder, pers. comm. 1979).

MM-8

St. Joseph River (42°07', 86°29'). A spawning run occurs (Jude et al. 1975; Crowe 1979a).

Bridgman (41°56′, 86°35′). In 1973, many small coho salmon were seined in the beach zone near the Cook Power Plant (41°59', 86°34') in June (Jude et al. 1975). Stocked fingerlings are present in the beach zone (Jude et al. 1979b; Jude, pers. comm. 1979).

Chinook salmon were first introduced into Lake Michigan in 1873, but self-sustaining populations were not established (Parsons 1973). Annual plantings of chinook salmon in Lake Michigan since 1967 (Daly et al. 1975; GLFC 1973a,b, 1975, 1976, 1978; Parsons 1973) have produced fall spawning runs in a number of tributaries, and self-sustaining populations are established in some areas (Carl 1977, 1978, 1979). The first reported spawning runs of chinook salmon in the Great Lakes occurred in the Muskegon (43°15', 86°15') and Little Manistee (44°13', 86°16') rivers in 1970 (Parsons 1973).

Wisconsin

WM-1

Almost every major tributary of Green Bay (45°05', 87°25') has a spawning run during September and October. Redd building and egg deposition occur, but reproduction is usually not successful (Belonger and Kernen, pers. comm. 1979).

Menominee River (45°06', 87°35'). A run occurs (Belonger and Kernen, pers. comm. 1979). Chinook salmon enter the river, which forms the boundary between Wisconsin and Michigan, in late October; some of these fish were tagged earlier at the Point Beach Power Plant (44°17', 87°32') (Spigarelli, unpubl. data).

Little River (45°03', 87°38'), Peshtigo River (44°58', 87°39'), Oconto River (44°54', 87°50'), and Pensaukee River (44°49', 87°54'). Runs occur from stocked returns (Belonger and Kernen, pers. comm. 1979).

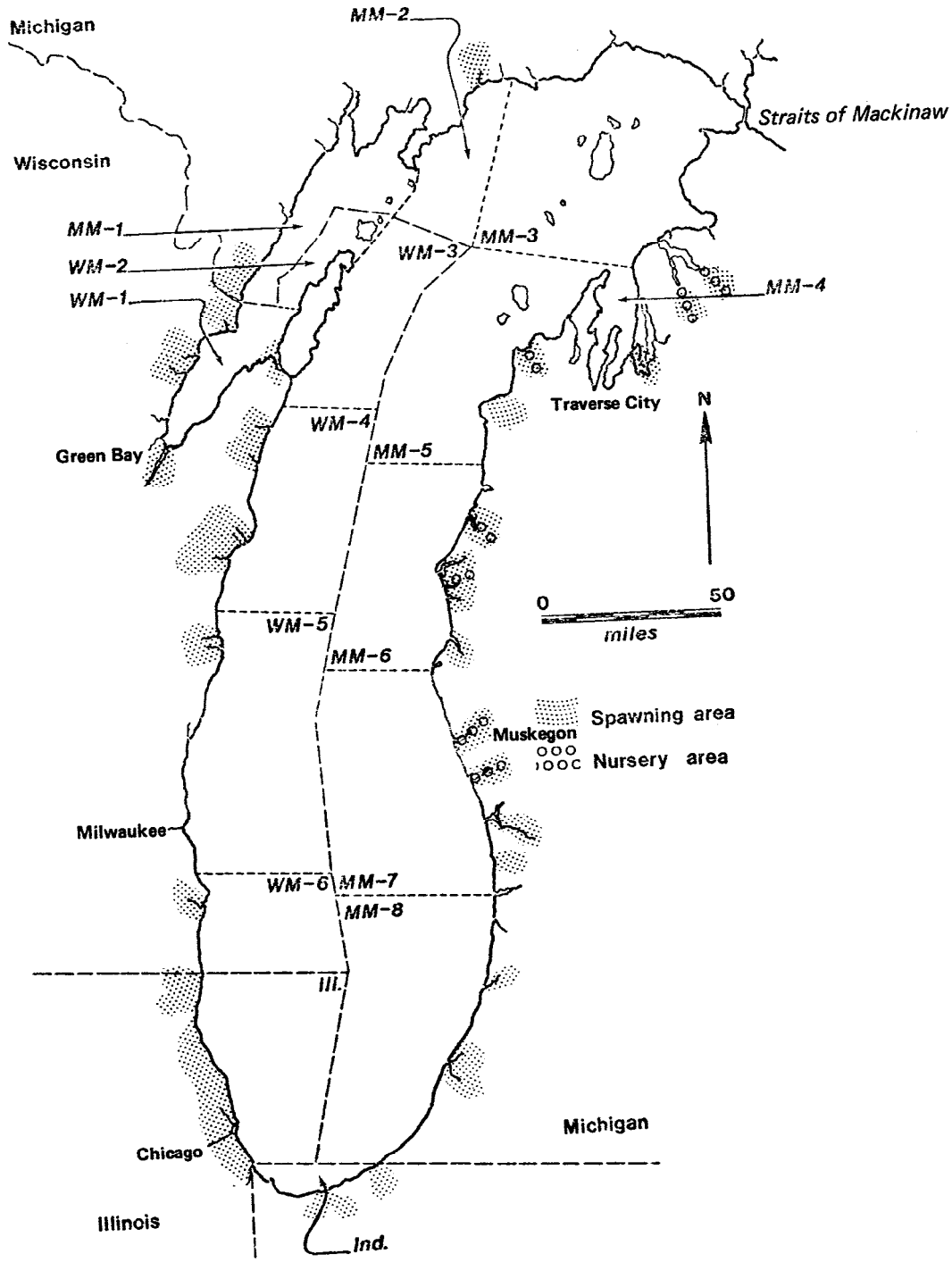
Fox River (44°32', 88°00'). A run occurs (Belonger and Kernen, pers. comm. 1979; FWS 1979d).

Sturgeon Bay (44°53', 87°24'). Young-of-the-year (YOY) are stocked in the bay and frequent the entire Lake Michigan shoreline (Kernen, pers. comm. 1979). Tagging studies show that adults move into the bay in late October and November from the Point Beach area (44°17', 87°32') (Spigarelli, unpubl. data). Runs enter Strawberry Creek (44°49', 87°22'), and 2-3 million eggs are collected annually from these fish (Kernen, pers. comm. 1979; WDNR 1974b).

WM-4

Ahnapee River (44°36', 87°26'). A run occurs (Kernen, pers. comm. 1979). Tagging studies show that adults move into the river in September and October from the Point Beach area (44°17', 87°32') (Spigarelli, unpubl. data).

Kewaunee River (44°28', 87°30'). A run occurs (Kernen, pers. comm. 1979). During 1972-73, catches in Kewaunee Harbor (44°28', 87°30') peaked in September, prior to the major fall spawning run (Spigarelli and Thommes 1976). Ripe adults are collected in the vicinity of the Kewaunee Power


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
MM-3
WM-3
MM-4
Traverse City
N
WM-4
Green Bay
MM-5
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
Ill.
Michigan
Chicago
Illinois
Ind.

Plant (44°21', 87°32') during October when they move inshore; they congregate near the mouths of rivers or move into the rivers in the area. The substrate in the area is hard clay and cobble-size rock with a few boulders (LaJeone, pers. comm. 1979). Many chinook salmon tagged at the Point Beach Power Plant (44°17', 87°32') move into the Kewaunee River in October and November (Spigarelli, unpubl. data).

Point Beach Power Plant (44°17′, 87°32′). In 1976, female chinook salmon were collected here from August through October (Wis. Elec. Power and Wis . Mich. Power, undated c). During 1972-73, catches peaked in September, prior to the major spawning runs (Spigarelli and Thommes 1976).

East Twin River (44°09', 87°34'). A run occurs (Hanson, pers. comm. 1979). Fish move into the river in late October and early November from the area of the Point Beach Power Plant (44°17', 87°32') (Spigarelli, unpubl. data).

West Twin River (44°09', 87°34'). A run occurs; adults enter the river by mid-September (Hanson, pers. comm, 1979). During 1972 and 1973, catches peaked in September in Two Rivers Harbor (44°09', 87°34'), prior to the major spawning run (Spiqarelli and Thommes 1976). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured in the river in late October (Spiqarelli, unpubl. data).

Little Manitowoc River (44°06′, 87°39′). A run occurs (Hanson, pers. comm. 1979). Ripe fish tagged at the Point Beach Power Plant (44°17′, 87°32′) were recaptured in the river in October and November (Spigarelli, unpubl. data).

Manitowoc River (44°05′, 87°39′). A run occurs; adults move into the river by September (Hanson, pers comm. 1979a). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured in the river in mid- to late October (Spigarelli, unpubl. data).

WM-5

Haven (43°51′ , 87°44′). Ripe fish were collected in the area in October as they were moving inshore to rivers in the area (LaJeone, pers. comm. 1979).

Sheboygan River (43°45', 87°42'). A chinook salmon tagged at the Point Beach Power Plant (44°17', 87°32') moved into the river in late October (Spigarelli, unpubl. data).

WM-6

Root River (42°44', 87°47'). A chinook salmon tagged at the Point Beach Power Plant (44°17′, 87°32′) moved into the river in mid-October (Spigarelli, unpubl. data).

Illinois

Spawning runs occur in harbors all along the Illinois shoreline (Muench, pers. comm. 1979).

Kellogg Creek (42°28', 87°48'). A spawning run occurs from mid-September to the third week in October; eggs have been collected here (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In this area, a few ripe-running fish were collected over a substrate of fine sand with a few rocks (LaJeone, pers. comm. 1979), but no spawning is believed to occur in the area (Commonw. Edison 1976).

Indiana

Burns Waterway (41°38', 87°10') and Trail Creek (41°44', 86°54'). Chinook salmon move into the streams from early September through the third or fourth week of October (Koch, pers. comm. 1973; Morgan 1978). Chinook salmon enter Burns Ditch (Waterway) enroute to spawning grounds in the Little Calumet River (41°37', 87°10') (USAEC 1972f).

Michigan

MM-2

Manistique River (45°57', 86°15'). Some natural reproduction occurs (North Woods Call 1980a).

MM-3

Boyne River (45°13', 85°01'). Large spawning runs enter this river (GLFC 1972), and in 1978, naturally produced YOY were observed here (Galbraith 1978).

Jordan River (45°09', 85°08'). Runs enter this river and its tributaries (North Woods Call 1979n), and naturally produced YOY were found in Landslide Creek in May 1978 (Carl 1978).

MM-4

Elk River (44°54', 85°25'). A chinook salmon tagged on October 12 at the Point Beach Power Plant (44°17', 87°32') in Wisconsin was recaptured only 3 days later at the dam at Elk Rapids (Spigarelli, unpubl. data).

MM-5

Crystal River (44°55', 85°58'). Naturally produced YOY were found in this river in early June (Carl 1978).

Platte River (44°44', 86°09'). In 1972, runs entered this river in the fall (Taube 1974a). In 1979, chinook salmon schooled in Platte Bay (44°451, 86°07′) during August (Crowe 1979a).

MM-6

Big (44°15′, 86°18') and Little (44°13', 86°16') Manistee Rivers. Chinook salmon return to the Big and Little Manistee Rivers to spawn (Carl 1977, 1978, 1979; MDNR 1970; Merna 1979; Tody 1970). In the Little Manistee River, the first major spawning run occurred in 1970; redds were common, and large numbers of eggs were deposited (Parsons 1973). Between 1969 and 1974, spawning runs started as early as October 6 and ended as late as November 4. The duration of the run varied from 6 days to more than 3 weeks and the run usually peaked in mid-October (Parsons 1975). Chinook salmon school off the common mouth of these rivers and enter these rivers in August. Extensive spawning runs proceed up the Big Manistee River and into Pine Creek, a tributary to the Big Manistee River; choice spawning areas in Pine Creek are used repeatedly throughout the spawning period, which lasts at least 90 days (Merna 1979). Natural reproduction is widespread in the river, and large numbers of YOY are produced. In 1977-79, YOY were found in Pine Creek from early May to early June (Carl 1977, 1978, 1979).

Big Sable River (44°02', 86°30'). Heavy runs enter the river, but no natural reproduction occurs (Brazo, pers. comm. 1979; Carl 1979).

Pere Marquette River (43°56', 86°26'). In 1979, chinook salmon schooled off the mouth of the river in August (Crowe 1979a). Heavy spawning runs enter the river, and some natural reproduction results (Carl 1977, 1978, 1979; FWS 1979d; North Woods Call 1979n). Runs start on approximately the first of September and peak in October (Brazo, pers. comm. 1979). In 1977-79, YOY were found from early May to early June in the Baldwin River, a tributary to the Pere Marquette River (Carl 1977, 1978, 1979).

Ludington Pumped Storage Plant (43°54', 86°27'). Ripe chinook salmon are collected in the fall; these fish are probably migrating to area streams. Ripe adults are also attracted to the intake and discharge area of the plant (Brazo, pers. comm. 1979; Brazo and Liston 1977). Spawning runs in the area begin on about the first of September, and peak during October. By mid-June, large numbers of YOY are present in the immediate area of the plant; it is not known if these fish are naturally produced or planted (Brazo, pers. comm. 1979).

Pentwater River (43°46′, 86°24′). Spawning runs are suspected (Brazo, pers. comm. 1979), In 1979, chinook salmon schooled at the mouth of the river in August (Crowe 1979a).

MM-7

White River (43°25', 86°21'). Runs presently occur in the river and its tributaries and peak around mid-October. Natural reproduction occurs throughout the watershed, and many YOY are produced (Burns 1979; Carl 1979).

Muskegon River (43°15', 86°15'). Stocked fish return to the river to spawn; natural reproduction is successful in this river (Carl 1977, 1978, 1979; Consumers Power 1976f; FWS 1979d; Merna 1979; Rybicki 1973; Tody 1970). The first major spawning run occurred in 1970; redds were common and large numbers of eggs were deposited (Parsons 1973). In 1979, chinook salmon schooled at the mouth of the river and were present in the river in August (Crowe 1979a). Extensive spawning runs proceed upstream as far as Bigelow Creek, Newaygo County, where choice spawning areas are used repeatedly throughout the spawning season, which lasts more than 90 days (Merna 1979). Natural reproduction is widespread in the Muskegon River, and large numbers of YOY are produced. In 1977-79, YOY were found in Bigelow Creek from early May to early June (Carl 1977, 1978, 1979).

Grand River (43°03', 86°15'). In 1979, chinook salmon entered the Grand River in August (Crowe 1979a).

Port Sheldon (42°54', 86°13'). Chinook salmon enter the Pigeon River (42°54', 86°12') in the fall to spawn. Many fish in spawning condition were observed in the discharge canal of the Campbell Power Plant (42°55', 86°12') in the fall (Jude et al. 1978, 1979a). Ripe adults enter the discharge and intake areas during October and November. Fingerlings, most of hatchery origin, are collected in beach seines in the areas approximately 1 mi N and S of the plant discharge (Jude 1978; Jude and Neufelder, pers. comm. 1979; Jude et al. 1978).

MM-8

Black River 142°24', 86°17'). During 1979, chinook salmon entered the Black River in August (Crowe 1979a).

Paw Paw River (42°07', 86°28'). A chinook salmon tagged at the Point Beach Power Plant (44°17', 87°32') was captured in the river in mid-September (Spigarelli, unpubl. data).

St. Joseph River (42°07', 86°29'). Most of the chinook salmon in the southeast Michigan area probably enter this river during the spawning season (Indiana-Mich. Power 1975; Jude et al. 1975). A fish tagged in late September at the Point Beach Power Plant (44°17', 87°32') was recaptured at the Berrien Springs Dam (41°55', 86°20') in late October (Spigarelli, unpubl. data). In 1979, chinook salmon schooled off the river mouth and entered the river in August (Crowe 1979a). There is an influx of chinook salmon every fall at the Cook Power Plant (41°59', 86°34') south of the St. Joseph River; these fish are undoubtedly migrating to the St. Joseph River to spawn (Jude 1977). Stocked

fingerlings are present in the beach zone waters near the plant (Jude, pers. comm. 1979).

ROUWD WRITEFISB

Round whitefish usually spawn in November and December over honeycombed rock and gravel in water 12-36 ft deep (Koelz 1929). Ripe round whitefish are collected from mid-October through November, at the same time that ripe lake whitefish are collected (Frederick, pers. comm. 1979).

Wisconsin

WM-3

Running-ripe and spent fish were collected on the reefs along the lake side of the Door Peninsula (45°05', 87°10') from mid-October through November (Copes, pers. comm. 1979; Frederick, pers. comm. 1979).

Rowley Bay (45°13', 87°01'). Running-ripe adults were collected over rock and patches of sand. Young-of-the-year (YOY) round whitefish and YOY lake whitefish were captured together here (Frederick, pers. comm. 1979).

North Bay (45°09', 87°04'). This bay is an historical spawning ground for round whitefish (Binkowski, pers. comm. 1979). Running-ripe round whitefish were collected in the bay over gravel and honeycombed rock from mid-October through November (Binkowski, pers. comm. 1979; Frederick, pers. comm. 1979). Young-of-the-year round whitefish and YOY lake whitefish were captured together here (Frederick, pers. comm. 1979).

Moonlight Bay (45°05', 87°05') and Baileys Harbor (45°03, 87°07'). Running-ripe adults were collected over rock and patches of sand. Young-of-the-year round whitefish and YOY lake whitefish were captured together here (Frederick, pers. comm. 1979).

Sturgeon Bay Ship Canal (44°48', 87°19'). In 7951, over 200 recently spent round whitefish were collected just north of the Ship Canal in 24 ft of water in mid-December (Mraz 1964a).

WM-4

Kewaunee Power Plant (44°21', 87°32') In the mid-1970s, ripe adults were collected in this area within the 15-30 ft depth contours in November. The substrate in these areas is hard clay with cobble-size rock; the substrate also includes a few boulders near Haven (LaJeone, pers. comm. 1979).

WM-5

Haven (43°51', 87°44'). In the mid-1970s, ripe adults were collected in this area within the 15-30 ft depth contours in November. The substrate in these areas is hard clay with cobble-size rock; the substrate also includes a few boulders near Haven (LaJeone, pers. comm. 1979).

Michigan

MM-1

Middle Rluff (45°44', 86°39'). Since 1915, spawning has occurred here over sand and gravel (Organ et al. 1978).

MM-2

Wiggins Point Shoal (45°51', 86°18')--Manistique (45°57', 86°15'). Since the 1920s, spawning has occurred along this shoreline over sand, gravel, and rock at a depth of about 12 ft. Since 1940, spawning has occurred at Wiggins Point Shoal over rock and gravel (Organ et al. 1978).

MM-3

Scott Point (45°58', 85°42')--Rock River (46°05', 85°32'). Since 1950, spawning has occurred here over rock, sand, and gravel at depths of 6-24 ft (Organ et al. 1978).

Rock River (46°05', 85°32')--Biddle Point (46°05', 85°23'). From 1967 to 1969, spawning occurred here over rock at depths of 6-30 ft (Organ et al. 1978).

Potter Reef (46°00', 85°32'). From 1967 to 1969, spawning occurred here over rock (Organ et al. 1978).

Biddle Point (46°05', 85°23')--Davenport Creek (46°04', 85°16'). Spawning occurred (no dates given) east of the creek on a small area (46°03, 85°15') of sand and gravel in 6-8 ft of water. Since 1950, spawning has occurred along the entire shoreline from the mouth of the creek west to Biddle Point, over rock and gravel at depths of about 6-30 ft (Organ et al. 1978).

Srevort (46°01', 85°02'). From the 1940s to 1976, spawning occurred on rock areas east and west of Brevort (Organ et al. 1978).

Manitou Paymen Shoal (45°58', 85°04'). From 1965 to 1976, spawning occurred here over rock (Organ et al. 1978).

St. Helena Island (45°52', 84°52') and Shoal (45°52', 84°55'). Spawning occurred (no dates given) along the south side of the island and around the shoal over rock at depths of 40-50 ft (Organ et al. 1978).

Fox Islands (45°27', 85°50'). From 1954 to 1971, spawning occurred on the northeast shore of South Fox Island (45°25', 85°51'), on the entire shoal area off the southern tip of the island, and off the southwest end of North Fox Island (45°29', 85°47') (Organ et al. 1978).

MM-4

Grand Traverse Bay (45°05', 85°30'). Spawning has occurred over rock and gravel in the outer part of Bowers Harbor (44°53', 85°33')--Marion Island (44°52', 85°35') (Organ et al. 1978). Round whitefish are taken in Bowers Harbor, at Northport Point (45°80', 85°33'), and at Raft's Camp (location unknown) as they move inshore during October and November to spawn (Price and Kelly 1976).

MM-5

Leelanau Peninsula (45°00', 85°40'). In 1954 to 1971, spawning occurred along shore at 45°07', 85°41' (Organ et al. 1978).

Manitou Islands (45°04', 86°03). From 1954 to 1971, spawning occurred along the entire east side (45°02', 86°07'--45°00', 86°06') of South Manitou Island (45°01', 86°80'), along the southwest shore of North Manitou Island (45°07', 86°01') from Donner Point (45°03, 86°00') north to 45°05', 86°03, and over sand along the north and east shores of North Manitou Island south to Dimmicks Point (45°04', 86°58'). Prom 1916 to 1971, spawning occurred on the North Manitou Shoals (45°02', 85°58') over sand and rock (Organ et al. 1978).

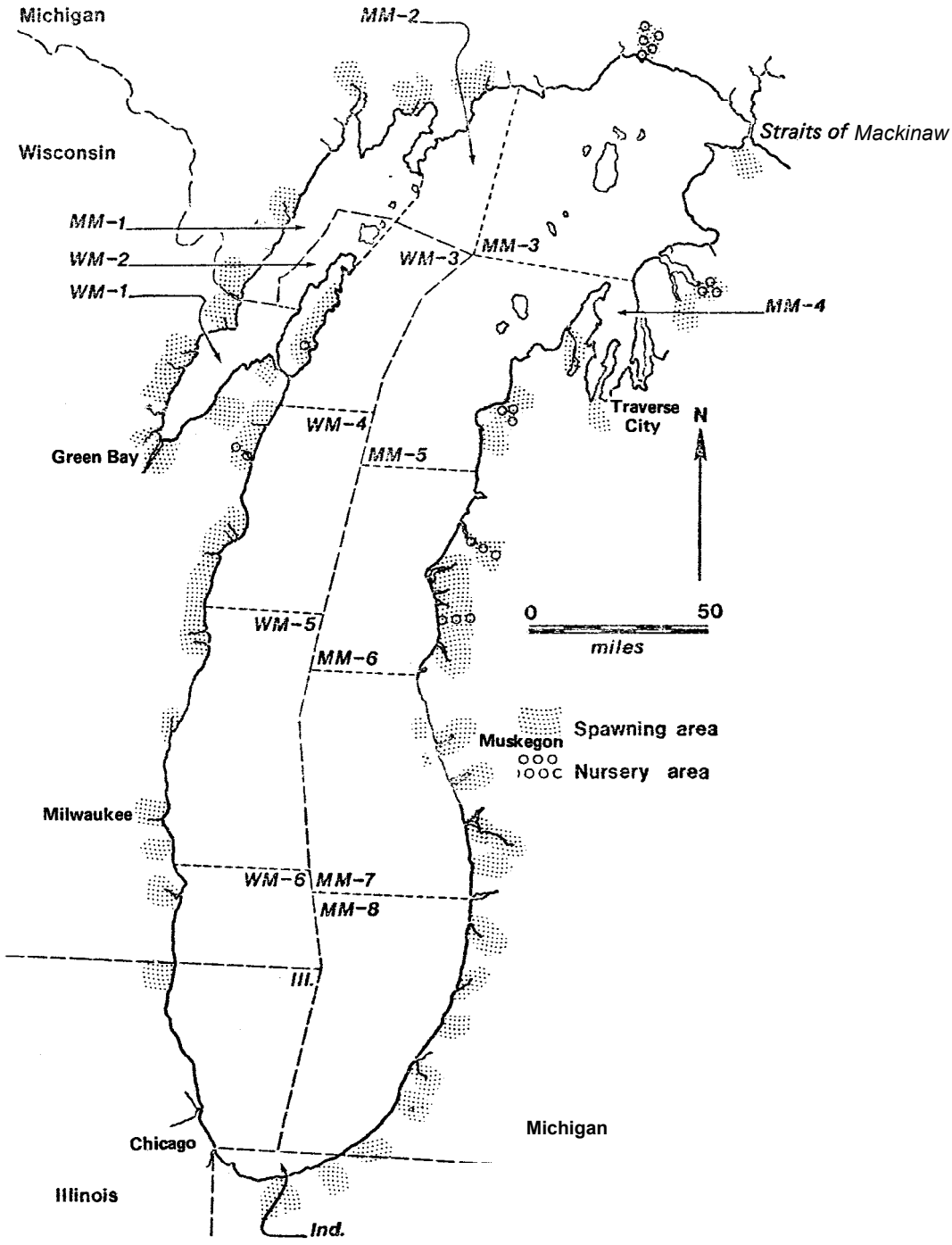
Carp River Point (45°01', 85°47'). From 1954 to 1971, spawning occurred along the point over unknown substrate and on the rocky shoal area (45°02', 85°49') northwest of the point (Organ et al. 1978).

Pyramid Point Shoal (44°59', 85°55'). From 1954 to 1971, spawning occurred here over sand and rock (Organ et al. 1978).

MM-6

Big Sable Point (44°03', 86°31')--Ludington (43°57', 86°28'). Round whitefish spawn along shore over gravel at depths of about 15-18 ft (Organ et al. 1978). Round whitefish begin moving into waters less than 30 it deep near the Ludington Pumped Storage Plant (43°54', 86°27') in large numbers in early September; abundance peaks in October and November in about 28 ft of water (Brazo, pers. comm. 1979; Liston and Tack 1973, 1975). Ripe round whitefish are first collected in the area in November; spawning peaks in late November and early December after lake whitefish have completed spawning (Brazo, pers. comm. 1979; Consumers Power 1972a). Larvae are generally not caught here in the spring, but large numbers of YOY are collected later in trawls near the rock jetties of the plant. More YOY are collected at the 5-, IO-, and 15- ft depth contours than in the beach zone (Brazo, pers. comm. 1979).

RAINBOW TROUT



Rainbow trout, or "steelheads," were first introduced into the Lake Michigan drainage in 1880 when fry were planted in the Boyne, Paw Paw, and Kalamazoo rivers (Smiley 1881, as cited in MacCrimmon and Gots 1972). The first recorded capture of rainbow trout in Lake Michigan waters were young recovered from the Pere Marquette River, Michigan, in 1886 from plantings made in the previous year. The first natural reproduction was recorded in the Muskegon River, where fish planted in 1886 spawned the following spring in Cheney Creek, a tributary of the Muskegon River (Smedley 1938). By 1920, rainbow trout were present throughout most of Lake Michigan. Rainbow trout stocks in Lake Michigan diminished in the 1950s, possibly as a result of the invasion of the sea lamprey in 1936 and the beginning abundance of alewife in 1949 (MacCrimmon and Gots 1972). Beginning in 1955, rainbow trout were planted in many Lake Michigan tributaries during various years (GLFC 1978, in press; Hansen and Stauffer 1967, 1971; Morgan 1978a).

Rainbow trout are qenerally distributed and are locally abundant throughout the lake, but spawning runs are limited essentially to Michigan and Wisconsin tributaries (MacCrimmon and Gots 1972). Steelheads move into tributaries and seek suitable gravel areas for spawning (Shetter 1937; Smith and Van Oosten 1939). Spring and fall runs have become established; the fall runs are minor compared to spring runs (Becker 1976). Pall run rainbow trout may overwinter in the streams and spawn in the spring (Koch, pers. comm. 1979; Taube 1974a). There is evidence that fall spawners will drop eggs in the lake if stream conditions are not suitable (Daly 1968b, as cited in Becker 1976). Spawning occurs as early as November (Jude et al. 1978) or as late as May (Brazo, pers. comm. 1979).

Wisconsin

Most Wisconsin tributaries to Lake Michigan proper and to Green Hay (45°05', 87°25') have spring and fall runs of steelheads; adults are present in these streams from January through April (Helonger and Kernen, pers. comm. *1979;* Copes, pers. comm. 1979). In Wisconsin about half of the steelheads migrate and spawn in the spring, the other half in the fall (Romberg and Spigarelli 1973). Redd building and egg deposition occur, but little or no successful spawning, hatching, or recruitment occurs (Belonger and Kernen, pers. comm. 1979).

WM-1

Menominee River (45°06', 87°35') (Belonger and Kernen, pers. comm. [illegible].

Little River (45°03', 87°38') (Belonger and Kernen, pers. comm, *1979).* In *1972* to *1974,* fish tagged at the Point Beach Power Plant (44°17', 87°32') were recovered in the river in late November and early May (Spigarelli, unpubl. data).

Peshtigo River (44°58', 87°39') (Belonger and Kernen, pers. comm. 1979). A fish tagged on October 2 at the Point Beach Power Plant (44°17', 87°32') was recovered 9 days later below the dam in the river (Spigarelli, unpubl. data), The removal of dams on the Peshtigo River would increase access to prime spawning grounds (GLFC 1979b).

Oconto River (44°54', 87°50') (Belonger and Kernen, pers. comm. 1979; Carlson et al. 1977). Ripe-running males and females have been collected in the river (Imhof, pers. comm. 1979). The removal of dams on the Oconto River would increase access to prime spawning grounds (GLFC 1979b).

Pensaukee River (44°49', 87°54') (Belonger and Kernen, pers. comm. 1979; Imhof, pers. comm. 1979). A few ripe-running males and females have been collected here (Imhof, pers. comm. 1979).

Little Suamico River (44°42', 87°59'). A few ripe-running males and females have been collected here (Imhof, pers. comm. 1979).

Duck Creek (44°34', 88°02'). A fish tagged at the Point Beach Power Plant (44°17', 87°32') was recaptured here in early January (Spigarelli, unpubl. data).

Fox River (44°32', 88°00') (Belonger and Kernen, pers. comm. 1979). A large egg tentatively identified as a rainbow trout egg was entrained from the Fox River at the Pulliam Power Plant (44°32', 88°00') (NALCO, undated a).

Red River (44°40', 87°45'). Ripe-running males and females were collected here; these were planted fish (Imhof, pers. comm. 1979).

Strawberry Creek (44°49', 87°22'). Eggs were collected here (Kernen, pers. comm. 1979).

WM-3

Reiboldt Creek (45°06', 87°05'). Significant natural reproduction occurs here (MacCrimmon and Gots 1972).

Baileys Harbor (45°03, 87°07'). Several fish tagged at the Point Peach Power Plant (44°17', 87°32') were recovered here in October and November (Spigarelli, unpubl. data).

Hibbard Creek (44°59', 87°10'). Significant natural reproduction occurs here (MacCrimmon and Gots 1972).

Whitefish Bay Creek (44°55', 87°13'). Significant natural reproduction occurs here (MacCrimmon and Gots 1972). Successful reproduction occurred here in 1964-1966; fingerlings were collected from the creek (Daly 1968a).

Stony Creek (44°40', 87°23'). Ripe-running males and females were collected here (Imhof, pers. comm. 1979). Fish tagged at the Point Beach Power Plant (44°17', 87°32') in September and October were recovered here in October and the beginning of December (Spigarelli, unpubl. data). Successful reproduction has occurred here; yearlings and fingerlings have been collected from the creek (Daly 1968a).

Ahnapee River (44°36', 87°26') (Kernen, pers. comm. 1979). Ripe-running adults were collected here; these fish were stocked as smolts in Silver Creek, a tributary of the Ahnapee River (Imhof, pers. comm. 1979). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were found in the river in October, November, and April and in Silver Creek in October (Spigarelli, unpubl. data).

Three Mile Creek (44°34', 87°27') and Mashek Creek (44°30', 87°29'). Ripe-running males and females were collected here (Imhof, pers. comm. 1979).

Kewaunee River (44°28', 87°30') (Kernen, pers. comm. 1979; Imhof, pers. comm. 1979). Ripe-running males and females were collected here (Imhof, pers. comm. 1979). Fish tagqed at the Point Beach Power Plant (44°17', 87°32') were recaptured in the river (Spigarelli, unpubl. data). Significant natural reproduction occurs in Little Scarboro Creek, a tributary of the Kewaunee River (MacCrimmon and Gots 1972). Yearlings were collected here (Daly 1968a). In 1971 and 1972, young-of-the-year (YOY) averaging 2.7 in. long were collected in Little Scarboro Creek during September. In 1972, yearlings migrated out of the creek between April and August (Avery 1974).

Kewaunee Power Plant (44°21', 87°32'). An onshore migration occurs during the spawning season from September to December. The substrate in the area is hard clay and cobble-size rock with a few boulders (LaJeone, pers comm. 1979).

Point Beach Power Plant (44°17', 87°32'). Rainbow trout are most abundant in the area during the fall and spring spawning migrations (Romberg and Thommes 1974). From November 1975 through March 1976, ripe females were collected here (Wis. Elec. Power and Wis.-Mich. Power, undated c).

Molash Creek (44°11', 87°31'). An extensive spring run enters the creek (Weber, Desparte, and Threinen 1968).

East and West Twin Rivers (44°09', 87°34'). Spawning runs enter these rivers (Hanson, pers. comm. 1979; Weber, Desparte, and Threinen 1968). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured in the West Twin River in December and in the East Twin River in December and April (Spigarelli, unpubl. data).

Little Manitowoc River (44°06', 87°39') (Hanson, pers. comm. 1979; Weber, Desparte, and Threinen 1968). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured here in November (Spigarelli, unpubl. data).

Manitowoc River (44°05', 87°39') (Hanson, pers. comm. 1979; Weber, Desparte, and Threinen 1968). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured here in November and in March of the following year (Spigarelli, unpubl. data).

Silver Creek (44°04', 87°39') (Weber, Desparte, and Threinen 1968). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recovered here in October and November (Spigarelli, unpubl. data).

Pine Creek (43°59', 87°42'). One fish tagged at the Point Beach Power Plant (44°17', 87°32') was recovered here in late April (Spigarelli, unpubl. data).

Point Creek (43°58', 87°42'). A spring run occurs here (Weber, Desparte, and Threinen 1968).

Fischer Creek (43°56', 87°43') (Avery 1974; Belonger and Kernen, pers. comm. 1979; Weber, Desparte, and Threinen 1968). In the past, minor natural reproduction occurred here (Belonger and Kernen, pers. comm. 1979). Fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured here in early November (Spigarelli, unpubl. data).

Centerville Creek (43°55', 87°43'). A spawning run occurs here (Weber, Desparte, and Threinen 1968).

WM-5

Sevenmile Creek (43°51', 87°44'). In 1974, adults in spawning condition were collected near the creek in March and in the creek in May (Ind. Rio-Test 1977; LaJeone, pers. comm. 1979).

Pigeon River (43°47', 87°43') (Weber, Desparte, and Threinen 1968; Weber, Poff, and Threinen 1968). Two fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured here in mid-March (Spigarelli, unpubl. data).

Sheboygan River (43°45', 87°42') (Weber, Poff, and Threinen 1968). A fish tagged at the Point Beach Power Plant (44°17', 87°32') was recovered in the river in late October (Spigarelli, unpubl. data).

Black River (43°42', 87°42') (Weber, Poff, and Threinen 1968). In 1974, six ripe adults were collected in the discharge of the Edgewater Generating Station (43°43', 87°42'), near the river, in early March. In 1975, three ripe or mature females were impinged in late March and early April. In 1977, ripe and spent steelheads were collected at the pier in April, May, October, and December (Swanson Environ. 1976, 1979).

Port Washington (43°23', 87°52'). Fish tagged at the Point Reach Power Plant (44°17', 87°32') were recaptured here in late October, November, and February. In mid-February, one ripe adult was captured in Sauk Creek (43°23', 87°52') (Spigarelli, unpubl. data). In 1975, ripe adults were impinged at the Port Washington Power Plant (43°23', 87°52') (Wis. Elec. Power 1976e).

Milwaukee River (43°02', 87°54'). Spawners run up the river in April to the North Avenue Dam (Norden, pers. comm. 1980).

Oak Creek (42°54', 87°51'). Ripe females were collected here at the end of April and May (Norden, pers. comm. 1979).

WM-6

Root River (42°44', 87°47'). A fish tagged at the Point Reach Power Plant (44°17', 87°32') in June was recaptured at Racine (42°44', 87°47') in early November; another tagged in September was recaptured in the river in late November (Spigarelli, unpubl. data).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Ripe-running adults are occasionally collected in this area over a substrate of fine sand and scattered rocks during the spring and fall (Cochran, undated; LaJeone, pers. comm. 1979). A spawning run enters Kellogg Creek (42°28', 87°48'); in 1979, fish were observed making redds in the mouth of the creek in April (Muench, pers. comm. 1979). In 1975, one egg was collected at the Zion Generating Station (42°27', 87°48') in June (Cima et al. 1976).

Indiana

Spawning runs into tributaries usually begin in August. Adults remain in the tributaries over winter, spawn during March and April, and then return to the lake. Very little successful natural reproduction occurs (Koch, pers. comm. 1979).

Burns Waterway (41°38', 87°10'). Spawning runs enter Rurns Waterway and the Little Calumet River (41°37', 87°10') (Koch, pers. comm. 1979).

Railly Generating Station (41°39', 87°07'). The abundance of mature steelheads in the fall suggests that spawning may occur here in the lake (Tex. Instrum. 1975b, 1977b).

Trail Creek (41°44', 86°54'). Spawning runs enter the creek (Koch, pers. comm. 1979; Morgan 1978c) until early December or ice-up; the run beqins again in the spring after ice breakup (Morgan 1978c).

MM-1

Turtle Creek (45°09', 87°36′). A fish tagged at the Point Beach Power Plant (44°17′, 87°32') was caught on November 1 in the creek (Spigarelli, unpubl. data).

Beattie Creek (45°14′, 87°31′). A fish tagged at the Point Beach Power Plant (44°17′, 87°32') was recovered (date unknown) in spent condition in the creek (Spigarelli, unpubl. data).

Cedar River (45°24', 87°21'). Spawning runs enter this river from mid-April to early June (Ann Arbor News 1979a).

Whitefish River (45°55', 86°57'). A small run occurs from natural reproduction and stocking (FWS 1979d; MacCrimmon and Gots 1972).

Fishdam River (45°54', 86°35') and Sturgeon River (45°50', 86°40'). A small run occurs in these rivers (MacCrimmon and Gots 1972).

MM-2

Thompson Creek (45°54', 86°19'). Spawning runs enter Thompson Creek from mid-April to early June (Ann Arbor News 1979a; MacCrimmon and Gots 1972). In 1979, rainbow trout appeared at the mouth of this creek in August (Crowe 1979a). Steelheads tagged at the Point Reach Power Plant (44°17′, 87°32') were caught in Thompson Creek; two were taken on September 1 and a third fish was taken at the end of October (Spigarelli, unpubl. data).

Manistique River (45°57', 86°15'). A fish tagged at the Point Beach Power Plant (44°17′, 87°32') was recovered in the Manistique River in late October (Spigarelli, unpubl. data).

MM-3

Black River (46°06′, 85°21′). Since the early 1950s, large runs have occurred here (Robertson and Cheney 1953; Stauffer 1972; Westerman 1952b, 1954, 1957a) from mid-April to early June (Ann Arbor News 1979a). Downstream migration of juveniles, in their second or third year of life, begins in late April, when the water temperature reaches about 45-50°F, and continues to late July; peak migration occurs from late May through June at temperatures of about 48-63°F (Stauffer 1972a).

Boyne River (45°13′, 85°01′). Large runs occur in April (Ann Arbor News 1979a; GLFC 1973), and naturally produced young have been collected (Galbraith 1978).

Jordan River (45°09', 85°08'). A run occurs in April (Ann Arbor News 1979a).

MM-4

Boardman River (44°46', 85°37'). A run occurs in April (Ann Arbor News 1979a; MacCrimmon and Gots 1972; UPI 1979).

MM-5

Leland (Carp) River (45°01′, 85°46′). A run occurs in April (UPI 1979).

Otter Creek (44°46', 86°04'). A minor spring run occurs (Edsall, pers. comm. 1979).

Platte River (44°44', 86°09'). Since the 1920s, spawning runs have occurred in April and May (Ann Arbor News 1979a; Carbine and Shetter 1945; Greeley 1933; Taube 1969, 1974a, 1975; UPI 1979; Westerman 1942). Some adults also enter the river in the fall, mainly in October, and remain in the river throughout the winter (Carbine and Shetter 1945; Taube 1974a). In 1968-72, redds were observed during April (Taube 1971a,b, 1974b). In 1970-1972, YOY were collected from nursery areas in the stream during the fall (Taube 1971a,b, 1972, 1973). The migration of smolts to Lake Michigan usually begins in April and peaks during May and June (Taube 1974c, 1975). Steelheads are no longer planted here, and the river is managed for "wild" steelheads (North Woods Call 1980d).

Betsie River (44°37′, 86°13′). Since the late 1920s, runs have been reported in April and May (Ann Arbor News 1979a; Shetter 1937; UPI 1979; Westerman 1950, 1952b, 1954, 1957a,b).

MM-6

Big (44°15′, 86°18′) and Little (44°13', 86°16') Manistee Rivers. These two streams empty into Lake Manistee which discharges into Lake Michigan. Since the late 1920s, spawning runs have entered both streams in April and May (Cook 1961, 1962; Greeley 1932, 1933; Hubbs 1930; MacCrimmon and Gots 1972; Rybicki 1973; Shetter 1937, 1938b; Taube 1974a; Tody 1969, 1970; Westerman 1930, 1950, 1952b, 1954, 1957a,b, 1959; Wicklund and Dean 1957). From 1929 to 1931, tagging of adult steelheads on the spawning grounds in the Big and Little Manistee Rivers during late April and early May indicated that steelheads generally return to the same river to spawn; however, some straying was observed (Shetter 1937, 1938b). Eggs and fry were found in the Little Manistee (Greeley 1932). In 1979, runs were expected to peak in April in both rivers (Ann Arbor News 1979a,b; UPI 1979). Steelhead do not appear to move into these rivers in large numbers during the fall (Wicklund and Dean 1957). A fish tagged at the Point Beach Power Plant (44°17′, 87°32′) in October was captured in late April in Bear Creek, a tributary of the Big Manistee River (Spigarelli, unpubl. data). The Little Manistee River is no longer planted and is managed for "wild" steelheads; this river reportedly has the best run of wild steelheads in the Great Lakes (North Woods Call 1979a, 1980d).

Big Sable River (44°02', 86°30'). A fish tagged at the Point Beach Power Plant (44°17', 87°32') in early October was recovered at the river mouth in early November (Spigarelli, unpubl. data).

Pere Marquette River (43°56', 86°26'). Spring and fall runs enter the river; the major run begins in late March and peaks in mid-April (Ann Arbor News 1979a,b; Baz 1979; FWS 1979d; Greeley 1933; UPI 1979). Steelheads are no longer planted, and the river is managed for "wild" steelheads (North Woods Call 1980d).

Ludington Pumped Storage Plant (43°54', 86°27'). Many ripe adults were collected as early as January near the plant (Brazo, pers. comm. 1979; Liston 1976). Most were taken near shore at depths of 10 ft or less; large numbers were taken around the rock jetties of the plant. Peak runs occur in March and early April (Brazo and Liston 1977). Ripe adults are collected in the storage reservoir which contains water pumped from Lake Michigan. A small unnamed stream about 300 ft long just south of the lower jetty, has a small spawning run in the fall (Brazo, pers. comm. 1979; Liston 1976); redds and YOY are observed, indicating that successful natural reproduction occurs in the stream. Ripe steelheads are collected as early as October 1, but the fall run peaks in November. Ripe adults are occasionally collected throughout the fall and early winter. Large numbers of ripe steelhead are taken in late March, when the ice breaks up. The spawning season extends into mid-May, and a few ripe adults are taken as late as June 1 (Brazo, pers. comm. 1979).

Pentwater River (43°47', 86°26'). Spring and fall runs occur (Brazo, pers. comm. 1979).

MM-7

White River (43°25', 86°21') (UPI 1979). Runs usually peak in late April (Ann Arbor News 1979a). Prom 1952 to 1962, spawning occurred in Lake Michigan on rock areas nearshore, about 2 mi N and 1 mi S of White Lake (43°23', 86°26') (Organ et al. 1978).

Muskegon River (43°15', 86°15') (Consumers Power 1976f; FWS 1979d; Greeley 1933; MacCrimmon and Gots 1972; Shetter 1937; UPI 1979; USDI 1966). Runs usually peak in late April (Ann Arbor News 1979a,b). An adult taqged at the Point Beach Power Plant (44°17', 87°32') in late September was recovered in late November at Croton Dam (Spigarelli, unpubl. data).

Grand River (43°03, 86°15'). Limited runs occur here (Ann Arbor News 1979a; MacCrimmon and Gots 1972; Nottingham 1979; UPI 1979). In 1979, runs were predicted to peak from mid-April to the first of May (Nottingham 1979).

Pigeon River (42°54', 86°12'). Ripe-running and spent adults were collected from late September to November along the Lake Michigan shore north and south of the river, when the water temperature was 50°F (Jude, pers. comm. 1979; Jude et al. 1978, 1979a). Spring-run steelheads were also collected in the area (Jude, pers. comm. 1979). A ripe-running male steelhead was collected in Pigeon Lake (42°54', 86°12') in November (Jude et al. 1978).

Kalamazoo River (42°40', *86°13').* Limited runs occur here (MacCrimmon and Gots 1972); the runs usually peak in late April (Ann Arbor News 1979a).

Black River (42°24', 86°17'). Limited runs occur here (MacCrimmon and Gots 1972); the runs usually peak here in late April (Ann Arbor News 1979a). A fish tagged at the Point Reach Power Plant *(44°17', 87°32')* in mid-October was recovered in the river in early December (Spigarelli, unpubl. data).

Palisades Power Plant (42°19', 86°19'). Many ripe and spent steelheads were collected and observed in the plant discharge through most of December 1972 and early January 1973 and again in October 1973 (Consumers Power 1973b, 1974, 1975).

St. Joseph River (42°07', 86°29') (Ann Arbor News 1979a,b; North Woods Call 1979d; UPI 1979). Limited runs occur here (MacCrimmon and Gots 1972); runs usually peak in late April (Ann Arbor News 1979a). In 1979, runs occurred from mid- to late April (Ann Arbor News 1979b; UPI 1979).

Bridgman *(41°56', 86°35').* In 1973, ripe-running steelheads were taken near the Cook Power Plant (41°59', 86°34') in October and February (Jude et al. 1975). Spent fish were observed in the area in November, March, and May; gonad data suggest a spawning peak from November to January and another in March (Jude et al. 1979b).

Galien River (41°48', 86°45'). Spawnfng runs peak in late April (Ann Arbor News 1979a).

ATLANTIC SALMON

Atlantic salmon were first introduced into Lake Michigan in *1872;* subsequent intermittent plantings occurred until 1932. No self-sustaining populations were established from these plantings (Parsons 1973; Wells and McLain 1973).

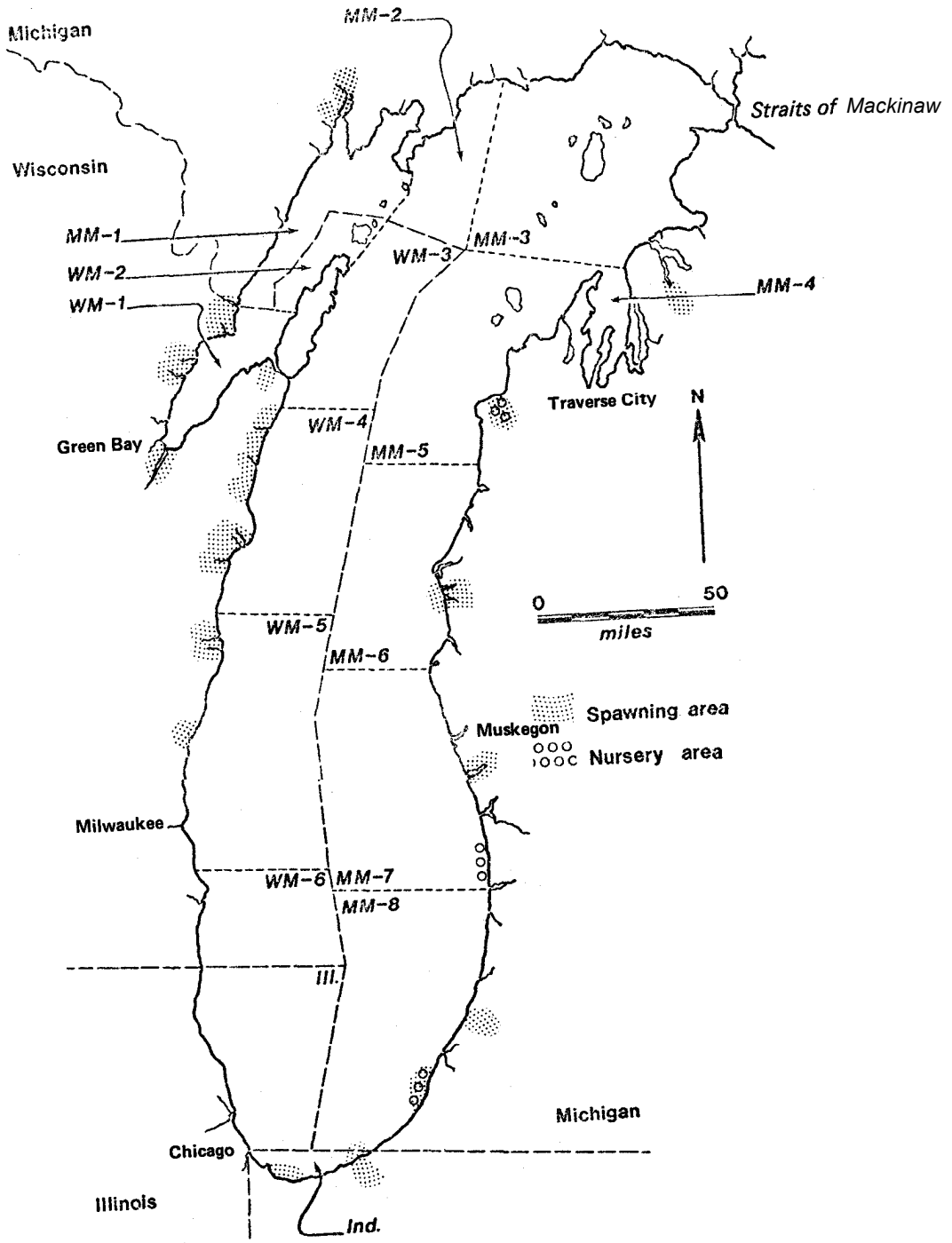
Michigan

Between 1972 and 1977, Atlantic salmon were planted in the Pere Marquette (43°56', 86°26'), Little Manistee (44°13', 86°16'), Platte *(44°44',* 86°09'), and Boyne (45°13', *85°01')* rivers (Galbraith 1977, 1978; GLFC 1973b, 1975, 1976a, 1978, in press; Ryhicki 1973). These plantings were largely unsuccessful (few returns to stocked tributaries) (Galbraith 1978), and no plantings have occurred in recent years.

MM-3

Boyne River *(45°13', 85°01').* In *1974-77,* a few fish returned to spawn in late October and the latter half of November, but in 1978 *only* one adult was observed (Galbraith 1976, 1977, 1978). Hatchery-reared brood stock planted in the Boyne River spawned and produced young that were observed in *1977* (Galbraith 1977).

BROWN TROUT


Michigan
Wisconsin
MM-2
Straits of Mackinaw
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Traverse City
N
Green Bay
WM-4
MM-5
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
III.
Michigan
Chicago
Illinois
Ind.

Brown trout were planted in Lake Michigan as early as 1883. Those planted in Lake Michigan since the mid-1960s have produced fall spawning runs in a number of Lake Michigan tributaries (Wells and McLain 1973); self-sustaining populations are established in some areas.

Wisconsin

Brown trout were first planted in the Wisconsin waters of Lake Michigan in 1966 (Daly 1968b); they now spawn in tributaries of Green Bay (45°05', 87°25') and the Door Peninsula (45°05', 87°10') mainly in fall (Copes, pers. comm. 1979; Kernen, pers. comm. 1979). Most of the bays in this area have populations of brown trout (Copes, pers. comm. 1979). Fall runs are often limited by tributary flow (Kernen, pers. comm. 1980). When low flow prevents runs into streams, spawning occurs over rocky areas in the lake (Daly 1968b). Adults often drop their eggs around docks and harbors along the Door Peninsula (Kernen, pers. comm. 1980).

WM-1

Menominee River (45°06', 87°35'). Brown trout enter this river to spawn (Belonger and Kernen, pers. comm. 1979). In 1973, brown trout were collected at Marinette (45°05', 7°35') in late October (Spigarelli and Smith 1976).

Little (45°03, 87°38'), Peshtigo (44°58', 87°39'), Oconto (44°54', 87°50'), Pensaukee (44°49', 87°54') and Fox (44°32′, 88°00′) Rivers. Spawning runs enter these rivers in the fall (Belonger and Kernen, pers. comm. 1979).

Sturgeon Bay (44°53', 87°24'). Spawning runs enter Strawberry Creek (44°49', 87°22') (Belonger and Kernen, pers. comm. 1979). In 1972-74, fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured in Sturgeon Bay and Big Creek (location unknown) off Sturgeon Bay in mid- and late October (Spigarelli, unpubl. data).

WM-3

Baileys Harbor (45°03, 87°07'). In 1972-74, brown trout were captured in Baileys Harbor in mid- and late October (Spigarelli, unpubl. data; Spigarelli and Smith 1976).

WM-4

Stony Creek (44°40', 87°23'). In 1972-74, brown trout tagged at the Point Beach Power Plant (44°17′, 87°32') were recaptured in the creek in early October (Spigarelli, unpubl. data).

Ahnapee River (44°36', 87°26'). This river supports a spawning run of stocked brown trout (Kernen, pers. comm. 1979); fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured in the river in late September and October (Spigarelli, unpubl. data).

Kewaunee River (44°28', 87°30'). Stocked brown trout have returned to the river to spawn (Kernen, pers. comm. 1979). In 1972-74, fish tagged at the Point Reach Power Plant (44°17', 87°32') entered the Kewaunee River in late September to mid-October. Fish taken in mid-September were not quite ripe; those taken in early October were ripe (Spigarelli, unpubl. data).

Kewaunee Power Plant (44°21', 87°32'). In 1975, ripe-running brown trout were collected in September and October at the intake to the plant in 20 ft of water, 1/2 mi N of the plant in 12 ft of water, and 2 mi S of the plant in 15 ft of water; the water temperature was 45-46°F at these locations. Spent adults were collected at these same sites in November when the water temperature was about 44°F (LaJeone 1976). Inshore spawning migrations occurred here from September to December (NALCO undated b). Ripe adults were collected in the vicinity of the plant over hard clay and cobble-size rocks (LaJeone, pers. comm. 1979).

Point Beach Power Plant (44°17', 87°32'). In 1975, brown trout were collected for fecundity counts in the vicinity of the Point Beach Power Plant in September and October (Wis. Elec. Power and Wis.-Mich. Elec. Power, undated c). Spawning brown trout are attracted to the plant discharge and accumulate in great numbers there seasonally (Reed 1972). In 1974, 48% of the salmonids tagged here during the fall were brown trout (Romberg and Thommes 1974). Fish captured during the second and third weeks of Octo'oer were ripe to very ripe, and one collected on October 3 was spent (Spigarelli, unpubl, data).

Two Rivers (44°09', 87°34'). Stocked brown trout return to and enter the East and West Twin rivers (44°09', 87°34') in the fall (Hansen, pers. comm. 1979). In 1972-74, fish taqged at the Point Beach Power Plant (44°17', 87°32') were recaptured in late September and early October in Two Rivers Harbor and in the West Twin River (Spigarelli, unpubl. data).

Manitowoc (44°05', 87°39'). Stocked brown trout return to and enter the Manitowoc (44°05', 87°39') and Little Manitowoc (44°06', 87°39') rivers in the fall (Hansen, pers. comm. 1979). In 1972-74, fish tagged at the Point Beach Power Plant (44°17', 87°32') were recaptured in late September and early October in the Little Manitowoc River and also in Silver Creek (44°04', 87°39') (Spigarelli, unpubl. data).

WM-5

Sheboygan (43°45', 87°42'). The Pigeon River (43°47', 87°43') supports a run (Weber, Poff, and Threinen 1968). In 1975, adults were observed on redds in the Pigeon River in early October (LaJeone, pers. comm. 1979). Ripe-running adults have been collected near Haven (43°51', 87°44'), just north of the river, over a hard clay and cobble-sized rock substrate with a few boulders. Fish in spawning condition were collected along the shoreline in Octo'oer 1974 and November 1973 (Ind. Rio-Test 1977; Wis. Elec. Power et al. 1979a). Most of these fish were collected at the 20- and 30-ft depth contour. The substrate was generally small rock cobble and boulders overlaying hard clay; areas of sand and gravel covered with silt occurred among the rocks (Ind. Rio-Test 1977). Brown trout tagged at the Point Beach Power Plant (44°17', 87°32') moved into the

Shehoygan area and the mouth of the Pigeon River in early to mid-October. One fish recaptured on November 8 was spent (Spigarelli, unpubl. data).

Black River (43°42', 87°42'). A spawning run enters the river (Weber, Poff, and Threinen 1968).

Port Washington (43°23', 87°52'). In 1975, most large adults impinged at the Port Washington Power Plant (43°23', 87°52') in early October were in breeding condition (Wis. Elec. Power 1976e).

Illinois

Waukegan (42°22', 87°50'). Brown trout are in spawning condition in the fall in the Waukegan area. The substrate in this area is fine sand with scattered rocks (LaJeone, pers. comm. 1979). In 1972, two running-ripe males were collected at the Waukegan Generating Station (42°23', 87°49') on October 25 and 26 (Cochran undated).

Indiana

Spawning may occur at several different locations along the Indiana shore (Koch, pers. comm. 1979).

Bailly Generating Station (41°39', 87°07'). In 1974 and 1975, sexually mature fish were observed here during the fall (Tex. Instrum. 1977b).

East Chicago (41°39', 87°26'). Stocked brown trout return to spawn at Joerse Park (41°39', 87°26') (Koch, pers. comm. 1979).

Michigan City (41°43′, 86°54′). Spawning-run brown trout are collected in Trail Creek (41°44', 86°54') in August and September. Spawning was observed in the Michigan City Yacht Basin (41°43', 86°54') in 3-4 ft of water in September. Spawning was also observed in the Outer Basin on both sides of the mouth of Trail Creek (Koch, pers. comm. 1979). Brown trout in spawning condition were netted in early October at the Michigan City Generating Station (41°43', 86°54') (Morgan 1978b).

Michigan

MM-1

Whitefish River (45°55', 86°57') and Rapid River (45°55', 86°58'). Large spawning runs enter these rivers in September (Worth Woods Call 1980b).

Days River (45°54', 86°59'). A very small run enters the river, unless there are fall rains (North Woods Call 1980b).

MM-3

Jordan River (45°09', 85°08'). Brown trout spawn in tributaries of this river (North Woods Call 1979n).

MM-5

Platte River (44°44', 86°09'). Spawning runs enter the river. In 1968-71, spawning was observed on gravel bottom (Taube 1974b). In 1970, spawning was observed on November 8 (Stauffer 1971). Young fish move out into Lake Michigan at an early age and return in summer and fall (Taube 1974a).

MM-6

Ludington (43°57', 86°28). A spawning run enters the Pere Marquette River (43°56', 86°26') (FWS 1979d). Large numbers of ripe adults are taken at the Ludington Pumped Storage Plant (43°54', 86°27') beginning in late August; peak catches are from October through mid-November. Concentrations of adults occur around the rock jetties at the plant intake, and many fish are pumped up into the reservoir (Brazo, pers. comm. 1979)'

MM-7

Muskegon River (43°15', 86°15'). A spawning run enters this river (FWS 1979d).

Pigeon River (42°54', 86°12'). Ripe adults were collected 1 mi S of the Pigeon River; their gonad development suggested that spawning occurred in the fall (Jude and Heufelder, pers. comm. 1979; Jude et al. 1979a). In 1977, gonad development of fish caught in the area from June to November suggested that spawning occurred from late September to November. In 1978, brown trout about 4 in. long were collected in the lake (Jude et al. 1978, 1979a).

MM-8

Palisades Power Plant (42°19', 86°19'). In 1973, ripe and spent adults were collected in the discharge area in October; most were taken when the water temperature was 50-60°F (Consumers Power 1974).

Bridgman (41°56', 86°35'). The gonads of fish collected in this area suggest that spawning occurs here in the lake in the fall. Brown trout less than 4 in. long have been captured in the beach zone (Jude et al. 1975, 1979b).

BROOK TROUT

It is believed that native lake-run brook trout, or "coasters", were eliminated from Lake Michigan in 1956, at about the same time that lake trout were eliminated by the sea lamprey (Becker 1976). Brook trout planted in Lake Michigan since the mid-1960s (Wells and McLain 1973) have produced fall spawning runs in a number of Lake Michigan tributaries.

Wisconsin

WM-1

Menominee River (45°06', 87°35*), Little River (45°03', 87°38'), Peshtigo River (44°58', 87°39'), Oconto River (44°54', 87°50'), Pensaukee River (44°49', 87°54'), Fox River (44°32', 88°00'), and Strawberry Creek (44°49′, 87°22′). Spawning runs of stocked fish enter these tributaries (Kernen, pers. comm. 1979).

WM-2

Door Peninsula (45°05', 87°10'). Brook trout enter streams along the Green Bay shore of Door County and streams of Washington Island (45°23', 86°54'), but the water temperature and stream beds are not highly suitable for natural reproduction (Booke and Copes, pers. comm. 1979). Spawning generally occurs in August and September (Kernen, pers. comm. 1979).

WM-4

Ahnapee River (44°36', 87°26') and Kewaunee River (44°28′, 87°30′) (Kernen, pers. comm. 1979).

East Twin River (44°09', 87°34'), West Twin River (44°09', 87°34'), Manitowoc River (44°05', 87°39'), and Little Manitowoc River (44°06', 87°39') (Hanson, pers. comm. 1979).

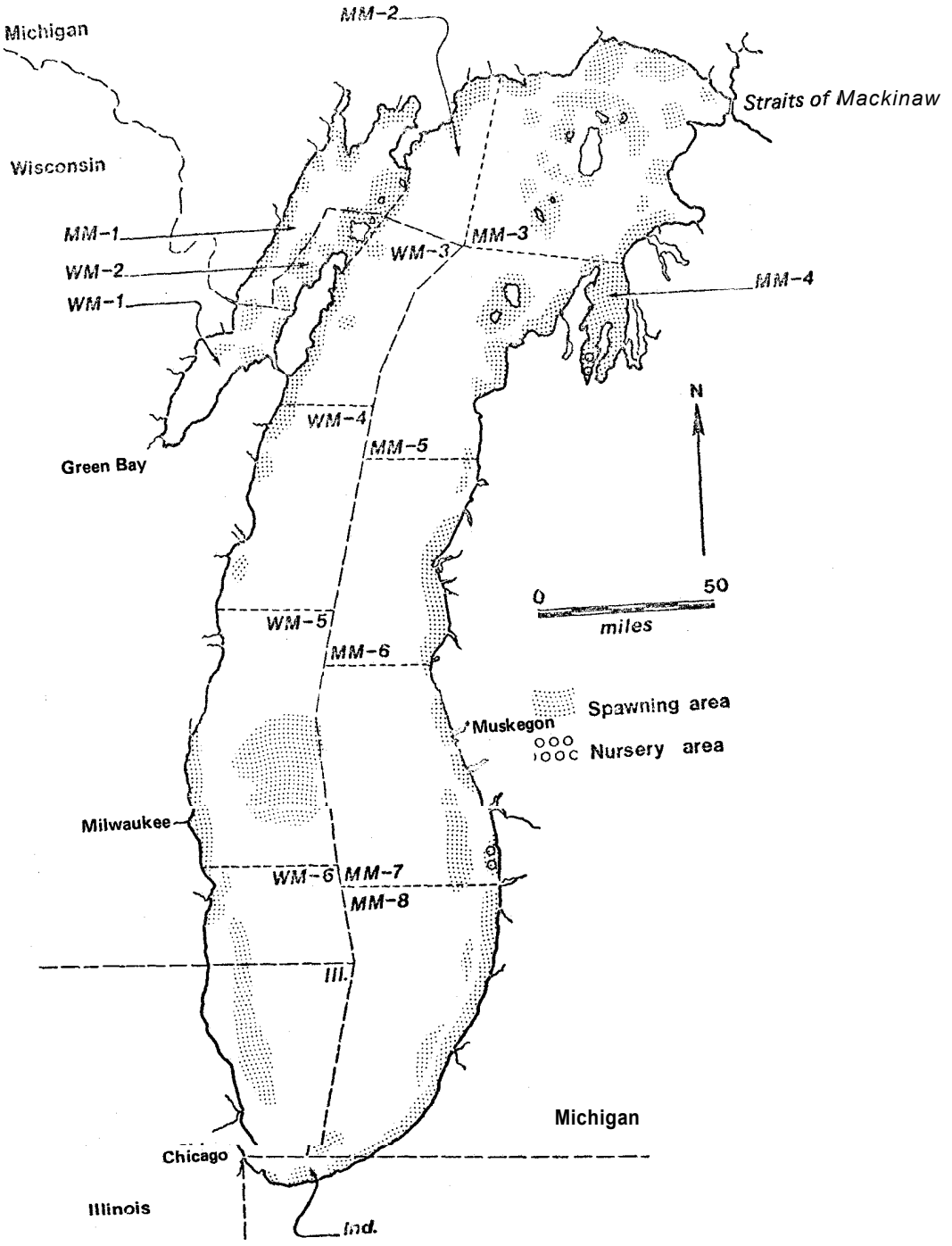
Michigan

MM-1

Days River (45°54', 86°59') and Whitefish River (45°55', 86°57'). In 1979, coasters entered these rivers in the fall (North Woods Call 1980b).

MM-4

Grand Traverse Bay (45°05', 85°30'). Prior to the 1880s, coasters probably spawned in the streams of Grand Traverse Bay. Spawning occurred in autumn over fine gravel (Price and Kelly 1976).


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
N
WM-4
MM-5
Green Bay
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
III.
Michigan
Chicago
Illinois
Ind.

Historically, lake trout were abundant in Lake Michigan. Lake trout moved onto spawning grounds in October (Goode 1884), and spawning lasted from mid-October to early December with a peak in mid-November (Goode 1884; Lagler 1948; Leach 1923; Smith 1909; U.S. Comm. Fish Fish. 1900; Van Oosten and Eschmeyer 1956). Spawning occurred on reefs of honeycombed rock in 3 to more than 200 ft of water, 10-15 mi from shore (Calhoun and Coon 1941; Goode 1884; Leach 1923; U.S. Comm. Fish Fish. 1900; Walburg 1973). Early records distinguished two types of lake trout: a "deepwater" trout that spawned over clay bottom, at depths to 360 ft, and a "shallow water," "shoal," or "Mackinaw" trout that spawned on honeycombed rock at depths to 150 ft (Cook 1929; Eschmeyer 1964; Horrall 1976; Koelz 1926; Smith 1909; U.S. Comm. Fish Fish. 1900; Van Oosten 1944a). The deepwater trout was reportedly limited to the southern portion of the lake (Eschmeyer 1964; Koelz 1926). The shallow water trout spawned on reefs around islands in the northern portion of the lake (Van Oosten 1944a) in September, about one month earlier than the other lake trout (U.S. Comm. Fish Fish. 1900). The spawning habits of the lake trout in northern Lake Michigan were very similar to those of the Lake Superior "lean" trout (Pycha 1978). Commercial fishermen believe that there were as many as seven different races of lake trout present in the lake and that these races spawned at different times and in different locations (Coberly and Horrall 1980a).

Intensive commercial fishing and sea lamprey predation severely depleted the native lake trout stocks in the late 1940s and early 1950s (Pycha and King 1975), and by 1955 the species was near extinction (Eschmeyer 1957b). Extinction occurred in Lake Michigan in about 1956, probably as a result of continued sea lamprey predation (Wells and McLain 1972, 1973). However, lake trout are again abundant in Lake Michigan as a result of extensive plantings of hatchery reared juveniles, which began in 1965 (GLFC, in press; Wells and McLain 1972, 1973). Planted lake trout usually spawn from the last week of October to mid-November, when the water temperature at the bottom falls to 48-54°F (Peck 1979a).

In 1971 and 1972, spawning took place along much of the shoreline of the lake over all substrate types, primarily in water less than 30 ft deep; many of these shallow shoreline areas are subjected to severe -wave and ice conditions and therefore may be unsuitable for egg and fry survival (Harris and Eschmeyer 1975). Eggs deposited on sand in 1971 were subjected to severe ice action and were probably buried by sand (Harris and Eschmeyer 1972). In 1975, fish stocked on Milwaukee Reef spawned in Green Bay (GLFC 1976b). The first evidence of successful natural reproduction by planted lake trout was obtained in 1977, when naturally spawned fry -were collected from March to May from the water intake of the Traverse City Municipal Power Plant (44°46', 85°37') in northern Lake Michigan (Stauffer 1978a). In 1980, naturally spawned lake trout fry were also collected in May near the Campbell Power Plant (42°55', 86°15') in southern Lake Michigan (Jude, pers. comm. 1980).

WM-1

Most of the lake trout that spawned here were "reef trout" or "redfins." Substrate on the reefs was various combinations of boulders, gravel, and honeycombed rock (Coberly and Horrall 1980b).

Green Island (45°03', 87°30'). Historically, spawning grounds were located near Green Island (Goode *1884).*

Trout Bar (Strawberrys Reef) *(45°01',* 87°34'). Lake trout spawned here over gravel and honeycombed rock (Coberly and Horrall 1980b).

Youngs Reef (44°54', 87°42'). Spawning occurred here (Coberly and Horrall 1980b).

Sturgeon Bay (44°53', 87°24'). Historically, spawn was collected from ripe adults captured on various spawning grounds (locations unknown) near Sturgeon Bay during the last half of October and early November (Nevin 1901b). Lake trout were planted at Larsens Reef (44°53', 87°29'), between Sturgeon Bay and Little Sturgeon Bay (44°50', 87°33') (GLFC 1976c, *1978;* Horrall, pers. comm. 1979), and eggs have been collected from ripe females captured on the reef (WDNR 1972, 1975). Many ripe adults of both sexes and spent females were collected on unnamed reefs just outside Sturgeon Bay (Moore 1970).

Monument Shoal (45°00', 87°22') and Horseshoe Point *(45°01',* 87°20')--Leroys Point (45°02', 87°19'). Lake trout spawned here (Coberly and Horrall 1980b).

WM-2

Clarks Reef (45°04', *87°19'),* Hat Island (45°06', *87°19'),* Chambers Island North Reef (45°14', 87°19'), Strawberry Islands *(45°10', 87°16'),* unnamed reef (45°12', *87°13'),* Horseshoe (Eagle) Island *(45°11', 87°13'),* Sister Shoals *(45°12',* 87°10'), and Sister Islands *(45°13', 87°09').* Lake trout spawned here (Coberly and Horrall 1980b).

Horseshoe Reefs ("the Frying Pan") *(45°13', 87°12').* This was a very important spawning ground in the 1930s and 1940s (Copes, Ebener, and Leary, pers. comm. 1979; Frederick, pers. comm. 1979; Horrall, pers. comm. 1979). Fishermen believed this was the most productive lake trout spawning reef in Green Bay (Coberly and Horrall 1980b). The substrate in this area at depths to 30-60 ft is rubble, tablerock, and some honeycombed rock (Horrall, pers. comm. 1979; Marine Studies Center 1978).

West Grounds (45°20', *87°12'--45°15', 87°17').* Lake trout that were caught here during the spawning season were called "salmon trout" or "bay trout." They spawned over sand, gravel, and mud bottom in up to 100 ft of water. These lake trout spawned later than reef trout; spawning began on about November 1 (Coberly and Horrall 1980b).

Honeycomb Reef (45°17', 87°05'). Lake trout spawned here over honeycombed rock (Coberly and Horrall 1980b).

Deathdoor Bluff Reef (45°18', 87°04'). Lake trout spawned here; the substrate is tablerock at depths of 15-35 ft and honeycombed rock at 35-70 ft (Horrall, pers. comm. 1979).

Gills Rock (45°17', 87°02'). Commercial fishermen fished here during the spawning season (Owens, pers. comm. 1979).

Washington Island (45°23', 86°54'). Lake trout spawned along the east shore of the island from 45°24', 86°49'--45°20', 86°50'; around Boyer Bluff (45°25', 86°56'), and on a shoal (,45°24', 86°57') on the northwest shore (Coberly and Horrall 1980b).

Six Fathom Reef (45°26', 86°54'), The Little Reef (45°26', 86°47'), Fish Island (45°24', 85°46'), and Fisherman Shoal (45°22', 85°47'). Lake trout spawned here (Coberly and Horrall 1980b).

Waverly Shoal (45°17', 86°57') and Nine Foot Shoal (45°17', 86°57'). These shoals are the northern limits of an extensive series of lake trout spawning reefs that line the east shore of the Door Peninsula (Coberly and Horrall 1980b).

WM-3

Lake trout probably spawned throughout the entire reef area from Europe Bay (45°16', 86°59') to Whitefish Point (44°52', 87°12'); the substrate in this area is gravel, sand, boulders, and honeycombed rock outcroppings. Lake trout were usually taken along the outer edges of the reefs at depths of 30-70 ft. Spawning occurred during mid-October to early December; the run began a week earlier at *Whitefish Point than at Baileys Harbor (45°03, 87°07') (Coberly and Horrall 1980b). During the 1930s and 1940s, spawning fish were collected from the ridges of honeycombed rock extending off all the points from Cana Island (45°05', 87°03) south to Jacksonport (44°59', 87°11') (Frederick, pers. comm. 1979). Commercial catches indicated that spawning occurred at the following sites.

Fisherman Shoal Deep Reef (45°20', 86°45') and Spider Island (45°13', 86°59') (Coberly and Horrall 1980b).

Four Foot Shoal (45°10', 87°00') (Coberly and Horrall 1980b; Frederick, pers. comm, 1979).

Cana Island (Sucker Reef) (45°05', 87°03). This appeared to be one of the most productive areas, based on the number of boats fishing there (Coberly and Horrall 1980b).

Baileys Harbor (45°03, 87°07'). Spawners were historically collected from the five ridges of honeycomb extending from the harbor (Frederick, pers. comm. 1979). Black Stake Reef (45°03, 87°05') was one

of the most productive areas, based on the number of boats fishing there. Fishermen from as far away as Two Rivers (44°09', 87°34') came to the Baileys Harbor area to collect spawn in the fall (Coberly and Horrall 1980b).

Jacksonport (44°59', 87°11'). Jacksonport Reef (45°02', 87°06' -- 44°57', 87°10') and Jacksonport Deep Reef (44°57', 87°03) were identified as spawning sites (Coberly and Horrall 1980b; Frederick, pers. comm. 1979). Cardys Reef in the same area was exceptionally productive, but fishermen disagreed on its exact location (Coberly and Horrall 1980b).

Whitefish Bay (44°54', 87°12'). Spawning occurred on the rocky areas off Cave Point (44°56', 87°10') (Copes, Ebener, and Leary, pers. comm. 1979). Whitefish Point Reef (Red Stake) (44°52', 87°11') was a major spawning ground (Coberly and Horrall 1980b; Frederick, pers. comm. 1979; Horrall, pers. comm. 1979); substrate here was honeycombed rock and boulders (Coberly and Horrall 1980b). This area included a site called Sy's Reef (Coberly and Horrall 1980b). Spawning may presently occur at whitefish Point Reef (Copes, Ebener, and Leary, pers. comm. 1979). The Spits (44°54', 87°10'), a 16 ft deep shoal at the mouth of Whitefish Bay, is an historical spawning ground (Coberly and Horrall 1980b; Horrall, pers. comm. 1979).

Lily Bay Shoals (44°51', 87°13'--44°49', 87°16'), Allies Reef (44°48', 87°13'), and Black Can Reef (44°45', 87°18') (Coberly and Horrall 1980b).

Sturgeon Bay Ship Canal (44°48', 87°19'). Eggs were collected in late October from ripe fish captured over a reef area just south of the entrance to the canal (GLFC 1976c).

Clay Banks (44°42', 87°20'). This is an historical spawning area; the substrate is rubble and honeycombed rock (Coberly and Horrall 1980b; Horrall, pers. comm. 1979). In the late 1800s, fishing for spawners occurred over a rocky bottom, to depths of 60-84 ft, in an area extending 2 mi N and S of the town of Clay Banks (44°43', 87°21') (Kumlien and True 1887).

WM-4

Stony Creek Reef (44°40', 87°19') (Coberly and Horrall 1980b). This was a fishing ground for spawners during the late 1800s (Kumlien and True 1887).

Algoma (44°37', 87°26'). Spawning lake trout were caught on Gaulkes Reef (44°37', 87°24'), Rraemmers Reef (44°36', 87°25'), Eleven Fathoms Reef (44°35', 87°23'), and Kewaunee Hill (44°36', 87°26') (Coberly and Horrall 1980b).

Kewaunee (44°27', 87°30'). Kewaunee Shoal (44°27', 87°28') was identified as an historical spawning ground by fishermen (Coberly and Horrall 1980b).

Kewaunee Power Plant (44°21', 87°32'). This area may be a spawning ground (Ind. Rio-Test 1972). Impingement at the plant indicates that an onshore migration occurs from September to December (NALCO, undated b). Ripe-running adults were found throughout the area near the plant, from September to November, at depths of about 15-20 ft, over a substrate of hard clay, rubble, and cobble (Ind. Bio-Test 1972; LaJeone 1976, pers. comm. 1979).

Point Beach Power Plant (44°17', 87°32'). There are large influxes of adults into the area during September and October. In 1976, catches in the latter part of September at water temperatures of about 55-61°F suggest that fish move into nearshore areas prior to spawning; larger catches in October suggest that spawning may occur in the vicinity (Wis. Elec. Power, undated; Wis. Elec. Power and Wis.-Mich. Power, undated c).

Pine Creek (43°59', 87°42'). A "big redfin" trout spawned on the honeycombed rock reef (44°01', 87°39'--43°59', 87°41') off the creek mouth (Coberly and Horrall 1980b).

WM-5

Haven (43°51', 87°44'). An influx of ripe-running adults occurs here during October and November; highest concentrations of fish occur at depths of about 15-20 ft over a substrate of rocks, cobbles, and boulders overlying hard clay (Ind. Bio-Test 1977; LaJeone, pers. comm. 1979). Surveys conducted with pumps found no lake trout eggs in the area (LaJeone, pers. comm. 1979).

Sheboygan (43°45', 87°42'). Lake trout are most abundant in the vicinity of the Edgewater Power Plant (43°43, 87°42') during October, but spawning is not expected here due to the lack of silt-free rock substrate (Swanson Environ. 1979).

Port Washington (43°23', 87°52'). Ripe males and mature females were collected in mid-October at the beginning of the spawning run over rock and rubble in an area (43°22', 87°52'--43°16', 87°53') extending S for about 8 mi from Port Washington and offshore to a depth of about 90 ft (Eck, pers. comm. 1979). Most adults impinged in the fall at the Port Washington Power Plant (43°23', 87°52') were in spawning condition; these fish were most abundant in late October (Wis. Elec. Power 1976e).

Milwaukee-Sneboygan Reef Complex (43°20', 87°10'--42°59', 87°10'). Historically, this reef system, including Milwaukee (42°59', 87°05'--43°11', 87°20'), Sheboygan (43°14', 87°10'--43°27', 87°10'), Northeast (43°20', 87°30'--43°08', 87°32') and East (43°10', 87°28', 43°00', 87°21') reefs, was the major spawning ground in the lower two-thirds of the lake for the native deepwater lake trout (Coberly and Horrall 1980b; Daljj et al. 1962; Goode 1884; Harris and Eschmeyer 1975; Horrall 1976; Poff et al. 1964). Almost every commercial fisherman recently interviewed referred to this area, and to Sheboygan Reef in particular, as the most important spawning ground in the entire lake (Coberly and Horrall 1980b). From the 1930s to the late 1940s, spawning occurred here in 120-260 ft of water

over clay with patches of rock, honeycombed rock, and clinkers from mid-October to mid-November (Coberly and Horrall 1980b; Organ et al. 1978). Because of its historical productivity, plantings have been made on the reef (Brown 1977; GLFL 1970, 1972, 1973). During surveys in 1973 and 1974, several ripe or nearly ripe adults were collected on the shallowest portion of Milwaukee Reef (138 ft) in late October and early November (Wells 1975).

Milwaukee (43°02', 87°54). In the late 1800s, spawning lake trout were fished in the fall on a small reef (location unknown) 6 mi off Milwaukee (Goode 1884; Kumlien and True 1887). This may be the same area (43°05', 87°45'), about 6 mi E of North Point (43°04', 87°52'), where a commercial fisherman collected spawn from ripe fish over sand and clay in 120-138 ft of water (Coberly and Horrall 1980b). Planted lake trout presently begin moving onshore at the end of September, when water temperatures are about 41°F at the bottom and 59°F at the surface; spawning begins in about the last week of October (Norden, pers. comm. 1979). In the 1970s, ripe-running males and females were netted from mid-October to mid-November in the area between Whitefish Bay (43°08', 87°53') and Bradford Beach (43°04', 87°52') in 30-40 ft of water over a hard bottom of clay, rubble, cinders, and boulders. The abundance of ripe adults suggests that spawning occurs in the area between Atwater Beach (43°05', 87°52') and North Point (43°04', 87°52') (Binkowski and Yeo, pers. comm. 1979). Slimy sculpins that had eaten lake trout eggs were also collected in this vicinity (Binkowski and Yeo, pers. comm. 1979; Norden, pers. comm. 1979).

Milwaukee (43°02', 87°53')--Oak Creek Harbor (42°51', 87°50'). "Yellow-fins," "yellow-bellies," and "reefers" spawned on the shoals throughout this area during October 10 to November 15. Spawning also occurred on the reef (42°58', 87°47') about 4 mi E of Cudahy (42°57', 87°51') (Coberly and Horrall 1980b).

WM-6

Deepwater trout spawned throughout the area about 10 mi offshore from Racine (42°44', 87°47') south to Chicago (41°53', 87°37') (Coberly and Horrall 1980b).

Wind Point (42°47', 87°45'). Lake trout spawned on North Shoal (43°48', 87°44') and South Shoal (42°46', 87°44'), which form Bullshit Reef (Coberly and Horrall 1980b).

Racine Reef (42°44', 87°45'). This was a spawning ground before the sea lamprey became established in the lake (Ver Duin 1974, as cited in Horrall 1976).

Illinois

Some of the early literature indicates that no areas in the Illinois waters of Lake Michigan were recognized as lake trout spawning grounds; the grounds were reported to begin south of Racine (42°44', 87°47') and to

extend north along the entire lake shore (Goode 1884; Milner 1874a). Waukegan (42°22', 87°50'), however, was a site of spawn collection (Nevin 1899). Deepwater trout were caught by Illinois fishermen in 198-270 ft of water in a wide band from the Wisconsin state line (42°29', 87°48') across the southern portion of the lake and into Michigan waters. Deepwater trout spawned from October 20 to late November; peak spawning occurred in mid-November (Coberly and Horrall 1980a).

A geological survey of the shoreline platform extending from the Great Lakes Naval Training Center (42°18', 87°50') south to Indiana Harbor (41°40', 87°25') located more than 100 shallow reefs and small prominences with physical characteristics that may be able to support spawning by the shallow water variety of lake trout that is presently stocked. Most of the reefs are small exposures of dolomite bedrock with patches of gravel and cobble, honeycombed rock structures and cavities, and an occasional thin covering of glacial till (Collinson et al. 1979). Most of these reefs lie in offshore waters in the area between Zion and Evanston, bounded generally by longitudes 87°45' and 87°25' and by latitudes 42°05' and 42°30', at optimum depths of 50-100 ft. A second area adjacent to and east of the first area contains several bedrock reefs at depths of 100-200 ft; its potential as a spawning ground is believed to be slightly less than that of the first area (Norby and Collinson 1977). Patches of gravel occurring intermittently along the entire Illinois shore should also provide good spawning habitat and protection for eggs. Several of these areas have been identified at the 30 ft depth east of Evanston (Norby and Collinson 1977).

North Grounds (42°24', 87°35') and Middle Grounds (42°22', 87°30'). These areas, 12 1/2 mi NE and 16 mi E of Waukegan (42°22', 87°50'), respectively, were spawning grounds for deepwater lake trout. The substrate was a combination of sand, silt, clay, and mud (Coberly and Horrall 1980a).

South Grounds (42°14', 87°30'). This area, 20 mi SE of Waukegan (42°22', 87°50') was the most productive site for deepwater trout; catches of 5,000 lbs per net gang were made consistently during the spawning season. The substrate was a combination of sand, silt, mud, and clay (Caberly and Horrall 1980a).

Waukegan Reef (42°21', 87°38') and Highland Park Reef (42°11', 87°43'). Ripe lake trout are returning to planting sites here in mid-September and October (Muench, pers. comm. 1979). Both of these reefs have been studied to determine their potential for reproduction, Minimum water depth is 126 ft on waukegan Reef and 22 ft on Highland Park Reef (Collinson et al. 1979).

Lake Bluff 18-Mile Reef (42°18', 87°28'). This is a potential spa-wning area. The reef is a mound of glacial till covered with sand and clay; it lies in 250-255 ft of water, and the minimum water depth on the reef is 40 ft (Collinson et al. 1979).

Fort Sheridan Nearshore Bedrock Platform (42°14', 87°47'). This area is a potential spawning area. It extends along the shoreline from the north end of Forest Park in Lake Forest (42°15', 87°49') to the municipal

waterworks in Highland Park (42°11', 87°47') and to the 70 ft depth contour about 9 mi offshore. The substrate is mainly dolomite with scattered patches of sand and gravel (Collinson et al. 1979).

Julian's Reef (42°13', 87°32'). During the 1940s, this area, 14 1/2 mi E of Port Sheridan (42°13', 87°48'), was a very productive spawning ground for reef trout; as many as 11,400 lbs of lake trout, mainly "redfin" trout, were taken in one net set. This was one of the last reefs in Lake Michigan known to support spawning of native lake trout; the spawning stock using Julian's Reef was depleted by 1945 (Coberly and Horrall 1980a; Collinson et al. 1979; Mueneh, pers. comm. 1979). A fishery survey conducted in 1952 took only one native adult on the reef during the spawning season (Muench, pers. comm. 1979). The last reported catch of native trout in Illinois also occurred in 1952 (Coberly and Horrall 1980a). Reef trout also spawned on a small unnamed reef (42°13', 87°32') just west of Julian's Reef (Coberly and Horrall 1980a).

Wilmette (Glencoe) Reef (42°08', 87°35') and Grossepoint Reef (42°80', 87°27'). These are potential spawning areas for lake trout. Wilmette Reef lies in 60-80 ft of water; the southeast slope is relatively steep and irregular with gravel on the lower slopes and offers the best possibility for spawning. Grossepoint Reef has a minimum water depth of 117 ft, and its slopes and surface irregularities are favorable for spawning (Collinson et al. 1979).

Evanston (42°03, 87°40'). In 1979, a few nearly ripe females were collected in August about 3 mi offshore in 30 Et of water; a few running-ripe males and a nearly ripe female were collected here in mid-October (Janssen, pers. comm. 1979). Northwestern Reef (42°03, 87°35') is a potential spawning area; the substrate is bedrock, and minimum water depth on the reef is 41 ft (Collinson et al. 1979).

Indiana

Until the 1940s, lake trout were fished along the Indiana shoreline at depths of 80-120 ft in November (Westerman, pers. comm. 1979).

East Chicago (41°39', 87°26'). Lake trout are stocked at Joerse Park (41°39', 87°26'); concentrations of ripe adults are found in Octo'oer and November, but there is no evidence of natural reproduction here (Koch, pers. comm. 1979).

Gary (41°37', 87°20'). Adults in spawning condition have been found near the Mitchell Power Station (41°38', 87°22') in November, but there is no evidence of natural reproduction (NALCO 1976a).

Burns Waterway Harbor (41°38', 87°09'). Lake trout are now stocked at the mouth of the harbor, and concentrations of ripe adults are found here in October and November (Koch, pers. comm. 1979). Concentrations of adults are also found in the fall near the Railly Generating Station (41°39', 87°07'), about 1 mi E of the harbor (Tex. Instrum. 1975b, 1977b).

Spawning occurs over limestone rock along the west wall of the outer basin of the Burns Waterway Harbor, but there is no evidence of successful. natural reproduction (Koch, pers. comm. 1979).

Michigan City (41°43′, 86°54′). Lake trout are stocked here (Koch, pers. comm. 1979). Spawning occurs in an area (41°42', 86°57') about 2 mi W of Michigan City from near shore out to a depth of about 50 ft; large concentrations of ripe-running and spent adults are collected here beginning in the last week of October, and spawning lasts to mid-November (Koch, pers. comm. 1979; McComish, pers. comm. 1979). Windrowed eggs have been observed in the area from the Indiana Dunes (41°40', 87°02') to the Michigan state line (41°46′, 86°49') after a north wind (McComish, pers. comm. 1979).

Michigan

MM-1

Birch Point Reef (location unknown; possibly off Birch Creek, 45°01′, 87°34′) . Historically, spawning occurred here in November (Van Oosten 1927a).

Beattie Creek (43°14′, 87°31′). Lake trout spawned in an area (45°13', 87°30') off the creek mouth over rocky substrate in 18-40 ft of water (Organ et al. 1978).

Arthur Bay (45°19', 87°26'). From the 1920s to the 1950s, lake trout spawned in an area (45°19', 87°25'--45°20', 87°24′) over rock and gravel (Organ et al. 1978).

Whaleback Shoal (45°21', 87°11′). This is an historical spawning area where fishermen collected spawn (Coberly and Horrall 1980b; Frederick, pers. comm. 1979; Horrall, pers. comm. 1979). From 1915 to the 1950s, spawners were caught here over rock and gravel in about 30 ft of water (Organ et al. 1978).

Sugar Creek (45°22', 87°23'). Two reef areas (45°22', 87°22' and 45°21', 87°23′) off the mouth of Sugar Creek are historical spawning areas; these presently have poor reproductive potential (Peck 1979a).

Cedar River (45°24', 87°21′). During the 1920s to 1950s, native lake trout spawned from the mouth of the Cedar River to Deadmans Point (45°26', 87°20') over rock and gravel at a depth of about 24 ft. In 1978, planted lake trout spawned at the river mouth (Organ et al. 1978).

Bakers Reef (45°28', 87°18') and Halsteads Reef (45°32', 87°15′). These are traditional spawning areas; both now have poor reproductive potential based on the catch of very few mature planted fish (Peck 1977, 1979a).

Ford River (45°40', 87°08'). A stream-run population, which resulted from an unintentional plant in 1969, enters the river mouth in October, but the success of reproduction is unknown (Becker 1976).

Round Island Reef (45°38', 87°10′) and North Round Island (45°38', 87°10′). These are historical spawning grounds. Round Island has excellent reproductive potential based on the collection of several ripe and spent males and females in October and November 1975 and 1976 (Peck 7976, 1977, 1979a; Rybicki and Keller 1976).

Stonington Reef (45°43', 86°59'). This is an historical spawning area; in 1976, several ripe males were found here in mid-October, and the reproductive potential is considered fair (Peck 1977, 1979a). Spawning also occurred (no dates given) off the mouth of the Escanaba River (45°47, 87°03′) (Organ et al. 1978).

Corona (45°37', 86°58'), Eleven Foot (45°38', 86°59'), Peninsula Point (45°40', 86°58'), and Minneapolis Shoals (45°35', 87°00'). Lake trout spawned over rock and sand here (Organ et al. 1978; Peck 1979a). Surveys have found few mature fish present in these areas during the spawning season, and reproductive potential is considered poor (Peck 1979a). Only one spent and two ripe males were found at Eleven Foot Shoal in 1975 (Peck 1976).

Big Bay de Noc (45°45', 86°45'). Spawning occurred in this area from mid-October to late October or mid-November (Van Oosten 1927a).

Rocky Island (45°37', 86°43'). Since 1915, lake trout have spawned on the rock shoal west of the island (Organ et al. 1978). [Author's note: Native lake trout were extinct in Lake Michigan by about 1956 (Wells and McLain 1972, 1973). Hatchery reared juveniles were not planted in Lake Michigan until 1965 (GLFC, in press; Wells and McLain 1972, 1973) and would probably not have spawned before 1970.1

Poverty Island Shoal (45°33', 86°42'), Gravelly Island (45°31′, 86°44'), Gravelly Island Shoals (45°32', 86°44'), Gull Island (45°3 I′, 86°43'), and Little Gull Island (45°30', 86°43'). From 1915 to the 1950s, lake trout spawned over rock and gravel here (Organ et al. 1978).

Poverty Island (45°32', 86°40') and the shoal south of Summer Island (45°32′, 86°39′) . Lake trout spawned here (no dates given) over rock (Organ et al. 1978).

St. Martin Island (45°30', 86°46'). Historically, fishermen collected spawn from ripe lake trout here (Frederick, pers. comm. 1979). From 1915 to the 1950s, spawning occurred on the St. Martin Island Shoals (45°27′, 86°46') over rock and gravel (Organ et al. 1978).

MM-2

Kregg Bay (45°42', 86°34'). Lake trout spawned on the rock shoal (45°41', 86°31′), about 2 mi E of the bay (Organ et al. 1978).

Parent Bay (45°47', 86°25'). Spawning occurred on the rock shoal on the west side of the bay (Organ et al. 1978).

point aux Barques (45°48', 86°21'). Spawning occurred here in late October to mid-November (Van Oosten 1927a). Native lake trout spawned

here over rock and gravel until the 1940s; the earliest reported catch of spawners was in 1915 (Organ et al. 1978). In 1976, only one ripe fish of each sex was captured here in late October, and the reproductive potential is poor (Peck 1977, 1979a).

Wiggins Point Shoal (45°51', 86°18'). Native lake trout spawned here over rock and gravel (Organ et al. 1978).

Manistique (45°57', 86°15'). From the 1930s to 1947, native lake trout spawned about 3 mi S of the mouth of the Manistique River (45°57', 86°15') over a rocky shoal (45°54', 86°15') at a depth of 23 ft. During the 1970s, planted fish spawned along the rocky shoreline for about 1 mi on each side of the river mouth (Organ et al. 1978).

MM-3

Seul Choix Point (45°55', 85°55'). Spawning historically occurred around the point in November (Organ et al. 1978; Van Oosten 1927a). In 1976, a few ripe adults were caught here in late October, but the reproductive potential is considered poor ('Peck 1977, 1979a).

Hughes Point (45°58', 85°50'). Until 1948, native lake trout spawned about 5 mi S of the point over a rock shoal (45°54', 85°50') at a depth of 36 ft (Organ et al. 1978).

Boulder Reef (45°36, 85°58'). This is an historical spawning ground (Peck 1979a); spawning occurred here until about 1948 (Organ et al. 1978).

Gull Island (45°42', 85°50'). Gull Island Reef (45°38', 85°48') is an historical spawning ground (Peck 1979a); spawning occurred here until about 1948 (Organ et al. 1978). During the 1920s, spawning occurred on the shoal area (45°41', 85°51') off the southwest point of Gull Island (Organ et al. 1978).

Richards Reef (45°34', 85°44'). This rock and rubble reef is an historical spawning ground (Peck 1979a); in 1975, planted trout spawned here (Organ et al. 1978). In 1975, a few ripe and spent adults were found here in late October, but reproductive potential is considered poor (Peck 1976, 1979a).

Trout Island Shoal (45°47', 85°44'). This is an historical spawning ground (Peck 1979a); spawning occurred here until about 1948 (Organ et al. 1978).

High Island (45°44', 85°40'). This is an historical spawning ground (Peck 1979a).

Naubinway (46°06', 85°27'). Native lake trout historically spawned at Naubinway on October 8-20 and at Naubinway Reef (46°03, 85°26') on October 10-20 (Peck 1979a; Van Oosten 1927a). In 1975, planted lake trout spawned at Naubinway Island (46°04', 85°27') over rock and sand (Organ et al. 1978).

Whiskey Island Shoal (45°48' , 85°38'). This is an historical spawning ground (Peck 1979a).

Beaver Island (45°40', 85°33'). Beaver Harbor (45°44', 85°30'), at the north end of the island, and "Head of the Beavers" (45°34', 85°36'), at the south end, are historical spawning grounds (Peck 1979a). Trout were also taken in large numbers in the fall at "Middle Ground" (precise location unknown), a ledge in 48-60 ft of water half way between Beaver Island and North Fox Island (45°29', 85°47') (Smith and Snell 1891). Spawning occurred in this area on about November 1 (Strang 1855); spawn was collected from ripe fish here during October and November (Ravenel 1898).

Lansing Shoals (45°55', 85°35'). In 1942-43, lake trout spawned here (Organ et al. 1978).

Garden Island Shoal (45°52', 85°29'). Native lake trout spawned here during October (Organ et al. 1978; Van Oosten 1927a).

Mille Coquins Reefs (46°00′, 85°27') and Potter Reef (46°00', 85°32′). Native lake trout spawned here on October 5-20 (Organ et al. 1978; Peck 1979a; Van Oosten 1927a).

Hog Island (45°47', 85°22'). Hog Island Reef (45°44', 85°21'), about 4 mi S of the island, is an historical spawning ground (Peck 1979a); in the 1920s, spawning occurred here during October (Organ et al. 1978; Van Oosten 1927a). The north end of Hog Island and the Hog Island Humps (location unknown) were spawning areas (Van Oosten 1927a), as were Horseshoe Reef (45°46', 85°20') and Hat Island (45°49', 85°18') (Peck 1979a).

Joe Smith Reef, Five Mile Reef, and Metty Outer Reef (locations unknown). Lake trout spawned on these reefs in mid-October (Van Oosten 1927a).

Epoufette (46°03', 85°10'). Spawn was collected near Epoufette during October and November (Ravenel 1898). Spawning occurred at Epoufette from October 10 to November 1 and on Pelkie Reef (46°02', 85°15′) on October 10-20 (Van Oosten 1927a).

Manitou Paymen Shoal (45°58', 85°04'), Simmons Reef (45°55', 85°12'), and Fagan Reef (45°57', 85°18′). Spawning occurred at these locations on October 10 to November 1 (Van Oosten 1927a). Native lake trout spawned at Manitou Paymen, Fagan Reef, and Simmons Reef until the 1950s, and planted fish have spawned at Manitou Paymen (Organ et al. 1978).

Cross Village (45°39', 85°02')--Good Hart (45°34', 85°07'). The nearshore reefs directly off Cross Village and Good Hart are historical spawning grounds as are Ile aux Galets (45°41', 85°10') and Dahlia Shoal (45°38′ , 85°12') (Peck 1979a). During the 1920s, spawning occurred at Ile aux Galets in October (Van Oosten 1927a). At Dahlia Shoal, spawning occurred over honeycombed rock during the 1920s and in 1973-75 (Organ et

1973 and 1975, a few ripe males were found here in November (Peck 1974b, 1976). Spawning also occurred on a rock shoal (45°16', 85°58') at depths of 60-75 ft deep about 8 mi W of the southern tip of the South Fox Island Shoals (Organ et al. 2978).

MM-4

Grand Traverse Bay (45°05', 85°30'). Lake trout were most plentiful here from October IO to November 10 and were almost the only fish taken at this time (Smith and Snell 1891).

Nor-wood Reef (45°13', 85°24'). This reef is an historical spawning ground (Peck 1979a); during 1930-50 spawning occurred over rock, to depths of 50-60 ft (Organ et al. 1978).

Traverse Shoal (45°08', 85°26'). This rock and rubble area is a traditional spawning ground (Peck 1979a). Spawning occurred over honeycombed rock here during 1935-50 (Organ et al. 1978. Lake trout have been planted here (Rybicki and Keller 1978), and spawning fish are generally abundant in the area (Rybicki et al. 1975). Spawning occurred here in 1975 (Organ et al. 1978). In 1973-76, ripe and spent males and females were present from late October to mid-November, and in 1973 and 1974 eggs were found in the stomachs of lake trout captured here; the reproductive potential here is fair (Peck 1974, 1975b, 1976, 1979a; Rybicki et al. 1975; Rybicki and Keller 1978).

Elk River (44°54', 85°25'). Construction of a dam here in 1851 blocked the upstream spawning migration of lake trout in this tributary to the bay (Price and Kelly 1976).

Old Mission Point Reef (45°02', 85°29'). This is an historical spawning ground (Peck 1979a). In the 1920s, spawning occurred during November at Old Mission Reef (probably Old Mission Point Reef) and Old Mission Point Shoal (45°01', 85°29') (Van Oosten 1927a).

Tucker Point (44°54', 85°34'). This is an historical spawning ground; in 1976, only one mature male was found, and the reproductive potential is presently considered poor (Peck 1979a).

Bowers Harbor (44°54', 85°32'). This is an historical spawning ground; the substrate is boulders, cobbles, pebbles, and sand (Peck 1979a). In 1975, planted trout spawned around the harbor shore (Organ et al. 1978). In 1976, spawning males and females were found here in early November, live eggs were subsequently collected off the bottom, and the reproductive potential is good (Peck 1979a; Stauffer and Peck 1977); however no live-eggs or fry were found the following spring (Stauffer and Peck 1977). Spawning is believed to occur in the middle portion of the head of the harbor at a depth of 8-15 ft over gravel and rounded rock, 6-12 in. diameter, with patches of sand, large boulders, and silt (Stauffer and Peck 1977).

Marion Island (44°52', 85°35'). The boulder and sand reef at the south end (44°51′, 85°36') of the island and the cobble and boulder reef at the north end (44°53', 85°34') of the island are historical spawning grounds (Peck 1979a). In 1975, planted lake trout spawned on the north reef (Organ et al. 1978). In 1976, a few mature males were collected on the south reef in late October, and the reproductive potential is fair. More mature adults of both sexes were found at the north reef, and the reproductive potential is considered excellent (Peck 1979a).

Traverse City (44°46', 85°37'). Historically, lake trout may have spawned in nearby tributaries to the bay; the dam built in 1847 on Kid's Creek (44°46', 85°38') blocked the lake trout spawning migration (Price and Kelly 1976). In 1897, spawn of lake trout *or* whitefish, or both, was collected from a tributary (location unknown) of the bay (Ravenel 1898). In 1975, planted trout spawned over rock in an area (44°46′, 85°38′) just west of the Boardman River (44°46', 85°37') and in another (44°47', 85°38′ --44°47′, 85°39') directly off Greilickville (44°47', 85°39') to depths of 50-60 ft (Organ et al. 1978). In 1977-78, evidence of successful natural reproduction in the Traverse City area was found (Rybicki and Keller 1978). In 1977, lake trout fry were found in the intake water of the Traverse City Municipal Power Plant (44°46', 85°37') during March to May, and live eggs were found in November and December in 30 ft of water about 1,500 ft offshore, on the 2-6 in. diameter rocks in the power plant intake crib and on the rock spilling from the crib. These eggs were ready to hatch in mid-April 1978, but no fry were found (Stauffer 1979a). Live eggs were also found here in late November 1978 (Stauffer 197913). In 1977, live eggs were also found in November on the outside of the southeast rock and rubble break wall of the Elmwood Marina (44°47', 85°38'); no live eggs were found there in April 1978, but many fry were collected in late May and June (Stauffer 1978a). In 1978, live eggs were collected at the Elmwood Marina in late November; in 1979, fry about 1 in. long were collected from May 2 to July 2. In 1979, anglers reported a concentration of spawners at the Clinch Park Marina (location unknown), but few live eggs and no fry were found there (Stauffer 1979b).

Lee Point (44°56', 85°36'). Moss trout spawned over honeycombed rock and moss on the shoal (44°54', 85°37') about 2 mi S of Lee Point (Organ et al. 1978).

suttons Bay (44°59', 85°37'). Moss trout spawned over rock and moss in an area (45°00', 85°38') on the west side of Suttons Bay (Organ et al. 1978). Suttons Point Reef (45°00', 85°36') is an historical spawning ground (Peck 1979a). In 1975, planted fish spawned on the reef over rock and rubble (Organ et al. 1978); in 1976 many mature adults were found here, and the reproductive potential is excellent (Peck 1979a).

New Mission Point (45°03, 85°34'). The boulder and cobble reef off the north side (45°04', 85°34') is an historical spawning ground (Peck 197%). In 1975, planted lake trout spawned here (Organ et al. 1978). The substrate consists of 4-15 in. diameter rock rubble with patches of sand and large boulders. A rock ridge extends to the northeast to at least the 50 ft depth contour and contains crevices 3-14 in. deep. Lake currents apparently keep the top of the ridge free of silt (Stauffer and Peck 1977). In 1976, several spawning adults were found here in late October, live eggs were subsequently pumped from the bottom, and the reproductive potential is excellent (Peck 1979a; Stauffer and Peck 1977); however no live eggs or fry were found the following spring (Stauffer and Peck 1977). "Moss" trout spawned over rock and moss near the 30 ft depth contour in an area (45°02', 85°35') on the west side of New Mission Bay (Organ et al. 1978).

Bellow Island (45°06', 85°34'). This boulder and cobble area is an historical spawning ground (Peck 1979a). In 1975, planted lake trout spawned around the island and on the shoals (45°07', 85°34') north of the island (Organ et al. 1978). In 1976, several ripe adults were found at the island in late October, and the reproductive potential is excellent (Peck 1979a; Stauffer and Peck 1977). The substrate consists of 6-12 in. diameter rock rubble arranged in a series of ridges, 6-10 ft across, with crevice depths greater than 10-14 in. (Stauffer and Peck 1977).

Northport Point (45°08', 85°33'). The rock and rubble reef here is an historical spawning ground (Peck 1979a). Until 1940, lake trout spawn was collected in the Northport (45°08', 85°37') area (Westerman 1940). In 1975, planted fish spawned on the shoals along the entire east side of the point (45°10', 85°33'--45°08', 85°33') (Organ et al. 1978). In 1976, mature adults were found here in early November, and the reproductive potential is considered good (Peck 1979a).

MM-5

Lighthouse Point (45°13', 85°33')--Cat Head Point (45°11', 85°37'). During the 1920s, spawning occurred in November at Lighthouse Reef and Lighthouse Point Shoal (locations unknown) and Cat Head Point (Van Oosten 1927a). The areas east and northeast of Lighthouse Point were identified as one of the greatest spawning grounds in the lake (Kumlien and True 1887). Cat Head Point Reef (45°12', 85°35'), in Cat Head Bay (45°11' 85°36'), is an historical lake trout spawning ground (Peck 1979a).

Leland (45°01', 85°46'). Lake trout spawned (no dates given) over the rock reef (45°02', 85°46'--45°05', 85°43'), extending about 5 mi N from Leland (Organ et al. 1978); this may be the "North Reef" fished out of Leland in the 1920s, where spawning occurred from late October to late November (Van Oosten 1927a). Spawning also occurred north of Leland Green

woods (location unknown) during November and 8 mi N (precise location unknown) of Leland (Van Oosten 1927a). Until 1940, spawn was collected in the Leland area (Westerman 1940).

Manitou Islands (45°04', 86°03). This area is‘an historical spawning ground (MSBFC 1893). During the 1920s, spawning occurred at North (45°07', 86°01') and South (45°01', 86°08') Manitou islands from late October to late November (Van Oosten 1927a); in the 1930s spawning occurred on the rock, gravel, and clay shoals surrounding both islands and on the North Manitou Shoals (45°02', 85°58') (Organ et al. 1978).

Good Harbor Reef (44°59', 85°49'). This is an historical spawning ground (Peck 1979a), and may be the "South Reef" fished out of Leland (45°01', 85°46') in the 1920s, where spawning occurred from late October to late November (Van Oosten 1927a). Lake trout were planted on this reef during the 1970s, and some fish have returned here to spawn (North Woods Call 1979c; Rybicki and Keller 1978).

Pyramid Point (44°58', 85°56'). Spawning occurred on Pyramid Point Reef (Shoal) (44°59', 85°55') (Peck 1979a) in November (Van Oosten 1927a). Lake trout spawned (no dates given) over rock (45°01', 85°55') directly north of Pyramid Point Shoal in about 30-60 ft of water and on the rock reef (44°56', 85°59') along the west side of the point, just north of Sleeping Bear Bay (44°55', 86°00') (Organ et al. 1978).

Sleeping Bear Point (44°55', 86°03')--Point Betsie (44°42', 86°15'). During the 1920s, lake trout spawned during November at Sleeping Bear Reef (Shoal) (44°54', 86°05') Empire Reef (44°48', 86°07'), and Platte River Reef (44°44', 86°09') (Van Oosten 1927a).

MM-6

Arcadia (44°30', 86°14'). In the late 1800s, lake trout spawned on a reef area (location unknown) about 4 mi from Portage Lake (44°22', 86°14') (Smith and Snell 1891). In the 1920s, spawning occurred on *Arcadia Reef" (location unknown) and on a small reef (location unknown) off Arcadia during November (Van Oosten 1927a). During the 1930s-50s, spawning occurred on the reef area (44°25', 86°18'--44°28', 86°18') about 4 mi SW of Arcadia over honeycombed rock at a least depth of 29 ft (Organ et al. 1978); this is probably the same location identified by Smith and Snell (1891) and Van Oosten (1927a).

Portage Lake (44°22', 86°14'). During the 1930s-50s, lake trout spawned on the 30 ft deep rock reef (44°22', 86°17') about 2 mi off Portage Lake (Organ et al. 1978).

Manistee (44°15', 86°20')--Little Sable Point (43°39', 86°33'). Lake trout have been stocked at Manistee and Ludington (Rybicki and Keller 1978), and planted fish spawn along the entire shoreline from Manistee to Little Sable Point, over rock and gravel to a depth of about 50-60 ft (Organ et al. 1978). During the 1930s and 1940s, native lake trout also spawned in a nearshore area (44°11', 86°24') with gravel bottom about 6 mi SW of Manistee and in a rock area (43°55', 86°30'), about 4 mi SW of Ludington, at depths of about 50-70 ft (Organ et al. 1978). Native lake

trout spawned at the "Ludington clay banks" (location unknown) from November 10 to December 10 and at a "small spot of rocks" 6 mi S of Ludington (43°57', 86°28') (Van Oosten 1927a). Spawning occurs in an area (43°52', 86°29') about 6 mi S of Ludington over rock and clay in 40-70 ft of water; this location may be the same rock area identified as a spawning ground for native lake trout by Van Oosten (1927a). Spawning also occurs in an area (43°54', 86°30') directly west of the Ludington Pumped Storage Plant (43°54', 86°27') over clay bottom in 70-90 ft of water (Brazo, pers. comm. 1979; Organ et al. 1978); this location may be the clay banks identified by Van Oosten (1927a). Spawning occurs here slightly later than it does in nearshore areas (Brazo, pers. comm. 1979). During the 1970s, large numbers of ripe lake trout were collected in an area (43°52', 86°27'-- 43°55', 86°27') extending from 1/2 mi S to 1/2 mi N of the plant, as they moved inshore from mid-September to mid-November; many partly spent and fully spent fish were present by mid-November (Brazo, pers. comm. 1979; Brazo and Liston 1977; Consumers Power 1972; Liston and Tack 1973, 1974, 1975). The heaviest spawning occurs on the rocky areas around the jetties and breakwall during the third and fourth weeks of October (Brazo, pers. comm. 1979) or early November (Chiotti 1973).

MM-7

Stony Lake (43°34', 86°30')--Duck Lake (43°20', 86°24'). Several nearshore spawning areas have been identified in this region. From the 1940s to 1963 [see Authors' note, p. 951, lake trout spawned in an area (43°33', 86°31'--43°29', 86°29'), between Stony Lake and Flower Creek. From 1952 to 1963 [see Authors' note], lake trout spawned in an area (43°24', 86°27') about 1 1/2 mi N of White Lake over rock and in an area (43°24', 86°27'--43°18', 86°24'), extending from White Lake (43°23', 86°26') to about 2 mi S of Duck Lake Lake over rock and sand. Since 1952 [see Authors' note], spawning occurred in an area (43°28', 86°29'--43°24', 86°27'), extending from White Lake to Flower Creek (43°28', 86°28'), over sand (Organ et al. 1978).

Muskegon (43°13', 86°17'). Lake trout spawn in Lake Michigan at Muskegon, but spawning is not successful (FWS 1979d).

Mona Lake (43°10', 86°18')--Lake Macatawa (42°46', 86°13'). Commercial fishermen reported that spawning occurred throughout this area offshore at depths of about 250-350 ft. Native lake trout spawned until about 1946 in the northern portion (43°10', 86°35'--43°03', 86°35') of this area, between Mona Lake and Grand Haven (43°04', 86°13'), over a substrate of mud, clay, sand, and gravel. Spawning also occurred over mud and clay in the southern portion (43°03, 86°35'--42°46', 86°35') of the area (Organ et al. 1978). Plantings occurred at Port Sheldon (42°54', 86°13') in 1965, 1966, and 1968 (Rybicki and Keller 1978), and large numbers of ripe-running adults were collected in October and November 1977-78 in the vicinity of the Campbell Power Plant (42°55', 86°12') at Port Sheldon (Jude et al. 1978, 1979a; Jude, Heufelder, and Klinger, pers. comm. 1979). In late May 1980, 10 lake trout fry were captured south of the plant and north of the plant at the discharge and new intake structures at depths up to 50 ft (Jude, pers. comm. 1980).

The early literature reports no spawning grounds for native lake trout between Michigan City (41°44', 86°54') and St. Joseph (42°06, 86°29') (Milner 1874a). The major spawning areas were north of St. Joseph (Goode 1884). During the 1970s, planted lake trout spawned along the entire southeast shore of the lake over all bottom types in water less than 30 ft deep. This contrasts with the deeper water (60-240 ft or more) spawning of native trout which were present here prior to the 1940s (Tait 1973; Wells 1972). Lake trout were stocked at New Buffalo (41°48', 86°45') in 1967 (Rybicki and Keller 1978), and these stocked fish return inshore south of St. Joseph. In 1971, lake trout apparently spawned in large numbers in shallow water (generally less than 30 ft deep) over sand and boulders along the shoreline from the Indiana state line (41°46', 86°49') north to Holland (42°47', 86°07') (Wells 1972, Wells et al. 1971). All of these areas may also be nursery grounds (Wells 1972).

Saugatuck (42°40', 86°12'). In the late 1800s, "Honey Comb" Reef (42°39', 86°15'--42°36', 86°15'), about 2 mi S of Saugatuck, was a good lake trout spawning ground (Smith and Snell 1891). This reef has a substrate of rock and boulders and extends offshore to depths of about 72 ft (Wells 1972). In 1967-68, stocked fish spawned on Honey Comb reef (Organ et al. 1978). In 1971, ripe and spent females and males in spawning condition were collected off Saugatuck at 18-30 ft depths from mid- to late November (Wells et al. 1971). Since 1972, lake trout have spawned in an area (42°41', 86°13'--42°45', 86°13'), extending about 5 mi N from Saugatuck, over rock and gravel (Organ et al. 1978). In 1976, lake trout eggs were washed up on beaches in the Saugatuck area after a storm (Jude and Dorr, pers. comm. 1979).

Ganges (42°35', 86°13'). In 1967-68, planted lake trout spawned along shore in an area (42°34', 86°14'--42°37', 86°14') over gravel (Organ et al. 1978).

South Haven (42°24', 86°17'). Until 1948, native lake trout spawned in a large area (42°31', 86°24'--42°21', 86°27') about 10 mi offshore between South Haven and Glenn (42°31', 86°14') over a bottom of clay and mud at depths of about 130-200 ft (Organ et al. 1978). According to a commercial fisherman, native lake trout also spawned on clay banks (42°31', 86°28'--42°27', 86°28') in this same general area, about 15 mi offshore from Glenn, at a depth of about 240 ft (Owens, pers. comm. 1979). In 1971, ripe and spent females and males in spawning condition were collected off South Haven at 18 and 30 ft depths from mid- to late November (Wells et al. 1971).

Palisades Power Plant (42°19', 86°19'). Ripe and spent adults were collected near the plant in late October to early November 1972 (Consumers Power 1973a) and in late October 1973 (Consumers Power 1974). Large numbers of adults in spawning condition were also collected near the plant in early November 1978 (Wapora 1979c,d).

Lake Michigan Beach (42°13', 86°23'). Lake trout spawned here over a sand bottom at depths to 70 ft (Organ et al. 1978).

St. Joseph (42°06', 86°29'). Lake trout historically spawned here over clay (Stockwell 187533). Spawning occurred in an area (42°09', 86°29') 2 mi N of St. Joseph over sand at depths of about 36 ft (Organ et al. 1978). In 1971, ripe and spent females and males in spawning condition were collected off St. Joseph in water 18 and 30 ft deep from mid- to late November (Wells et al. 1971).

Bridgman (41°56', 86°35'). During the 1930s-50s, native lake trout spawned in the area 12-15 mi offshore between Bridgman and Shoreham (42°03, 86°31') over mud at depths greater than 200 ft (Organ et al. 1978). During the 1970s, ripe adults of planted stocks moved inshore in October and November in the vicinity of the Cook Power Plant (41°59', 86°34') and also at Warren Dunes (41°54', 86°37') (Indiana and Mich. Power 1975; Jude 1977; Jude and Dorr, pers. comm. 1979; Jude et al. 1975, 1979b). The numbers of spent fish peaked in November (Jude et al. 1979b). Adults concentrate on riprap at the power plant and on a clay bank north of the plant (Jude and Dorr, pers. comm. 1979). Spawning evidently occurs somewhere in the area. In 1975, eggs were found windrowed on beaches in the area after a storm in November, and sculpins with lake trout eggs in their stomachs have been impinged at the plant (Jude and Dorr, pers. comm. 1979; Jude et al. 1979b).

Bridgman Reef (41°52', 86°42'). Since 1970, spawners have been caught on this reef over a rock substrate at a depth of about 30 ft (Organ et al. 1978).

New Buffalo (41°48', 86°45'). In the late 1940s, many ripe-running adults of both sexes were caught in an area (41°48', 87°09') 20 mi w of New Buffalo at a depth of about 100 ft over a bottom of shale rock and stones (Westerman, pers. comm. 1979).

SALMORID spp.

Indiana

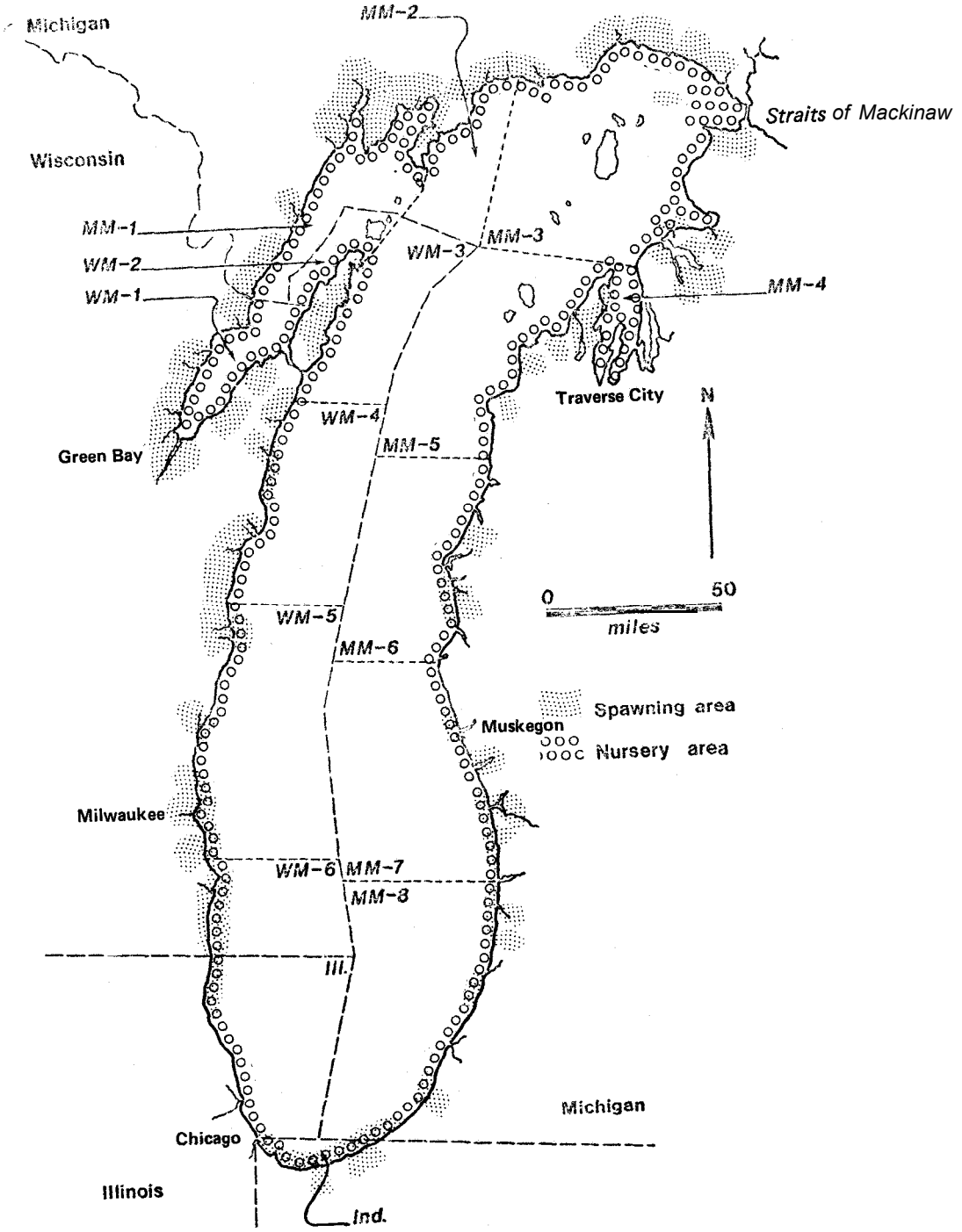
Bailly Generating Station (41°39', 87°07'). The eggs of an unidentified salmonid were entrained at the station during the last 2 weeks of December 1975 and the second week of November 1976 (Tex. Instrum. 1977b; 1976c).

Michigan

MM-7

Muskegon Lake (43°14', 86°18'-). In 1974, a larva of an unidentified salmonid was entrained at the Cobb Power Plant (43°15', 86°15') in early March; salmonid eggs were entrained in early June (Consumers Power 1976f).

RAINBOW SMELT



Rainbow smelt eggs planted in Crystal Lake, Michigan, in 1912 are believed to be the source of rainbow smelt found in all the Great Lakes except Lake Ontario (Van Oosten 1937a). Rainbow smelt made the first large spawning run from Crystal lake into Cold Creek in 1919 (Mich. Conserv. 1936). In 1923, rainbow smelt were first captured from Lake Michigan at Frankfort, near the mouth of the tributary that connects Crystal Lake and Lake Michigan (Creaser 1932; Dymond 1944; Wells and McLain 1972, 1973). By 1932, very large spawning runs had developed in streams along the north shore of Lake Michigan (Creaser 1932), and by 1936, rainbow smelt were dispersed throughout the lake (Wells and McLain 1972, 1973). Spawning runs enter tributary streams throughout the lake; spawning usually occurs within 1 mi of the stream mouth. Spawning also occurs in the lake in shallow gravel areas where there is current (Becker 1976; USBFC 1965; Walburg 1973; Wells and McLain 1973).

The largest populations of rainbow smelt and the greatest amount of reproduction occur in the northern areas of the lake (Wells and McLain 1973). All streams along the north shore probably have spawning runs (Leary, pers. comm. 1979). Green Bay is the center of rainbow smelt abundance in Lake Michigan (Hile et al. 1953; Wells, pers. comm. 1979). All the tributaries of Green Bay, especially those along the western shore, probably have spawning runs; spawning may also occur along shore (Belonger, pers. comm. 1979; Copes, pers. comm. 1979). Runs probably also occur in every Wisconsin tributary along the western shore of Lake Michigan proper (Copes, pers. comm. 1979; Kernen, pers. comm. 1979). Along the eastern shore, spawning occurs primarily on the beaches because there are few suitable tributaries (Owens, pers. comm. 1979). Stream runs along the southeast shore are sporadic (Warner 1979).

Rainbow smelt generally migrate from deeper water to inshore areas and then into tributary streams about the time of ice breakup. The abundance of adults peaks along shore during March and April at water temperatures of 40-50°F (CDM/Limnetics 1977; Copes, pers. comm. 1979; Euers 1960; Hile et al. 1953; Schneberger 1935; USDI 1966). The average length of the spawning period in Lake Michigan is about 2 weeks; spawning activity peaks in late April (Van Oosten 1953), although in 1979 spawning was still occurring in Little Bay de Noc in May (Copes, pers. comm. 1979). The time of hatching depends on the temperature and depth of the water where the eggs undergo embryonic development; hatching can occur as early as mid-May and as late as the first week in July (Owens, pers. comm. 1979). The nearshore waters of the entire lake are nursery areas for rainbow smelt larvae; older young-of-the-year (YOY) use the entire pelagic zone, especially the upper depth strata (Walburg 1973; Wells 1968, pers. comm. 1979).

Wisconsin

WM-1

Menominee River (45°06', 87°35'). The first reported run here occurred in March and April 1932 (Van Oosten 1937a; Wis. Dep. Agric. Mark.

1936); this tributary, which forms the boundary between Wisconsin and Michigan, still supports one of the largest runs in Green Bay (Belonger, pers. comm. 1979). The area from Marinette (45°05, 87°36') south to Peshtigo Reef (44°58', 87°36') appears to be a nursery area. Young-of-the-year are found here throughout the summer in 30 ft of water; densities are greater here than farther south in Green Bay (Belonger, pers. comm. 1979).

Oconto River (44°54', 87°50'). The first large spawning run here occurred in March 1934 under the ice; in 1935 the run was almost over by mid-April (Van Oosten 1937a; Wis. Dep. Agric. Mark. 1936). This tributary now supports one of the heaviest runs in Green Bay (Belonger, pers. comm. 1979). In 1978, many YOY were found in early September near Oconto Shoal (44°51′, 87°47') in about 10 ft of water (Belonger 1979).

Pensaukee River (44°49', 87°54'). Prior to 1942, runs here occurred early in the spring while there was still ice cover; after 1942, the runs started later in April (Euers 1960; Wis. Dep. Agric. Mark. 1936). Runs also entered the river in the late 1950s (FWS 1979c).

Little Suamico River (44°42', 87°59'). In the early 1930s runs ascended the river annually (Wis. Dep. Agric. Mark. 1936).

Big Suamico River (44°38', 88°00'). The first runs here occurred in 1933 (Van Oosten 1937a; Wis. Dep. Agric. Mark. 1936); these runs occurred under the ice until 1942; after 1942, the runs started later in the season (Euers 1960).

Fox River (44°32', 88°00'). In the early 1930s runs ascended the river annually (Wis. Dep. Agric. Mark. 1936). Rainbow smelt still spawn at the head of Green Bay. In 1975-76, 98% of all the rainbow smelt impinged at the Pulliam Power Plant (44°32', 88°00') were taken in April during their inshore migration. Rainbow smelt eggs were entrained at the plant in April and May (NALCO, undated a); larvae were also entrained (CDM/Limnetics 1977).

Bay Settlement (44°33', 87°54'). Runs occurred in this area during the early 1930s (Wis. Dep. Agric. Mark. 1936).

Dyckesville (44°38', 87°46'). In 1933, the first runs of rainbow smelt were reported in several unnamed streams near Dyckesville (Van Oosten 1937a; Wis. Dep. Agric. Mark. 1936).

Red River (44°40′, 87°45′). A spawning run occurs here (Poff and Threinen 1966a,b).

Sugar Creek (44°47', 87°40'). The first run here occurred in 1930 (Van Oosten 1937a).

Little Sturgeon Bay (44°50', 87°33'). In the 1930s runs occurred in the small streams entering the bay (Van Oosten 1937a; Wis. Dep. Agric. Mark. 1936).

Sturgeon Bay (44°53', 87°24'). In 1932, runs occurred in Big and Little creeks (locations unknown) (Van Oosten 1937a).

WM-2

Egg Harbor (44°03, 87°17'). In the early 1930s rainbow smelt spawned here (Wis. Dep. Agric. Mark. 1936).

Ephraim River (45°09', 87°10'). Rainbow smelt were present here in 1955 (FWS 1979c).

WM-3

Rainbow smelt may spawn along the shore from Four Foot Shoal (45°10', 87°00') to Baileys Harbor (45°03', 87°07') (Frederick, pers. comm. 1979).

Rowley Bay (45°13', 87°01'), North Bay (45°09', 87°04'), and Moonlight Bay (45°05', 87°05'). Rainbow smelt enter tributaries of these bays to spawn (Frederick, pers. comm. 1979).

Heins Creek (45°01', 87°09'). Spawning runs may enter the creek (Poff and Threinen 19651.

Hibbard Creek (44°59', 87°10'). The first run here was reported in 1930 (Van Oosten 1937a); runs also occurred here in the late 1950s (Fws 1979c) and in the 1960s (Poff and Threinen 1965).

South Creek (probably Whitefish Bay Creek, 44°55', 87°13'). The first run here was reported in 1930 (Van Oosten 1937a).

Shivering Sands Creek (44°52', 87°14'). Good fishing for rainbow smelt occurs here during the spawning runs (Poff and Threinen 1965).

Lilly Bay Creek (44°51', 87°16'). Good spawning runs occur here (Poff and Threinen 1965).

Woodard Creek (44°45', 87°20'). Rainbow smelt may spawn near the mouth of this creek (Poff and Threinen 1965).

Bear Creek (44°42', 87°21'). Spawning runs enter this river (Poff and Threinen 1965).

WM-4

Stony Creek (44°40', 87°23'). The first run here was reported in 1933 (Van Oosten 1937a; Wis. Dep. Agric. Mark. 1936); runs continued at least into the 1960s (Poff and Threinen 1965, 1966b).

Ahnapee River (44°36', 87°26'). A spawning run enters the river (Poff and Threinen 1966a,b). Runs were first reported at Algoma in the early 1930s (Wis. Dep. Agric. Mark. 1936).

Kewaunee River (44°28′, 87°30'). In the early 1930s spawning runs ascended the river annually (Wis. Dep. Agric. Mark. 1936); a run still occurs here (Poff and Threinen 1966a,b).

Kewaunee Power Plant (44°21', 87°32'). Rainbow smelt spawn along much of the shore zone near the plant (LaJeone 1976b; USAEC 1972e). An influx of ripe-running adults has been observed mainly in late April when water temperatures reach 46-49°F (Ind. Rio-Test 1972; LaJeone, pers. comm. 1979; NALCO 1976b, undated b). Spent adults were found near the plant in late May (NALCO 1976b). Eggs were also found in the area and were entrained at the plant in April and May; peak abundance occurred in late April (LaJeone 1976; NALCO, undated b). Larvae entrained from April to July were mostly rainbow smelt (NALCO, undated b); YOY were present here in the inshore waters in the fall (Ind. Bio-Test 1972).

Point Beach Power Plant (44°17′, 87°32′). Rainbow smelt apparently spawn in many areas along the shoreline here and exhibit little preference for substrate (Wis. Elec. Power 1975a). Ripe adults enter the inshore zone in large numbers in March and April; many fish are attracted to the discharge area of the plant (Limnetics 1974; Reed 1972; Romberg and Spigarelli 1973; Wis. Elec. Power, undated, 1975a, 1976c; Wis. Elec. Power and Wis. Mich. Power, undated a,b). Catches in the area decline rapidly in May coinciding with the end of spawning (Limnetics 1974; Wis. Elec. Power and Wis.-Mich. Power, undated a), and the adults leave the area by June and July, when alewives appear (Romberg and Spigarelli 1973; Wis. Elec. Power and Wis.-Mich. Power, undated b). Many rainbow smelt eggs are found in the area near the plant from March to June, when large number of adults are present (Limnetics 1974; Wis. Elec. Power, undated, 1975a; Wis. Elec. Power and Wis.-Mich. Power, undated a,b,c). Larvae, fry, and YOY were collected in the area from May to September (Limnetics 1974; Wis. Elec. Power , undated, 1975a, 1976c; Wis. Elec. Power and Wis.-Mich. Power, undated a,b,c).

Molash Creek (44°11', 87°31'). A spawning run occurs here (Weber, Desparte, and Threinen 1968).

TWO Rivers (44°09', 87°34'). Annual spawning runs were first reported in the early 1930s (Wis. Dep. Agric. Mark. 1936).

Manitowoc River (44°05', 87°39'). In the early 1930s rainbow smelt ascended the river annually (Wis. Dep. Agric. Mark. 1936).

Silver Creek (44°04', 87°39') and Calvin Creek (44°02', 87°40'). Spawning runs occur here (Weber, Desparte, and Threinen 1968).

Pine Creek (43°59', 87°42'). A spawning run occurs here during favorable years (Weber, Desparte, and Threinen 1968).

Point Creek (43°58'. 87*42') and Fischer Creek (43°56', 87°43'). Spawning runs occur here (Weber, Desparte, and Threinen 1968).

Haven (43°51', 87°44'). Ripe-running adults were collected here in April and May (Ind. Bio-Test 1977; LaJeone, pers. comm. 1979). Larvae and fry were collected from April to September and were most abundant from May to August in 5-20 ft of water (Ind. Bio-Test 1977; Wis. Elec. Power, unpubl. data; Wis. Elec. Power et al. 1979a,b). A run enters Sevenmile Creek (43°51', 87°44') (Weber, Poff, and Threinen 1968).

Sheboygan (43°45', 87°42'). Spring runs of rainbow smelt occur in the Pigeon River (43°47', 87°43') (Weber, Poff, and Threinen 1968), the Sheboyqan River (43°45', 87°42') (USDI 1966), and the Black River (43°42' 87°42') (Weber, Poff, and Threinen 1968). In 1975-76, ripe or ripening adults were impinged at the Edgewater Power Plant (43°43', 87°42') from late March to mid-April. A few larvae were entrained from April to September (Swanson Environ. 1976). In 1977-78, early postlarvae were collected nearshore from May to mid-October; YOY were abundant in the nearshore waters in September (Swanson Environ. 1979).

Port Washington (43°23', 87°52'). The first run was reported in Sauk Creek (43°23', 87°52') in 1933 (Van Oosten 1937a). Spawning runs occur throughout Ozaukee County (43°33', 87°48'--43°12', 87°54') (Poff et al. 1964). Large numbers of fish spawn at Port Washington (Binkowski, pers. comm. 1979). Spawning adults were collected at the Jones Island Waste Water Treatment Plant (43°23', 87°52') (Binkowski, pers. comm. 1979); fishermen frequently catch rainbow smelt here in April over a sandy bottom (Janssen, pers. comm. 1979). In 1975, ripe adults were impinged at the Port Washington Power Plant (43°23', 87°52') from late March to late May; peak impingement occurs in April and May (Wis. Elec. Power 1976e). Eggs were entrained in May; larvae were entrained from mid-July through September (Norden, pers. comm. 1979; Wis. Elec. Power 1976e). Larvae were collected in the lake from May through August (Wis. Elec. Power, unpubl. data, 1976e).

Milwaukee (43°02', 87°54'). Rainbow smelt spawn very close to shore in the Milwaukee area. The inshore movement usually occurs in April, but the timing of the run is dependent upon water temperature (Binkowski, pers. comm. 1979; Schaefer 1955). Ripe-running males and females are collected in Whitefish Bay (43°08', 87°53') and Milwaukee Harbor (43°02', 87°53') (Janssen, pers. comm. 1979). Runs enter the unnammed creek (43°12', 87°54') north of Fox Point (43°10', 87°53') (Norden, pers. comm. 1979) and the Milwaukee River (43°02', 87°54') (Poff and Threinen 1964). Spawning occurs at Doctor's Park on Fox Point, at North Point (43°04', 87°52'), and at Bradford (43°04', 87°52') and McKinley (43°03', 87°53') beaches (Binkowski, pers. comm. 1979; Norden, pers. comm. 1979). Larvae are caught in Milwaukee Harbor (Janssen, pers. comm. 1979; Norden, pers. comm. 1979); YOY are present off McKinley Beach during the summer, when inshore water temperatures are between 45-52°F (Binkowski, pers. comm. 1979). In 1973, eggs were found in May at the Lakeside Power Plant (42°58', 87°51') 4 mi S of Milwaukee Harbor; YOY were also collected there (Limnetics 1974; Wis. Elec. Power 1975c).

Oak Creek (42°54', 87°51'). Adults enter the creek to spawn (Norden, pers. comm. 1979).

Oak Creek Harbor (42°51', 87°50'). Spawning appears to occur along the entire shoreline here (Wis. Elec. Power 1975b). Ripe males and females were impinged at the Oak Creek Power Plant (42°51', 87°50') beginning in late March (Limnetics 1974; Wis. Elec. Power 1976d). Eggs were found in April to June, and larvae, fry, and YOY were present from April to October (Ball 1971; Limnetics 1974; Wis. Elec. Power 1975b, 1976d). Large numbers of eggs were collected at the plant intake in April; the plant's intake channel is reported to be a favored spawning area. Adults leave the nearshore zone by early summer (Limnetics 1974).

WM-6

Kenosha (42°40', 87°48'--42°29', 87°48') and Racine (42°49', 87°49'--42°40', 87°48') Counties. Rainbow smelt enter shallow water and streams in the area to spawn (Poff and Threinen 1961a,b).

Illinois

Spawning may occur along the entire Illinois shoreline (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). The shoreline area from just north of the Wisconsin stateline (42°29', 87°48') and south to Waukegan is a spawning and nursery area (Cochran, undated; Cochran and Cima 1974; Commonw. Edison 1976; Ind. Bio-Test 1975b; LaJeone, pers. comm. 1979). Seine catches and impingement of ripe and spawning adults at the Waukegan (42°23', 87°49') and Zion (42°27', 87°48') Generating Stations increase during the inshore run in March and April, at a water temperature of about 37°F (CDM/Limnetics 1976c; Cima 1977; Cochran and Kitchell 1976; Kitchell and Otto 1974; Muench 1974; Orpret and Cochran 1976; Otto 1975). Spawning begins at water temperatures of about 41-43°F and peaks during the last 2 weeks of April and ends in May (CDM/Limnetics 1976c; Cima et al. 1974; Cochran, undated; Cochran and Cima 1974). A post-spawning migration to offshore waters occurs in May and June (Otto 1975). Spawning appears to be restricted to the beach zones and does not occur in any of the small streams in the area (Otto 1975). Spawning fish seem to be attracted to the discharge current of the Zion Generating Station, where maximum spawning activity occurs in water about 22 ft deep (Cima et al. 1976; Muench 1974; Otto 1975). Eggs were found throughout the entire Zion-Waukegan area in April and May when water temperatures were about 43-50°F; most eggs were collected in the beach zone at depths of less than 30 ft (CDM/Limnetics 1976c; Cima 1977; Cima et al. 1976; Cochran, undated; Cochran and Cima 1974; Muench, pers. comm. 1979; Otto 1975). Larval abundance peaks in late June; YOY have been collected throughout the summer, mainly at depths of 30 ft or less (CDM/Limnetics 1976c; Cima 1977; Cima and Cochran, undated; Cima et al. 1976; Cochran, undated; Cochran and Cima 1974; Ind. Bio-Test 1975b; LaJeone, pers. comm. 1979; Otto 1975).

Rainbow smelt spawn along the entire shoreline and in tributaries; peak spawning activity usually occurs in mid-April (Koch, pers. comm. 1979). Ripe adults were caught by fishermen everywhere along the shore as early as late March (Westerman, pers. comm. 1979). Almost the entire Indiana beach zone is a nursery area (McComish, pers. comm. 1979).

Hammond (41°40', 87°30'). In 1975-76, impingement of adults at the Stateline Generating Station (41°42', 87°31') peaked during the spawning period. Rainbow smelt are believed to spawn successfully in the area. Eggs were present during April and May. Larvae were collected from May to August, most were taken from late May to late June (NALCO 1976c).

Joerse Park (41°39', 87°26'). Rainbow smelt are caught here during spawning runs (Palacios, pers. comm. 1979).

Gary (41°37', 87°20'). Rainbow smelt spawn successfully in the vicinity of the Mitchell Power Station (41°37', 87°22') (NALCO 1976a). Adults are netted by sport fishermen during the spawning run in late April (NALCO 1976a). Eggs are present in May; larvae are present from May to September (Krueger 1976; NALO 1976a).

Bailly Generating Station (41°39', 87°07'). Spawning runs enter tributaries near the station, including Burns Ditch (41°38′, 87°10'), Little Calumet River (41°37', 87°10'), and Dunes Creek (41°39', 87°05') (Tex. Instrum. 1975b, 1976a). Spawning also may occur here along the lake shore (Tex. Instrum. 1976a). Spawning usually begins in early April and peaks in May, and impingement of adults at the plant is highest at this time (Tex. Instrum. 1976c). Eggs and larvae were collected in the area and were entrained at the station from March to July; peak abundance occurred in May (Tex. Instrum. 1975b, 1976c, 197713). Young-of-the-year were captured with seines along shore in August (Tex. Instrum. 1979a).

Michigan City (41°43', 86°54'). Spawning runs occur at the dunes area (41°42, 86°57') west of Michigan City (Palacios, pers. comm. 1979). Runs also occur at the Michigan City Pier (Koch, pers. comm. 1979), at the Yacht Basin (41°43', 86°54') (Palacios, pers. comm. 1979), and in Trail Creek (41°44′, 86°54′) from April to early May (McComish, pers. comm. 1979). At the Michigan City Generating Station (41°43', 86°54') on Trail Creek, large numbers of ripe adults are impinged from March to May (Morgan 1978a). Most adults move offshore in June or July (McComish, pers. comm. 1979; Morgan 1978a). A few larvae are entrained at the station (Morgan 1978a), and many YOY are found in the nearshore zone from July to September (Koch, pers. comm. 1979; McComish, pers. comm. 1979; Willis 1975).

Michigan

MM-1

Turtle Creek (45°09', 87°36'). In 1932, a small run occurred in March and April (Van Oosten 1937a).

Springer Creek (45°11', 87°34'). The first run here occurred on March 27-28, 1930 (Van Oosten 1937a).

Beattie Creek (45°14', 87°31'). In 1932, a small run occurred in March and April (Van Oosten 1937a).

Cedar River (45°24', 87°21'). The first run here was reported in March to April 1932 (Van Oosten 1937a); a run also occurred in 1955 (FWS 1979c).

Bark River (45°34', 87°14'). Many adults were present in the river in 1955 (FWS 1979c). In 1978, many eggs were found north of the *river* mouth in early May. Larvae were present from May through August near the river mouth; peak abundance occurred from mid-May to mid-June (Wis. Elec. Power, unpubl. data).

Ford River (45°40', 87°08'). A spawning run occurs here (Warner 1979). In 1978, eggs were collected off the river mouth in May; larval abundance peaked there in late May, and larvae were present in the area until late August (Wis. Elec. Power, unpubl. data).

Little Bay de Noc (45°45', 87°00'). Adults are very common in the bay during April and May (Peck 1974; Wagner 1972, 1973). During 1960-65, ripe adults were collected as they entered the Rapid River (45°55', 86°58') from late April to early May (Norden, pers. comm. 1979). In 1932, a run occurred in the Days River (45°54', 86°59') (Van Oosten 1937a), and in 1954 and 1955, adults were found in the Days, Tacoosh (45°55', 86°58'), and whitefish (45°55', 86°57') rivers and Squaw Creek (45°48', 86°59') (FWS 1979c). In 1968, a run occurred in the Whitefish River (Jenkins 1968).

Big Bay de Noc (45°45', 86°45'). In 1931 and 1932, extensive runs occurred in all tributaries of Delta County, which surrounds both Big and Little Bay de Noc (45°45', 87°00'). These streams included the Ogontz (45°52', 86°46'), Sturgeon (45°50', 86°40'), and Fishdam (45°54', 86°35') rivers (Mich. Conserv. *1932c;* Van Oosten *1937a).* In 1954 and *1955,* rainbow smelt were found in the Sturgeon and Fishdam rivers (FWS *1979c).* In *1979,* good runs occurred in tributaries near Garden (45°46', 86°33') during the last week in April (Ann Arbor News 1979b).

MM-2

Southtown Creek (45°56', 86°16'). A small run occurred in April *1944* (Van Oosten 1944b).

Crow River (46°02', 85°36'). A run occurred in April 1936 (Van Oosten 1937a).

Rock River (46°05', 85°32'). A run occurred in the spring of 1936 (Van Oosten 1937a), and in 1976 (FWS 1979c).

Black River (46°06', 80°21'). A run occurred in the spring of 1936 (Van Oosten 1937a), in the late 1950s (Stauffer 1972), and in 1979 (Warner 1979).

Mille Coquins River (46°06', 85°29'). A run occurred in the spring of 1936 (Van Oosten 1937a).

Paquin Creek (46°04', 85°13') and Davenport Creek (46°04', 85°16'). Runs occurred in the spring of 1936 (Van Oosten 1937a).

Cut River (46°03, 85°07'). A run occurred in April 1932 (Van Oosten 1937a).

White Shoal (45°50', 85°09'). In 1972, spawning occurred on the shoal in April and May, over sand, rock, and mud to depths of 40 ft (Organ et al. 1978).

Brevoort River (45°57', 84°56'). A run occurred in 1979 (Warner 1979).

Carp Lake River (45°45', 84°50'). The first run here was reported in 1931 (Van Oosten 1937a).

Big Sucker Creek (45°44', 84°56') and Little Sucker Creek (45°44', 84°57'). The first runs here were reported in April 1936 (Van Oosten 1937a).

Bear River (45°23', 84°58'). A run was first reported here in early April 1931 (Van Oosten 1937a).

Big Rock Point (45°22', 85°12'). In 1974-75, adults were impinged at the Big Rock Power Plant (45°22', 85°12') in mid-April and May. Eggs were collected in April and May and were most abundant in late May. Larvae were collected from late May to mid-September (Consumers Power 1976e).

Lake Charlevoix (45°17', 85°10'). In 1929, spawning runs developed in several tributaries to Lake Charlevoix (Creaser 1932). The following creeks and rivers developed spawning runs by 1930 (Creaser 1930).

> Boyne River (45°13', 85°01'). In 1930, a run moved upstream to the dam from March to late April, when temperatures were often just above freezing; runs were heaviest in mid-March when the water temperature was about 37°F.

Porter Creek (45°13', 85°04'). In 1929, a run moved about 750 ft upstream to the dam; the run began in mid- to late March, when the water temperature was about 33°F.

Jordan River (45°09', 85°08'). In 1930, a small run moved upstream to the dam on Deer Creek (45°08', 85°07'); the run began on March 21 when the water temperature was about 35°F.

Brown Creek (45°10', 85.°08'). In 1930, a run occurred on March 21.

Horton Creek (45°17', 85°15'). In 1930, a run moved 1/4 mi upstream to the dam on March 20.

Stover (Strover) Creek (45°18', 85°15'). In 1929, a run entered the creek in late March.

MM-4

Grand Traverse Bay (45°05', 85°30'). In 1972, rainbow smelt were more abundant in the bay than in any other area of Lake Michigan. Runs enter many small tributaries to the bay in late March-April; dams limit reproduction in these streams (Bower 1954; Price and Kelly 1976).

Leo Creek (44°58', 85°39'), Belangers Creek (45°01', 85°37'), Weaver Creek (45°02', 85°36'), and Deuster Creek (location unknown). Spawning runs were first reported here in 1935 (Van Oosten 1937a).

Northport Bay (45°07', 85°35'). The first run was reported here on April 10, 1953; the run lasted only 3 hours. Spawning occurred along the shores of the bay, near the village of Northport. Eggs were found attached to stones in about 3 ft of water (Lievense 1954).

MM-5

Platte River (44°44', 86°09'), Otter Creek (44°46', 86°04'), Shalda Creek (44°57', 85°53'), and Leland Harbor (45°01', 85°46'). Spawning runs occurred in 1979 (Warner 1979).

MM-6

Gurney Creek (44°08', 86°25') and Connor Creek (44°07', 86°26'). Small runs occur here (Brazo, pers. comm. 1979).

Ludington (43°57', 86°28'). Spawning occurs in the area from Ludington south to approximately Bass Lake (43°50', 86°26'), and peak spawning occurs sometime between mid-April and early May (Brazo, pers. comm. 1979). Spawning occurs primarily along shore; there are no heavy runs into creeks in the area (Brazo, pers. comm. 1979), although rainbow smelt are abundant in Pere Marquette Lake (43°56', 86°26') during the

spring (FWS 1979d). Spawning adults have been collected throughout the area (Brazo, pers. comm. 1979); the largest numbers of adults are present at the Ludington Pumped Storage Plant (43°54', 86°27') during the spawning runs (Brazo and Liston 1977; Liston and Tack 1975). Large numbers of larvae are collected at the plant beginning in mid- or late May (Brazo, pers. comm. 1979; Liston et al. 1978). Young-of-the-year are collected near the plant (Brazo, pers. comm. 1979; Liston and Tack 1974); in 1979, YOY were found in large numbers throughout the summer between the 5 and 40 ft depth contours (Brazo, pers. comm. 1979).

Bass Lake outlet (43°50', 86°26'). A small spawning run occurs here (Brazo, pers. comm. 1979).

MM-7

Muskegon (43°13', 86°17'). During 1932-70, spawning occurred over sandy substrate at depths less than 30 ft in an area extending from Mona Lake (43°10', 86°18') to White Lake (43°23', 86°26') (Organ et al. 1978). Rainbow smelt are also abundant in Muskegon Lake (43°14', 86°18') in the spring. In 1974-75, most adults were impinged at the Cobb Power Plant (43°15' 86°15') on Muskegon Lake from Late April to mid-May (Consumers Power 1976f; FWS 1979d).

Grand Haven (43°04', 86°13'). Larvae were collected off Grand Haven, primarily in late June to late July (Brandt 1978; Wells 1973).

Little Pigeon (Pine) Creek (42°58', 86°13'). A spawning run occurs here (Tin and Heufelder, pers. comm. 1979).

Port Sheldon (42°54', 86°13'). Adults spawn in shallow areas here and then return to deeper water (Jude et al. 1978, 1979a). Many ripe-running adults were collected in the sandy beach zone during late April and early May (Jude 1978; Jude et al. 1978, 1979a; Tin and Heufelder, pers. comm. 1979). In 1978, peak spawning occurred near the Campbell Power Plant (42°55', 86°12') in late April and early May; limited spawning extended into early June (Jude et al. 1979a). Spawning runs may also enter Pigeon Lake (42°54'. 86°12'), from which the plant withdraws water. About 75% of the impingement at the plant occurred in April and May during the spawning season (Consumers Power 1976b; Jude 1978). Eggs were entrained at the plant in late April (Consumers Power 1976b). Entrainment of larvae peaked in late May and continued into September. In 1978, entrainment of larvae declined in early June after peak hatching had occurred and larvae began to move offshore (Jude 1975; Jude et al. 1979a; Wapora 1979a). Newly hatched larvae were found in Lake Michigan in water about 10 ft deep in mid-May and at depths to about 50 ft during late June and early July (Jude et al. 1978, 1979a; Tin and Heufelder, pers. comm. 1979). In 1979, huge schloos of larvae were observed in August in 10-18 ft of water along the jetties where Pigeon Lake enters Lake Michigan (Tin and Heufelder, pers. comm. 1979; Wapora 1979a). Young-of-the-year are caught with seines and trawls during July to November; the largest trawl catches are made at water depths of 10-60 ft (Jude et al. 1978, 1979a).

Rainbow smelt larvae are generally common or abundant all along shore from the beach zone out to depths of about 240 ft from early May to mid-August (Harris and Eschmeyer 1975; Owens, pers. comm. 1979).

Halfway Creek (42°43', 86°12'). Rainbow smelt spawn over gravel at the mouth of the creek (Owens, pers comm. 1979).

Saugatuck (42°40', 86°12'). In 1979, spawning was observed in approximately 3 ft of water at Oval Reach (42°40', 86°13') south of Saugatuck from April 25 to May 10, and rainbow smelt eggs were collected here on artificial substrates (Owens, pers. comm. 1979). In 1980, adults in spawning condition were captured on the reef (42°38', 86°17') near Saugatuck from shore out to a depth of about 60 ft during late April and early May (Owens, pers. comm. 1980). According to fishermen, spawning runs entered the Kalamazoo River (42°40', 86°13') and smaller tributaries in the area; runs have not been observed here recently (Owens, pers. comm. 1979).

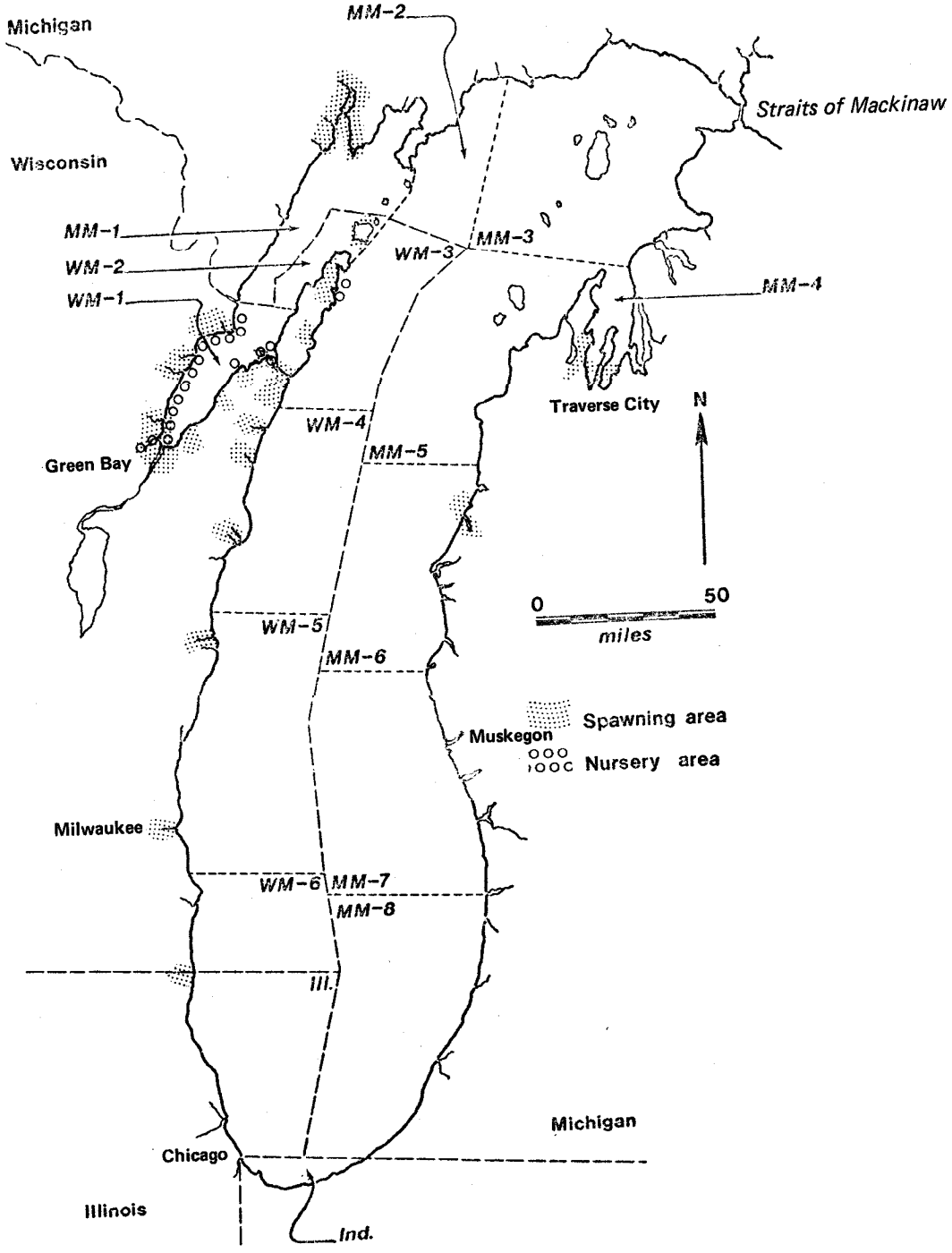
Cove Creek (42°35', 86°14'). Rainbow smelt spawn over gravel that extends along shore approximately 1 mi on each side of the creek mouth; a spawning run also probably enters the creek. Spawning occurs here from the end of April to about May 10 (Owens, pers. comm. 1979).

Palisades Power Plant (42°19', 86°19'). Rainbow smelt spawn in this area (Consumers Power 1972b; Patriarche 1972). Spawning was observed along the shoreline from late April to mid-May (Wapora 1979c,d). Many adults were impinged at the plant in April‘and May during the spawning run (Consumers Power 1975); adults disperse offshore after spawning (Wapora 1979d). Many eggs were collected in the area, as early as March; highest densities occurred along the shoreline (Consumers Power 1973b, 1976g; Wapora 1979c). Rainbow smelt larvae were collected from April to October; maximum abundance occurred in mid- to late May. Many small prolarvae were collected; postlarvae were reported to disperse offshore to depths of 27-30 ft or more and then to move back inshore as juveniles, just over 1 in. long (Wapora 1979c). Numerous fry and YOY were collected throughout the area (Consumers Power 1974, 1975; Patriarche 1973a,b, 1974; Wapora 1979d; Wells 1973, 1974). In 1973, many fry were found in late August, which indicated that spawning had been delayed or that the spawning period had been extended. Young-of-the-year were impinged at the power plant in September and October (Consumers Power 1974).

Bridgman (41°56', 86°35'). Spawning runs occur throughout the area from the Cook Power Plant (41°59', 86°34') to the Warren Dunes (41°54', 86°37') principally in April and May (Indiana and Mich. Power 1975; Jude, pers. comm. 1979; Jude et al. 1975, 1979b). Most spawning occurs in the beach zone and at the mouths of the creeks at Warren Dunes and at Weco Beach (41°56', 86°35') (Jude 1976a, pers. comm. 1979; Jude et al. 1975, 1979b) from mid-April to early May when the water temperature reaches approximately 43-50°F (Indiana and Mich. Power 1975; Jude 1976a; Jude et al. 1975, 1979b); adults move to deeper water by late May (Indiana and

Mich. Power 1975). Eggs were found in the area, almost exclusively in the beach zone; eggs were also entrained at the Cook Power Plant (CDM/Limnetics 1977; Indiana and Mich. Power 19751. Larvae and YOY are abundant in the area through October (Jude et al. 1973, 1975, 1979b; Jude, pers. comm. 1979; Wells 1973, 1974). The entire area from the beach zone out to a depth of 30 ft is a nursery area for rainbow smelt (Jude, pers. comm. 1979; Jude et al. 1979b).

NORTHERN PIKE



WM-1

The west shore of Green Bay (45°05', 87°25') has a substantial population of northern pike; these fish migrate up virtually every stream and drainage ditch in the area to spawn in the spring. When there is an increase in stream flow, runs may begin at the end of March before ice breakup. After spawning is completed, adults return to the lake. There may also be resident populations of adults in the streams (Belonger, pers. comm. 1979). The entire west shore and all areas with emergent vegetation are nursery grounds (Kernen, pers. comm. 1979).

Peshtigo River (44°58', 87°39'). Ripe northern pike are caught by sport fishermen at Peshtigo Point (44°59', 87°38') and in the Peshtigo River just before ice breakup (Ebener, pers. comm. 1979).

Thomas Slough (44°57', 87°49'). Northern pike migrate from the lake into the slough during the spring to spawn (Carlson et al. 1977).

Pensaukee River (44°49', 87°54'). Spawning runs enter the river. These runs may occur under the ice, and usually precede the white sucker runs that begin in April (Horrall, pers. comm. 1979; Imhof, pers. comm. 1979).

Little Suamico River (44°42', 87°59'). A spawning run occurs in the river prior to the sucker run in April (Horrall, pers. comm. 1979).

Peaks Lake (44°34', 88°02')--Little Tail Point (44°40', 87°59'). Before 1920, this marsh area was one of the most heavily utilized spawning grounds in Green Bay (Coberly and Horrafl 1980b). In 1975, northern pike were observed on several spawning grounds in flooded fields, weed choked ditches and marshy areas between Long Tail Point (44°35', 87°59') and Duck Creek (44°34', 88°02'). A few males appeared on April 4 when an inch of ice still covered the ditches; more adults were present a few days later. Spawning was underway on April 11; water temperatures at this time ranged from 35°F in the morning to 54°F in the afternoon. By April 15 most of the fish had spawned and returned to the bay (Langhurst 1975a). In 1976, ripe females were collected and spawning was observed in this area on March 27; two days of 60°F temperatures and heavy rain initiated pike movement into the ditches (WDNR 1976). The marshy edges of the west shore of Green Bay are nursery grounds for northern pike. Larvae may remain for weeks in streams before migrating out (Kernen, pers. comm. 1979). In 1975, yolk-sac larvae approximately 1 in. long were observed and collected in the spawning areas in early May (Langhurst 1975b).

Fox River (44°32', 88°00'). During the mid-1920s, the spawning run of northern pike in the river was stopped by the dam at DePere (44°27', 88°04'). Spawning occurred below the dam, and the eggs were swept downstream (Izaak Walton League 1925, as cited in Bertrand et al. 1976). Northern pike presently move into the river to spawn (FWS 1979d). In 1975, eggs believed to be those of northern pike were entrained at the

Pulliam Power Plant (44°32', 88°00') at Green Bay (44°30', 88°00') during April and May; the water enterinq the plant is pumped from both Green Bay (45°05', 87°25') and the Fox River (NALCO undated a);

Red River (44°40′, 87°45'). A spawning run enters the river in the spring (Poff and Threinen 1965, 1966a,b).

Sugar Creek (44°47', 87°40'). A spawning run enters the creek in the spring (Poff and Threinen 1965).

Little Sturgeon Bay (44°50', 87°33'). Spawning runs enter Keyes Creek (44°49', 87°33') and two other unnamed tributaries in the spring (Poff and Threinen 1965). The marshy shorelines with emergent vegetation are nursery areas (Kernen, pers. comm. 1979).

Sturgeon Bay (44°53', 87°24'). In 1972, northern pike were observed migrating into Sawyer Creek in Sawyer Harbor (44°53', 87°26') on April 16. The run entered the creek under the ice and progressed 1 mi upstream. A ripe female was collected on April 20 in Sawyer Creek. On April 24 most of the northern pike collected in the harbor were ripe; two spent females were also taken. Spawning probably occurred from April 16 through April 30 and may have occurred earlier in the creek than in the harbor. Spawning probably occurs in the marsh areas of the harbor after the ice cover breaks up. During years of low runoff when the creek is impassable, spawning probably takes place only in the marshy shorelines of the harbor (Kernen 1972). Successful spawning also occurs in the Sturgeon Hay Ship Canal (44°48', 87°19') (FWS 1979d). In Sturgeon Bay, any area with emerqent vegetation is a nursery qround for northern pike. Fry about 1 in. long were present in Sawyer Creek during June (Kernen, pers. comm. 1979) .

WM-2

Washington Island (45°23', 86°54'). Northern pike spawn in Detroit (45°21', 86°55'), West (45°22', 86°57') and Jackson (45°24', 86°51') harbors (Coberly and Horrall 1980b).

WM-3

Mink River (45°14', 87°02'). A spawning run enters the river immediately after ice out, which usually occurs in late March or early April; this run precedes the white sucker runs, which occur in April (Daly 1974; Frederick, pers. comm. 1979; Poff and Threinen 1965). In 1974, ripe males and females were collected in the river from April 13-20, and the first spent females were collected on April 20 (WDNR 1974a). The head of Rowley Bay (45°13', 87°01') is also an important northern pike spawning area (Coberly and Horrall 1980b). The marshes of Rowley Bay are nursery areas for northern pike (Kernen, pers. comm, 1979).

Three Springs Creek (45°09', 87°04') and Reiboldt Creek (45°06', 87°05') Spawning runs enter these creeks immediately after ice out, which usually occurs in late March or early April; the runs precede the

white sucker runs, which occur in April (Frederick, pers. comm. 1979; Poff and Threinen 1965). The marshes of North Bay (45°09', 87°04') and Moonliqht Bay (45°05', 87°05') are nursery areas for northern pike (Kernen, pers. comm. 1979).

Heins Creek (45°01', 87°09'). This creek may support a run (Poff and Threinen 1965).

Hibbard Creek (44°59', 87°10'), Whitefish Bay Creek (44°55', 87°13'), and Bear Creek (44°42', 87°21'). Spawning runs occur here (Poff and Threinen 1965).

WM-4

Stony Creek (44°40', 87°23'). A spawning run enters the lower 4-6 mi of the creek in the spring (Poff and Threinen 1965).

Ahnapee River (44°36', 87°26') and Kewaunee River (44°28', 87°30'). Significant runs enter these rivers in early spring, possibly under the ice; these runs precede the white sucker runs (Horrall, pers. comm. 1979; Imhof, pers. comm. 1979; Poff and Threinen 1966).

East Twin River (44°09', 87°34'). Spawning runs enter the river. After spawning, many northern pike move out of the river and into the area around Two Rivers Harbor (44°09', 87°34') (Hanson, pers. comm. 1979).

West Twin River (44°09', 87°34'). Runs enter the river early in the spring, probably under the ice; the runs precede the white sucker run (Imhof, pers. comm. 1979). After spawning, many northern pike move out of the river and into the area around Two Rivers Harbor (44°09', 87°34') (Hanson, pers. comm. 1979).

WM-5

Pigeon River (43°47', 87°43'), Spawning runs enter the river in favorable years (Weber, Desparte, and Threinen 1968).

Milwaukee River (43°02', 87°54'). Northern pike are common in the river in the spring during the spawning run (Poff and Threinen 1964).

Illinois

Dead River (42°24', 87°48'). Northern pike enter the river and spawn in marshy areas (Muench, pers. comm. 1979).

Michigan

MM-1

Little Bay de Noc (45°45', 87°00'). Northern pike spawn in the marshy areas and small marshy tributaries of Little Bay de Noc (Copes and

Ebener, pers. comm. 1979; FWS 1979d). Spawning occurs successfully in the large wetland in the vicinity of Portage Point (45°42', 87°04') (FWS 1979d). During 1959-62, eggs were collected from ripe northern pike in the bay (Cook 1961, 1962).

MM-4

Grand Traverse Bay (45°05', 85°30'). The few wetlands of this bay are extremely important spawning areas (FWS 1979d). Specific spawning grounds were not identified, but the wetlands are generally located at the heads of the east and west arms of the bay and near Lee Point (44°56', 85°36').

MM-6

Manistee (44°15', 86°20'). Since the 1930s northern pike have spawned along the shoreline between Manistee and Bar Lake (44°18', 86°18') over rock (Organ et al. 1978). Northern pike from Manistee Lake (44°15', 86°18') spawn heavily in the sloughs and the floodplain of the lower Little Manistee River (44°13', 86°16') (Wicklund and Dean 1957).

Ludington Pumped Storage Plant (43°54', 86°27'). A few adults in spawning condition are caught onshore and around the jetties here from late March to the third week of April. These fish are probably migrating through the area, enroute to riverine spawning grounds (Brazo, pers. comm. 1979).

MM-7

Port Sheldon (42°54', 86°13'). Examination of the gonads of fish taken in the area indicates that most spawning probably occurs in March and that spawning is completed by May (Jude et al. 1979a); no specific spawning areas were identified.

MUSRELLUNGE

Wisconsin

m-1

Peaks Lake (44°34', 88°02'). Muskellunge spawn in the marshes here. Before 1920, this area, north to Little Tail Point (44°40', 87°59'), was one of the most heavily utilized spawning areas in Green Bay (Coberly and Horrall 1980b).

sturgeon Bay (44°53', 87°24'). Historically, muskellunge spawned in the marshes here. Young-of-the-year muskellunge have recently been stocked in Sturgeon Bay, and this is now a nursery area (Kernen, pers. comm. 1979).

WM-4

Ahnapee River (44°36', 87°26') and Kewaunee River (44°28', 87°30'). Historically, muskellunge frequented the estuaries of these rivers, and probably spawned there (Kernen, pers. comm. 1979).

GOLDFISH

No information was found concerning the first appearance of goldfish in Lake Michigan.

Wisconsin

WM-5

Milwaukee (43°02', 87°54'). Successful reproduction apparently occurs in the lower Milwaukee River (43°02', 87°54'). In 1975, eggs were entrained in very small numbers from late May to late June at the Commerce Street Power Plant (43°02', 87°54') on the lower river; larvae were collected from late May to late July. In 1976, a few larvae were also entrained in early July at the Lakeside Power Plant (42°58*, 87°51') (Wis. Elec. Power 1976b).

Illinois

Spawning probably occurs in sheltered lagoons and harbors all alonq the shore (Muench, pers. comm. 1979).

LAKE CHUB

Lake chubs occasionally move short distances into tributaries to spawn. In Wisconsin, the lake chub usually spawns in mid-April, at about the same time as white suckers and rainbow smelt (Becker 1976).

Wisconsin

Lake chubs are commonly captured with shore seines from Sheboygan (43°45', 87°43') north, around the Door Peninsula (45°05', 87'°10'), to Sturgeon Bay (44°53', 87°24'). They are not as prevalent on the Green Bay shore of the Door Peninsula as they are on the shoreline of Lake Michigan proper (Kernen, pers. comm. 1979).

WM-3

Hibbard Creek (44°59', 87°10'). In 1960, lake chubs were collected at the FWS sea lamprey weir in the creek during the spring (FWS 1979c); this may have been a spawning run from Lake Michigan.

WM-4

Kewaunee Power Plant (44°21', 87°32'). Spawning probably occurs in the vicinity of the plant along shore and in intermittent tributaries. Ripe adults were collected near the power plant, and YOY were collected along shore in late June and early July. The substrate in the area is hard clay and cobble-size rock with a few boulders (LaJeone, pers. comm. 1979). In 1976, ripe adults were collected on May 20 onshore near the mouth of an intermittent stream (44°21', 87°32') 1/2 mi N of the plant intake, onshore next to the plant intake, and onshore at Two Creeks (44°18', 87°33') 2 mi S of the plant. Abundance was highest at the mouth of the intermittent creek, which suqgests that a spawning run may enter the creek. On June 23, ripe-running or spent lake chubs were collected at the mouth of the intermittent stream and at Two Creeks (LaJeone 1976). Almost 300 eggs were collected at Two Creeks on July 6-7 (Wis. Elec. Power and Wis. Mich. Power, undated c). Many small lake chubs were collected during July and Auqust 1976 near the intermittent stream; these may have been young-of-the-year (YOY) (LaJeone 1976).

Point Beach Power Plant (44°17', 87°32'). During 1972-76, adults collected near the plant in April were larger than those taken at other times; this suggests that an onshore spawning migration may occur (Wis. Elec. Power and Wis.-Mich. Power, undated b,c).

WM-5

Haven (43°51', 87°44'). Lake chubs spawn in intermittent tributaries in the area. Ripe adults were collected here; YOY were also collected along shore during late June to early July. The substrate is hard clay and cobble-size rock with a few boulders (LaJeone, pers. comm. 1979). Lake chubs apparently migrate into Sevenmile Creek (43°51, 87°44') to spawn. In 1974, running-ripe adults were collected in the creek during May, and spent adults were collected during June and July (Ind. Bio-Test 1977).

Port Washington (43°23', 87°52'). A run enters Sauk Creek (43°23', 87°52*) and proceeds 1/2-1 mi upstream (Becker 1976).

Milwaukee (43°02', 87°54'). In 1975, ripe adults were collected in Whitefish Bay (43°08', 87°53') and at North Point (43°04', 87°52') in May and June, when the water temperature was about 44°F; these fish were taken in 30 ft of water over a substrate of rubble, gravel, and some sand (Norden, pers. comm. 1980).

Oak Creek Harbor (42°51', 87°50'). In 1972-73, catches of adults near the Oak Creek Power Plant (42°51', 87°50') peaked during May; these

catches were dominated by ripe females that were presumably migrating to shallow water to spawn (Limnetics 1974).

Michigan

MM-1

Cedar River (45°24', 87°21'). In 1955, 1,125 adults were collected at the FWS sea lamprey weir in the Cedar River during the spring (FWS 1979c); this may have been a spawning run from Lake Michigan.

Bark River (45°34', 87°14'). In 1955, 530 lake chubs were collected at the FWS sea lamprey weir in the Bark River during the spring (FWS 1979c); this may have been a spawning run from Lake Michigan.

MM-3

Carp Lake River (45°45', 84°50'). During 1948-51, lake chubs entered the river to spawn, and adults were collected as they migrated downstream after spawning (Applegate and Brynildson 1952).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Lake chubs are rare to uncommon at the plant, but ripe adults are present 1/2 mi S of the plant from early June to early July, over rocks in 18 ft of water (Brazo, pers. comm. 1979).

MM-8

Ganges (42°35', 86°13'). In 1979, gravid females were collected at the mouth of Cove Creek (42°35', 86°14') in 3 ft of water over gravel on May 7 (Owens, pers. comm. 1979).

CARP

The initial plantings of carp were made in the inland waters of the U.S. as early as 1831 (McCrimmon 1968), but the introduction of carp into Lake Michigan is not recorded. Commercial catches of carp in Lake Michigan appear on the first commercial production records started in 1883 (Wells and McLain 1972, 1973).

Wisconsin

WM-1

Green Bay (45°05', 87°25'). Carp may be more abundant in the shallow areas of the bay than elsewhere in Lake Michigan (Wells, pers. comm. 1979). The entire shoreline of western Green Bay from Marinette (45°05',

87°36') south supports a substantial carp population, most of which inhabits the marshes of southern Green Bay (Belonger, pers. comm. 1979; Ebener and Leary, pers. comm. 1979). Spawning usually occurs in the Green Bay area during May and peaks on approximately May 15 (Kernen, pers. comm. 1979), however, spawning has been observed in mid-June (Ebener and Leary, pers. comm. 1979). Carp probably move into many streams in the Green Bay area to spawn. Carp appear to move upstream to spawn following the white sucker runs (Horrall, pers. comm. 1979). Young-of-the-year (YOY) are abundant in southern Green Bay over soft, silty bottom (Belonger, pers. comm. 1979).

Peshtiqo Point (44°59', 87°38'). Spawning has been observed in marshy areas here in mid-June (Ebener and Leary, pers. comm. 1979).

Pensaukee (44°49', 87°54') and Little Suamico (44°42', 87°59') Rivers. Spawning runs of carp enter these rivers in early to mid-May (Horrall, pers. comm. 1979).

Fox River (44°32', 88°00'). Carp enter the river to spawn (FWS 1979d). In 1975, carp eggs were entrained at the Pulliam Power Plant (44°32′, 88°00′) in June; large numbers of early larvae, about 0.2 in. long, *were* entrained from late May through July. The plant withdraws cooling water from both Green Bay and the Fox River (NALCO, undated a).

Sawyer Harbor (44°53', 87°26'). Carp are present in Sawyer Harbor throughout the year and probably spawn there in marshy areas along the shoreline (Kernen 1972).

WM-3

Rowley Bay (45°13′, 87°01′), North Bay (45°09', 87°04'), Moonlight Bay (45°05', 87°05') and Baileys Harbor (45°03', 87°07'). Carp spawn in the marshy areas in these bays during May and June (Frederick, pers. comm. 1979).

WM-4

Ahnapee River (44°36', 87°26'). A spawning run enters the river during May and early June, following the white sucker runs (Horrall, pers. comm. 1979; Imhof, pers. comm. 1979).

Kewaunee (44°27', 87°30'). A spawning run enters the Kewaunee River (44°28', 87°30') during early to mid-May, after the white sucker run (Horrall, pers. comm. 1979).

Kewaunee Power Plant (44°21′, 87°32′). In 1975, carp larvae, 0.2-0.4 in. long, were entrained at the plant during July (NALCO, undated b).

Point Beach Power Plant (44°17′, 87°32′). Spawning runs are attracted to the discharge of the power plant, and carp are found there in great numbers for a period of time (Reed 1972). In 1973, the greatest concentrations occurred at the plant discharge in April and July; July water temperatures were favorable for spawning, but no spent females were collected (Wis. Elec. Power and Wis.-Mich. Power, undated b).

Sheboygan (43°45', 87°42'). In 1977, a few ripe carp were collected at the discharge of the Edgewater Power Plant (43°43', 87°42') in late May and farther offshore in June. One prolarvae, 0.2 in. long, was captured near the plant on June 15. The area near the plant is not ideal spawning habitat; however the Black River (43°42', 87°42') south of the plant is suitable for spawning (Swanson Environ. 1979).

Illinois

Carp are found in the harbors, embayments, and warmwater discharges of power plants along the Illinois shore, and spawning probably occurs in these areas (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Studies during the 1970s have shown that limited spawning occurs in this area (Cochran and Cima 1974; Commonw. Edison 1976; Raney 1972). Some adults in spawning condition have been seen in the area (Cochran, undated; LaJeone, pers. comm. 1979). A resident population exists in the vegetated intake basin of the Waukegan Generating Station (42°23', 87°49'). Spawning has been observed in the basin, and it also serves as a nursery area (Cima et al. 1976). A few eggs were collected in the inshore waters of the lake in July to September (Ind. Bio-Test 1975a,b; Cima and Cochran, undated; Cima et al. 1976; Cochran and Cima 1974). Eggs were entrained at the Zion Generating Station (42°27', 87°48') as early as mid-April (Cima et al. 1976). Larvae were collected in the area and entrained at the generating station during June to August, indicating an extended spawning season (Ind. Bio-Test 1975a; Cima 1977; Cima et al. 1976; Cochran, undated; Cochran and Cima 1974; LaJeone, pers. comm. 1979).

Indiana

Hammond (41°40', 87°30'). Carp are believed to spawn successfully near the Stateline Generating Station (41°42', 87°31'). In 1975-76, carp exhibiting spawning behavior were frequently observed at night in the station forebay and discharge area, but spawning was not confirmed. Eggs were entrained at the station from late April through August; peak entrainment occurred on May 23-24. Larvae were entrained from May 23 through August; peak entrainment occurred on May 27. Larvae were also collected in the lake and were most abundant inshore, especially near the station discharge (NALCO 1976c).

Gary (41°37', 87°20'). Spawning carp are frequently observed in the discharge canal of the Mitchell Power Station (41°37', 87°22'); these fish are believed to be permanent residents in the canal. Successful spawning occurs in the area. In 1975, many eggs were entrained from May through July; peak entrainment occurred in May. Larvae were entrained from mid-May through July; most were entrained in late May (Krueger 1976; NALCO 1976a).

Burns Ditch (41°38', 87°10'). In 1976, spawning was observed here in June (Tex. Instrum. 1977b).

Bailly Generating Station (41°39', 87°07'). In 1974, a few carp in gravid condition were collected in the immediate vicinity of the station. Spawning may have occurred in the area, but no eggs or larvae were collected (Tex. Instrum. 1975b). In 1976, spawning occurred in the area during June and July and peaked during the first 2 weeks of June and the second week of July (Tex. Instrum. 1977b). In 1976, spawning was observed in the plant discharge canal during June, and eggs were entrained during the first 2 weeks of June, all of July, and the last week of October. Larvae were collected in the plant area from June through August; peak abundance occurred during the last 2 weeks of June and the last 3 weeks of July (Tex. Instrum. 1976c, 1977b).

Michigan City (41°43', 86°54'). In 1976 and 1977, carp exhibiting spawning behavior were observed in the discharge canal of the Michigan City Generating Station (41°43', 86°54') from May through August. The high temperatures of the discharge water extended the spawning period for carp (Morgan 1978a, 1978b).

Michigan

MM-1

Bark River (45°34', 87°14'). In 1978, carp larvae were collected near the river mouth, to depths of 10 ft, from late May to early July (Wis. Elec. Power, unpubl. data).

Ford River (45°40', 87°08'). In 1978, a few carp larvae were collected near the river mouth, to depths of 20 ft, from late May to mid-July (Wis. Elec. Power, unpubl. data).

MM-3

Waugoshance Point (45°45', 85°01'). During 1954 and 1955, carp migrated into the shallows at the point to spawn. In 1955, carp were first observed on June 3 in a cove that had silt and detritus over a gravel bottom. Spawning was observed in 1954 on June 8-13, and in 1955 on June 3-8. In 1954, carp had moved out of the shallows by June 13. In both years, the carp spawning period coincided with that of the smallmouth bass (Latta 1957, 1963).

MM-6

Ludington (43°57', 86°28'). A large population of carp resides in the marsh in the lower Pere Marquette River (43°56', 86°26'). At the Ludington Pumped Storage Plant (43°54', 86°27'), ripe carp (mostly males) are present at depths of less than 10 ft throughout most of the year; abundance increases in late April and peaks from mid-May to late June. The area around the plant lacks vegetation and is not a major spawning ground (Brazo, pers. comm. 1979).

MM-7

Muskegon (43°13', 86°17'). In 1946-69, spawning occurred in June in the southwest corner (43°13', 86°19') of Muskegon Lake in 20-40 ft of water over a sand bottom (Organ et al. 1978).

Port Sheldon (42°54', 86°13'). In 1977, a few carp larvae 0.2-0.3 in. long were entrained at the Campbell Power Plant (42°55', 86°12') in July; larvae were also collected in Lake Michigan near the plant in July (Jude et al. 1978). In 1978, early larvae were entrained from the end of May, at a water temperature of about 64°F, through August, suggesting an extended spawning season (Jude et al. 1979a).

MM-8

Bridgman (41°56', 86°35'). Spawning occurs near the discharge of the Cook Power Plant (41°59', 86°34') over riprap and Cladophora. The adults may be attracted to the plant discharge. Larvae were entrained at the plant and collected in the lake near the plant; no larger YOY were collected near the plant (Jude, pers. comm. 1979; Jude et al. 1979b).

Lakeside (41°51', 86°40'). Since 1916, spawning occurred in an area (41°51', 86°41') just south of Lakeside in May in 10-20 ft of water over a rock bottom (Organ et al. 1978).

EMERALD SHINER

Wisconsin.

WM-4

Manitowoc (44°05', 87°39'). Emerald shiners are present here throughout the year and probably spawn in the area (Copes, pers. comm. 1979).

Illinois

It is believed that in 1960, emerald shiners spawned in all the harbors along the Illinois shoreline (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Breeding emerald shiners were collected with dip nets from Waukegan Harbor approximately 20 years ago (Muench, pers. comm. 1979). In 1974, a few young-of-the-year about 1 in. long were collected in the Zion-Waukegan area in August (Ind. Bio-Test 1975).

Wilmette Harbor (42°05', 87°41'). Breeding emerald shiners were collected here with dip nets approximately 20 years ago (Muench, pers. comm. 1979).

Indiana

Bailly Generating Station (41°39', 87°07'). Adult emerald shiners were collected in the area of the generating station; spawning may occur there (Tex. Instrum. 1976a).

Michigan

MM-7

Port Sheldon (42°54', 86°13'). Spawning occurs in the vicinity of Pigeon Lake (42°54', 86°12') from early June to July (Jude et al. 1979a). Emerald shiner larvae are entrained at the Campbell Power Plant (42°55', 86°12'), and a few larvae were collected in the plant discharge area. Pigeon Lake is a major nursery area for emerald shiners (Heufelder, pers. comm. 1979).

COMMON SHINER

Michigan

MM-1

Bark River (45°34', 87°14')--Ford River (45°40', 87°08'). In 1978, common shiner larvae were collected along the shore from the Bark River to the Ford River from late June to late August; most were taken just north of the mouth of the Ford River in mid-July. Larvae were most abundant at about the 5 ft depth contour in mid-June (Wis. Elec. Power, unpubl. data).

MM-3

Waugoshance Point (45°45', 85°01'). In 1954, concentrations of common shiners were observed over smallmouth bass nests. The shiners were assumed to be spawning; male shiners were in breeding colors and had tubercles, and three ripe adults were collected (Latta 1957). Common shiner eggs were also found with smallmouth bass eggs in bass nests. Fry of common shiner and smallmouth bass were collected in the smallmouth bass nesting area (Latta 1963).

carp Lake River (45°45', 84°50'). In 1948-51, common shiners migrated into Carp Lake to spawn, and adults were collected as they returned to Lake Michigan after spawning (Applegate and Brynildson 1952).

SPOTTAIL SHINER

The spawning and nursery grounds of spottail shiners are probably in water less than 30 ft deep along the entire shoreline of Lake Michigan (Wells and House 1974). Adults are most common in the southeast and extreme southern parts of the lake proper; these areas are probably the primary spawning and nursery grounds (Wells, pers. comm. 1979). Adults are also abundant in Green Bay (45°05', 87°25'), and young-of-the-year (YOY) are found along shore (Belonger, pers. comm. 1979).

Wisconsin

WM-2

Fish Creek Harbor (45°08', 87°15'). Spawning concentrations occur here (Belonger, pers. comm. 1979).

Northport Dock (45°17', 86°59'). Schools of gravid females were observed here (Belonger, pers. comm. 1979).

WM-3

Rowley Bay (45°13', 87°01'), North Bay (45°09', 87°04') and Moonlight Bay (45°05', 87°05'). Running-ripe fish were observed in the shallows of these bays (Frederick, per-s. comm. 1979).

WM-4

Manitowoc (44°05', 87°39'). Ripe spottail shiners were collected on shore here during May (Copes, pers. comm. 1979).

WM-5

Milwaukee (43°02', 87°54'). Spottail shiners probably move inshore to spawn. Spawning spottail shiners were collected off Bradford (43°04', 87°52') and McKinley (43°03', 87°53') beaches and the South Shore Yacht Club (43°00', 87°53') in 20-30 ft of water, during the summer (Binkowski, pers. comm. 1979).

Oak Creek Harbor (42°51', 87°50). In 1972-73, ripe females were abundant in March at the Oak Creek Power Plant (42°51', 87°50'); they were assumed to be migrating to shallows to spawn, however, this was earlier than the typical spawning season (Limnetics 1974).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Ripe spottail shiners were collected in this area (LaJeone, pers. comm. 1979; Muench,

pers. comm. 1979). The substrate in this area is fine sand with a few rocks (LaJeone, pers. comm. 1979). In 1972, spottail shiners were observed in spawning condition in the vicinity of the Zion (42°27', 87°48') and Waukegan (42°23', 87°49') generatinq stations (Cochran, undated). Spottail shiners spawn from June to August but spawning success in this area is limited. In 1973, a few larvae were collected in the area in July and August (Cochran and Cima 1974). In 1974, one YOY was captured in August, and three others were captured in October (Ind. Bio-Test 1975).

Indiana

Hammond (41°40', 87°30'). In 1975-76, spottail shiners were believed to have spawned successfully in the vicinity of the Stateline Generating Station (41°42', 87°31'); spottail shiner eggs were less than 0.1% of the eggs taken in the lake and spottail shiner larvae were only 0.5% of the larvae taken in the lake (NALCO 1976).

Bailly Generating Station (41°39', 87°07'). Spottail shiners spawn in the area adjacent to the plant from the third week in May through the third week in July. Spawning is heaviest in water shallower than 30 ft (Tex. Instrum. 1975b, 1977b). Limited spawning is thought to occur in the station discharge area (Tex. Instrum. 1976c). Spottail shiners captured in beach seines in May were probably in the area to spawn (Tex. Instrum. 1975b). Spottail shiner eqgs were entrained at the station from late April through July; peak abundance occurred in June and early July. Larvae were entrained during June to August; peak abundance occurred from late June through July (Tex. Instrum. 1976c, 3977b). Catches of YOY in beach seines indicate that spottail shiners use this area as a nursery ground through October (Tex. Instrum. 1975b, 1976b). Adults and first year juveniles probably moved offshore to deeper waters in early fall (Tex. Instrum. 1975b).

Michigan City (41°43', 86°54'). Spottail shiners spawn along shore from the Michigan state line (41°46', 86°49') to the Indiana Dunes (41°40', 87°02'). Ripe adults were collected here in large numbers from June through August. Spawning occurred in late July and August in waters often 1 ft deep or less (McComish, pers. comm. 1979). Spawning adults were collected at Kintzele Ditch (41°43', 86°56') about 1 mi W of Michigan City (Palacios, pers. comm. 1979). Sharply reduced catches of adults in October indicate that they migrate offshore in the fall (McComish, pers. comm. 1979; Willis 1975). The nearshore waters are an important nursery area for spottail shiners; YOY are evenly distributed along shore (McComish, pers. comm. 1979). About 8% of the total larvae entrained at the Michigan City Generating Station (41°43', 86°54') were spottail shiners (Morgan 1978a). Young-of-the-year were collected at Kintzele Ditch (Palacios, pers. comm. 1979). In 1979, YOY were collected along the Indiana Dunes in 15 ft of water durinq August (Koch, pers. comm. 1979).

Michigan

MM-1

Bark River (45°34', 87°14')--Ford River (45°40', 87°08'). In 1978, larvae were common in this area. They were collected onshore during May 31 to August 15 and out to the 10 ft depth contour beginning in June (Wis. Elec. Power, unpubl. data).

Little Bay de Noc (45°45', 87°00'). Spottail shiners spawn in Little Bay de Noc from mid-June through July (Basch 1968).

MM-4

Grand Traverse Bay (45°05', 85°30'). Spottail shiners spawn on sandy shoals or in stream mouths during the spring and summer (Price and Kelly 1976).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). In 1972, several ripe females were collected here on August 28. This suggests that there may be two discrete spawning periods during the year because spawning usually occurs during June and July (Liston and Tack 1973). Ripe adults were present from approximately mid-June to the end of July; peak abundance occurs in July. The greatest concentrations of ripe adults was found near shore approximately 2 mi S of the plant; ripe adults were also collected to depths of 15 ft (Brazo, pers. comm. 1979). Larvae were present from late June throughout the summer; they were most abundant at the 5 ft depth contour. Young-of-the-year about 1 in. long were captured in mid-August (Brazo, pers. comm. 1979; Liston et al. 1978).

MM-7

Port Sheldon (42°54', 86°13'). The high concentrations of adults in the nearshore zone here indicate that spawning occurs during May to August (Jude et al. 1978, 1979a). In 1977, eggs were collected along the beach north of the Campbell Power Plant (42°55', 86°12') in late June; spawning may occur in the vicinity of the plant discharge canal (Jude et al. 1978). Spawning also occurs in Pigeon Lake (42°54', 86°12') (Jude et al. 1979a). In 1974, some spottail shiner eggs were entrained at the plant in early May; these were believed to have been released prematurely by entrained fish (Consumers Power 1976b). The nearshore area of Lake Michigan is a nursery ground for spottail shiners. Larvae were first collected at two beach stations, north and south of the discharge canal, in early June. These early larvae may have resulted from spawning near or in the discharge canal during May. Larvae were collected through August, and abundance peaked in late July. Larvae were found almost exclusively near shore. Young-of-the-year were collected at depths of 20 ft or less until October, when they moved to deeper water (Consumers Power 1977; Jude et al. 1978, 1979a).

In southeast Lake Michigan, spottail shiners spawn in the nearshore zone during June to August (Wells and House 1974).

Palisades Power Plant (42°19', 86°19'). Large numbers of ripe spottail shiners moved into the beach zone beginning in late May; spawning occurred primarily in June and July (Consumers Power 1972b; Wapora 1979c,d). Few adults were present in the area after August (Wapora 1979d). Spottail shiner eggs were collected in the area and entrained at the power plant beginning in late June (Wapora 1979c). Many early larvae were found in the beach zone; in 1978, 97% of the larvae collected were less than about 0.3 in. long (Wapora 1979c). Many YOY were captured in the area from July to September (Patriarche 1972b; Wapora 1979d).

Bridgman (41°56', 86°35'). Spawning generally occurs in the vicinity between the Cook Power Plant (41°59', 86°34') and Warren Dunes (41°54', 86°37') from June to August at water temperatures of 64-72°F. Adults begin moving inshore as early as March; peak abundance occurs in June (Indiana and Mich. Power 1975; Jude 1976a, pers. comm. 1979; Jude et al. 1975, 1979b). Adults are most abundant inside the 20 ft depth contour, and spawning occurs along the entire shoreline in water less than IO ft deep (Indiana and Mich. Power 1975; Jude, pers. comm. 1979; Jude et al. 1975, 1979b). Divers observed female spottail shiners depositing eggs on Cladophora at the water intake crib of the power plant in mid-June; an estimated 500-1,000 ripe males and females were observed above and in the Cladophora. Eggs were collected here, reared in the laboratory, and identified as spottail shiners (Indiana and Mich. Power 1975; Jude 1976a, pers. comm. 1979; Jude et al. 1975, 1979b). Adults dispersed from the beach zone to deeper offshore waters in July and August after spawning (Indiana and Mich. Power 1975; Jude et al. 1975, 1979b). The nearshore area is also a nursery ground for spottail shiners (Indiana and Mich. Power 1975; Jude, pers. comm. 1979). Newly hatched larvae were usually present from early June to August; YOY first appeared in beach seine catches in July or August (Jude 1977; Jude et al. 1973, 1975, 1979b).

BLUNTNOSE MINNOW

Illinois

Ripe adults were collected along the entire Illinois shoreline (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In 1975, a few larvae were collected in this area in July (Cima et al. 1976).

Michigan

MM-1

Ford River (45°40', 87°08'). In 1978, larvae were collected in seines off the mouth of the river from June to October (Wis. Elec. Power, unpubl. data).

MM-7

Port Sheldon (42°54', 86°13'). In 1978, a few young-of-the-year were taken along the beach during September (Jude et al. 1979a).

FATHEAD MINNOW

The habitat requirements of fathead minnows suggest that this species does not reproduce successfully in Lake Michigan proper (CDM/Limnetics 1976c).

Illinois

Ripe adults were collected along the entire Illinois shoreline (Muench, pers. comm. 1979).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In 1972, adults in spawning condition were observed in this area (Cochran, undated).

LONGNOSE DACE

Wisconsin

Longnose dace are common along the shoreline from Sheboygan (43°45', 87°43') north, around the Door Peninsula (45°05', 87°20'), to Sturgeon Bay (44°53', 87°24') (Kernen, pers. comm. 1979).

WM-4

Kewaunee Power Plant (44°21', 87°32'). In 1975, ripe longnose dace were collected on June 23 onshore in an area (44°21', 87°32') approximately 1/2 mi N of the plant, at the power plant, and at Two Creeks (44°18', 87°33') 2 mi S of the plant at water temperatures of 47-49°F. Ripe-running and spent fish were collected on July 21 when the water temperature was about 52°F. A few young-of-the-year (YOY) were collected durinq September and October (LaJeone 1976b, pers. comm. 1979).

WM-5

Haven (43°51', 87°44'). Adults in spawning condition and YOY were collected here in June and July. The substrate consists of hard clay and cobble-size rock with a few boulders (LaJeone, pers. comm. 1979). In 1974, ripe longnose dace were collected in the area during May and June (Ind. Bio-Test 1977; Wis. Elec. Power et al. 1979a, b). Peak abundance of ripe adults occurred *in* May along shore, and spawning apparently occurred along shore in June. In 1977, longnose dace migrated into Sevenmile Creek (43°51', 87°44'); this may have been a spawning run (Ind. Bio-Test 1977).

Port Washington (43°23', 87°52'). In 1975, ripe adults were impinged at the Port Washington Power Plant (47°23', 87°52') in late June and early July (Wis. Elec. Power 1976e).

Milwaukee (43°02', 87°54'). In 1971-75, longnose dace were observed spawning at McKinley Beach (43°03, 87°53') in 3-8 in. of water along the shore. The substrate is sandy with many rocks approximately 3 in. in diameter. Adults with spawning colors and running milt were collected among the rocks. After 1975, longnose dace were no longer found in the area (Binkowski, pers. comm. 1979).

Oak Creek Harbor (42°51', 87°50'). Longnose dace larvae were entrained at the Oak Creek Power Plant (42°51', 87°50') (CDM/Limnetics 1977).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Ripe longnose dace were collected inshore from the Wisconsin state line (42°29', 87°48') south to the Great Lakes Naval Training Center (42°18', 87°50') (Muench, pers. comm. 1979). Younq-of-the-year were collected in the Zion-Waukegan area over a substrate of fine sand with a few rocks (LaJeone, pers. comm. 1974). During 1972, longnose dace in spawning condition were observed near the Zion (42°27', 87°48') and Waukegan (42°23', 87°49') generatinq stations (Cochran, undated). A few YOY were collected in this area in the fall (Ind. Rio-Test 1975; Cima et al. 1976).

Michigan

MM-1

Bark River (45°34', 87°14')--Ford River (45°40', 87°08'). In 1978, longnose dace larvae were collected in this area in late May and June; they were more abundant near the Bark River than the Ford River (Wis. Elec. Power, unpubl. data).

MM-3

Carp Lake River (45°45', 84°50'). In 1948-51, longnose dace migrated into the river to spa-wn; adults left the river after spawning (Applegate and Brynildson 1952).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). In 1975-76, onshore migrations of longnose dace occurred in mid-May when water temperatures were about 46-57°F. Ripe adults were first collected in mid-May; all were spent by late July. Spawning peaked from late June to early July at about 57-66°F (Brazo et al. 1978, pers. comm. 1979). Many adults entered the surf zone within the 10 ft depth contour in mid-May to spawn; these fish were present in the surf zone only at night (Brazo et al. 1978). Ripe adults and YOY about 1 in. long were most abundant on a gravel bar (43°51', 86°26'), 2 mi S of the plant (Brazo, pers. comm. 1979). Fry 0.7-0.8 in. long were first collected in early August (Brazo et al. 1978).

CYPRINID spp.

Wisconsin

WM-4

Kewaunee Power Plant (44°21', 87°32'). Several species of minnows spawn along much of the shoreline in the vicinity of the plant (USAEC 1972e).

Indiana

Bailly Generating Station (41°39', 87°07'). In 1976, cyprinid eggs and larvae were entrained at the station during June and July (Tex. Instrum. 1977b). In 1978, cyprinid eggs were collected directly off the plant discharge at the 5 ft depth contour (Tex. Instrum. 1979).

Michigan

MM-1

Bark River (45°34', 87°14'). In 1978, a few cyprinid eggs were collected just north of the river mouth at the 5 ft depth contour on May 24 (Wis. Elec. Power, unpubl. data).

MM-7

Port Sheldon (42°54', 86°13'). During 1977, high numbers of unidentified cyprinid larvae were entrained at the Campbell Power Plant (42°55', 86°12'); peak entrainment occurred from early June to early August. In 1977, more than 765,000 larvae were entrained on July 8;

larvae were also found along the Lake Michigan beach near the plant in late July (Jude et al. 1978, 1979a).

QUILLBACK

Michigan

MM-7

Port Sheldon (42°54', 86°13'). In 1978, three quillbacks captured at the Campbell Power Plant (42°55', 86°12') in June and July had well developed gonads. Many young-of-the-year were observed in the plant discharge canal in July; spawning may occur there (Heufelder, pers. comm. 1979; Jude et al. 1979a).

LONGNOSE SUCKER

Longnose suckers are abundant in Green Bay (45°05', 87°25') and are also probably found in most of the shallow areas of Lake Michigan proper (Wells, pers. comm. 1979). Prior to 1966, most of the commercial catches of longnose suckers were from the northeast section of the lake (USBCF 1965; USDI 1966).

Wisconsin

WM-1

Pensaukee River (44°49', 87°54'). The river supports a commercial fishery for longnose suckers during the spawning run (Belonger, pers. comm. 1979).

WM-3

It is believed that longnose suckers spawn along the shoreline and in bays of the Door Peninsula; they apparently do not spawn in many tributaries in this area (Imhof, pers. comm. 1979).

Rowley (45°13', 87°01'), North (45°09', 87°04'), and Moonlight (45°05', 87°05') Bays. Longnose suckers enter the bays to spawn following the white sucker runs which occur in April (Frederick, pers. comm. 1979).

Baileys Harbor (45°03', 87°07'). A spawning run occurs here in June (Frederick, pers. comm. 1979).

Hibbard Creek (44°59', 87°10'). In 1971, many spawning adults were present in the creek (GLFC 1973).

WM-4

Kewaunee Power Plant (44°21', 87°32'). Tributaries in the vicinity probably serve as spawning and nursery areas for longnose suckers (LaJeone 1976).

Point Beach Power Plant (44°17', 87°32'). Catches of longnose suckers here increase markedly between February and May and peak in April and May. Spent females were collected throughout the area after May; no gravid females were taken after June (Limnetics 1974; Wis. Elec. Power, undated; Wis. Elec. Power and Wis.-Mich. Power, undated a, b). Larvae were collected at the power plant (CDM/Limnetics 1977).

WM-5

Oak Creek Harbor (42°51', 87°50'). No gravid female longnose suckers are found in the area after March, when presumably they move into rivers in the area to spawn (Limnetics 1974).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Spawning occurs in the area; successful spawning is believed to be limited (Cochran and Cima 1974; Commonw. Edison 1976). In 1974, one egg, but no larvae, were found here in May (Cochran and Cima 1974).

Michigan

MM-1

Cedar River (45°24', 87°21'). In 1976, many thousands of spawning adults entered the river (Dahl and McDonald 1980; GLFC 1979a).

Bark River (45°34', 87°14'). In 1955, longnose suckers were collected at the FWS sea lamprey weir in the spring (FWS 1979c); these catches suggest that a spawning run enters the river,

Ford River (45°40', 87°80'). A spawning run of longnose suckers enters the Ford River; the run occurs one to two weeks after the white sucker runs (Michaud, pers. comm. 1980).

Days (45°54', 86°59'), Sturgeon (45°50', 86°40'), and Fishdam (45°54', 86°35'), rivers. In 1954 and 1955, longnose suckers were collected at FWS sea lamprey weirs on these rivers in the spring (FWS 1979c); these catches suggest that spawning runs enter the rivers.

MM-3

Rock River (46°05′, 85°32′). In 1955, longnose suckers were collected at the FWS sea lamprey weir in the spring (FWS 1979c); these catches suggest that a spawning run enters the river.

MM-5

Platte River (44°44', 86°09'). Spawning runs occurred here in 1942 and 1943 (Carbine and Shetter 1945; Westerman 1942).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Ripe longnose suckers were found in shallow water during April within the area one mi N and S of the plant. These fish were probably migrating through the area to spawn in nearby rivers (Rrazo, pers. comm. 1979). In 1972, both ripe and spent males and females were collected within the 30 ft depth contour during April and May (Liston and Tack 1972).

MM-7

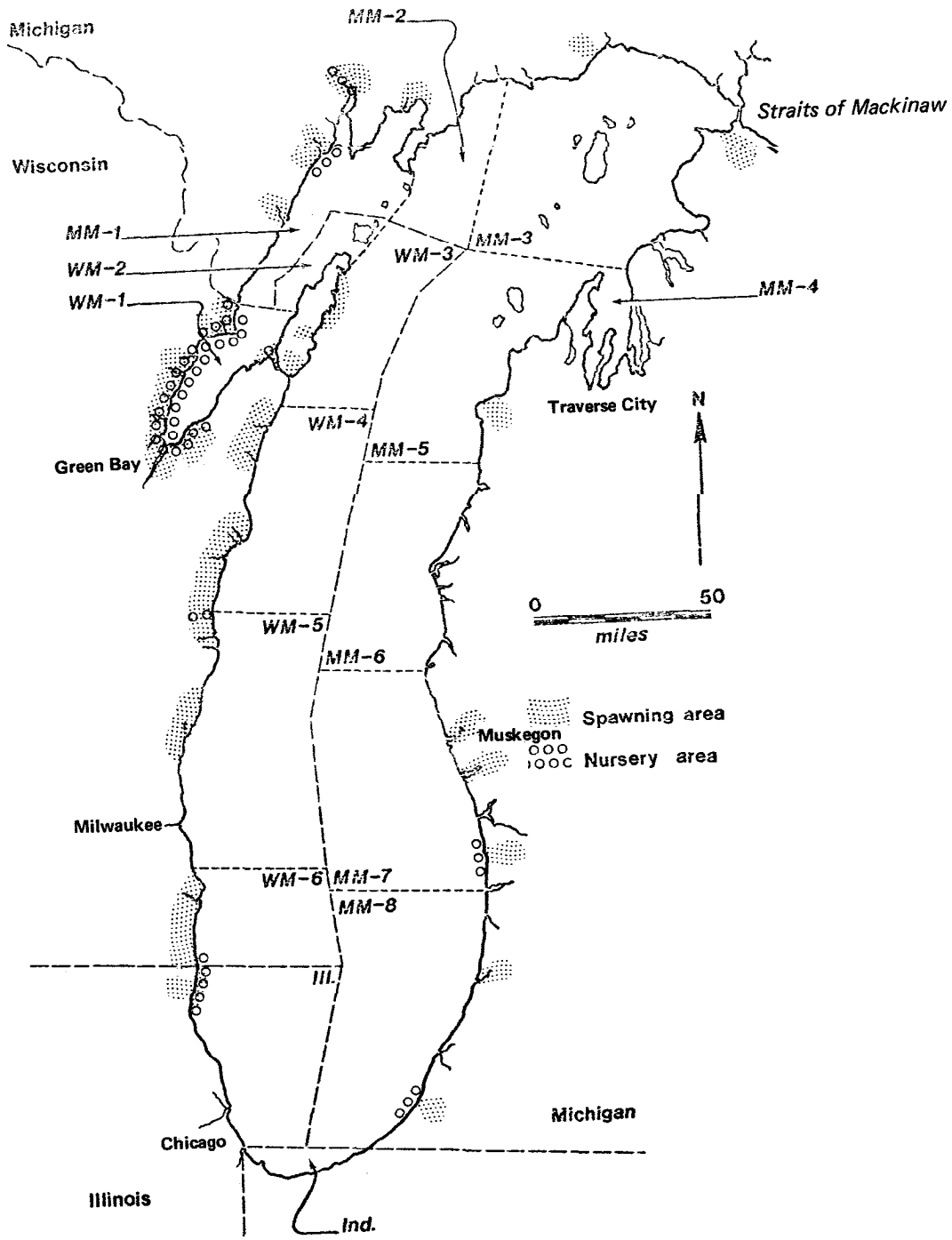
port Sheldon (42°54', 86°13'). Gonad analyses of fish collected in 1978 indicated that spawning probably took place here in May. Low catches of longnose suckers in April suggested that this species may spawn in streams and rivers in the area (Jude et al. 1979a).

MM-8

Tributary streams are the major spawning grounds in eastern Lake Michigan, but limited spawning may also occur in shallow areas of the lake (Consumers Power 1975).

south Haven (42°24', 86°17'). Longnose suckers from Lake Michigan enter the Black River (44°24', 85°17') to spawn (Stauffer 1972). In 1973, many longnose suckers were impinged at the Palisades Power Plant (42°19', 86°19') about 5 mi S of South Haven during June; these fish may have been migrating along the shoreline en route to tributary streams (Consumers Power 1975).

Bridgman (41°56′, 86°35′). In 1973-74, ripe and spent adults were present near the Cook Power Plant (41°59', 86°34'); however no eggs were collected. Longnose suckers probably entered nearby tributaries to spawn (Indiana and Mich. Power 1975; Jude, pers. comm. 1979; Jude et al. 1975, 1979b). Adults were most abundant at Warren Dunes (41°54′, 86°37') and may have been attracted to a small stream there (Jude et al. 1979b). In 1973, longnose suckers were scarce in the area during April but reappeared later in the season. Gonad analyses indicated that spawning probably occurred in late March to May; most spawning occurred in April (Jude, pers. comm. 1979; Jude et al. 1975, 1979b).


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Traverse City
N
WM-4
MM-5
Green Bay
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
Ill.
Michigan
Chicago
Illinois
Ind.

White suckers enter Lake Michigan tributaries to spawn; spawning also presumably occurs in the shallows of the lake (USBCF 1965; USDI 1966). White suckers are harvested by fishermen during the spawning runs (CDM/Limnetics 1976c).

Wisconsin

WM-1

The Wisconsin tributaries along the west shore of Green Bay have substantial runs of white suckers. Runs occur in the spring in almost all of the tributaries to the bay that have a continuous flow (Belonger, pers. comm. 1979; Horrall, pers. comm. 1979). Runs usually occur during late March or early April to early May at water temperatures of 46-64°F and peak at water temperatures of approximately 57°F; runs sometimes occur under the ice. Limited spawning may occur in the lake. Spawning areas are probably also nursery areas. Larvae may remain in the streams for 5-6 months (occasionally up to one year) before migrating to the lake (Horrall, pers. comm. 1979). Young-of-the-year (YOY) inhabit the western shore of Green Bay (Belonger, pers. comm. 1979).

Little River (45°03, 87°38'). In 1955, white suckers were collected at the FWS sea lamprey weir in the spring (FWS 1979c); this catch suggests that a spawning run from the lake enters the river.

Peshtigo River (44°58', 87°39') (Horrall, pers. comm. 1979). Removal of dams on the river would increase access to prime spawning grounds (GLFC 1979b).

Oconto River (44°54', 87°50') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980). Removal of dams on the river would increase access to prime spawning grounds (GLFC 1979b).

Pensaukee River (44°49', 87°54') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980). Substantial runs supporting commercial production enter the river (Belonger, pers. comm. 1979). Thousands of white suckers (160,000 in 1957) were collected at the FWS sea lamprey weir during the spawning miqration (Dahl and McDonald 1980; FWS 1979c).

Little Suamico River (44°42', 87°59') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Big Suamico River (44°38', 88°00') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980). Substantial runs supporting commercial production enter the river (Belonger, pers. comm. 1979).

Duck Creek (44°34', 88°02') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Fox River (44°32', 88°00'). White sucker eggs and larvae were entrained during April and May at the Pulliam Power Plant (44°32',

88°00'), which withdraws water from both Green Bay (45°05', 87°25') and the Fox River (CDM/Limnetics 1977; NALCO, undated a).

Point Sable Creek (44°35', 87°54') (Imhof, pers. comm. 1980).

Red River (44°40', 87°45'). Spawning runs occur in April (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Sturgeon Bay (44°53', 87°24'). Spawning occurs in the bay in late April (Moore, pers. comm. 1979). White suckers may be found in Sawyer Harbor (44°53', 87°26') throughout the year; spawning may occur along the marshy shoreline of the bay (Kernen 1972).

WM-3

Rowley Bay (45°13', 87°01'), North Bay (45°09', 87°04'), and Moonlight Bay (45°05', 87°05') and Baileys Harbor (45°03, 87°07'). White suckers enter these bays to spawn prior to the longnose sucker runs (Frederick, pers. comm. 1979).

Hibbard Creek (44°59', 87°10') (Imhof, pers. comm. 1980). Large numbers of spawning white suckers were found in the creek (GLFC 1973).

Lily Bay Creek (44°51', 87°16'). In 1955, white suckers were collected at the FWS sea lamprey weir in the spring (FWS 1979c); this catch suggests that a spawning run enters the creek from the lake.

WM-4

Stony Creek (44°40', 87°23') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Ahnapee River (44°36', 87°26') (Frederick, pers. comm. 1979; Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Three Mile Creek (44°34', 87°27') (Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Mashek Creek (44°30', 87°29') (Imhof, pers. comm. 1980).

Kewaunee River (44°28', 87°30'). Very large white sucker spawning runs enter the river; the runs may begin under the ice and continue until late April or early May (Frederick, pers. cormm. 1979; Horrall, pers. comm. 1979; Imhof, pers. comm. 1980).

Point Beach Power Plant (44°17', 87°32'). In 1973, gravid females were collected from November through March; no ripe females were collected after March (Wis. Elec. Power and Wis.-Mich. Power, undated a).

Molash Creek (44°11', 87°31') (Weber, Desparte, and Threinen 1968).

East (44°09', 87°34') and West (44°09', 87°34') Twin Rivers (Belonger, pers. comm. 1979; Imhof, pers. comm. 1980; Weber, Desparte, and Threinen 1968).

Little Manitowoc River (44°06', 87°39') (Weber, Desparte, and Threinen 1968).

Manitowoc River (44°05', 87°39') (Belonger, pers. comm. 1979; Weber, Desparte, and Threinen 1968).

Silver (44°04', 87°39'), Calvin (44°02', 87°40'), Pine (43°59', 87°42'), Point (43°58', 87°42'), and Centerville (43°55', 87°43') Creeks (Weber, Desparte, and Threinen 1968).

WM-5

Sevenmile Creek (43°51', 87°44'). A few ripe adults were found in the creek in April, when few adults were found in the lake; adults reappeared in the lake in June and July when adults were no longer found in the creek. This pattern of distribution and absence of eggs, larvae, and YOY in the lake, indicates that white suckers entered area streams to spawn. Eggs, larvae, and YOY were found in Sevenmile Creek (Ind. Bio-Test 1977; LaJeone, pers. comm. 1979; Wis. Elec. Power et al. 1979a,b).

Pigeon River (43°47', 87°43'). A spring run enters the river; a large dip net fishery for white suckers occurs along the entire length of the river (Weber, Poff, and Threinen 1968).

Sheboyqan (43°45', 87°42'). A spawning run enters the Sheboygan River (43°45', 87°42') (Imhof, pers. comm. 1980). In 1975, small numbers of ripe adults were impinged at the Edgewater Generating Station (43°43', 87°42') in mid-March to April (Swanson Environ. 1976).

Ozaukee County (43°33', 87°48'--43°12', 87°54'). Spring spawning runs enter the tributaries (Poff et al. 1964).

WM-6

Racine County (42°49', 87°49'--42°40', 87°48'). Early spring runs enter the tributaries (Poff and Threinen 1961a).

Kenosha County (42°40', 87°48'--42°29', 87°48'). Early spring runs enter tributaries. The Pike River (42°36', 87°49') supports an important run; runs formerly entered Barnes Creek (42°31', 87°49') (Poff and Threinen 1961b).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). White suckers spawn in this area, however, spawning success appears to be limited

(Cochran and Cima 1974). Ripe adults were collected as they entered the Dead River (42°24', 87°48') during April (Muench, pers. comm. 1979). In 1973-75, a few eggs were collected in the area from February through June (Cochran and Cima 1974; Cima et al. 1976). In 1975, a few larvae were found in the lake during April and May (Cima et al. 1976). During June and July, YOY were collected in beach seines near the Waukegan Generating Station (42°23', 87°49') (Cochran, undated).

Michigan

MM-1

Cedar River (45°24', 87°21'). Spawning runs enter the river during early April (Imhof, pers. comm. 1980; Leary, per-s. comm. 1979). Many thousands of spawning white suckers were observed in the river (Dahl and McDonald 1980; GLFC 1979a).

Bark River (45°34', 87°14'). In 1955, white suckers were collected at the FWS sea lamprey weir in the spring (FWS 1979c); this catch suggests that a spawning run from the lake enters the river. In 1978, larvae were collected in seines near the river mouth from May 26 to June 12 (Wis. Elec. Power, unpubl. data).

Ford River (45°40', 87°08'). White sucker spawning runs enter the river about one to two weeks before the longnose sucker runs. In 1978, white sucker larvae were collected in seines near the river from May 26 to June 12; peak densities occurred on May 31 (Michaud, pers. comm. 1980; Wis. Elec. Power, unpubl. data).

Days River (45°54', 86°59'). In 1960-65, white suckers were observed migrating up the Days River during the end of April and early May. Ripe adults and larvae were collected from the stream (Norden, pers. comm. 1979).

Tacoosh (45°55', 86°58'), Rapid (45°55', 86°58'), Sturgeon (45°50', 86°40'), and Fishdam (45°54', 86°35') rivers. In 1954 and 1955, white suckers were collected at the FWS sea lamprey weirs on these rivers in the spring (FWS 1979c); these catches suggest that spawning runs from the lake enter the river.

MM-3

Rock River (46°05', 85°32'). In 1975 and 1976, white suckers were collected at the FWS sea lamprey weir in the spring (FWS 1979c); these catches suggest that a spawning run from the lake enters the river.

Carp Lake River (45°45', 84°50'). From 1948-51, white suckers migrated into the river to spawn, and adults were collected when they migrated downstream after spawning (Applegate and Brynildson 1952).

MM-5

Platte River (44°44', 86°09'). A spawning run occurred here in 1942 (Westerman 1942).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Ripe white suckers are collected during April just north and south of the plant. Spent adults are present in late May. No larvae were collected at the plant; spawning probably occurs in the nearby tributaries (Brazo, pers. comm. 1979; Liston and Tack 1972).

MM-7

White River (43°25', 86°21'). In 1969, large numbers of spawning white suckers were found in the river (GLFC 1970a,b).

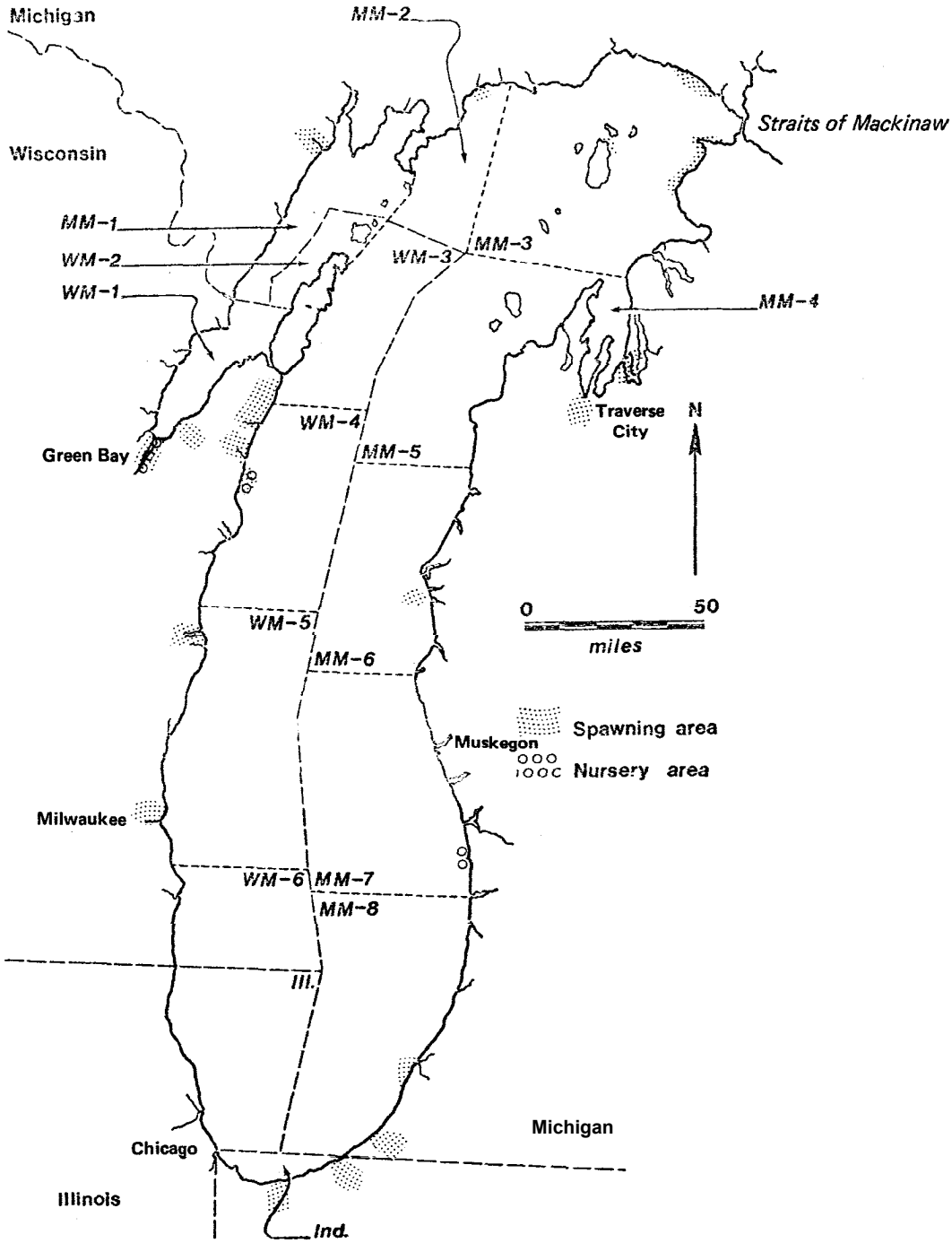
Muskegon (43°13', 86°17'). In 1974-75, peak impingement at the Cobb Power Plant (43°16', 86°15') on Muskegon Lake (43°14', 86°18') occurred from mid-April to mid-May (Consumers Powers 1976f); this corresponds to the spawning period and suggests that a run enters the Muskegon River (43°15', 86°15') from the lake. Many white suckers were captured at the FWS weir here in April-July (Dahl and McDonald 1980).

Port Sheldon (42°54', 86°13'). White suckers may enter Pigeon Lake (42°54', 86°12') to spawn. At the Campbell Power Plant (42°55', 86°12'), impingement peaked from March to May, when spawning runs occurred (Consumers Power 1976b; Jude et al. 1979a). Some larvae were found here in May (Jude et al. 1979a).

MM-8

Black River (42°24', 86°17'). White suckers enter this river from Lake Michigan to spawn (Stauffer 1972).

Bridgman (41°56', 86°35'). Spawning probably occurs here in late March through May. Although common in the area, few white suckers were collected during April, and it is suspected that adults leave the vicinity or enter area streams to spawn. The numbers of spent fish present in the area increased after April. A few YOY were collected in beach seines and observed in a creek at Warren Dunes (41°54', 86°37') (Jude, pers. comm. 1979; Jude et al. 1975, 1979b).


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
WM-4
Traverse City
N
Green Bay
MM-5
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
III.
Michigan
Chicago
Illinois
Ind.

The abundance of suckers in Lake Michigan may have declined because spawning streams, particularly those in Green Bay have been degraded (Wells and McLain 1973).

Wisconsin

Suckers commonly enter tributaries along the western shore of Lake Michigan in March and April to spawn (Wis. Elec. Power 1975a,b,c). Suckers are seasonal migrants in most Green Hay and Lake Michigan tributaries of Door County (Poff and Threinen 1965).

WM-1

Fox River (44°32', 88°00'). Suckers enter the river in the spring to spawn (FWS 1979d). Catostomid larvae were entrained at the Pulliam Power Plant (44°32', 88°00'), which withdraws water from the river and from Green Bay (CDM/Limnetics 1977).

Red River (44°40', 87°45'). A fishery for suckers occurs at the river mouth in the spring (Poff and Threinen 1966b).

WM-3

Heins Creek (45°01', 87°09'). A spawning run may enter the creek (Poff and Threinen 1965).

Woodard Creek (44°45', 87°20'). Suckers may spawn near the creek mouth (Poff and Threinen 1965).

Bear Creek (44°42', 87°21'). A spawning run enters the creek in the spring (Poff and Threinen 1965).

WM-4

Ahnapee (44°36', 87°26') and Kewaunee (44°28', 87°30') Rivers. A fishery for suckers occurs at the river mouths in the spring (Poff and Threinen 1966b).

Kewaunee Power Plant (44°21', 87°32'). In 1975, catostomid eggs were entrained at the plant in late April and mid-May; a few larvae were also entrained (CDM/Limnetics 1977; NALCO, undated b).

WM-5

Sheboygan River (43°45', 87°42'). A fishery for suckers occurs at the river mouth in the spring (USDI 1966).

Milwaukee (43°02', 87°54'). A spawning run of suckers entered the Milwaukee River (43°02', 87°54'), but by 1885 the fishery was almost entirely abandoned (Gregory 1931 as cited in Poff and Theinen 1964; Smith

and Snell 1891). Runs presently occur in the Milwaukee and Kinnickinnic (43°02', 87°54') rivers (Poff and Threinen 1964).

Indiana

Burns Waterway (41°38', 87°10') and Trail Creek (41°44', 86°54'). Suckers enter these tributaries to spawn (Koch, pers. comm. 1979).

Michigan

MM-1

Ford River (45°40', 87°08'). In 1978, sucker eggs (> 19,000 per m^3) were collected in large numbers near the river mouth at the 5 ft depth contour on May 11, after heavy rains washed them out of the river (Wis. Elec. Power, unpubl. data).

MM-2

Manistique (45°57', 86°15'). Suckers spawned in an area (45°55', 86018'--45°56', 86°16') near the mouth of the Manistique River (45°57', 86°15); the substrate was honeycombed rock, and the water depth was about 12 ft (Organ et al. 1978).

MM-3

Beaver Island (45°40', 85°33'). Runs of suckers occurred here. In 1885, suckers were caught in seines as they entered St. James Harbor (45°451, 85°31') in the spring (Smith and Snell 1891).

Brevort (46°01', 85°02'). From the 1960s to 1976, suckers spawned along the shoreline from the Brevoort River (45°57', 84°56') to the Cut River (46°03, 85°07'), over sand and rock in approximately 4-5 ft of water, during late June to early July (Organ et al. 1978).

Waugoshance Island (45°46', 85°04')--Good Hart (45°34', 85°07'). During the 1930s to 1950s, suckers spawned here at depths of less than 12 ft from May to mid-June. The substrate around Waugoshance Island and Waugoshance Point (45°45', 85°01') is primarily rock and mud; elsewhere along the shoreline the substrate is gravel and sand (Organ et al. 1978).

Callam's Mill (location unknown). In 1885, suckers were captured in seines here in early May (Smith and Snell 1891).

MM-4

Grand Traverse Bay (45°05', 85°30'). The first dams were erected on the Elk River (44°54', 85°25') and Kid's Creek (44°46', 85°38') in 1847 and 1851 respectively; these dams blocked the upstream spawning migration of suckers (Price and Kelly 1976).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Spawning occurred on a small area (43°52', 86°29') of rock and hard clay south of the plant, offshore at a depth of about 100 ft (Organ et al. 1978).

MM-7

Port Sheldon (42°54', 86°13'). In 1978, sucker larvae were collected here in May (Jude et al. 1979a).

MM-8

Galien River (41 °48', 86°45'). Suckers were abundant in the river during the spawning season in early spring (Hankinson 1920).

St. Joseph (42°06', 86°29'). From the 1940s to 1960, spawning occurred on a shallow, sand area (42°05', 86°30') just south of St. Joseph (Organ et al. 1978).

BUFFALO spp.

Indiana

Spawning runs of buffalo enter streams along the Indiana shoreline (Westerman, pers. comm. 1979).

GOLDEN REDHORSE

Wisconsin

WM-1

Peshtigo (44°58', 87°39'), Menominee (45°06', 87°35'), and Oconto (44°54', 87°50') Rivers. Golden redhorses are found in these rivers. It is believed that most of these are stream residents but some fish may enter these streams from the lake to spawn. Golden redhorse runs in this area tend to occur later than sucker runs (Moore, pers. comm. 1979).

Michigan

MM-6

Ludinqton Pumped Storage Plant (43°54', 86°27'). A few ripe qolden redhorses were collected at the 5 ft depth contour in April (Brazo, pers. comm. 1979).

SHORTHEAD REDHORSE

Wisconsin

WM-1

Menominee (45°06', 87°35'), Peshtigo (44°58', 87°39'), and Oconto (44°54', 87°50') Rivers. Shorthead redhorses are found in these rivers. Most of these are stream residents, but some fish may enter these streams from the lake (Moore, pers. comm. 1979). Shorthead redhorse runs tend to occur later than the sucker runs. In the Peshtigo River, shorthead redhorses spawn in early May at a water temperature below 52°F (Hawley 1967).

WM-4

East Twin (44°09', 87°34'), West Twin (44°09', 87°34'), and Manitowoc (44°05', 87°39') Rivers. Shorthead redhorses are found in these rivers (Belonger and Moore, pers. comm. 1979).

Michigan

MM-7

Port Sheldon (42°54', 86°13'). A few shorthead redhorses with moderate to well developed gonads were collected here in June; these fish may have been migrating into Pigeon Lake (42°54', 86°12') to spawn (Jude et al. 1979a).

GREATER REDHORSE

Wisconsin

WM-1

Pensaukee River (44°49', 87°54'). A minor spawning run enters the river (Imhof, pers. comm. 1979).

WM-4

west Twin River (44°09', 87°34'). Minor spawning runs enter the river (Imhof, pers. comm. 1979).

REDHORSE spp.

Michigan

MM-7

Muskegon River (43°15', 86°15'). Redhorses enter the river to spawn (Consumers Power 1976f).

White River (43°25', 86°21'). In 1969, many spawners were found in the river (GLFC 1970a,b).

BLACK BULLHEADS

Wisconsin

WM-1

Black bullheads are found along the western and southern shores of Green Bay (Belonger, pers. comm. 1979). It appears that they spawn in the sheltered bays and harbors, where they are normally found. They are also abundant year-round residents of Sawyer Harbor (44°53', 87°26') (Kernen 1972).

Illinois

Black bullheads probably reproduce in the harbors and bays along the Illinois shore (Muench, pers. comm. 1979).

Michigan

MM-7

port Sheldon (42°54', 86°13). In 1978, one spent male black bullhead was collected in July in the area, suggesting that spawning occurred in June or July (Jude et al. 1979a).

CHANNEL CATFISH

Spawning runs enter tributaries (USDI 1966); the large rivers in the southeast **portion** of the lake, particularly the Grand River (43°03', 86°15'), probably serve as spawning and nursery areas (Wells, pers. comm. 1979). Limited spawning may occur in the lake proper (Jude, pers. comm. 1979; Wells, pers. comm. 1979).

Wisconsin

WM-1

Peaks Lake (44°34', 88°02')--Little Tail Point (44°40', 87°59'). Prior to 1920, Peaks Lake and the surrounding area north to Little Tail Point was one of the most heavily utilized spawning areas in Green Bay (Coberly and Horrall 1980b).

Fox River (44°32', 88°00')--Sable Point (44°35', 87°55'). Young-of-the-year (YOY) were collected in this area (Belonger, pers. comm. 1979) .

Indiana

Michigan City (41°43', 86°54'). Channel catfish are present in the discharge canal of the Michigan City Generating Station (41°43', 86°54') during the spawning season (Morgan 1978c).

Michigan

MM-8

St. Joseph River (42°07', 86°29'). Spawning is believed to occur in the river (Jude, pers. comm. 1979).

Bridgman (41°56′, 86°35′). A few YOY were taken at the Cook Power Plant (41°59', 86°34') (Jude, pers. comm. 1979).

BULLHEAD spp.

Wisconsin

WM-3

Rowley (45°13', 87°01'), North (45°09', 87°04'), and Moonlight (45°05', 87°05′) Bays. Spawning occurs at the heads of North and Moonlight bays and in the marshy areas at the mouth of the Mink River (45°14', 87°02') (Frederick, pers. comm. 1979).

TROUT-PERCH

Trout-perch spawn along beaches in Lake Michigan during July and August; they may also spawn in tributaries. Young-of-the-year (YOY) inhabit inshore areas (Walburg 1973).

WM-1

Fox River (44°32', 88°00'). In 1975, eggs tentatively identified as those of trout-perch were entrained at the Pulliam Power Plant (44°32', 88°00') from May through July (CDM/Limnetics 1977; NALCO, undated a).

WM-5

Milwaukee (43°02', 87°54'). In 1972, ripe trout-perch were collected at McKinley Beach (43°03, 87°53'), over a sandy substrate on June 30 (Norden, pers. comm. 1979).

Oak Creek Harbor (42°51', 87°50'). A few ripe trout-perch were impinged at the Oak Creek Power Plant (42°54', 87°51') in June and August (Wis. Elec. Power 1976d).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Trout-perch spawn in this area (Commonw. Edison 1976). Ripe trout-perch, larvae, and YOY were collected here (Cochran, undated; LaJeone, pers. comm, 1979). In 1974, three trout-perch eggs were collected in the area; this suggests that spawning success is limited (Cochran and Cima 1974).

Indiana

Hammond (41°40', 87°30'). Trout-perch are believed to spawn successfully in the vicinity of the Stateline Generating Station (41°42', 87°31'). Peak impingement of adults occurred in July and August and coincided with the reported spawning time of this species. In 1975-76, eggs were entrained during late July and August; peak entrainment occurred in August. A few trout-perch larvae were collected in the lake near the plant; a few larvae were entrained on August 27 and September 5 (NALCO 1976c).

Gary (41°37', 87°20'). Trout-perch spawn in the vicinity of the Mitchell Power Station (41°37', 87°22'). In 1975, ripe trout-perch *were* most abundant during August, peak abundance of eggs occurred from July through September, and peak abundance of larvae occurred in August and September (NALCO 1976a). A few eggs were entrained from August to October. A few larvae less than 1 in. long were entrained from August to November; peak entrainment occurred in September (Krueger 1976).

Bailly Generating Station (41°39', 87°07'). Trout-perch eggs were entrained from April to October; larvae were entrained during February to December. The prolonged presence of eggs and postlarvae suggests that the spawning season may be extended by the warm water discharge (Tex. Instrum. 1976c).

Michigan City (41°43', 86°54'). The area extending from the Indiana Dunes (41°40', 87°02') to the Michigan state line (41°46', 86°49') is a nursery area for trout-perch; YOY were collected in this area, mostly west of Michigan City (McComish, pers. comm. 1979; Willis 1975). In 1979, YOY were collected in night tows at the 15 ft contour east and west of Michigan City in August (Koch, pers. comm. 1979). An offshore movement of adults is underway by October (McComish, pers. comm. 1979).

Michigan

MM-1

Bark River (45°34', 87°14'). In 1978, a few trout-perch eggs were found just north of the river mouth at the 30 ft contour (Wis. Elec. Power, unpubl. data).

Ford River (45°40', 87°08'). In 1978, small numbers of larvae were collected near the river mouth from mid-May to early August; peak abundance occurred on July 11 at the 5 ft depth contour (Wis. Elec. Power, unpubl. data).

Days River (45°54', 86°59'). In 1954 and 1955, 11,477 and 1,855 trout-perch, respectively, were collected at the FWS sea lamprey weir in the river in the spring (FWS 1979c); these catches suggest that a spawning run enters the river from the lake.

Fishdam River (45°54', 86°35'). In 1954, 50 trout-perch were collected at the FWS sea lamprey weir in the river in the spring (FWS 1979c); this catch suggests that a spawning run enters the river from the lake.

MM-3

Jordan River (45°09', 85°08'). Trout-perch appear as transients in the lower river in June and July (Quick 1971).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Trout-perch are commonly collected in trawls in this area. Ripe adults are found from late May to late August; peak spawning usually occurs from mid-June to mid-July. Larvae are present from early June through September. Young-of-the-year are seldom collected, but yearlings are abundant in the spring (Brazo, pers. comm. 1979).

MM-7

Grand Haven (43°04', 86°13'). In 1972, a few fry were collected in August within 3 ft of the surface off Grand Haven (Wells 1973).

Port Sheldon (42°54', 86°13'). An inshore migration of trout-perch occurs here in April and May; gonad data indicate that spawning occurs from April to September, In 1977 and 1978, ripe-running and spent adults

and larvae were present from April to September (Jude et al. 1978, 1979a; Tin and Heufelder, pers. comm. 1979). Most spawning occurred from June through August; in 1977 and 1978, peak spawning occurred in June and August, respectively. By September most adults begin to migrate offshore. Fry about 0.8-1.6 in. long were first collected in trawls during September at depths of 30-50 ft. A few YOY were collected in October and November, but most had apparently moved out to deeper water for the winter (Jude et al. 1978, 1979b).

MM-8

Saugatuck (42°40', 86°12'). Collections of spent trout-perch in 1972 suggested that spawning occurred from late June or early July to late September (House and Wells 1973).

Palisades Power Plant (42°19', 86°19'). In 1972 and 1973, many trout-perch were impinged at the plant during the spawning season in April and June (Consumers Power 1975). In 1978, trout-perch were believed to have spawned in the nearshore waters from mid-July through mid-August. A few larvae were present from early August to late October (Wapora 1979c).

Bridgman (41°56', 86°35'). Spawning occurs in the area from the Cook Power Plant (41°59', 86°34') to Warren Dunes State Park (41°54', 86°37') from May to September. In 1973, the first major influx of adults occurred in the inshore waters in June. Spawning probably occurs from June to August; peak spawning occurred in July. Ripe adults were present from May through August; spent adults were present in increasing numbers from June through August. High inshore catches of trout-perch in July near the Cook Power Plant may have coincided with the peak spawning period (Jude et al. 1975, 1979b). Eggs and larvae were entrained at the plant (CDM/Limnetics 1977). Newly hatched larvae are collected in May and September (Jude, pers. comm. 1979); YOY are taken in seines and trawls beginning in July (Jude et al. 1975). In the fall, larvae and YOY are found in water about 20-30 ft deep; by November these fish have moved offshore (Jude, pers. comm. 1979; Jude et al. 1973, 1975, 1979b).

BURBOT

wisconsin

Large numbers of adults are present in the fall and probably also in the winter in southern Green Bay (GLFC 1976c). Burbot probably spawn on most of the reefs in Green Bay under the ice in February (Moore, pers. comm. 1979).

WM-1

Youngs Reef (44°54', 87°42'). A commercial fisherman caught ripe burbot here under the ice in February (Coberly and Horrall 1980b).

Fox River (44°32', 88°00'). In 1975, eggs tentatively identified as those of burbot were entrained in April (NALCO, undated a). Larvae were entrained at the Pulliam Power Plant (44°32', 88°00') from late April to early June.

WM-2

Horseshoe Reefs (45°13', 87°12'). Extensive spawning occurs here under the ice; gill nets fished under the ice for whitefish catch large numbers of rips burbot in January and February (Copes, Ebener, and Leary, pers. comm. 1979; Frederick, pers. comm. 1979).

Plum Island (45°19', 86°57'), Boyer Bluff (45°25', 86°56') and Deathdoor Bluff (45°18', 87°04'). Ripe-running burbot were caught through the ice here usually in February (Coberly and Horrall 1980b).

WM-4

Kewaunee Power Plant (44°21', 87°32'). In 1975, a few burbot larvae averaging about 0.2 in. long were entrained at the plant in April and May (LaJeone, pers. comm. 1979; NALCO, undated b).

WM-5

Haven (43°51', 87°44'). In 1974, larvae were collected here in April and May (LaJeone, pers. comm. 1979; Wis. Elec. Power et al. 1979b).

Sheboygan (43°45', 87°42'). In 1977-78, two burbot prolarvae were captured onshore near the Edgewater Generating Station (43°43', 87°42') on May 13 (Swanson Environ. 1979).

Port Washington (43°23', 87°52'). In 1979, one larva was entrained at the Port Washington Power Plant (43°23', 87°52') on April 28 (Wis. Elec. Power 1976e).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In 1973-77, a few burbot larvae were collected in this area from March to July (Cima 1977; Cima et al. 1976; Cochran and Cima 1974).

Michigan

MM-1

Whaleback Shoal (45°27', 87°11'). Gill nets fished under the ice for whitefish catch large numbers of ripe burbot in January and February (Frederick, pers. comm. 1979).

Bark River (45°34', 87°14')--Ford River (45°40', 87°08'). In 1977-78, burbot larvae were collected in shore seines near the Bark and Ford rivers during May 4-26. Larvae were found most consistently near the 'Ford River, however the greatest density occurred near the Bark River on May 18. Larvae were caught in the lake from April 25 to June 14; a maximum density of 24,500 per 1,000 m^3 occurred on May 11 at the 10 ft depth contour near the Bark River (Wis. Elec. Power, unpubl. data).

MM-3

Simmons Reef (45°55', 85°12') and Manitou Paymen Shoal (45°58', 85°04'). In the 1930s spawning occurred in February and March on Simmons Reef and Manitou Paymen Shoal; both are rocky areas with water depths of about 30 ft (Organ et al. 1978).

MM-6

Ludington (43°57', 86°28'). Young-of-the-year burbot were found in tributaries of the Pere Marquette River (43°56', 86°26') (Brazo, pers. comm. 1979). Many larvae were collected along the 5 ft depth contour from Ludington to 2 mi S of the Ludington Pumped Storage Plant (43°54', 86°27') from late April through May (Brazo, pers. comm. 1979; Liston et al. 1978).

MM-7

Muskegon (43°13', 86°17'). In 1974-75, 840 burbot eggs were collected from water passing through the Cobb Power Plant (43°15', 86°15') on April 2-3; these eggs may have been released by impinged adults (Consumers Power 1976f).

Port Sheldon (42°54', 86°13'). Impingement of adults from January to April at the Campbell Power Plant (42°55', 86°12') and entrainment of eggs in January and of newly hatched larvae from February to June suggest that spawning may occur in the vicinity of the plant (Consumers Power 1976b; Heufelder, pers. comm. 1979; Jude 1978; Jude et al. 1979a). Burbot probably spawn nearshore from January to March and move to deeper water by April (Jude 1978). Newly hatched larvae are collected along shore; peak abundance occurs in April (Heufelder, pers. comm. 1979; Jude et al. 1979a). The capture of a male with well developed testes and the observation of larvae in Pigeon Lake (42°54', 86°12') suggest that Pigeon Lake may also be a spawning area for burbot (Jude 1978; Jude et al. 1978, 1979a).

MM-8

Palisades Power Plant (42°19', 86°19). In 1978, sampling 5 mi S of the plant revealed that eggs were present in low densities on April 15. Larvae were present at this site and at the plant from April 15 to May 15 (Wapora 1979c).

Bridgman (41°56', 86°35'). The collection of a few ripe-running burbot and eggs in December and January suggests that spawning occurs in

the shallow inshore waters from the Cook Power Plant (41°59', 86°34') to Warren Dunes (41°54', 86°37') (Indiana and Mich. Power 1975, 1977; Jude, pers. comm. 1979; Jude et al. 1975, 1979b). Ripe adults were collected as late as April (Jude et al. 1979b). This area is also a nursery area; a few larvae were collected in April and May (Indiana and Mich. Power 1977; Jude, pers. comm. 1979; Jude et al. 1979b).

BROOK STICKLEBACK

Wisconsin

WM-5

Haven (43°51', 87°44'). A few ripe brook sticklebacks were collected in Lake Michigan here. It is suspected that these were migrants from Sevenmile Creek (43°51', 87°44') and the Pigeon River (43°47', 87°43'), where they are abundant (LaJeone, pers. comm. 1979).

Michigan

MM-3

Cross Village (45°39', 85°02'). In 1952, nests of brook sticklebacks were observed in the nearshore waters near Cross Village on July 6; the nests were attached to Scirpus and grass (Winn 1960).

Waugoshance Point (45°45', 85°01'). Nests and nesting fish were observed in an area (location unknown) near the point, over gravel among Scirpus; males were observed guarding these nests (Norden, pers. comm, 1979).

NINESPINE STICKLEBACK

Wisconsin

WM-4

Point Reach Power Plant (44°17', 87°32'). In 1975, a few ripe males and females were impinged at the plant from late May to the end of July (Wis. Elec. Power 1976c).

WM-5

Haven (43°51', 87°44'). In 1978, larvae were collected here in July and August; peak abundance occurred in July at the 30 ft depth contour (Wis. Elec. Power, unpubl. data).

Port Washington (43°23', 87°52'). In 1975, ripe adults were impinged at the Port Washington Power Plant (43°23', 87°52') from March to August; peak impingement occurred in late May and early June. A few larvae were entrained at the plant in late July and early August (Wis. Elec. Power 1976e). In 1978, larvae were collected at Port Washington; peak abundance occurred at the 30 ft depth contour in September (Wis. Elec. Power, unpubl. data).

Milwaukee (43°02', 87°54'). Ripe-running adults were collected in the McKinley Beach Marina (43°03', 87°53') area in 20 ft of water in July (Binkowski, pers. comm. 1979).

Oak Creek Harbor (42°51', 87°50'). In 1975, a few ripe adults were impinged at the Oak Creek Power Plant (42°51', 87°50') in May (Wis. Elec. Power 1976d).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Some ripe-running adults and larvae were collected in this area over sandy bottom with a few rocks (LaJeone, pers. comm. 1979). In 1972, half of the mature females collected in this area in June were ripe; one ripe female was collected at Waukegan in July (Cochran, undated). Spawning success in this area is limited (Cochran and Cima 1974); in 1973, only one larva was taken near Waukegan in 50 ft of water. In 1974-77, larvae were generally collected in the area from July to September; young-of-the-year were collected during August to October (Ind. Bio-Test 1975; Cima et al. 1976; Cima 1977).

Indiana

Hammond (41°40', 87°30'). Successful spawning is believed to occur in the vicinity of the Stateline Generating Station (41°42', 87°31'). In 1975, ninespine stickleback larvae were 0.3% of larvae collected in the lake and about 9% of those entrained at the plant; larvae were most abundant in nearshore areas (NALCO 1976c).

Michigan

MM-1

Hark River (45°34', 87°14'). In 1978, larvae were collected off the mouth of the river in July and August (Wis. Elec. Power, unpubl. data).

MM-5

Sleeping Bear Bay (44°55', 86°00'). In 1956, ninespine sticklebacks were observed nesting in the bay at depths of 50-60 ft in July. Nests were constructed of the alga Dichotomosiphon and located in small depressions on the bottom (Anderson 1967).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Ripe adults were collected in this area from mid-June to early July. Spawning may occur in coastal marshes. Larvae first appear in the area in mid-June, and peak concentrations are observed by late June; they appear to move to deeper water as they grow (Brazo, pers. comm. 1979).

MM-7

Port Sheldon (42°54', 86°13'). Gonad data suggest that sticklebacks spawn in the vicinity of the Campbell Power Plant (42°55', 86°12') in June and July; in 1977, many females caught in June and July had moderately to well developed ovaries (Jude et al. 1978). In 1978, ripe-running adults were collected in the area in April and May at water temperatures of about 47-63°F. After spawning in the shallows, adults may return to deeper water. In 1978, a few larvae were collected; spawning probably occurred in June and July (Jude et al. 1979a).

MM-8

Bridgman (41°56', 86°35'). Gravid adults are fairly common in this area during April and May; however, the vegetation needed for spawning is not present in this area. Only one larva has been collected near the Cook Power Plant (41°59', 86°34') (Jude 1977, pers. comm. 1979; Jude et al. 1979b).

WHITE BASS

white bass migrate into small and medium-sized tributaries of Lake Michigan to spawn (Riggs 1952). They apparently reproduce now only in the Green Bay area.

Wisconsin

WM-1

Long Tail Point (44°35', 87°59')--Red Banks (44°37', 89°52'). Young-of-the-year (YOY) just over an inch long were captured along shore in the area from Long Tail Point to Red Banks in mid- to late June (Belonger, pers. comm. 1979). At Red Banks, YOY were found in an open, rocky area; at Duck Creek (44°34', 88°02'), YOY were collected in marshes. Spawning may occur in the areas where young were found (Belonger, pers. comm. 1979). According to commercial fishermen, the area from Little Tail Point (44°40', 87°59') to Peaks Lake (44°34', 88°02') was one of the most heavily used spawning areas until around 1920, when the marshes were filled (Coberly and Horrall 1980b). In 1975, a few larvae were collected in the Fox River (44°32', 88°00') and in Green Bay near the Pulliam Power Plant (44°32', 88°00') in early June (NALCO, undated a).

Illinois

Calumet River (41°44', 87°32'). Historically, white bass runs entered the river in June; runs sometimes moved as far upstream as Lake Calumet (41°41', 87°35') (Nelson 1878).

Michigan

MM-1

Whitefish River (45°55', 86°57'). In 1954, 50 white bass were caught at the FWS sea lamprey weir in the spring (FWS 1979c).

ROCK BASS

Illinois

Montrose Harbor (41°58', 87°38'), Belmont Harbor (41°57', 87°38'), Diversey Harbor (41°56', 87°38'), Lincoln Park Lagoon (41°55', 87°38'), Navy Pier (41°54', 87°36'), Burnham Harbor (41°51', 87°37'), 51St Street Harbor (41°48', 87°35'), Jackson Harbor (41°47', 87°35'), and Calumet Harbor (41°43', 87°31'). Spawning may occur in these areas (Muench, pers. comm. 1979).

Michigan

MM-3

Beaver Island (45°40', 85°33'). From 1970-77, rock bass spawned in the gravel shallows of Heaver Harbor (45°44', 85°30') in late June (Organ et al. 1978).

Garden Island (45°48', 85°30'). From 1970-77, spawning occurred on clay shallows (42°47', 85°30') *on* the west side of the island in late June (Organ et al. 1978).

Waugoshance Point (45°45', 85°01'). Rock bass spawn in nests used earlier in the season by smallmouth bass (Latta 1963).

GREEN SUNFISH

Illinois

Green sunfish may spawn in the harbors and lagoon areas along the Illinois shoreline (Muench, pers. comm. 1979).

PUMPKINSEED

Pumpkinseed probably do not spawn successfully in Lake Michigan proper; this species is usually found only near tributaries (CDM/Limnetics 1976c).

Wisconsin

WM-1

Sawyer Harbor (44°53', 87°26'). The pumpkinseed is a year-round resident and probably spawns here (Kernen, pers. comm. 1979).

Illinois

Trident Harbor (42°28', 87°48'). Young-of-the-year have been collected here (Muench, pers. comm. 1979).

Michigan

MM-7

Port Sheldon (42°54', 86°13'). In 1978, one ripe-running pumpkinseed was caught here in April. Young-of-the-year were collected here in July (Jude et al. 1979a).

BLUEGILL

Bluegills tend to spawn in harbors and tributaries rather than in Lake Michigan proper (CDM/Limnetics 1976c).

Illinois

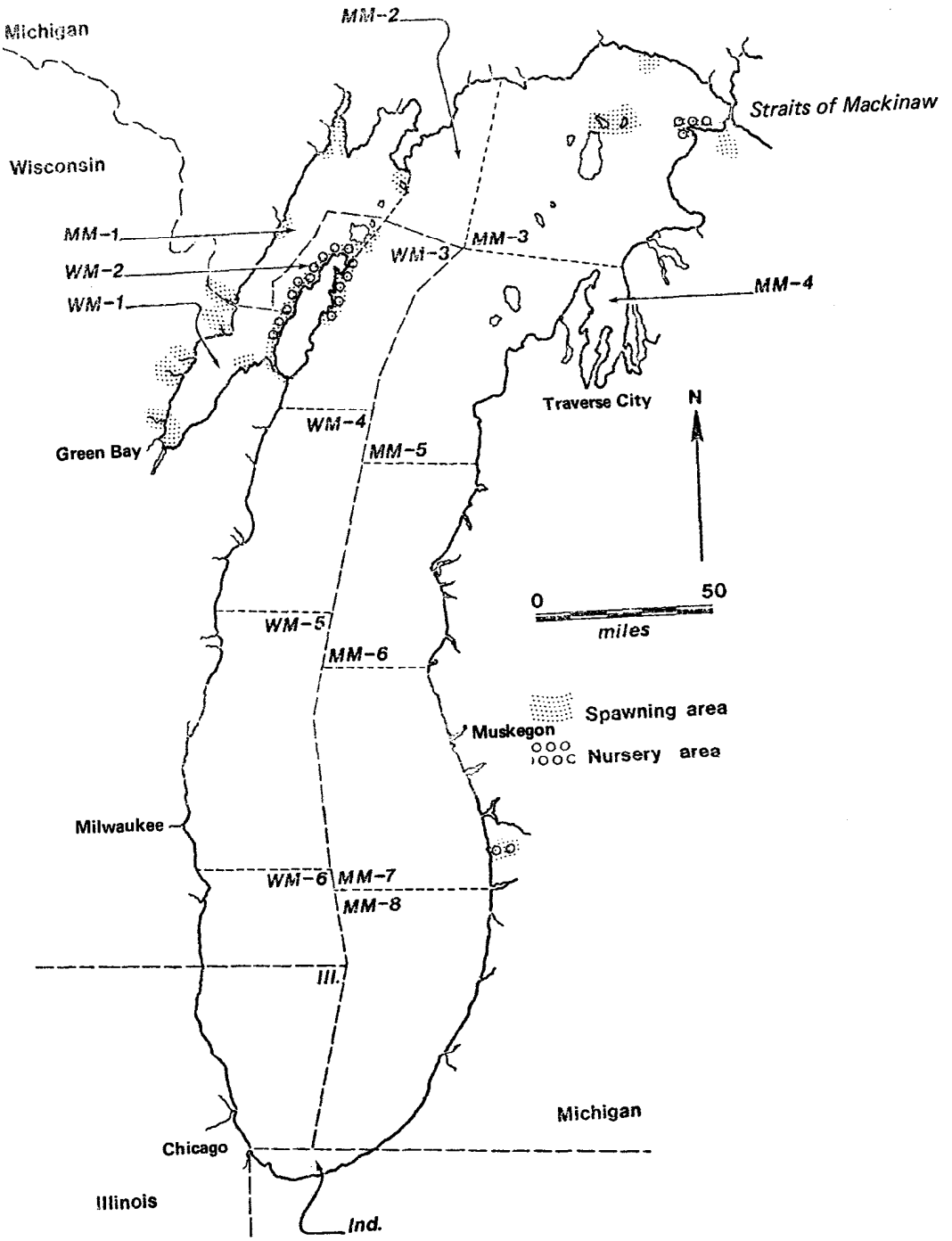
Bluegills probably spawn in the harbor and lagoon areas along the Illinois shoreline (Muench, pers. comm. 1979).

Indiana

Michigan City (41°43', 86°54'). A few bluegill eggs and larvae were entrained at the Michigan City Generating Station (41°43', 86°54'); these probably originated from spawning that occurred in Trail Creek (41°44', 86°54') (Morgan 1978a).

MM-7

Port Sheldon (42°54', 86°13'). A few larvae and young-of-the-year were found in Lake Michigan here; these were assumed to have originated from spawning that occurred in Pigeon Lake (42°54', 86°12') *or* in the discharge canal of the Campbell Power Plant (42°55', 86°12') (Jude et al. 1978). In 1978, bluegill larvae were found in one entrainment collection in June (Jude et al. 1979a).


Michigan
Wisconsin
MM-2
Straits of Mackinaw
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Traverse City
N
Green Bay
WM-4
MM-5
0
50
miles
WM-5
MM-6
Spawning area
Muskegon
Nursery area
Milwaukee
WM-6
MM-7
MM-8
Ill.
Michigan
Chicago
Illinois
Ind.

There are two major smallmouth bass spawning areas in Lake Michigan; these are the Green Bay-Door Peninsula area in Wisconsin and the Wauqoshance Point area of Michigan.

Wisconsin

The protected areas of the Door Peninsula (45°05', 87°10') from Little Sturgeon Bay (44°50', 87°33') around to Baileys Harbor (45°03, 87°07') are spawning and nursery areas (Kernen, pers. comm. 1979). Smallmouth bass are not common in the waters south of Baileys Harbor which are not warmed by the outflow from Green Bay (Kernen, pers. comm. 1979).

WM-1

Menominee River (45°06', 87°35'), Oconto River (44°54', 87°50'), Peshtigo River (44°58', 87°39'), Pensaukee River (44°49', 87°54'), and Big Suamico River (44°38', 88°00'). Spawning runs enter these rivers (Kernen, pers. comm. 1979).

Peaks Lake (44°34', 88°02'). Before 1920, Peaks Lake and the surrounding area north to Little Tail Point (44°40', 87°59'), was heavily utilized by smallmouth bass for spawning (Coberly and Horrall 1980b).

Little Sturgeon Bay (44°50', 87°33'). Commercial fishermen report that spawning occurs here (Coberly and Horrall 1980b).

Sturgeon Bay (44°53', 87°24'). Fishermen report that spawning occurs in Sawyer Harbor (44°53', 87°26'), along the east shore (44°54', 87°23') of the bay (Coberly and Horrall 1980b), and in the Ship Canal (44°48', 87°19') (FWS 1979d).

WM-2

Sister Islands (45°13', 87°09'). Nests defended by males were observed in June and July on a substrate of sand and rock (Frederick, pers. comm. 1979).

Washington Island (45°23', 86°54'). Detroit Harbor (45°21', 86°55') is a smallmouth bass spawning area (Coberly and Horrall 1980b; Frederick, pers. comm. 1979; Leary and Ebener, pers. comm. 1979). Smallmouth bass also spawn in West Harbor (45°22', 86°57'), Jackson Harbor (45°24', 86°51'), and along shore between Jackson Harbor and Detroit Harbor (Coberly and Horrall 1980b).

WM-3

Rowley Bay (45°13', 87°01'). Adults were seen defending nests on a bottom of sand and rock at the head of the bay near the mouth of the Mink River (45°14', 87°02') (Frederick, pers. comm. 1979). The Mink River estuary has long been known as prime smallmouth bass spawning habitat (Daly 1974).

North Bay (45°09', 87°04'). Adults were seen here defending nests built on a rock and sand bottom (Frederick, pers. comm. 1979; Leary and Ebener, pers. comm. 1979).

Michigan

MM-1

Arthur Bay (45°19', 87°26'). Since the 1950s, smallmouth bass have spawned in an area (45°19', 87°25'--45°21', 87°24') just north of Arthur Bay; spawning occurs from mid-May through mid-June over rock in water 3-15 ft deep (Organ et al. 1978).

Little Bay de Noc (45°45', 87°00'). Smallmouth bass are believed to spawn in 2-20 ft of water along both shores of the bay over sand, gravel, rubble, and boulders (FWS 1979d).

Summer Islands (45°35', 86°40'). This island complex is probably a spawning area (Ebener, pers. comm. 1979).

MM-3

Beaver Island (45°40', 85°33'). In 1970-77, smallmouth bass spawned in Heaver Harbor (45°44', 85°30') over coarse gravel during the latter part of June (Organ et al. 1978).

Garden Island (45°48', 85°30'). In 1970-77, spawning occurred in the bay on the west shore (45°47', 85°30') over coarse gravel during the latter part of June. In 1972-76, spawning occurred along the southeast shore in early June (Organ et al. 1978).

Hog Island (45°47', 85°22'). In 1954, smallmouth bass spawned along the west shore of the island on gravel bottom during July; spawning also occurred along the east shore of the island over rock and gravel (Latta 1963; Organ et al. 1978).

Carp Lake River (45°45', 84°50'). In 1948-51, smallmouth bass entered the river to spawn; adults were captured as they migrated downstream (Applegate and Brynildson 1952).

Waugoshance Point (45°45', 85°01'). In 1954-55, smallmouth bass moved into the shallow areas at the point to spawn (Latta 1957). Nesting fish preferred areas in the protected back parts of shallow bays over gravel bottom in about 2 ft of water. Quiet water appeared to be a more important criterion governing nest site selection than substrate type or shelter (Latta 1957, 1963). Nesting usually began in early June when water temperatures rose above 60°F (Latta 1957, 1963). Eggs were found in the nests (Latta 1963), and larvae and fry were collected in the area (Latta 1957, 1963; Norden, pers. comm. 1979). From the 1930s to 1972, smallmouth bass spawned on rock and silt on both the north and south sides of Waugoshance Point and Waugoshance Island (45°46', 85°04'). Spawning occurred as late as June or early July in water 3-4 ft deep (Organ et al. 1978).

MM-7

Port Sheldon (42°54', 86°13'). Smallmouth bass from Pigeon Lake (42°54', 86°12') or the nearshore waters of Lake Michigan may enter the Pigeon River (42°54', 86°12') to spawn. In 1978, smallmouth bass larvae were collected in Pigeon Lake; young-of-the-year about 3-4 in. long were impinged at the Campbell Power Plant (42°55', 86°12') (Jude et al. 1979b).

LARGEMOUTH BASS

Illinois

Trident Harbor (42°28', 87°48'), Waukegan Generating Station Lagoon (42°23', 87°49'), Waukegan Harbor (42°22', 87°49'), Great Lakes Naval Harbor (42°18, 87°50'), Wilmette Harbor (42°05', 87°41'), Northwestern University Laqoon (42°03', 87°40'), Montrose Harbor (41°58', 87°38'), Belmont Harbor (41°57', 87°38'), Diversey Harbor (41°56', 87°38'), Lincoln Park Lagoon (41°55', 87°38'), Navy Pier (41°54', 87°36'), Burnham Harbor (41°51', 87°37'), 51st Street Harbor (41°48', 87°35'), Jackson Harbor (41°47', 87°35'), and Calumet Harbor (41°43', 87°31'). Young-of-the-year were collected here, and reproduction probably occurs in these areas (Muench, pers. comm. 1979).

Michigan

MM-1

Arthur Hay (45°19', 87°26'). Largemouth bass spawn in an area (45°19', 87°25'--45°21', 87°24') north of Arthur Bay; spawning occurred over rock in 3-15 ft of water from mid-May to mid-June (Organ et al. 1978).

MM-3

Point Epoufette (46°03, 85°12'). Largemouth bass spawn over mud and weeds on both sides of the point in mid-May (Organ et al. 1978).

MM-7

Port Sheldon (42°54', 86°13'). In 1978, larvae and spawning concentrations of adults were observed in Pigeon Lake (42°54', 86°12') near the Campbell Power Plant (42°55', 86°12'). Larvae were entrained at the plant in early June. Young-of-the-year largemouth bass were collected in seines from July to September (Jude et al. 1979a).

BASS spp.

Illinois

Calumet River (41°44', 87°32'). In the late 1870s, black bass were seined as they ran into the river during spring and summer (Nelson 1878); this may have been a spawning run.

WRITE CRAPPIE

It is unlikely that white crappie spawn successfully in Lake Michigan proper (CDM/Limnetics 1976c).

Illinois

Montrose Harbor (41°58', 87°38'), Belmont Harbor (41°57', 87°38'), Diversey Harbor (41°56', 87°38'), Lincoln Park Lagoon (41°55', 87°38'), Navy Pier (41°54', 87°36'), Burnham Harbor (41°51', 87°37')' 51St Street Harbor (41°48', 87°35'), Jackson Harbor (41°47', 87°35'), and CalUmet Harbor (41°43', 87°31'). These may be spawning areas (Muench, pers. comm. 1979).

BLACK CRAPPIE

It is unlikely that black crappie spawn in Lake Michigan proper (CDM/Limnetics 1976c).

Illinois

Montrose Harbor (41°58', 87°38'), Belmont Harbor (41°57', 87°38'), Diversey Harbor (41°56', 87°38'), Lincoln Park Lagoon (41°55', 87°38'), Navy Pier (41°54', 87°36'), Burnham Harbor (41°51', 87°37'), 51st Street Harbor (41°48', 87°35'), Jackson Harbor (41°47', 87°35'), and Calumet Harbor (41°43', 87°31'). These may be spawning areas (Muench, pers. comm. 1979).

CRAPPIE spp.

Michigan

MM-7

Port Sheldon (42°54', 86°13'). In 1978, larvae were entrained at the Campbell Power Plant (42°55', 86°12') from late May through the first week of August at water temperatures of about 58-68°F. A small population of crappie may inhabit and spawn in the intake canal of the plant. A few larvae were captured in Pigeon Lake (42°54', 86°12') in June (Jude et al. 1979a).

JOHNNY DARTER

Indiana

Hammond (41°40', 87°30'). Successful spawning is believed to occur in the vicinity of the Stateline Generating Station (41°42', 87°31'). In 1975-76, johnny darter larvae were common in the area in June and July (NALCO 1976c).

Michigan City (41°43', 86°54'). Young-of-the-year (YOY) were collected west of Michigan City on clay mounds off Kintzele Ditch (41°43', 86°56') (Palacios, pers. comm. 1979).

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Spawning occurs in this area (Brazo, pers. comm. 1979). In 1979, ripe adults were collected in an area (43°55', 86°26') about 2 mi S of the plant in mid-June to mid-July, over sand, in water 5-15 ft deep; eggs and larvae were also collected. Larvae were found here and 1/2 mile S of the plant over large rocks and clay outcroppings (Brazo, pers. comm. 1979; Liston et al. 1978).

MM-7

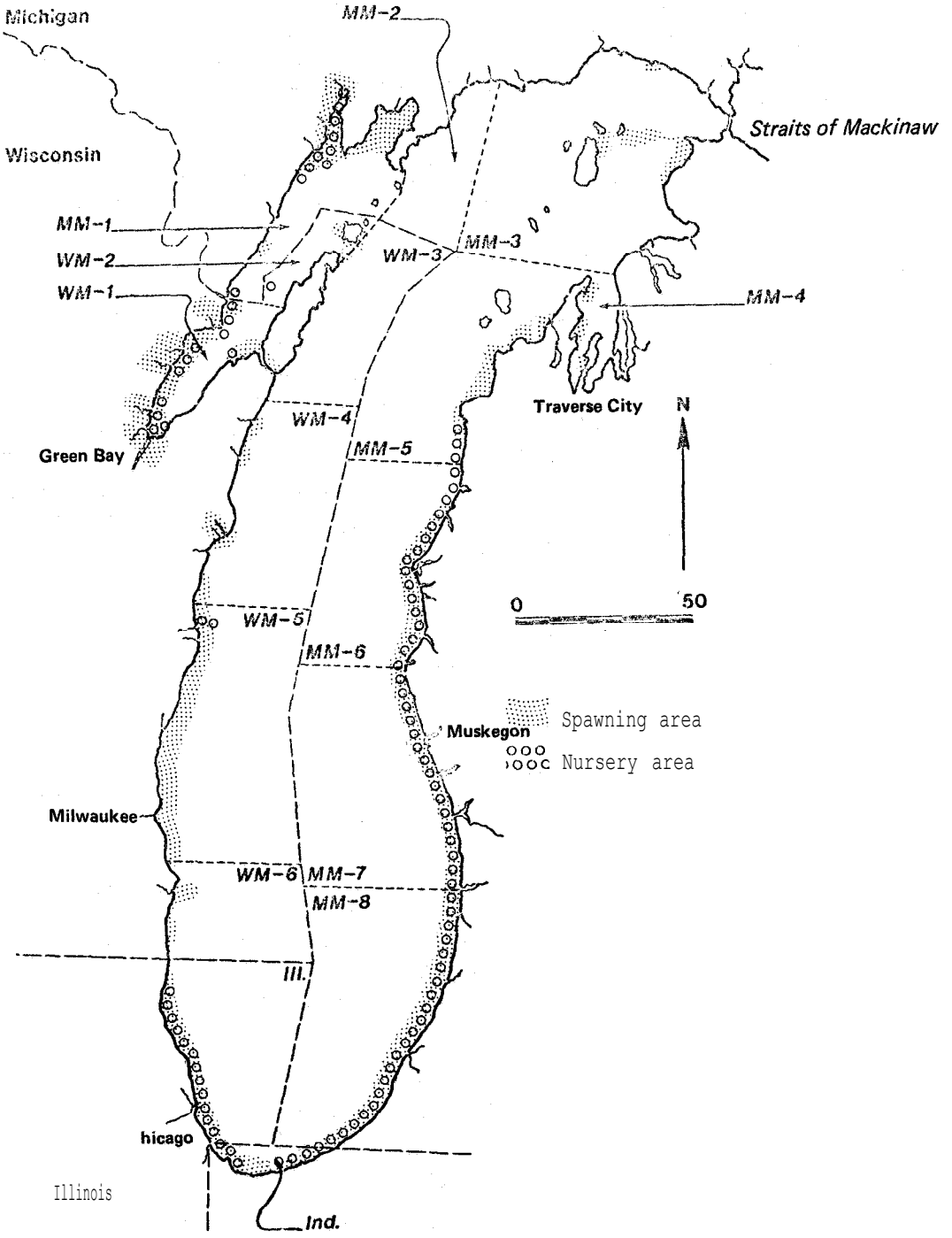
Port Sheldon (42°54', 86°13'). Johnny darters move inshore in this area to spawn. In 1978, running-ripe females and one spent male were collected during June (Jude et al. 1979a). Gonad data suggest that spawning occurred in June and July in Lake Michigan and from late April to mid-May in Pigeon Lake (42°54', 86°12'). Larvae were 'caught at beach stations near the Campbell Power Plant (42°55', 86°12') during June (Jude et al. 1978); larvae were collected from Pigeon Lake and were entrained at the plant (Heufelder, pers. comm. 1979). After spawning, adults may move to a sand or gravel substrate in deeper water (Jude et al. 1978, 1979a).

MM-8

Palisades Power Plant (42°19', 86°19'). In 1978, spawning occurred in the vicinity of the plant from mid-July to mid-August. Eggs were

collected on August 4 in an area (42°15', 86°21') 5 mi S of the power plant. Larvae were collected in the area from early August to late October. Larvae were also entrained at the plant (Wapora 1979c).

Bridgman (41°56', 86°35'). Spawning occurs near the Cook Power Plant (41°59', 86°34') (Jude 1977; Jude, pers. comm. 1979; Jude et al. 1975, 1979b). Catches of ripe-running adults suggest that spawning occurs during May and June (Jude et al. 1975, 1979b). Eggs were collected from the riprap around the intake structure. The area near the plant at the 20-30 ft depth contours is a nursery area. The Warren Dunes area (41°54', 86°37') may also be a nursery ground (Jude, pers. comm. 1979).


Michigan
MM-2
Straits of Mackinaw
Wisconsin
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Traverse City
N
WM-4
MM-5
Green Bay
0
50
WM-5
MM-6
Spawning area
Nursery area
Muskegon
Milwaukee
WM-6
MM-7
MM-8
III.
hicago
Illinois
Ind.

In Lake Michigan, most yellow perch spawning areas are located in Green Bay (45°05', 87°25') and along the east and south shores of the lake proper. Yellow perch spawn from about mid-May to July 1, when water temperatures are 49-62°F. In the southern two-thirds of the lake, spawning usually occurs in May and June. Most spawning apparently occurs among weeds or on rocky shoals; these areas provide substrate to which egg masses can cling. The largest catches of fry are made in water about 16 ft deep; very few fry are collected at depths greater than 33 ft. Larvae and fry are probably most abundant in water shallower than 20 ft (Brown and Wells 1976; CDM/Limnetics 1976c; GLFL 1970; Rile and Jobes 1942; Walburg 1973; Wells 1974).

In the Green Bay area, yellow perch runs enter many streams after the ice goes out. Spawning occurs from mid-April to May, when temperatures reach about 47-50°F (Belonger, pers. comm. 1979; Kernen and Hawley 1978; Sager, pers. comm. 1979); spawning occurs earlier in southern Green Bay than in the lake proper (Wells 1977a). Yellow perch migrated into the southern end of Green Bay, apparently to spawn (Hile, pers. comm. 1979). Commercial fishermen recently reported that small numbers of yellow perch could be found spawning nearly everywhere in the southern half of the bay, but that ripe fish and egg masses were most abundant along the western shore of the bay (Coberly and Horrall 1980b). The marshy shorelines in some parts of Green Bay may be spawning and nursery grounds (Wells 1977a, pers. comm. 1979). Fishermen contended and tagging studies confirmed that the larger yellow perch that spawned in Green Bay tended to move northward after spawning, perhaps moving out of the bay and into Lake Michigan @roper (Hile 1953b; Mraz 1952).

Wisconsin

WM-1

Spawning probably occurs along the entire open shoreline from Marinette (45°05', 87°36') south to Green Bay (44°30', 88°00') (Belonger, pers. comm. 1979).

Marinette (45°05', 87°36'). Spawning occurs in marshy areas and off piers from early April through early May at water temperatures of about 50-52°F. In 1977 and 1978, young-of-the-year (YOY) were collected off Marinette in late August and early September (Belonger 1979, pers. comm. 1979; Belonqer et al. 1979; Kernen and Hawley 1978; USDI 1966).

Peshtigo River (44°58', 87°39'). Substantial spawning runs enter the river (Belonger, pers comm. 1979). The mouth of the river is an historical spawning area; in 1977, peak spawning occurred April 7-14 at water temperatures of about 43-50°F (Kernen and Hawley 1978). In 1977 and 1978, YOY were collected in the area (Belonger et al. 1979; Kernen and Hawley 1978).

Oconto River (44°54', 87°50'). Substantial spawning runs enter the river (Belonger, pers. comm. 1979). In 1977 and 1978, YOY were collected in the area (Belonger 1979; Belonger et al. 1979; Kernen and Hawley 1978).

Pensaukee River (44°49, 87°54'). A run enters the river, and spawning occurs in mid-April at water temperatures of about 46-55°F (Belonger, pers. comm. 1979; Kernen and Hawley 1978). In 1977, YOY were collected here (Kernen and Hawley 1978).

Little Suamico River (44°42′, 87°59′). A spawning run probably enters the river (Sager, pers. comm. 1979).

Peaks Lake (44°34', 88°02')--Little Tail Point (44°40', 87°59'). Before 1920, this area was one of the most heavily used spawning areas in Green Bay (Coberly and Horrall 1980b). Runs enter the Big Suamico River (44°38', 88°00'), Peaks Lake, and Duck Creek (44°34', 88°02') around the second week in April at water temperatures of about 46-57°F. Runs may begin before ice breakup. Spawning also occurs inside Long Tail (44°35', 87°59') and Little Tail points. This is a major nursery area; the highest densities of YOY are found inside Long Tail Point (Belonger 1979, pers. comm. 1979; Belonger et al. 1979; Kernen and Hawley 1978; Sager, pers. comm. 1979). It has been proposed that the area from Long Tail Point to the Fox River (44°32', 88°00') be designated as "reserve water" to enhance yellow perch reproduction (Daly 1977).

Fox River (44°32', 88°00'). Spawning runs enter the Fox River (Belonger, pers. comm. 1979). Pre-spawning concentrations of males are present in late March (Kernen and Hawley 1978). Spawning occurs from late April through the first 2 weeks of May at water temperatures of about 50-66°F (Kernen and Hawley 1978; Sager, pers. comm. 1979). At the Pulliam Power Plant (44°32, 88°00') on the lower river, yellow perch move inshore in April, spawn in April and May, and move offshore as the water warms. Larvae were collected in May and June, and young may spend their first and possibly second winter in the shallows near the plant. Many YOY have been impinged at the plant; impingement peaks in October (NALCO 1977, undated a).

Bay Beach Park (44°32', 87°59'). Spawning occurs east of the park (Sager, pers. comm. 1979).

Red River (44°40', 87°45'). In 1977, YOY were collected in this area (Kernen and Hawley 1978).

Little sturgeon Bay (44°50', 87°33'). Fishermen report this is a spawning area (Coberly and Horrall 1980b). In the late 1970s, YOY were collected here (Belonger et al. 1979; Kernen and Hawley 1978; Sager, pers. comm. 1980).

Larsens Reef (44°53', 87°29'). This is an historical spawning ground (Horrall, pers. comm. 1979).

Sturgeon Hay (44°53', 87°24'). Sawyer Harbor (44°53', 87°26') is a spawning area (Coberly and Horrall 1980b); spawning most likely occurs along the marshy shoreline (Kernen 1972). Spent females are present in the area as early as May 3 at water temperatures of about 52°F; cool temperatures may extend spawning into late May (Kernen and Hawley 1978).

Spawning also occurs along the east shore (44°54', 87°23') of Sturgeon Bay (Coberly and Horrall 1980b) and in the Ship Canal (44°48', 87°19') (FWS 1979d).

WM-2

Chambers Island (45°11', 87°21'). Larvae were collected along the south shore of the island from late April to early May (Frederick, pers. comm. 1979).

Washington Island (45°23', 86°54'). Commercial fishermen have identified West Harbor (45°22', 86°57'), Jackson Harbor (45°24', 86°51'), Detroit Harbor (45°21', 86°55'), and the east shore of the island as spawning areas (Coberly and Horrall 1980b).

Europe Bay (45°16', 86°59'). This is a spawning area (Coberly and Horrall 1980b).

WM-4

Algoma (44°37', 87°26'). Fishermen report that the harbor is a spawning area (Coberly and Horrall 1980b).

Kewaunee (44°27', 87°30'). Kewaunee Harbor is a spawning area (Coberly and Horrall 1980b).

Kewaunee Power Plant (44°21', 87°32'). A few ripe-running and spent adults were collected in the area at depths of 12-20 ft in May and June at temperatures of about 44-50°F. In the 1970s, a few. eggs and larvae were collected near the plant; no YOY were collected in the area (LaJeone, pers. comm. 1979; LaJeone 1976).

Point Beach Power Plant (44°17', 87°32'). Little successful spawning occurs in this area (Wis. Elec. Power 1975a; Wis. Elec. Power and Wis. Mich. Power 1970, undated a); however, adults migrated inshore here in large numbers in April and May and remained until September (Wis. Elec. Power and Wis.-Mich. Power, undated a).

Two Rivers (44°09', 87°34'). In 1979, a spawning run entered the west Twin River in the spring (Hanson, pers. comm. 1979). Two Rivers Harbor is also a spawning area (Coberly and Horrall 1980b).

WM-5

Pine Creek (43°59', 87°42')--Oak Creek Harbor (42°51', 87°50'). Yellow perch spawn here to depths of about 30 ft (Coberly and Horrall 1980b).

Haven (43°51', 87°44'). Ripe-running adults were collected in May and June throughout the area along the shoreline at the 20-30 ft contour. No eggs were collected, but larvae were taken in July, indicating that successful spawning may have occurred in June. Substrate in the area is generally small rocks, cobble, and boulders over a hard clay bottom (Ind. Rio-Test 1977; Wis. Elec. Power 1975c; Wis. Elec. Power et al. 1979a,b).

Milwaukee (43°02', 87°54'). Historically, yellow perch fry were preyed upon by lake trout near the piers at Milwaukee (Poff and Threinen 1964). Large numbers of yellow perch move into shallow water here in June (Shaefer 1975). Ripe adults were collected along shore and in water 30 ft deep from mid-June through the end of July (Binkowski, pers. comm. 1979; Norden, pers. comm. 1980; Shaefer 1975). Adults remained in water about 30 ft deep from June to September (Shaefer 1975).

WM-6

Racine Reef (42°44', 87°45') and Kenosha Harbor (42°35', 87°49'). A commercial fisherman reported that spawning occurs here (Coberly and Horrall 1980b).

Illinois

Reproduction and recruitment of yellow perch in Illinois waters of Lake Michigan has not been measured but is probably less than that occurring along the east and southeast shores of the lake (Muench 1979). Eggs, larvae, and YOY are found along the Illinois shoreline; however, during the 1970s, YOY were abundant only in 1979 (Muench, pers. comm. 1979). Spawning occurs in early June, probably in water shallower than 42 ft (Muench 1979). Limited substrate suitable for spawning is present in harbors and lagoons and on the shallow bedrock platform extending south from the Great Lakes Naval Training Center (42°18', 87°50') (Muench 1979, pers. comm. 1979; Norby and Collinson 1977).

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Limited spawning occurs in this area (Cochran, undated). Ripe-running males and females were found in June and July, and a few larvae and YOY were collected (Cima 1977; Cima et al. 1976; Cochran, undated; Cochran and Cima 1974; Commonw. Edison 1976; Ind. Bio-Test 1975; Muench 1979).

Evanston (42°03, 87°40'). In 1980, eggs were found off Evanston in early June, at depths of 20 and 27 f t on rocky substrate (Janssen, pers. comm. 1980).

Indiana

Yellow perch probably spawn along the entire Indiana shoreline during late May and early June, but areas of concentration exist (McComish, pers. comm. 1979). Ripe and spa*wning adults have been collected along the Indiana shoreline from late May through August; peak abundance occurs in May and June at depths of 60-70 ft (Koch, pers. comm. 1979; McComish, pers. comm. 1979: Westerman, pers. comm. 1979; Willis 1975).

Hammond (41°40′, 87°30′). Yellow perch spawned in Indiana Harbor (41°40', 87°25') in the area now being filled by the Inland Steel Company

(Palacios, pers. comm. 1979). Yellow perch are still believed to spawn successfully in the vicinity of the Stateline Generating Station (41°42', 87°31'); however, only a few eggs and larvae were collected (NALCO 1976c).

Bailly Generating Station (41°39′, 87°07′). Adults are present in May and June, and spawning appears to occur in this area in June or July. Larvae are entrained at the plant in June, and YOY are collected in beach seines in August (Tex. Instrum. 1975b, 1976a,c).

Michigan City (41°43′, 86°54′). The rough-bottomed area (41°42', 86°57') just west of Michigan City is an important spawning ground (McComish, pers. comm. 1979; Wells 1980). In 1966, ripe, partly spent, and spent adults were collected here in late May (GLFL, unpubl. data), and running-ripe males have recently been found over the clay mounds off Kintzele Ditch (41°43', 86°56') (Palacios, pers. comm. 1979). Spawning adults are present in the area into July (Willis 1975). Adults move offshore to deeper water by August (McComish, pers. comm. 1979; Willis 1975). Spawning is believed to occur over the crevice and drop-off areas where the substrate is hard-packed sand, clay, and shale (McComish, pers. comm. 1979). Eggs were found here on fishermen's nets (Palacios, pers. comm. 1979). The area west of Michigan City is also an important nursery area; YOY are collected inshore beginning in August and are more abundant here than east of Michigan City. Most YOY move to deeper water by October (Koch, pers. comm. 1979; McComish, pers. comm. 1979; Palacios, pers. comm. 1979; Willis 1975; Yager and McComish 1976).

Michigan

The shoreline from New Buffalo (41°48', 86°45') to Frankfort (44°38', 86°15'), in all areas shallower than 30 ft, is probably a nursery ground for yellow perch (Wells 1972, 1973).

MM-1

Arthur Bay (45°19', 87°26'). Since the 1950s, spawning has occurred in an area (45°17', 87°27'--45°20', 87°25') of sand and rock in about 30 ft of water (Organ et al. 1978).

Ford River (45°40′, 87°08')--Bark River (45°34', 87°14'). In 1978, larvae were collected along shore in May and June; they were most abundant (3,234 per 1,000 m^3) in early June near the mouth of the Bark River (wis. Elec. Power, unpubl. data).

Little Bay de Noc (45°45', 87°00') and Big Bay de Noc (45°45', 86°45'). Little Bay de Noc and Big Bay de Noc are major spawning areas (Copes and Leary, pers. comm. 1979). Yellow perch spawn successfully in many small, marshy tributaries along the west shore of Little Bay de Noc (FWS 1979d). Fry are first present in Little Bay de Noc in late April or early May (Peck 1974).

Portage Point (45°42', 87°04'). Yellow perch spawn in the large wetland here (FWS 1979d).

Whitefish River (45°55', 86°57'). Large numbers of yellow perch spawned in the lower river (Jenkins 1972; Wagner 1972). In 1965, spawning occurred just north of Nelson's Landing (45°54', 86°59') over sand, rock, and rubble (Wagner 1968).

Saunders Point (45°51', 87°00')--Stonington (45°45', 86°59'). Until 1940, yellow perch spawned along shore over shoal areas of sand and rock (Organ et al. 1978).

Ogontz Bay (45°50', 86°45*). Until the 1940s, spawning occurred in the bay over sand and rock at depths of 12-24 ft (Organ et al. 1978).

Valentine Point (45°51', 86°32')--Stony Point (45°50', 86°39'). Until the 1940s, yellow perch spawned in this area at depths of 6-12 ft over sand and gravel (Organ et al. 1978).

MM-3

Beaver Island (45°40', 85°33'). Since the 1920s, yellow perch have spawned over rock and gravel in Beaver Harbor (45°44', 85°30') and over rock just outside the harbor (Organ et al. 1978).

Hog Island (45°47', 85°22')--Grays Reef Passage (45°47', 85°09'). Spawning occurred here on rock and gravel shoals (Organ et al. 1978).

Point Epoufette (46°03, 85°12'). Spawning occurs nearshore over mud and vegetation in areas immediately east (46°04', 85°11') and west (46°03, 85°12') of Point Epoufette (Organ et al. 1978).

Waugoshance Point (45°45', 85°01 ')--Good Hart (45°34', 85°07'). From the 1930s to 1972, spawning occurred along the shoreline north of Cross village (45°39', 85°02') to a depth of about 30 ft, over sand and gravel; spawning also occurred south of Cross Village over an unknown substrate (Organ et al. 1978).

MM-4

Grand Traverse Bay (45°05', 85°30'). The wetlands in the bay are extremely important spawning grounds (FWS 1979d).

Bowers Harbor (44°53', 85°33'). From 1935-40, yellow perch spawned over rock and gravel in the outer part of the harbor, along the west side of Marion Island (44°52', 85°35'), and in an area (44°55', 83°33') extending about 2 mi along the north side of Tucker Point (44°54', 85°34') (Organ et al. 1978).

New Mission Point (45°03, 85°34'). From 1935-40, spawning occurred in an area (45°04', 85°34'--45°00', 85°38') to a depth of about 30 ft over rock, gravel, and moss (Organ et al. 1978).

Northport Point (45°08', 85°33'). From 1935-40, spawning occurred along the east side of the point to depths of about 40 ft, over rock and gravel (Organ et al. 1978).

MM-5

Leland (45°01, 85°46'). From the 1900s to 1968, spawning occurred along the shoreline extending about 3 mi N from Leland, at depths of about 18-20 ft over rock (Organ et al. 1978).

Pyramid Point Shoal (44°59', 85°55'). Spawning occurs on the shoal over sand and rock (Organ et al. 1978).

Empire (44°49', 86°04')--Sleeping Bear Point (44°55', 86°03). Spawning occurs along this shoreline over rock and gravel (Organ et al. 1978).

Platte River (44°44', 86°09'). Spawning occurs over the rocky reef at the mouth of the Platte River (Organ et al. 1978).

Frankfort (44°38', 86°14'). Yellow perch spawn along the shore, from Frankfort south to the Arcadia area (44°30', 86°14') (Hile, pers. comm. 1979). Spawning occurs directly off Frankfort to a depth of about 30 ft (Organ et al. 1978). In 1972, yellow perch fry were collected off Frankfort in late July from the surface to about the 12 ft depth stratum above the 18 and 30 ft depth contour (Wells 1973).

MM-6

Big Sable Point (44°03, 86°31')--Manistee (44°15', 86°20'). From the 1930s to 1965, spawning occurred along this shoreline over gravel (Organ et al. 1978).

Ludington (43°57', 86°28')--Little Sable Point (43°39', 86°33'). From the 1930s to 1965, yellow perch spawned all along the shoreline from about 5 mi N (44°01', 86°30') of Ludington, to Little Sable Point, to a depth of 36 ft, over rock and gravel (Organ et al. 1978). In the vicinity of the Ludington Pumped Storage Plant (43°54', 86°27') spawning takes place from mid-May through June; peak spawning occurs in the third week of June at water temperatures of about 50°F. Large numbers of yellow perch move into the area usually during late April to late May at water temperatures of about 36-39°F. Ripe males appear at depths of approximately 18-36 ft, when the water temperature reaches about 43-45°F (Brazo et al. 1977; Liston and Tack 1972). Ripe males have appeared as early as April in some years, and some are still ripe in late July; all females are usually spent by July (Brazo 1973, pers. comm. 1979; Liston and Tack 1973). Most eggs have hatched by the end of July (Liston and Tack 1973). Yellow perch may spawn here at depths of less than 40 ft (Liston and Tack 1973); adults are collected here in water as shallow as 5-10 ft (Brazo, pers. comm. 1979). Egg masses were collected here with trawls (Liston and Tack 1972). Spawning concentrations were observed a few miles south of the plant (Liston and Tack 1972); these fish may spawn over rock piles near the breakwater jetties of the plant (Brazo, pers.

comm. 1979). Spawning occurs just south of the plant's south breakwater (FWS 1979d). Larvae were collected in shallow water near the plant and south of the plant from mid- to late May (Brazo, pers. comm. 1979; Liston et al. 1978).

MM-7

stony Lake (43°34', 86°30')--Little Point Sable (43°39', 86°33'). In 1944-55, spawners were caught in an area from 3 mi S of Stony Lake to Little Point Sable, over sand to a depth of about 40 ft (Organ et al. 1978).

White Lake (43°23', 86°26')--Grand Haven (43°04', 86°13'). From the 1930s to the 1970s, spawning occurred along the shoreline, from just north of White Lake, to Grand Haven, to a depth of about 70 ft over a sand bottom (Organ et al. 1978).

Grand Haven (43°04', 86°13')--Holland (42°47', 86°07'). From the 1930s to 1975, spawning occurred along this entire shoreline to depths of about 70 ft over sand (Organ et al. 1978). Ripe-running adults move inshore at Port Sheldon (42°54', 86°13') in June when water temperatures are about 45-53°F (Heufelder, pers. comm. 1979; Jude et al. 1978); ripe-running adults were also impinged at the Campbell Power Plant (42°55', 86°12') in May (Jude 1978). Eggs were collected in Pigeon Lake (42°54', 86°12') and larvae were entrained at the plant and collected in the area in April; this indicates that spawning occurred in Pigeon Lake in April (Jude 1978). One group of yellow perch from Lake Michigan probably spawns in Pigeon Lake in late April to early May; a second group probably spawns in Lake Michigan in the vicinity of the plant in late May to early June (Jude et al. 1979a). Larvae were entrained at the plant and collected in the lake in the vicinity of the plant in May and June. By early or late June, yellow perch larvae are very abundant in Lake Michigan at depths of about 20-40 ft (Consumers Power 1977; Jude et al. 1978, 1979a; Wapora 1979a). Young-of-the-year were collected in beach seines in June to August (Heufelder, pers. comm. 1979; Jude et al. 1978, 1979a).

MM-8

Holland (42°47', 86°07')--Saugatuck (42°40', 86°12'). Since 1930, spawning has occurred along this entire shoreline over sand, rock, and gravel (Organ et al. 1978).

Saugatuck (42°40', 86°12')--South Haven (42°24', 86°17'). Since the 1940s, spawning has occurred along this shoreline to depths of 50-60 ft over clay, sand, and rock (Organ et al. 1978). In the Saugatuck area, yellow perch appear to favor rocky areas for spawning. During the spawning season, catches of adults in this area on sandy bottom are only about one fifth as large as catches over rocky bottom (Harris and Eschmeyer 1975), In 1971, large numbers of males in spawning condition were present on the reef (42°38', 86°17') off Saugatuck in late May. Females in spawning condition were present in fair numbers in mid-June (Tait 1973). This reef, known as "Honey Comb Reef" before the turn of the century, is made up of boulders and extends from shore to depths of about

72 ft (Wells 1972); this reef is now probably a major spawning area (Dorr, pers. comm. 1979; Wells 1972). Commercial fishermen report that spawning occurred here from 1934-77 (Organ et al. 1978). In 1973, fry were found off Saugatuck in May, but it is believed that these originated from spawning that occurred in tributaries (Harris and Eschmeyer 1975). In 1974, trawl catches of YOY were moderate in the Saugatuck area (Brown and Wells 1975).

south Haven (42°24', 86°17')--Benton Harbor (42°06', 86°27'). Since the 1930s and 1940s, spawning has occurred over sand and rock along most of this shoreline (Organ et al. 1978). Yellow perch is one of the principal species that spawns nearshore in the vicinity of the Palisades Power Plant (42°19', 86°19′) (Consumers Power l972b, 1975). Yellow perch generally move into the shallows in mid-May and June to spawn, as evidenced by increased catches and impingement of ripe adults at that time (Consumers Power 1972b, 1975; Patriarche 1969, 1971a, 1975; Wapora 1979c,d). In 1973, many yellow perch that had already spawned were captured in early May suggesting that spawning had occurred 3-4 weeks earlier than normal; this early spawning was attributed to early warming of the water by the power plant discharge (Consumers Power 1973b, 1975; Patriarche 1973b, 1974, 1975). In 1972 and 1974, eggs thought to be yellow perch were found at the intake during June (Consumers Power 1972b, 1976g; Patriarche 1972). In 1978, yellow perch larvae less than 0.5 in. long were collected in the area; the abundance of larvae peaked in late June (Wapora 1979C). Yellow perch fry were collected near the plant at depths to 30 ft (Consumers Power 1975; wells 1974). Young-of-the-year yellow perch were collected in seines in August and September (Consumers Power 1975; Patriarche 1974, 1975; Wapora 1979d).

Benton Harbor (42°06', 86°27')--St. Joseph (42°06', 86°29'). In the past, yellow perch spa-wning runs entered the shallow waters near Benton Harbor and St. Joseph (Brazo et al. 1977). In 1969, several hundred YOY were collected off Benton Harbor; however, only a few were collected in similar sampling in other years during the period 1967-75 (Wells 1977a). A small area called Rocky Gap (42°08', 86°28'), north of Benton Harbor, is a potential spawning area for yellow perch (Dorr, pers. comm. 1979).

Stevensville (42°01', 86°33'). Viable eggs were observed on clay rubble here (Dorr, pers. comm. 1979).

Bridgman (41°56′, 86°35′). Limited spawning occurs in the area from the Cook Power Plant (41°59', 86°34') to Warren Dunes (41°54', 86°37') during late May and June at water temperatures of 45-59°F. A few gravid adults were collected, and a few eggs were collected in nets and observed on the riprap of the intake structure of the power plant, In 1973-74, almost 90% of the adults collected in June were spent; most spawning was believed to occur outside the immediate area (Dorr, pers. comm. 1979; Indiana and Mich. Power 1975; Jude 1976a; Jude et al. 7973, 1975, 1979b). From 1959-69, yellow perch spawned in an area (41°57', 86°36') off Bridgman, over sand and clay at depths of 25-50 ft (Organ et al. 1978). The shoreline from the power plant to Warren Dunes is a nursery area (Jude and Tesar, pers. comm. 1979). Larvae less than 0.5 in. long first appear

in the nearshore waters in June, and many YOY are collected from July through October (Indiana and Mich. Power Co. 1975; Jude, pers. comm. 1979; Jude et al. 1973, 1975, 1979b).

New Buffalo (41°48', 86°45'). In 1945-68 spawning occurred along the sand-bottomed shoreline from Warren Dunes (41°54', 86°37') to the Indiana state line (41°46', 86°49') at depths to 50-60 ft. Since 1916, spawning has occurred to depths of about 12 ft on a rocky area between Union Pier (41°50', 86°42') and Lakeside (41°51', 86°40'). Spawning also occurs on Bridgman Reef (41°52', 86°42') over clay (Organ et al. 1978).

SAUGER

In Lake Michigan, saugers may reproduce only in Green Bay (Wells, pers. comm. 1980); the population is beginning to increase in the extreme southern part of Green Bay and in the Fox River (Kernen, pers. comm. 1979).

Wisconsin

WM-1

Little Tail Point (44°40', 87°59')--Little Sturgeon Hay (44°50', 87°33'). Saugers and walleyes were present together in this area during the spawning season. Refore 1920, Peaks Lake and the area north to Little Tail Point was one of the most heavily used spawning areas in Green Bay (Coberly and Horrall 1980b).

Fox River (44°32', 88°00'). In 1975, a few eggs tentatively identified as those of sauger were entrained in April at the Pulliam Power Plant (44°32', 88°00') (NALCO, undated a).

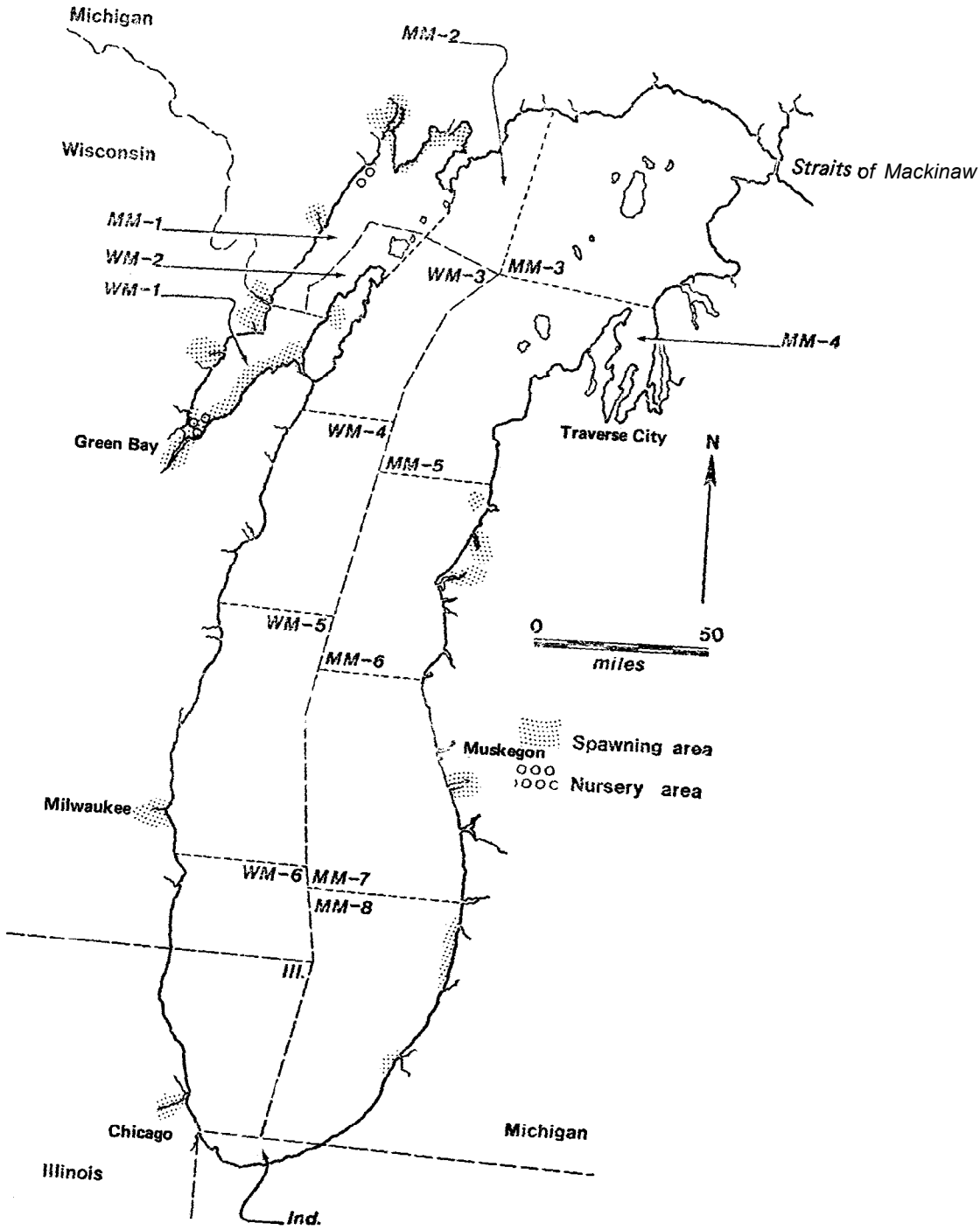
Larsens Reef (44°53', 87°29'). This was considered a spawning area by commercial fishermen (Coberly and Horrall 1980b).

Michigan

MM-1

Little Bay de Noc (45°45' , 87°00'). Until 1940, saugers spawned along shore between Gladstone (45°51', 87°00') and Stonington (45°46', 86°59') over sand and rock at depths of 6-18 ft (Organ et al. 1978).

Big Ray de Noc (45°45', 86°45'). Until the 1940s, saugers spawned in Ogontz Bay (45°50', 86°45') at depths of 12-24 ft over sand and rock and in an area between Stony Point (45°50', 86°39') and Valentine Point (45°51', 86°32') at depths of 6-12 ft over sand and gravel (Organ et al. 1978).


Michigan
MM-2
Wisconsin
Straits of Mackinaw
MM-1
WM-2
WM-1
WM-3
MM-3
MM-4
Green Bay
WM-4
Traverse City
N
MM-5
WM-5
0
50
miles
MM-6
Muskegon
Spawning area
Nursery area
Milwaukee
WM-6
MM-7
MM-8
Ill.
Chicago
Michigan
Illinois
Ind.

Historically walleyes were abundant only in Green Bay and in the southeastern portion of the lake (Schneider and Leach 1977; USDI 1966); only a few walleyes existed elsewhere in the lake. Stocks were greatly reduced by the late 1800s due to destruction of spawning habitat and overfishing (Schneider and Leach 1977). In Green Bay, spawning in most tributaries has declined because of siltation, damming, industrial pollution, and eutrophication (Leach 1977; Schneider and Leach 1979). A major decline of the population in southern Green Bay began during the 1920s (Schneider and Leach 1979). Walleye fry are being planted in an attempt to replenish this population (WDNR 1977, 1979a). Tagging studies have shown that the walleye population in Green Bay is composed of a number of discrete spawning stocks; individuals in each of these stocks return to the same spawning site annually (Crowe 1962, 1964; Crowe et al. 1963; USBCF 1965; USDI 1966). Spawning occurs in tributaries and also on shoals in the bay (USBFC 1965; USDI 1966).

Wisconsin

WM-1

Menominee River (45°06', 87°35'). During the 1800s, a spawning run entered the river (Goode 1884). The river, which serves as the boundary between Wisconsin and Michigan, presently supports a small, self-sustaining spawning run (Copes and Ebener, pers. comm. 1979; Kernen and Belonger, pers. comm. 1979; Schneider and Leach 1977, 1979).

Peshtigo River (44°58', 87°39'). Historically, a major fishery was associated with the spawning run here (Schneider and Leach 1979). The river has been stocked and supports a small run (Kernen and Belonger, pers. comm. 1979; WDNR 1979a). The removal of dams on the river would increase access to prime spawning grounds (GLFC 1979b).

Oconto River (44°54′, 87°50′). Historically, a major fishery was associated with the spawning run here (Schneider and Leach 1979). The river presently supports a small run (Kernen and Belonger, pers. comm. 1979). The removal of dams on the river would increase access to prime spawning grounds (GLFC 1979b).

Little Tail Point (44°40', 87°59')--Little Sturgeon Bay (44°50', 87°33′). This shoreline was considered by several commercial fishermen to be the best walleye spawning ground in the area; spawning occurred in water as shallow as 5-6 ft. Before 1920, the area from Little Tail Point to Peaks Lake (44°34', 88°02') was one of the most heavily used spawning areas in Green Bay (Coberly and Horrall 1980b). Historically, a spawning run occurred in the Fox River (44°32', 88°00'); a major fishery was associated with this run (Schneider and Leach 1979). A spawning run presently enters the river in May (Copes and Ebener, pers. comm. 1979; FWS 1979d; Kernen and Belonger, pers. comm. 1979). In 1975, a few eggs entrained at the Pulliam Power Plant (44°32', 88°00') on the lower river in April were tentatively identified as walleye eggs (NALCO, undated a). The area from the Fox River to Sable Point (44°35', 87°55') is a nursery

ground; young-of-the-year were collected here but it is not known if these were naturally produced or stocked (Kernen, pers. comm. 1979). Young-of-the-year about 1.5-2.6 in. long were also collected in seines at Red River (44°40', 87°45') and Peaks Lake (Kernen 1979).

Larsens Reef (44°53', 87°29'). Walleyes spawn here (Coberly and Horrall 1980b; Copes and Ebener, pers. comm. 1979).

Sturgeon Bay (44°53', 87°24'). The shoals of Sturgeon Bay are spawning grounds (Kernen, pers. comm. 1979); peak spawning usually occurs here in late April (WDNR 1977).

WM-2

Fish Creek (45°08', 87°15'). Walleyes were stocked here, and spawning runs were documented in 1979 (Kernen, pers. comm. 1980).

WM-4

West Twin River (44°09', 87°34'). A few ripe fish were collected in the river, but spawning is not documented (Hanson, pers. comm. 1979).

WM-5

Milwaukee River (43°02', 87°54'). Historically, spawning runs entered the river in the spring (Gregory 1931, as cited in Poff and Threinen 1964).

Illinois

Calumet River (41°44', 87°32'). In 1875, a large run entered the river in the spring; but only an occasional walleye was found prior to or just after 1875 (Nelson 1878).

Michigan

MM-1

Cedar River (45°24', 87°21'). Walleyes spawned in the river over a gravel substrate during May and June (Organ et al. 1978).

Bark River (45°34', 87°14'). In 1978, walleye larvae were found at the 10 ft depth contour near the river mouth in late May (Wis. Elec. Power, unpubl. data).

Little Bay de Noc (45°45', 87°00') and Big Bay de Noc (45°45', 86°45'). Both bays are major spawning areas (Copes and Ebener, pers. comm. 1979). Historically, large numbers of walleyes spawned here in the spring (Goode 18841. Spawning runs occurred later here than in areas such

as Saginaw Bay (44°00', 83°30') in Lake Huron, where the water warms earlier in the spring (Van Oosten 1938b). Tagging studies have shown that discrete populations of walleyes return each year to specific sites in the bays to spawn (Cook 1961; Crowe 1962, 1964; Crowe et al. 1963). Eggs were collected from ripe fish in Little Bay de Noc in 1931 and 1932 (Westerman 1933) and in 1961 and 1962 (Cook 1962; Schneider and Crowe 1977). Reefs in the Bay de Noc area (locations not identified) where fry have been stocked are also spawning sites; eggs have been collected at these sites (North Woods Call 1979f).

Gladstone (45°51', 87°00')--Stonington (45°45', 86°59'). Until 1940, walleyes spawned in this area over rock and sand in 6-18 ft of water (Organ et al. 1978). The Whitefish River (45°55', 86°57') supports a major spawning run (Crowe 1962; Norden, pers. comm. 1979; Schneider and Leach 1979; USDI 1966). In 1960-68, ripe adults were collected from the river in early May (Norden, pers. comm. 1979). In 1977, a good run of adults entered the river; it is not known if spawning was successful (FWS 1979d). Spawning may occur in the river about 4 mi above the river mouth and also in the bay near the river mouth (Crowe 1962; Schneider and Leach 1979). In 1930, eggs were collected from ripe fish at the mouth of the Days River (45°54', 86°59') in April and May (Westerman 1930, 1933).

Peninsula Point (45°40', 86°58')--Chippewa Point (45°43', 86°50'). From 1950-55, walleyes spawned along shore in April from just north of Peninsula Point to Chippewa Point, over rock in about 6 ft of water (Organ et al. 1978).

Ogontz Bay (45°50', 86°45'). Until the 1940s, spawning occurred in the bay over sand and rock at depths of 12-24 ft. Walleyes also spawned over rock at the mouth of the Ogontz River (45°52', 86°46') (Organ et al. 1978).

Nahma (45°50', 86°40'). Since the 1920s, walleyes have spawned in a sand area (45°49', 86°40') about 2 mi S of Nahma at a depth of about 12 ft (Organ et al. 1978). A spawning site is located at Nahma (Crowe 1962).

Stony Point (45°50', 86°39')--Valentine Point (45°51', 86°32'). Until the 1940s, walleyes spawned in this area over sand and gravel at depths of 6-12 ft. In 1950-55, spawning occurred over rock at the mouth of the Fishdam River (45°54', 86°35') (Organ et al. 1978).

Valentine Point (45°51', 86°32')--Kates Bay (45°49', 86°34'). Walleyes spawned here over rock at depths of 3-4 ft (Organ et al. 1978).

MM-6

Portage Lake (44°22', 86°14'). During the 1930s, walleyes spawned in a rock area (44°21', 86°18') about 1 mi off Portage Lake Channel at depths of about 3 ft (Organ et al. 1978).

Big Manistee River (44°15', 86°18'). In 1933, a spawning run entered the river in the spring (Mich. Conserv. 1933).

Big Sable River (44°02', 86°30'). From 1929-55, moderate numbers of walleyes congregated below the dam on the river; when netted and released, they continued upstream (Schneider and Leach 1979).

MM-7

Muskegon River (43°15', 86°15'). Records indicate that a majority of the population in southeastern Lake Michigan enters the Muskegon River to spawn (Consumers Power 1976f; Cook 1961, 1962; Crowe 1955, 1962; Eschmeyer 1949, 1950; Eschmeyer and Crowe 1955; Hazzard 1951; Mich. Conserv. 1933, 1935b; Tanner 1964; USDI 1966; Westerman 1952b, 1954, 1957a, 1959). Since 1923, this run has begun in late March or early April (Crowe 1955). No other stream on the eastern shore has had significant runs for at least several decades (Wells and McLain 1973; USDI 1966). The largest run in the Muskegon River probably occurred in 1933 (Schneider and Leach 1979). In 1944, 1947, and 1948, the maximum abundance of adults in the river occurred at water temperatures of 38°, 40°, and 44°F respectively (Eschmeyer 1949). In 1953 and 1954, which were typical years, more than 100,000 fish entered the river (GLFC 1957; Westerman 1954). The last major run probably occurred in 1960. Prior to 1969, spawning occurred just below the Newaygo Dam, approximately 40 mi upstream from Lake Michigan; spawning below the dam occurred in April, in 5-8 ft of water with a moderately fast current and a bottom of boulders, rubble, and gravel (Crowe 1955; Eschmeyer 1949, 1950; Eschmeyer and Crowe 1955; USDI 1966). Eggs were collected as far as 16 mi below the dam but were concentrated within the first 5 mi (Eschmeyer 1949). The Newago Dam was removed in 1969, providing about 12 mi of additional spawning habitat, but recruitment did not improve (Schneider and Leach 1979). Walleyes that spawn in this river exhibit a strong homing behavior; fish tagged in the river are caught nowhere else during subsequent spawning seasons (Crowe 1962; Schneider and Leach 1977, 1979; USBCF 1965; USDI 1966). By July, adult walleyes return to Lake Michigan and disperse widely along the eastern shore, moving as far south as Gary, Indiana (41°37', 87°20'), and as far north as Good Harbor Bay (44°58', 85°50') (Crowe 1962; GLFC 1957; Schneider and Crowe 1977; USBFC 1965; USDI 1966). It is assumed that fry drift down to Muskegon Lake (43°14', 86°18') after hatching in May and that the lake is an important nursery area (Schneider and Leach 1979).

MM-8

Saugatuck (42°40', 86°12'). Spawning occurred from the mouth of the Kalamazoo River south for 3 mi, to a depth of about 30 ft over rock and gravel (Organ et al. 1978).

Ganges (42°35', 86°13'). Spawning occurred in an area (42°34', 86°14'--42°36', 86°14') over gravel (Organ et al. 1978).

South Haven (42°24', 86°17'). Spawning occurred along shore in an area (42°25', 86°17'--48°28', 86°15') north of South Haven over sand, gravel, and rock (Organ et al. 1978).

St. Joseph (42°06', 86°29'). From the 1940s to 1959, spawning occurred immediately off St. Joseph over gravel in 7-20 ft of water, during late April to early June (Organ et al. 1978).

PERCID spp.

Indiana

Bailly Generating Station (41°39', 87°07'). In 1976 and 1978, a small number of percid larvae were collected near the plant at the 30 ft depth contour in June (Tex. Instrum. 1979a).

FRESHWATER DRUM

The freshwater drum is not common in Lake Michigan proper; the species is probably more abundant in Green Bay than elsewhere in the lake (Wells, pers. comm. 1979).

Wisconsin

WM-1

Little Tail Point (44°40', 87°59')--Peaks Lake (44°34', 88°02'). According to commercial fishermen, this area was one of the most heavily used spawning areas in Green Bay until about 1920 (Coberly and Horrall 1980b).

Fox River (44°32', 88°00'). In 1975, spawning occurred near the Pulliam Power Plant (44°32', 88°00') on the lower Fox River. Freshwater drum were 14% of the total larvae entrained at the plant. Most of the freshwater drum larvae entrained were prolarvae, about 0.2 in. long. Freshwater drum larvae were entrained from early June through mid-July; peak entrainment occurred in the first half of June (NALCO, undated a).

Indiana

Whiting (41°41', 87°30'). Historically, runs of freshwater drum began in early June at "South Chicago" (approximately at the present location of Whiting); in 1873, a large run occurred in July (Nelson 1878). This coincides with the known spawning period of freshwater drum.

MOTTLED SCULPIN

Illinois

Evanston (42°03, 87°40'). Young-of-the-year mottled sculpins were collected off Evanston in rock and rubble areas 20-50 ft deep from July to mid-September (Janssen, pers. comm. 1979). In 1980, gravid females were collected at 25-28 ft depths in mid-May; spawning had not yet taken place (Janssen, pers. comm. 1980).

Indiana

Bailly Generating Station (41°39', 87°07'). In 1976, larvae were entrained at the plant from the second week of June to mid-July (Tex. Instrum. 1976c, 1977b).

SLIMY SCULPIN

Slimy sculpins spawn at intermediate depths, in water shallower than that used by the deepwater sculpin (Brown, pers. comm. 1979; Wells, pers. comm. 1979). Spawning probably occurs in May in southeast Lake Michigan; slimy sculpin eggs have been found in yellow perch stomachs at this time (Wells 1980).

Wisconsin

WM-4

Kewaunee Power Plant (44°21', 87°32'). The collection of larvae less than 0.5 in. long in late May and many young-of-the-year (YOY) in July indicates that spawning occurs in the vicinity of the plant in May (LaJeone 1976, pers. comm. 1979).

Point Beach Power Plant (44°17', 87°32'). In 1972-77, spawning probably occurred in the vicinity of the plant (Wis. Elec. Power and Wis. Mich. Power, undated c). In 1976, ripe males and females were

impinged at the plant in mid- to late February and from late April to mid-May (Wis. Elec. Power 1976c). Slimy sculpin larvae and YOY are collected in this area from late March to September (Wis. Elec. Power and Wis. Mich. Power, undated c).

WM-5

Haven (43°51', 87°44'). In 1974, larvae were collected here (Wis. Elec. Power et al. 1979b). Fry and YOY were collected in inshore areas over a hard clay and cobble bottom in July. Spawning probably occurs in May (LaJeone, pers. comm. 1979).

Sheboygan (43°45', 87°42'). In 1975-76, slimy sculpin eggs and larvae were entrained at the Edgewater Power Plant (43°43', 87°42') in May and from late June to August respectively. Nearly ripe and ripe adults were impinged in April and May, and spawning is believed to occur in the area prior to June (CDM/Limnetics 1977; Swanson Environ. 1976).

Port Washington (43°23', 87°52'). In 1975-76, eggs, which were probably slimy sculpin eggs, and larvae were entrained at the Port Washington Power Plant (43°23', 87°52') (CDM/Limnetics 1977; Wis. Elec. Power 1976e). A few ripe adults were impinged at the plant during mid-March to late July; peak impingement occurred from late April to early May (Wis. Elec. Power 1976e).

Milwaukee (43°02', 87°54'). In 1975, eggs and YOY, believed to be slimy sculpins, were collected off Whitefish Bay at 43°08', 87°47' in about 165 ft of water; the eggs were collected from a log on a rocky substrate in May, and the YOY were collected among rocks in August (Janssen, pers. comm. 1979). Ripe adults and eggs were collected from the bottom in 50 ft of water off Milwaukee in May and June (Binkowski, pers. comm. 1979; Norden, pers. comm. 1979).

Oak Creek Harbor (42°51', 87°50'). In 1975, a few ripe adults were collected near the Oak Creek Power Plant (42°51', 87°50') from late April to mid-May (Wis. Elec. Power 1976d). Eggs, which were probably slimy sculpin eggs, were entrained at the plant in April and May (CDM/Limnetics 1977) l

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). Spawning occurs in this area (Commonw. Edison 1976; Ind. Rio-Test 1975; Muench, pers. comm. 1979). Ripe adults were collected in May; all fish collected in June were spent. Although adults migrated inshore to the 20-30 ft depth contours in April and May, the absence of eggs and larvae at these depths suggests that these adults may have returned to deeper water to spawn (Cochran, undated). The Zion-Waukegan area is a nursery ground; larvae and YOY are present from June to October at the 40-60 ft depth contours (Cima 1977; Cima and Cochran, undated; Cima et al. 1976; Cochran and Cima 1974; Ind. Rio-Test 197533).

Indiana

Hammond (41°40', 87°30'). Slimy sculpins are believed to spawn successfully in the vicinity of the Stateline Generating Station (41°42', 87°31'); a few larvae were collected here in 1975-76 (NALCO 1976c).

Gary (41°37', 87°20'). A few slimy sculpin eggs and larvae were collected at the Mitchell Power Station (41°37', 87°22') in July (CDM/Limnetics 1977; Krueger 1976).

Bailly Generating Station (41°39', 87°07'). In 1976, eggs were entrained at the station during the second through the fourth weeks of May; larvae were entrained in the second and third weeks of June and the first week of July (Tex. Instrum. 1976c, 1977b).

Michigan

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). Larvae and YOY were collected on rocky areas of the jetties at the plant; this area is a spawning and nursery ground (Brazo, pers. comm. 1979).

MM-7

Port Sheldon (42°54', 86°13'). In 1964, ripe females were collected in an area between Port Sheldon and Saugatuck (42°40', 86°12') at about the 102-270 ft depth contours over substrate ranging from fine sand to mud. Peak abundance occurred at a depth of 102 ft early in the spring and at a depth of 150 ft later in the spring. Most fish were collected on the bottom at water temperatures lower than about 43°F. Spawning probably began sometime before May 5 (Rottiers 1965). Gonads of fish collected near Port Sheldon in 1978 indicated that spawning occurred in the vicinity in late May (Jude et al. 1979a). In 1977, a few slimy sculpin larvae were collected south of the Campbell Power Plant discharge (42°55', 86°12') on July 7 (Jude et al. 1978).

MM-8

Saugatuck (42°40', 86°12'). Adults move shoreward to depths as shallow as 42 ft in mid-April; this movement may be related to spawning. Larvae are found in the area in midwater, mainly in the hypolimnion (Wells 1968).

Palisades Power Plant (42°19', 86°19'). Most slimy sculpins were impinged at the plant in the spring during the spawning period, and it appears that spawning is occurring at relatively shallow depths (Consumers Power 1975). In 1972, over 7,000 adult slimy sculpins were impinged from mid-May through June; about 350 of these were ripe (Consumers Power 1972b). In 1974-75, 5,000 fertile eggs and a few yolk-sac larvae were collected from intake water at the plant (Consumers Power 1976g).

Bridgman (41°56', 86°35'). Ripe-running adults are collected in this area in April and May (Jude, pers. comm. 1979; Jude et al. 1975). Spawning occurs on the intake and discharge structures of the Cook Power Plant (41°59', 86°34'); in 1974, divers observed clumps of eggs on the riprap of the structures on May 21-22 at a water temperature of 52°F (Indiana and Mich. Power 1975; Jude et al. 1975). Larvae are found in late June; YOY appear in trawl catches in July (Jude, pers. comm. 1979;. Jude et al. 1975, 1979b).

FOURHORN SCULPIN

In Lake Michigan, fourhorn sculpins probably spawn in the winter in water deeper than 240 ft (Wells, pers. comm. 1979, 1980; Wells and McLain 1973). From the late 1960s to the mid-1970s, stomachs of fourhorn sculpins collected in November contained many of their own eggs (Wells 1980). Fourhorn sculpin larvae are usually found in the hypolimnion in deeper areas of the lake (Wells 1968; Wells, pers. comm. 1979); some larvae are also present in shallower nearshore areas, when low water temperatures prevail in those areas (Wells, pers. comm. 1979). In the southern portion of the lake, fourhorn sculpins spawn at depths greater than 240-270 ft, and the young are also found in deep water (Brown, pers. comm. 1979) .

Wisconsin

WM-5

Haven (43°51', 87°44'). In 1977-79, larvae were collected here at the 30 and 40 ft depth contours in April (Wis. Elec. Power, unpubl. data; Wis. Elec. Power et al. 1979).

Port Washington (43°23', 87°52'). Larvae were collected off the Port Washington Power Plant (43°23', 87°52') from April to mid-May; peak abundance occurred in late April at the 40 ft depth contour. Larvae were entrained at the plant (CDM/Limnetics 1977; Wis. Elec. Power, unpubl. data).

Illinois

Zion (42°27', 87°48')--Waukegan (42°22', 87°50'). In 1975, a few larvae were collected from the lake in this area in April (Cima et al. 1976) . In 1977, larvae were collected in March, April, May, and August (Cima 1977). Spring upwellings and alongshore currents may have moved the larvae into these areas from the deeper offshore waters (LaJeone, pers. comm. 1979).

Indiana

Bailly Generating Station (41°39', 87°07'). Spawning may occur in this area; however in 1975 only one larva was collected in 50 ft of water near the plant in June (Tex. Instrum. 1976a).

Michigan

MM-6

Ludington Pumped Storage Plant (43°54', 86°27'). In 1978, larvae were collected near the plant (Liston et al. 1978). Larvae are found in the area from mid-April to mid-May, mainly in offshore waters (Brazo, pers. comm. 1979).

MM-7

Port Sheldon (42°54', 86°13'). Larvae were found occasionally in this vicinity in April and May at depths greater than about 20 ft (Jude 1978). The first appearance of larvae in early February suggests that spawning occurs in December (Jude et al. 1979a). Larvae were entrained at the Campbell Power Plant (42°55', 86°12') from February to May; highest densities occurred in mid-April (Jude 1978; Jude et al. 1979a). The offshore areas are believed to be nursery grounds; no larvae are collected in the nearshore waters after May (Heufelder, pers. comm. 19'79; Jude et al. 1979a). In 1977, two larvae were collected in August in deep water south of the plant discharge (Jude et al. 1978).

MM-8

Bridgman (41°56', 86°35'). Larvae were collected in water abut 70 ft deep in April and May; this is probably a nursery area. Spawning usually takes place offshore in the winter (Jude, pers. comm. 1979).

SCULPIR spp.

Wisconsin

WM-3

Rowley Hay (45°13', 87°01'), North Bay (45°09', 87°04'), Moonlight Bay (45°05', 87°05'), and Baileys Harbor (45°03', 87°07'). Ripe sculpins were collected in gill nets set near these bays (Frederick, pers. comm. 1979).

WM-4

Point Beach Power Plant (44°17', 87°32'). Sculpin eggs and larvae were more abundant than those of most other species found in this area. Young-of-the-year (YOY) were also collected in shore seines (Wis. Elec. Power, undated a).

Manitowoc (44°05', 87°39'). In 1975, four sculpin eggs were collected at the Manitowoc Generating Plant (44°05', 87°39') on May 22-23, and small numbers of larvae were collected at the surface from early July to mid-August (CDM/Limnetics 1976a).

WM-5

Haven (43°51', 87°44'). Sculpin larvae were collected here in June to September; peak abundance occurred in July at the 30 and 40 ft depth contours (Wis. Elec. Power, unpubl. data).

Sheboygan (43°45', 87°42'). Sculpins are believed to spawn successfully in the vicinity of the Edgewater Generating Station (43°43', 87°42'); divers observed many YOY, and a few postlarvae were entrained in late February and late March (Swanson Environ. 1979).

Port Washington (43°23', 87°52'). A few eggs and larvae were entrained at the Port Washington Power Plant (43°23', 87°52') from April through August. A few eggs and larvae were also collected in the lake in the vicinity of the plant from July to September; peak abundance occurred in July (Wis. Elec. Power, unpubl. data, 1976e).

Oak Creek Harbor (42°51', 87°50'). In 1972-73, fry less than 0.5 in. long were collected at the Oak Creek Power Plant (42°51', 87°50') in March and April (Limnetics 1974; Wis. Elec. Power 1975b, 1976d).

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15. Supplementary Notes

This document is one of a set of fourteen volumes.

16. Abstract (Limit: 200 words)

This atlas is a compilation of current spawning and nursery information concerning the fishes of the Great Lakes. The complete set consists of fourteen volumes. The information may be used to support permit and project reviews, impact statement reviews, planning of baseline research, and coordination with other agencies, and identification of data gaps. The report locates spawning and nursery areas in the Great Lakes and describes spawning and nursery characteristics, timing, and habitats of major fish species of the Great Lakes area.

The first volume is a summary by geographic area, volumes II through XII contain the specific areas referenced in volume I. Volume XIII contains the species spawning and nursery characteristics for the major species, and Volume XIV cites the references used in compiling this work.

The titles of the volumes addressing the spawning and nursery areas for each fish species site specifically are: II, Lake Superior; III, St. Mary's River; IV, Lake Michigan; V, Lake Huron; VI, St. Clair River; VII, St. Clair Lake; VIII, Detroit River; IX, Lake Erie; X, Niagara River; XI, Lake Ontario; XII, St. Lawrence River. The title of Volume XIV is, Species Reproduction Characteristics.

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