CLEAR TECHNICAL REPORT NO. 127

INVENTORY AND REVIEW OF LITERATURE DATA SOURCES PERTAINING TO ICHTHYOLOGICAL AND FISHERIES RESEARCH IN THE NEARSHORE ZONE OF LAKE ERIE

Prepared by

Mark D. Barnes

Prepared for
U.S. Environmental Protection Agency
Region V, Eastern District Office
Westlake, Ohio

Project Officer: A. Richard Winklhofer
Grant No. R005329-01

THE OHIO STATE UNIVERSITY
CENTER FOR LAKE ERIE AREA RESEARCH
COLUMBUS, OHIO

February 1979

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

A working definition of the nearshore zone of Lake Erie can be established on several different bases. From the standpoint of water quality, the nearshore zone can be delineated anywhere along a physicochemical gradient directed generally offshore from the shoreline. From a strictly physical point of view the nearshore zone may be considered as a region along the coast in which the scouring action of waves affects the bottom. A biological definition is somewhat more elusive, since the distribution of organisms is dependent on both physical and chemical factors. Fish are distributed along the shore according to depth, bottom type, cover availability, temperature, and water quality, and food availability. Therefore, from the standpoint of dish, the nearshore zone is comprised of a region of extremely variable width.

The purpose of this report is to review and inventory literature sources pertaining to the fishes of the nearshore zone of Lake Erie with some reference to Canadian waters but with primary emphasis on U.S. waters. Such a compilation has been previously lacking and is necessary for several reasons. The nearshore zone represents the immediate interface between the coastal activities of man and the fish communities of Lake Erie. Adequate planning of coastal activities and installations such that destructive effects on the fish communities are minimized is dependent on sufficient information concerning these fish communities. Such information is largely not available, and this report should aid in planning research such that pertinent data is obtained and past efforts not duplicated. For purposes of this report, the water quality definition of the nearshore zone according to Cooper (1979)(i.e., approximately one km) will be used, since this zone includes most areas less than 30 ft in depth to which the wave-scouring definition of the nearshore zone applies. Harbors and estuaries, as far inland as the mouths of their respective tributary streams, will also be reviewed.

It is hoped that this report will serve as a general data base upon which future research in the nearshore zone can be structured. Many data sources have been reviewed, and a few have most likely been overlooked. Several sources have been consciously omitted due to inaccessibility. The user of this report is urged to make the author or the sponsoring institution aware of such omissions.

INTRODUCTION

A working definition of the nearshore zone of Lake Erie can be established on several different bases. From the standpoint of water quality, the nearshore zone can be delineated anywhere along a physicochemical gradient directed generally offshore from the shoreline. From a strictly physical point of view the nearshore zone may be considered as a region along the coast in which the scouring action of waves affects the bottom. A biological definition is somewhat more elusive, since the distribution of organisms is dependent on both physical and chemical factors. Fish are distributed along the shore according to depth, bottom type, cover availability, temperature, and water quality, and food availability. Therefore, from the standpoint of dish, the nearshore zone is comprised of a region of extremely variable width.

The purpose of this report is to review and inventory literature sources pertaining to the fishes of the nearshore zone of Lake Erie with some reference to Canadian waters but with primary emphasis on U.S. waters. Such a compilation has been previously lacking and is necessary for several reasons. The nearshore zone represents the immediate interface between the coastal activities of man and the fish communities of Lake Erie. Adequate planning of coastal activities and installations such that destructive effects on the fish communities are minimized is dependent on sufficient information concerning these fish communities. Such information is largely not available, and this report should aid in planning research such that pertinent data is obtained and past efforts not duplicated. For purposes of this report, the water quality definition of the nearshore zone according to Cooper (1979)(i.e., approximately one km) will be used, since this zone includes most areas less than 30 ft in depth to which the wave-scouring definition of the nearshore zone applies. Harbors and estuaries, as far inland as the mouths of their respective tributary streams, will also be reviewed.

It is hoped that this report will serve as a general data base upon which future research in the nearshore zone can be structured. Many data sources have been reviewed, and a few have most likely been overlooked. Several sources have been consciously omitted due to inaccessibility. The user of this report is urged to make the author or the sponsoring institution aware of such omissions.

DATA SOURCES AND PRESENTATION

Data sources pertaining to the nearshore fish fauna of Lake Erie are of three general levels in terms of quality and accessibility: (1) published, refereed books and journal papers, (2) published or widely circulated technical reports (e.g., impact statements, progress and final reports for grant funded projects), and (3) unpublished, unreviewed file data of government agencies, educational institutions, libraries, and individuals. This report will include data sources (1) and (2) only. Although data source (3) is relatively extensive, its use in this report is foregone due to the dubious quality of some of the data and due to the massive effort required to locate and compile it into usable form. Users of this report who are aware of such data and believe it to be worthy of review are urged to compile and publish it in some readily accessible form. Similarly, information from data source (2), although circulated and generally accessible, is largely unreviewed and is often compiled for some specific legal or administrative purpose (i.e., impact assessment) which limits its scope and usefulness as a general basis for sound biological evaluation of nearshore areas.

Data pertaining to distribution and relative abundance is the most common type of information available concerning the fishes of the nearshore zone. Data pertaining to fish population and community structure and dynamics in the nearshore zone is comparatively scarce. Most of the fisheries research in Lake Erie has been related to major game and commercial populations which were not entirely nearshore in distribution, although some of the data generated by this research is partly applicable to the relationships of these populations to the nearshore zone. A few studies are specific to the fish communities, whether transient or resident, of more intensively studied areas entirely within the nearshore zone. To encompass this duality of emphasis, this report has been divided into two major sections. The first, "Species Backgrounds and Relationships to the Nearshore Zone," is a review of lakewide population-specific information with particular reference to the relationships of each species to the nearshore zone. The second, "Site-Specific Studies", inventories the available nearshore-specific information.

SPECIES BACKGROUNDS AND RELATIONSHIPS TO THE NEARSHORE ZONE

At least 138 species of fish occur in the waters of the Lake Erie basin (Van Meter and Trautman, 1970). Fifty-one of these species are largely restricted in distribution to tributaries, inland wetlands, lakes, and ponds and occur in the nearshore waters of Lake Erie only incidentally. Another five species are deepwater forms of the open lake and seldom enter the nearshore zone. These 56 species are not considered in this review, since they are of minor importance in the nearshore zone. The remaining 82 species make (or formerly made) some persistent, if often minimal, use of the nearshore zone at some time during their life cycles (Table 1). Few populations of these species can be considered confined in distribution to the nearshore zone, which has been somewhat arbitrarily delineated in this review. Rather, most populations are of one of the following types: (a) highly mobile, migratory populations which may concentrate randomly or seasonally in the nearshore zone, (b) populations which are perennially centered in offshore waters with roving individuals often entering the nearshore zone, (c) populations which are perennially centered in inland waters with roving individuals often entering the nearshore zone, and (d) populations which are perennially centered in the nearshore zone with roving individuals often entering the offshore zone or inland waters. Table 1 lists the 82 predominant species found in the nearshore zone, their relative abundance in Lake Erie in general, and their relative utilization of the nearshore zone.

The following discussions deal in detail with all species for which data beyond general abundance and distribution records are available. Most of these species are (or were) either numerically abundant or recreationally and commercially important. For each such species the discussion is divided into several parts. "Importance and Status" relates the general economic or biological importance and status of the species. "Life History Literature Review for Lake Erie" is a lakewide listing of literature sources pertaining to habitat, behavior, and population characteristics of each species, and "Relationship to the Nearshore Zone" draws on these sources to identify the specific relationships of each species to the nearshore zone, where possible. Finally, "Nearshore-Specific Studies" identifies nearshore areas where significant studies pertinent to each species have been conducted. Where such studies are extensive, they are reviewed in detail.

Following the discussions of major species, a general discussion of all other species and an overview of nearshore fish communities is presented.

Common and scientific names of fishes are used in this report according to the system of Bailey et al. (1970). Following Table 1, only standard common names will be used in the text, and the reader should refer to Table 1 to find the corresponding scientific names.

ALEWIFE AND GIZZARD SHAD

Importance and Status

The primary importance of the alewife and gizzard shad is as forage for larger predatory fishes, most of which are commercially or recreationally important. Both species are abundant in Lake Erie (Langlois, 1954; Trautman, 1957; Bodola, 1966; Van Meter and Trautman, 1970). The alewife is an anadromous invader from the Atlantic Ocean and presumably entered Lake Erie via the Erie or Welland canals. The gizzard shad may also have invaded Lake Erie via canals between the lake and the Ohio River (Miller, 1957), but no definitive evidence of this exists.

TABLE 1

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category [3]	Relative Abundance
Petromyzontidae		
Ichthyomyzon unicuspis (silver lamprey)	a	Formerly abundant, now decreased
Petromyzon marinus (sea lamprey)	a	Uncommon
Acipenseridae		
Acipenser fulvescens (lake sturgeon)	a	Formerly abundant, now rare
Lepisosteidae		
Lepisosteus oculatus (spotted gar)	c,d	Formerly uncommon, now rare
Lepisosteus osseus (longnose gar)	c,d	Numerous but decreasing
Amiidae		
Amia calva (bowfin)	c,d	Numerous locally, possibly decreasing
Clupeidae		
Alosa pseudoharengus (alewife)	a	Abundant
Dorosoma cepedianum (gizzard shad)	c,d	Abundant
Salmonidae		
Coregonus artedii (lake herring)	a	Formerly abundant, now rare
Coregonus clupeaformis (lake whitefish)	a	Formerly abundant, now rare
Oncorhynchus kisutch (coho salmon)	a	Common
Oncorhynchus nerka (sockeye salmon)	a	Rare, probably absent
Oncorhynchus tshawytscha (chinook salmon)	a	Common

TABLE 1 (Con't.)

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE
AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category[3]	Relative Abundance
Salmonidae		
Salmo gairdneri (rainbow trout)	a	Common
Salmo salar (Atlantic salmon)	a	Probably absent
Salvelinus namaycush (lake trout)	a	Formerly common, now rare, but possibly increasing
Osmeridae		
Osmerus mordax (rainbow smelt)	a	Abundant
Hiodontidae		
Hiodon tergisus (mooneye)	c, d	Rare
Umbridae		
Umbra limi (central mudminnow)	c, d	Common but decreasing
Esocidae		
Esox americanus vermiculatus (grass pickerel)	c, d	Once numerous locally, now decreased
Esox lucius (northern pike)	c, d	Common locally, but greatly decreased from original abundance
Esox masquinongy (muskellunge)	c, d	Rare
Esox niger (chain pickerel)	c	Introduced locally and uncommon
Cyprinidae		
Carassius auratus (goldfish)	c, d	Abundant
Cyprinus carpio (carp)	c, d c, d	Abundant
Hybopsis storeriana (silver chub)	b, c, d	Rare
Notemigonus crysoleucas (goldenshiner)	c, d	Greatly reduced from original abundance but still common locally

TABLE 1 (Con't.)

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category[3]	Relative Abundance
Cyprinidae		
Notropis anogenus (pugnose shiner)	c, d	Rare
Notropis atherinoides (emerald shiner)	c, d	Abundant
Notropis emiliae (pugnose minnow)	c, d	Rare, possibly extirpated
Notropis heterodon (blackchin shiner)	c, d	Rare
Notropis heterolepis (blacknose shiner)	c, d	Rare, possibly extirpated
Notropis hudsonius (spottail shiner)	c, d	Abundant
Notropis stramineus (sand shiner)	c, d	Common locally
Notropis volucellus (mimic shiner)	c, d	Numerous locally
Pimephales notatus (bluntnose minnow)	c, d	Common
Rhinichthys cataractae (longnose dace)	c, d	Common locally, decreasing
Catostomidae		
Carpiodes cyprinus (quillback)	c, d	Common
Catostomus catostomus (longnose sucker)	b	Locally common, decreasing
Catostomus commersoni (white sucker)	c, d	Abundant
Erimyzon sucetta (lake chubsucker)	c, d	Uncommon
Ictiobus cyprinellus (bigmouth buffalo)	c, d	Common locally
Minytrema melanops (spotted sucker)	c, d	Uncommon, decreasing
Moxostoma anisurum (silver redhorse)	c, d	Common but decreasing

TABLE 1 (Con't.)

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category [3]	Relative Abundance
Catostomidae		
Moxostoma erythrurum (golden redhorse)	c	Occasional
Moxostoma macrolepidotum (shorthead redhorse)	c, d	Common
Ictaluridae		
Ictalurus catus (white catfish)	c, d	Probably absent
Ictalurus melas (black bullhead)	c, d	Numerous
Ictalurus natalis (yellow bullhead)	c, d	Formerly common, now decreased
Ictalurus nebulosus (brown bullhead)	c, d	Numerous
Ictalurus punctatus (channel catfish)	c, d	Common
Noturus flavus (stonecat)	c, d	Common
Noturus gyrinus (tadpole madtom)	c, d	Formerly numerous, decreasing
Noturus miurus (brindled madtom)	c, d	Formerly numerous, now decreased
Pylodictis olivaris (flathead catfish)	c	Occasional
Anguillidae		
Anguilla rostrata (American eel)	c, d	Occasional
Cyprinodontidae		
Fundulus diaphanus (banded killifish)	c, d	Rare
Gadidae		
Lota lota (burbot)	b,	Common locally

TABLE 1 (Con't.)

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category [3]	Relative Abundance
Gasterosteidae		
Culaea inconstans (brook stickleback)	c, d	Formerly common, now greatly reduced
Percopsidae		
Percopsis omiscomaycus (trout-perch)	b, c, d	Formerly abundant, decreased to common
Percichthyidae		
Morone americana (white perch)	c, d	Uncommon but increasing
Morone chrysops (white bass)	a	Abundant
Centrarchidae		
Ambloplites rupestris (rock bass)	c, d	Formerly abundant, still common locally
Lepomis cyanellus (green sunfish)	c, d	Common locally
Lepomis gibbosus (pumpkinseed)	c, d	Common locally but decreasing
Lepomis macrochirus (bluegill)	c, d	Formerly abundant, still common
Micropterus dolomieui (smallmouth bass)	c, d	Formerly abundant, now common locally
Micropterus salmoides (largemouth bass)	c, d	Formerly abundant, now common locally
Pomoxis annularis (white crappie)	c, d	Common to abundant locally
Pomoxis nigromaculatus (black crappie)	c, d	Common locally.

TABLE 1 (Con't.)

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category[3]	Relative Abundance
Percidae		
Ammocrypta pellucida (eastern sand darter)		Rare, possibly extirpated
Etheostoma blennioides (greenside darter)	c, d	Formerly abundant locally, now decreased
Etheostoma exile (Iowa darter)	c, d	Formerly common, now present locally but uncommon
Etheostoma flabellare (fantail darter)	c, d	Formerly common locally, now decreased
Etheostoma nigrum (johnny darter)	c, d	Common
Perca flavescens (yellow perch)	a	Abundant
Percina caprodes (logperch)	c, d	Common
Percina copelandi (channel darter)	c, d	Formerly abundant, now rare
Stizostedion canadense (sauger)	a	Rare but increasing
Stizostedion vitreum (walleye)	a	Common but greatly reduced from former abundance
Sciaenidae		
Aplodinotus grunniens (freshwater drum)	a	Abundant
Cottidae		
Cottus bairdi (mottled sculpin)	c, d	Common

TABLE 1 (Con't.)

FISH SPECIES OF THE NEARSHORE ZONE OF LAKE ERIE AND THEIR RELATIVE ABUNDANCE IN THE LAKE[1]

Scientific Name (Common Name)[2]	Category[3]	Relative Abundance
Atherinidae		
<u>Labidesthes sicculus</u> (brook silverside)	c, d	Formerly abundant, greatly decreased

[1] based on Trautman (1957) and Van Meter and Trautman (1970)

[2] according to Bailey et al. (1970)

[3] categories based on relative utilization of nearshore zone:
(a) highly mobile, migratory populations which concentrate randomly or seasonally in the nearshore zone,
(b) populations centered in offshore waters with frequent entry into nearshore zone,
(c) populations centered in inland waters with frequent entry into nearshore zone,
(d) populations centered in nearshore zone.

Life History Literature Sources for Lake Erie

Bangham (1972): parasites; alewife and gizzard shad.

Bodola (1966): quantitative for gizzard shad; age, growth, spawning fecundity, movements.

Dechtiar (1972): parasites; alewife and gizzard shad.

Langlois (1954): general, qualitative life history; alewife and gizzard shad.

Price (1963): food habits; alewife and gizzard shad.

Trautman (1957): general, qualitative life history; alewife and gizzard shad.

Relationship to the Nearshore Zone

The adult alewife is primarily a deepwater, pelagic species of the open lake and seldom enters shallow waters or tributaries except to spawn in June or July (Langlois, 1954; Trautman, 1957). Consequently, young-of-the-year are the most abundant age group found in the nearshore zone, and the nearshore zone serves to some unknown extent as a spawning and nursery area for the species. Detailed, quantitative life history information is lacking for the alewife in Lake Erie.

The gizzard shad is primarily a nearshore species and reaches its greatest abundance in the nearshore zone and Bass Islands area of the Western Basin of Lake Erie. The gizzard shad increased markedly in abundance in Lake Erie during the 1960's, presumably due to increasing turbidity, phytoplankton production, and the elimination of large predator species. The species thrives in warm, low-gradient waters with an abundance of plankton and is highly tolerant of turbidity (Langlois, 1954; Trautman, 1957; Bodola, 1966).

Knowledge of the life history of the gizzard shad in Lake Erie is fragmentary. Spawning is dependent on water temperature and occurs primarily in June, probably on sand or gravel bars about one meter deep. The eggs are adhesive, heavier than water, and sink after spawning to adhere to stones, plants, or other surfaces. Knowledge of young-of-the-year movements is lacking. Female gizzard shad, and probably most males, mature at Age II. In Lake Erie the species can reach an age of at least six years and grows rapidly, generally becoming too large to serve as a major forage fish after Age I. The species is primarily planktivorous, although benthic invertebrates are also consumed (Langlois, 1954; Trautman, 1957; Price, 1963; Bodola, 1966).

Nearshore-Specific Studies

Beyond distribution records no nearshore-specific life history studies of the alewife or gizzard shad in Lake Erie have been conducted. However, most of Bodola's (1966) samples of gizzard shad were collected within one-half mile (0.8 km) of an island or mainland shore in the Western Basin.

MOONEYE

Importance and Status

The mooneye is generally distributed throughout the Great Lakes but is more abundant in the Ohio waters of Lake Erie than anywhere else (Van Oosten, 1961). The mooneye once constituted a minor portion of commercial catches, but is now greatly depleted and officially protected as rare by the states of Michigan and Ohio (Miller, 1972). Decreasing abundance of the species in Lake Erie has been attributed to siltation (Trautman, 1957).

Life History Literature Sources for Lake Erie

Boesel (1938): food habits.

Fish (1932): early life history (primarily larval identification and distribution).

Johnson (1951): spawning, fecundity, age, growth (discussion by Langlois [1954]).

Langlois (1954): general, qualitative life history.

Trautman (1957): general, qualitative life history.

Van Oosten (1961): distribution, age, growth, and summary of previous studies.

Relationship to the Nearshore Zone

The mooneye is not limited in distribution to the immediate nearshore zone, but apparently it seldom occurs at depths greater than 10.7 m (35 ft). When it was more common, it was most densely concentrated along the shore between Toledo, Ohio, and Erie, Pennsylvania (Van Oosten, 1961). The species preferred clear waters and fed mostly in flowing waters such as occurred below dams (Trautman, 1957). Spawning occurred in April and May (Johnson, 1951), but detailed spawning information is lacking. Food consisted of a variety of planktonic, benthic, and terrestrial invertebrates (Boesel, 1938) as well as small fish (Trautman, 1957; Johnson, 1951). Maximum age of the mooneye in Lake Erie was about seven years, with sizes ranging from an average 124 mm at Age I to 324 mm at Age VII. Sexual maturity was reached primarily after Age II (Van Oosten, 1961). Although detailed information of the mooneye's life history in Lake Erie is lacking, the nearshore zone is a probable spawning, nursery, and feeding area for the species. The species is clearly shore-oriented, although it also occurs in offshore waters.

Nearshore-Specific Studies

Beyond distribution records, no nearshore-specific studies of the mooneye in Lake Erie exist.

MOONEYE

Importance and Status

The mooneye is generally distributed throughout the Great Lakes but is more abundant in the Ohio waters of Lake Erie than anywhere else (Van Oosten, 1961). The mooneye once constituted a minor portion of commercial catches, but is now greatly depleted and officially protected as rare by the states of Michigan and Ohio (Miller, 1972). Decreasing abundance of the species in Lake Erie has been attributed to siltation (Trautman, 1957).

Life History Literature Sources for Lake Erie

Boesel (1938): food habits.

Fish (1932): early life history (primarily larval identification and distribution).

Johnson (1951): spawning, fecundity, age, growth (discussion by Langlois [1954]).

Langlois (1954): general, qualitative life history.

Trautman (1957): general, qualitative life history.

Van Oosten (1961): distribution, age, growth, and summary of previous studies.

Relationship to the Nearshore Zone

The mooneye is not limited in distribution to the immediate nearshore zone, but apparently it seldom occurs at depths greater than 10.7 m (35 ft). When it was more common, it was most densely concentrated along the shore between Toledo, Ohio, and Erie, Pennsylvania (Van Oosten, 1961). The species preferred clear waters and fed mostly in flowing waters such as occurred below dams (Trautman, 1957). Spawning occurred in April and May (Johnson, 1951), but detailed spawning information is lacking. Food consisted of a variety of planktonic, benthic, and terrestrial invertebrates (Boesel, 1938) as well as small fish (Trautman, 1957; Johnson, 1951). Maximum age of the mooneye in Lake Erie was about seven years, with sizes ranging from an average 124 mm at Age I to 324 mm at Age VII. Sexual maturity was reached primarily after Age II (Van Oosten, 1961). Although detailed information of the mooneye's life history in Lake Erie is lacking, the nearshore zone is a probable spawning, nursery, and feeding area for the species. The species is clearly shore-oriented, although it also occurs in offshore waters.

Nearshore-Specific Studies

Beyond distribution records, no nearshore-specific studies of the mooneye in Lake Erie exist.

SALMONIDS (NATIVE)

Importance and Status

The native salmonids of Lake Erie which commonly utilize(d) the nearshore zone include lake trout, lake herring, and lake whitefish. The brook trout (Salvelinus fontinalis) was primarily confined to tributaries, and the longjaw cisco (Coregonus alpenae) was primarily a deepwater form. The lake trout, lake herring, and lake whitefish were important and highly valued commercial species which declined to commercial extinction after 1900 due to a presumed combination of overfishing, siltation of spawning areas, decreasing seasonal dissolved oxygen levels in the deepwater regions of the Central Basin, and an increasing trend in lake water temperatures (Trautman, 1957; Scott and Smith, 1962; Regier et al., 1969; Van Meter and Trautman, 1970; Applegate and Van Meter, 1970; Hartman, 1973).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites; lake herring, lake whitefish.

Clemens (1922): age, growth, morphometry, food habits; lake herring.

Clemens and Bigelow (1922): food habits; lake herring.

Couch (1922): age and growth; lake whitefish

Dechtiar (1972): parasites; lake herring, lake whitefish.

Downing (1923): spawning areas, propagation; lake whitefish.

Ewers (1933): food habits; lake whitefish.

Fish (1932): early life history, mainly larval identification and distribution; lake trout, lake herring, lake whitefish.

Hartman (1973): general fishery and population trends; lake trout, lake herring, lake whitefish.

Langlois (1954): qualitative, general life histories; lake trout, lake herring, lake whitefish.

Regeir et al. (1969): general fishery and population trends; lake trout, lake herring, lake whitefish.

Scott (1951): factors relating to population fluctuations; lake herring.

Trautman (1957): general, qualitative life histories; lake trout, lake herring, lake whitefish.

Van Oosten (1930): factors relating to population fluctuations; lake herring.

Van Oosten and Hile (1947): age and growth; lake whitefish.

Relationship to the Nearshore Zone

The native lake trout was common primarily in the deeper waters of the Eastern Basin of Lake Erie, but it spawned in shallower waters around rock and gravel reefs (Trautman, 1957). Little more is known about the habits of the native lake trout in the nearshore zone, and it is now considered biologically extinct in the lake.

Lake whitefish and lake herring are not entirely eradicated in Lake Erie and occasionally occur in nets (Van Vooren and Davies, 1974; Bowman, 1974; Carr, 1964). Although these open-lake, pelagic species, when abundant, were not entirely confined to the nearshore zone, they were apparently common there, particularly during spawning season. Major nearshore spawning areas of lake whitefish once included the Detroit River and Maumee Bay (Langlois, 1954; Trautman, 1957). At present the utilization of the nearshore zone by these species is unknown, but the remnant populations may spawn and feed there.

Nearshore-Specific Studies

Beyond distribution records, no nearshore-specific studies of the lake trout, lake herring, or lake whitefish were located. Van Oosten and Hile (1947) and Clemens (1922) utilized lake herring and lake whitefish collected in the nearshore zone for age and growth studies, but data resulting from those studies is of little application given the present depleted condition of the populations.

SALMONIDS (INTRODUCED)

Importance and Status

Various salmonids have been introduced into Lake Erie in attempts to supplement natural production, particularly since the drastic depletion of native stocks. Introduced native and exotic species of nearshore significance included lake whitefish, lake trout, rainbow (steelhead) trout, coho salmon, chinook salmon, sockeye salmon, and Atlantic salmon. At present only the coho salmon, chinook salmon, steelhead, and lake trout are important, the other species introductions having failed or been discontinued (Trautman, 1957; Van Meter and Trautman, 1970). The five currently stocked species are (or have recently been) continuously planted as young in coastal areas and tributaries of Lake Erie by the states of Michigan, Ohio, Pennsylvania, and New York (Parsons, 1973). The primary objective of salmonid plantings today is the enhancement of the sport fishery, the need for terminal predators to augment lost or depleted stocks of walleye and blue pike (Hartman, 1973), and the economic development, via recreational utilization, of coastal areas. Although these introductions have failed to establish self-sustaining salmonid stocks (Hartman,1973), they have been moderately successful on a "put-and-take" basis.

Life History Literature Sources for Lake Erie

Ohio Department of Natural Resources (1971): growth, food habits, migrations; coho salmon.

Parsons (1973): history of introductions, growth and recovery; coho salmon, chinook salmon.

TABLE 2

PAST AND PRESENT SALMONID[1] PLANTING SITES IN LAKE ERIE

New York [2, 3]

Eighteenmile Creek - Co, St
Cattaraugus Creek - Br, Co, Ch, Ra
Dunkirk Harbor - Co, Br
Chautauqua Creek - Co, St
Barcelona beach area - Br, La
Hamburg beach area - Ra, Br

Pennsylvania [2, 4]

Orchard Beach Run - Co
Sixmile Creek - Co
Walnut Creek - Co
Trout Run - Co
Unnamed Creek - Co
Godfrey Run - Co
Grimshaw Run - Co

Ohio [2, 5]

Conneaut Creek - Co, St
Chagrin River - Co, Ch
Cuyahoga River[8] - Co, Ch
Huron River - Co, Ch
Cold Creek - At[7], Ch, Co, Bk, St
Pickerel Creek[8] - Co, Ch
Sandusky River[8] - At, Ch
Portage River[8] - At, Ch
Maumee River[8] - At, Ch

Michigan [2, 6]

Raisin River[8] - At, Ch
Huron River - At, Ch, So[7]

---

1 Co=coho, Ch=chinook, So-sockeye, Ra=domestic rainbow trout, St= steelhead, Br=brown trout, La=lake trout, Bk=brook trout

2 Based largely on Parsons (1973)

3 Current stocking information courtesy of J. Pomeroy (1979, New York State Department of Environmental Conservation, Olean, NY, personal communication)

4 Current stocking information courtesy of R. Kenyon (1979, Pennsylvania Fish Commission, Fairview, PA, personal communication); not site specific; Br, St, Co, some Ch currently planted in several areas

5 Current stocking information from Ohio Department of Natural Resources (1975, 1976, 1977, 1978)

6 Current stocking information courtesy of W. Bryant (1979, Michigan Department of Natural Resources, Mt. Clemens, MI)

7 Atlantic salmon have not been stocked anywhere in Lake Erie since 1932; sockeye not since 1970

8 Inactive sites

Ohio Department of Natural Resources (1978 and preceeding years): planting sites; coho salmon, chinook salmon, steelhead.

Relationship to the Nearshore Zone

Introduced salmonids are largely pelagic species of the open, deepwater areas of Lake Erie. Their critical relationship to the nearshore zone is their dependence on shallow, gravel or rocky areas along the shore or in tributaries, where they spawn (or attempt to spawn) in spring or fall. The nearshore zone may also serve as a wintering ground for some of these fish. Table 2 shows past and present salmonid planting sites in Lake Erie. Nearshore areas in the vicinity of these sites may be more heavily utilized by the fish than other nearshore areas.

Nearshore-Specific Studies

Beyond distribution records and planting studies, no nearshore-specific studies of introduced salmonids were located.

RAINBOW SMELT

Importance and Status

Rainbow smelt, first reported in Lake Erie in the 1930's, are thought to have originated from a single introduction in the Lake Michigan drainage in 1912 (Van Oosten, 1936, 1937; Trautman, 1957). Intense commercial and recreational fisheries for smelt have developed primarily in Canadian waters of Lake Erie (MacCallum and Regier, 1970). The smelt is presently abundant in the eastern and central basins (Van Meter and Trautman, 1970).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites.

Chen and Power (1972): parasite *Glugea hertwigi*.

Dechtiar (1972): parasites.

Ferguson (1965): bathymetric distribution.

Langlois (1954): general, qualitative life history.

MacCallum and Regier (1970): distribution, spawning, fishery.

Nepszy and Dechtiar (1972): parasite *Glugea hertwigi*.

Price (1963): food habits.

Thomasson (1963): distribution, spawning, movements.

Trautman (1957): general, qualitative life history.

Relationship to the Nearshore Zone

The adult smelt is primarily an inhabitant of deepwater regions of the eastern and central basins in Lake Erie. Some adults move into shallow nearshore waters and tributaries to spawn, while others spawn in deep water (9-22 m), in March and April, depending on location (Trautman, 1957; MacCallum and Regier, 1970). Spawning areas are generally known, most of them being in Canadian, New York, and Pennsylvania waters. Young-of-the-year smelt moved offshore by June and were distributed throughout the entire lake by surface currents. Neither adults nor YOY displayed a tendency to remain in nearshore waters after spawning (MacCallum and Regier, 1970). The nearshore zone is therefore primarily a spawning area for this species and is not otherwise greatly utilized.

Nearshore-Specific Studies

Beyond distribution records, the only nearshore-specific studies of smelt dealt with spawning areas. MacCallum and Regier (1970) showed known spawning areas on a map, and these are depicted in Figure 1.

NORTHERN PIKE AND MUSKELLUNGE

Importance and Status

Both northern pike and muskellunge were abundant and heavily fished in Lake Erie prior to the 1880's. Drastic decreases in abundance and commercial extinction of both species thereafter has been attributed to overfishing and draining and obstructing of spawning marshes. Both species also contributed to the recreational fishery (Langlois, 1954; Trautman, 1957). The muskellunge is presently very rare in Lake Erie, although a recreational fishery persists in the upper Niagara River (Harrison, 1978). The northern pike is sufficiently common to provide a minor sport fishery in the Western Basin.

Life History Literature Sources for Lake Erie

Bangham (1972): parasites; northern pike

Brown and Clark (1965): length-weight relationship; northern pike

Clark (1950): spawning habits; northern pike

Clark and Steinbach (1959): age and growth; northern pike

Dechtiar (1972): parasites; northern pike and muskellunge

Langlois (1954): general, qualitative life history; northern pike and muskellunge.

Trautman (1957): general, qualitative life history, northern pike and muskellunge

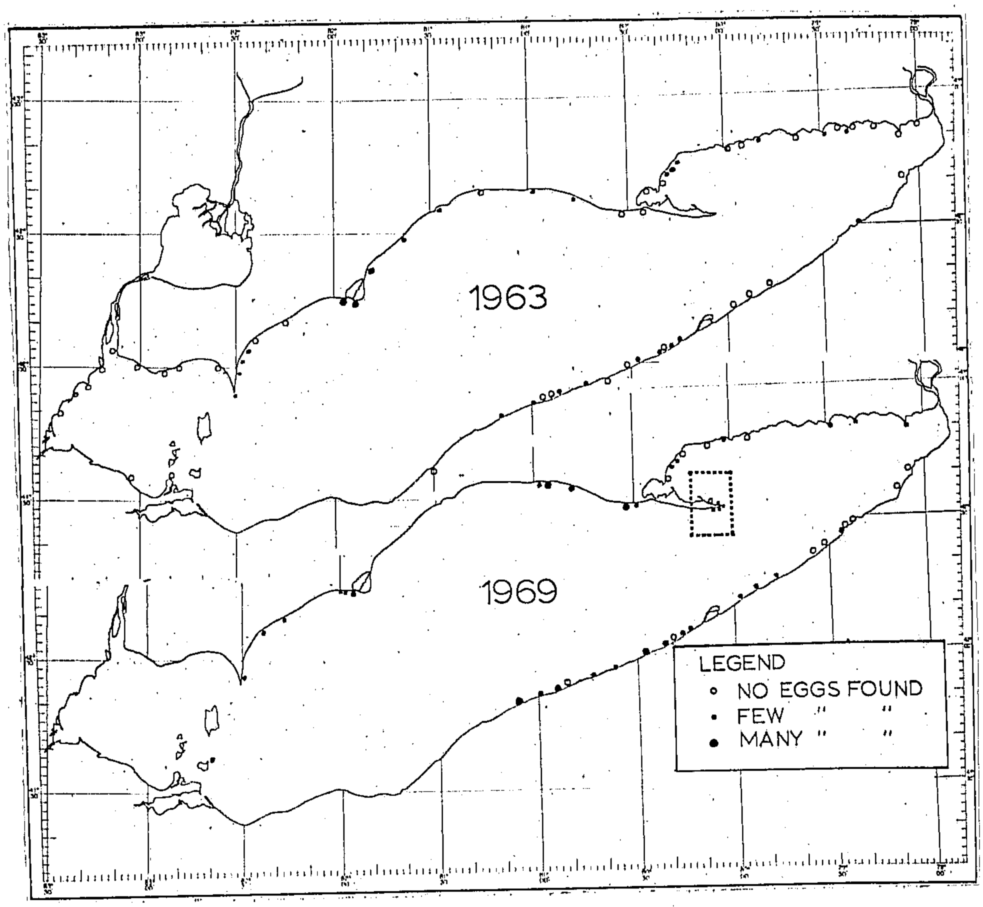

FIGURE 1. RAINBOW SMELT SPAWNING SURVEYS OF MACCALLUM AND REGIER (1970)

Relationship to the Nearshore Zone

Northern pike and muskellunge occurred generally along the Lake Erie shore, but they were most abundant in the nearshore zone and adjacent inland waters of the Western Basin. The muskellunge preferred the deeper nearshore waters of the Western Basin and spawned primarily in vegetated areas adjacent to larger tributaries like the Maumee and Detroit rivers. Spawning occurred in marshes, inundated woods, and flooded prairies or pastures soon after or during ice-out. These areas became the nursery habitats of young-of-the-year during the summer (Trautman, 1957).

The northern pike preferred shallower, more heavily vegetated waters than the muskellunge. Spawning was similar to the spawning of muskellunge, with Old Woman Creek, the Huron River, Wolf Creek, East Harbor, Turtle Creek, Sandusky Bay, and the Maumee River system being the more important (or better known) spawning areas (Clark, 1950; Clark and Steinbach, 1959; Brown and Clark, 1965; Langlois, 1954; Trautman, 1957).

Both species were and are predominantly nearshore and inland water forms, utilizing the marsh complexes of western Lake Erie. The primary limiting factor to their abundance is the scarcity or inaccessibility of suitable wetland spawning areas (Trautman, 1957).

Nearshore-Specific Studies

Beyond distribution records, the only nearshore-specific studies of northern pike were conducted in East Harbor, Ottawa County, Ohio by Clark and Steinback (1959) and Brown and Clark (1965). These studies addressed age, growth, and length-weight relationships and indicated relatively rapid growth of East Harbor pike compared to other Great Lakes pike populations. No nearshore-specific life history studies of muskellunge have been conducted in Lake Erie.

CARP AND GOLDFISH

Importance and Status

The Eurasian carp and goldfish were imported to North America for food and ornamental purposes, respectively, and were introduced into Lake Erie during the late 1800's. Both species reproduced prolifically and are now abundant, especially in the Western Basin. Goldfish have little recreational or commercial importance, but carp is a heavily harvested and economically important commercial fish in western Lake Erie (Trautman, 1957; Van Meter and Trautman, 1957; Baldwin and Saalfeld, 1962, 1970; Ohio Department of Natural Resources, 1978).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites; carp and goldfish

Battle (1940): embryology; goldfish

Crunkilton (1977): introgressive hybridization; carp and goldfish

Dechtiar (1972): parasites; carp and goldfish

Hartley and Herdendorf (1975): food habits; carp and goldfish

King and Hunt (1967): effect on marsh vegetation; carp

Langlois (1954): general, qualitative life history; carp and goldfish

Trautman (1957): general, qualitative life history; carp and goldfish

Relationship to the Nearshore Zone

Carp and goldfish are largely nearshore and inland water species, reaching greatest abundance in the warm, silty, low-gradient waters of bays, marshes, and estuaries of western Lake Erie. Sandusky Bay is an area of particularly dense concentration. Spawning also occurs in these areas in late May to early June and hybridization between the two species is common (Langlois, 1954; Trautman, 1957; Crunkilton, 1977).

Nearshore-Specific Studies

Crunkilton (1977) studied introgressive hybridization of carp and goldfish from several nearshore areas of Ohio. Hartley and Herdendorf (1975) reported food habits of carp and goldfish in Sandusky Bay. Chironomid larvae, oligochaetes, and diatoms were the major dietary items of both species. King and Hunt (1967) studied the effects of carp on vegetation in the Erie Fishing and Shooting Club marsh in Monroe County, Michigan (same data reported by Hunt and Mickelson, 1976). King and Hunt's (1967) data are reviewed in the SITE-SPECIFIC STUDIES section of this report.

SPOTTAIL SHINER

Importance and Status

The spottail shiner is not of recreational or commercial importance in Lake Erie, but it is an important forage species for larger predatory commercial and game fishes.

Life History Literature Sources for Lake Erie

Bangham (1972): parasites

Boesel (1938): food habits

Dechtiar (1972): parasites

Fish (1932): early life history, mainly larval identification and distribution

Langlois (1954): general, qualitative life history

Price (1963): food habits

Trautman (1957): general, qualitative life history

Wells and House (1974): spawning, fecundity, age and growth, trophic relationships

Relationship to the Nearshore Zone

The spottail shiner is a benthipelagic species, preferring shallower waters from 1-18 m deep (Trautman, 1957; Wells and House, 1974). As such the species is essentially shore-oriented and common in the nearshore zone throughout the lake, although it is common offshore as well. Spawning areas and behavior in Lake Erie are not recorded, but spawning activity apparently occurs in shallow water on sandy bottoms from early June to late July (Fish, 1932; Wells and House, 1974). Spottail shiners apparently have a maximum age of approximately four years in western Lake Erie and exhibit a higher than average mortality among older age groups, with a resulting preponderance of young fish. However, growth rates of spottail shiners from western Lake Erie were greater than growth rates of other Great Lakes populations (Wells and House, 1974).

Spottail shiners are opportunistic predators and feed on a variety of plant and animal material (Boesel, 1938; Price, 1963). In turn the species is prey for walleyes, white bass (Regier et al., 1969; Wells and House 1974), and probably other larger predator species.

The spottail shiner is largely a nearshore and inland water species and is abundant in the open beach areas, harbors, and tributaries of the lake. Its primary activities in the nearshore zone are spawning and feeding.

Nearshore-Specific Studies

Beyond distribution records and the generally applicable study of Wells and House (1974), no nearshore-specific studies of the spottail shiner in Lake Erie were located.

CHANNEL CATFISH

Importance and Status

The channel catfish is an important commercial and game fish in Lake Erie (Trautman, 1957; Van Meter and Trautman, 1970). Commercial production has remained relatively stable since the 1880's (Hartman, 1973).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites

Boesel (1938): food habits

Dechtiar (1972): parasites

De Roth (1965): age and growth

Griswold and Tubb (1977): food habits

Hartley and Herdendorf (1975): food habits (same as Hartley, 1975)

Langlois (1954): general, qualitative life history

Price (1963): food habits

Trautman (1957): general, qualitative life history

Tubb (1973): food habits

Van Vooren *et al.* (1978, 1977, 1976, 1975): age, growth, recreational and commercial harvest, seasonal abundance and distribution

Van Vooren and Davies (1974): age, growth, recreational and commercial harvest, seasonal abundance and distribution

Relationship to the Nearshore Zone

Although common throughout the lake, the channel catfish is most abundant in the nearshore and low-gradient inland waters of the Western Basin, particularly on sand or gravel bottoms. Adults are highly migratory, ascending bays and tributaries to spawn in July and August (Trautman, 1957; Langlois, 1954). Known spawning areas include Sandusky Bay, the Maumee River, and the Portage River, although many other areas are likely utilized. Current inventory techniques are inadequate to determine accurately the abundance and movements of young-of-the-year channel catfish in the nearshore zone of Ohio (Van Vooren et al., 1977), due evidently to the cryptic habits of that age group. Young-of-the-year appear to descend tributaries after hatching and distribute throughout bays, estuaries, and the nearshore zone. Yearlings were relatively abundant in the nearshore zone of Ohio, while adult abundance in the nearshore zone was greatest in spring (spawning concentration), declining progressively during summer and fall as spawned-out adults moved offshore again. Commercial harvest of channel catfish in the nearshore zone of Ohio was greatest during spring along the shore between Toledo and Sandusky, particularly in Sandusky Bay (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). Although the channel catfish ranges well outside the nearshore zone, this general area is clearly of seasonal importance as a spawning and feeding area for adults and of perennial importance as nursery and feeding grounds for yearlings and young-of-the-year.

Nearshore-Specific Studies

The Ohio Department of Natural Resources maintains nearshore trawling and gill netting stations in the Western and Central Basins for annual stock assessments of channel catfish and other species (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). These stations are shown in Figure 2. Food habits of channel catfish in Sandusky Bay were investigated by Tubb (1973), Hartley (1975), Hartley and Herdendorf (1975), and Griswold and Tubb (1977). These studies indicated that channel catfish in the bay were omnivorous, feeding primarily on fish, dipteran larvae, oligochaetes, and cladocerans. No further published nearshore-specific data regarding channel catfish in Lake Erie were located, other than distribution records.

WHITE BASS

Importance and Status

The white bass is a major game fish in Lake Erie and has increased substantially in commercial importance since the decline of commercial walleye

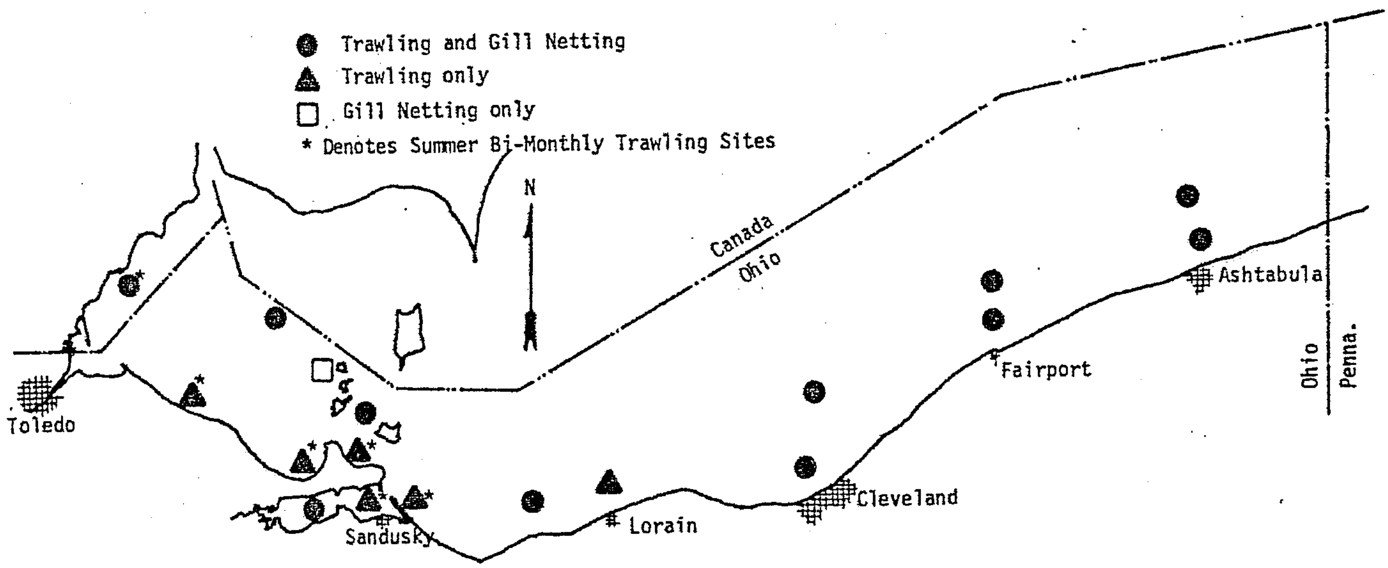

FIGURE 2. TRAWLING AND GILL NETTING STATIONS SAMPLED ANNUALLY BY THE OHIO DEPARTMENT OF NATURAL RESOURCES (VAN VOOREN AND DAVIES, 1974)

harvests. Although the species has been heavily exploited, no progressive decline in the stocks has been evident. However, a tendency toward cycles of abundance has been noted (Van Oosten, 1942; Trautman, 1957).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites

Dechtiar (1972): parasites

Ewers (1933): food habits

Griswold and Tubb (1977): food habits

Hartley and Herdendorf (1975): food habits (same as Hartley, 1975)

Langlois (1954): general life history

Price (1963): food habits

Trautman (1957): general life history

Tubb (1973): food habits

Van Oosten (1942): age and growth

Van Vooren et al. (1978, 1977, 1976, 1975): age, growth, hatching success, commercial and recreational harvest, seasonal abundance and distribution

Van Vooren and Davies (1974): age, growth, hatching success, commercial and recreational harvest, seasonal abundance and distribution

Relationship to the Nearshore Zone

The white bass is a highly mobile, benthipelagic species ranging from inland waters into the nearshore zone and far offshore in Lake Erie. It is particularly abundant throughout the Western Basin. White bass spawn in rocky areas in tributaries, particularly the Sandusky and Maumee rivers (Van Oosten, 1942) and probably in similar habitats in bays and on reefs (Van Vooren et al., 1975). Young-of-the-year white bass first appeared in nearshore trawl samples in Ohio waters from early June through early July. Particularly dense concentrations of YOY during the summers of 1974-1977 were found in Sandusky Bay, East Harbor, and the vicinities of Bono, Ohio, and Monroe, Michigan. By October the densest concentrations of YOY were found in the Central Basin. Yearlings apparently remained in the nearshore zone during spring, summer, and fall, with particularly dense concentrations occurring in Sandusky Bay. Adults were distributed throughout the Western Basin during summer, fall, and winter, but were heavily concentrated in the reef area west of the Bass Islands during the spring, reflecting a possible spawning concentration. Commercial white bass harvest in Ohio waters of Lake Erie was highest in nearshore areas between Toledo and Huron, including Sandusky Bay (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). The nearshore zone, particularly in the Western Basin, is an essential feeding, spawning, and nursery area for all ages of white bass.

Nearshore-Specific Studies

The Ohio Department of Natural Resources maintains nearshore trawling and gill netting stations in the Western and Central Basins for annual stock assessments of white bass and other species (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). These stations are shown in Figure 2. Food habits of white bass in Sandusky Bay were investigated by Tubb (1973), Hartley (1975), Hartley and Herdendorf (1975), and Griswold and Tubb (1977). Fish, primarily minnows, were the major dietary item of white bass in the bay, with dipteran larvae and cladocerans constituting important summer food sources.

SMALLMOUTH BASS

Importance and Status

The blackbasses, including both smallmouth bass and largemouth bass, were of great commercial importance in Lake Erie prior to 1900. The subsequent continuous decline and commercial extinction of blackbass stocks has been attributed to overfishing, siltation of spawning areas, and obstruction of tributary spawning runs by dams (Trautman, 1957). The smallmouth bass continues to furnish an important sport fishery in Lake Erie, particularly in the Bass Islands area (Hair, 1978).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites

Dechtiar (1972): parasites

Doan (1940): growth, spawning, food habits

Hair (1978): growth, fecundity, movements, food habits

Langlois (1954): general life history

Trautman (1957): general life history

Wickliff (1920): food habits

Relationship to the Nearshore Zone

The smallmouth bass is essentially a nearshore species, occurring generally along the entire Lake Erie shore but most abundantly around the limestone reefs and bars of the Bass Islands area. Spawning occurs in shallow water over coarse gravel in the nearshore zone, offshore reefs, and tributaries, generally around early May to late June, depending on water temperature and its rate of vernal increase. Nests may be constructed at depths between 0.6-6.7 m, as long as there is some current and the water is relatively clear. At depths less than 1.5 m nests are vulnerable to disruption by wave action, while at depths exceeding 1.5 m are subject to increasing siltation problems (Doan, 1940; Langlois, 1954; Trautman, 1957).

Smallmouth bass in Lake Erie (Bass Islands) appeared to grow faster than several other Great Lakes populations (Hair, 1978). Young-of-the-year in the

Bass Islands area fed mainly on small crustaceans, insect larvae, and fish larvae, but yearlings and adults were primarily dependent on fish and crayfish (Wickliff, 1920; Doan, 1940; Hair, 1978). Other mainland nearshore populations are probably similar in food habits.

Smallmouth bass are limited in their range of movements, seldom exceeding 3.2 km from point of capture in a Bass Islands area tagging study. Adults in this tagging study moved to preferred island nearshore spawning areas in spring, generally returning to the same general areas used the previous spring. After spawning, adults returned to nearshore reefs and adjacent deep water, where they remained the rest of the year. Nursery areas for young-of-the-year were apparently located in sheltered bays and backwaters (Hair, 1978).

The relationship to the nearshore zone of the smallmouth bass is probably twofold: (1) the nearshore areas provide habitat and feeding grounds for adults, and (2) sheltered bays and tributaries provide spawning ground, and later nursery areas for young-of-the-year. The open wave-swept beach areas are probably of minimal importance to this species. Stone et al. (1954) found sheltered bays and leeward shoal areas to be primary smallmouth bass habitats in the St. Lawrence River - eastern Lake Ontario region. Stands of submerged aquatic vegetation were also favored feeding and nursery grounds. Smallmouth bass were also abundant in Rondeau Harbor, Ontario, a sheltered, vegetated bay on the Central Basin of Lake Erie (Doan, 1940).

Nearshore-Specific Studies

Beyond distribution records, no published nearshore-specific information pertaining to smallmouth bass in Lake Erie was located. Hair's (1978) study pertained to nearshore areas of the Bass Islands region, which was not considered as part of the nearshore zone for this report.

YELLOW PERCH

Importance and Status

The yellow perch has long been an important commercial and sport fish in Lake Erie. It is currently widely distributed and abundant throughout the lake, although it has declined in abundance since 1900 (Trautman, 1957; Van Meter and Trautman, 1970). Commercial fishing pressure on yellow perch increased considerably as stocks of whitefish, cisco, and blue pike declined, until by the late 1950's, aided by strong consecutive year classes, the species dominated the Lake Erie fishery. Irregularity in year-class strength has characterized yellow perch in western Lake Erie since the late 1950's (Hartman, 1973).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites

Boesel (1938): food habits

Dechtiar (1972): parasites

Ewers (1933): food habits

Griswold and Tubb (1977): food habits

Harkness (1922): age and growth

Hartley (1975): food habits

Hartley and Herdendorf (1975): food habits

Jobes (1952): production

Jobes (1933): age and growth

Langlois (1954): general life history

Price (1963): food habits

Scott (1955): activity patterns

Sztramko and Teleki (1977): fecundity

Trautman (1957): general life history

Turner (1920): food habits

Van Vooren et al. (1978, 1977, 1976, 1975): age, growth hatching success, recreational and commercial harvest, seasonal abundance and distribution

Van Vooren and Davies (1974): age, growth, hatching success, recreational and commercial use, seasonal abundance and distribution

Relationship to the Nearshore Zone

The yellow perch is most abundant in the clearer, shallower waters of Lake Erie, although it occurs at a variety of depths and in more turbid waters such as Sandusky Bay and Maumee Bay. It is not strictly a fish of the nearshore zone (Trautman, 1957). Yellow perch in Lake Erie spawn in late April to late May, attaching gelatinous, adhesive ribbons of eggs to submerged vegetation, twigs, and various artificial structures (e.g. nets) in sheltered nearshore waters (Langlois, 1954; Sztramki and Teleki, 1977). Young-of-the-year yellow perch first appeared in nearshore zone trawl samples of western Lake Erie during mid-June. Nearshore areas of particularly dense YOY concentrations included Sandusky Bay, Cedar Point, and East Harbor. By October the densest concentrations of YOY were offshore in the island archipelago and the Central Basin. Yearlings and adults have displayed variable trends in nearshore abundance, sometimes increasing from spring to fall, then decreasing through winter, spring, and sometimes the reverse. Adults and yearlings were particularly abundant in the Bass Islands area, Sandusky Bay, and the vicinities of Cleveland, Lorain, Fairport, Ashtabula, and Vermilion (Ohio). Commercial yellow perch harvest in Ohio waters of Lake Erie appeared to be greatest in nearshore waters of the Central Basin during May and September-October (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). The critical relationships of yellow perch to the nearshore zone in Lake Erie have not been adequately defined as yet, but it is apparent that the nearshore zone furnishes essential spawning and nursery areas and is seasonally important as a concentration area for adults and yearlings (for feeding, spawning, or in response to physicochemical variables).

Nearshore-Specific Studies

The Ohio Department of Natural Resources maintains nearshore trawling and gill netting stations in the Western and Central Basins for annual stock assessments of yellow perch and other species (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). These stations are shown in Figure 2. Scott (1955) investigated activity patterns of yellow perch in Rondeau Bay, Ontario. Two groups of perch were identified in the bay: (a) two-and three-year-old migratory perch which lived near the mouth of the bay and migrated daily into Lake Erie, and (b) two-and three-year-old non-migratory perch which remained in the interior of the bay. Perch were very inactive during hours of darkness. Migratory perch activity was greatest at sunrise and sunset, when they migrated to the lake and back. Light appeared to be the major factor controlling daily activity. There was some evidence indicating that the migratory perch left the bay to selectively prey on Daphnia, which were scarce in the bay but more abundant in the lake. Daily migrations preceeded from May to October. It was not determined whether the migrations continued through the winter.

Sztramko and Teleki (1977) studied spawning and annual fecundity variations of perch in Long Point Bay, Ontario. During mid-April adult perch moved inshore to water of 8-10 m depth from deeper offshore wintering grounds (20 m). Spawning occurred in late May, after which adults displayed omnidirectional dispersion.

Food habits of yellow perch in Sandusky Bay were investigated by Tubb (1973), Hartley (1975), Hartley and Herdendorf (1975), and Griswold and Tubb (1977). These studies indicated that yellow perch (primarily yearlings and adults) fed mainly on dipteran larvae, oligochaetes, zooplankton, and fish, particularly emerald shiners and spottail shiners. No other nearshore-specific studies of yellow perch in Lake Erie were located.

WALLEYE

Importance and Status

The walleye has long been an important commercial and game species in Lake Erie. The walleye began to assume major commercial importance after 1900, when declining production of salmonids induced commercial enterprises to concentrate on "second rank" species such as walleye, blue pike, sauger, and yellow perch. The events and processes involved in the development, expansion, and ultimate collapse of the lucrative Lake Erie commercial walleye fishery, which lasted from approximately 1900 to 1960, have been discussed in detail by Regier et al. (1969). The decline in walleye stocks in Lake Erie has been attributed to a combination of overfishing, siltation of spawning areas, obstruction by dams of tributary spawning areas, deterioration of dissolved oxygen regimes in the Central and Eastern Basins, and, speculatively, to predation by rainbow smelt on young-of-the-year (Regier et al., 1969). Although stocks are depleted and commercial walleye fishing has been banned in Ohio and Michigan, under present conditions the walleye is not in imminent danger of biological or commercial extinction and continues to support a popular recreational fishery in the Western Basin and commercial fishing in Ontario, New York, and Pennsylvania (Hartman, 1973).

Life History Literature Sources for Lake Erie

Adamstone (1922): age and growth

Bangham (1972): parasites

Deason (1933): age and growth, maturity and fecundity

Dechtiar (1972): parasites

Ewers (1933): food habits

Ferguson and Derksen (1971): movements

Hohn (1966): food habits

Langlois (1954): general life history

Lawler (1948): age and growth

Leach (1928): maturity and fecundity

Ohio Department of Natural Resources (1971a): movements, spawning areas

Ohio Department of Natural Resources (1971b): movements

Parsons (1970): age and growth, year class contributions to fishery

Parsons (1971): food habits

Parsons (1972): age and growth, maturity and fecundity

Price (1963): food habits

Regier et al., (1969): general life history, history of fishery

Trautman (1957): general life history

Van Vooren and Davies (1974): age, growth, hatching success, recreational and commercial exploitation, seasonal abundance

Van Vooren et al., (1978, 1977, 1976, 1975): age, growth, hatching success, recreational and commercial exploitation, seasonal abundance and distribution

Van Vooren (1978): spawning

Wolfert (1963): movements

Wolfert et al., (1967): parasite B thriocephalus cuspidatus

Wolfert (1969): maturity and fecundity

Wolfert (1977): age and growth, year class contributions to fishery

Relationship to the Nearshore Zone

The walleye is distributed throughout Lake Erie, but it is primarily restricted to the Eastern and Western Basins (Trautman, 1957; Regier et al., 1969). Spawning areas included both tributaries and reefs, but dams or industrial pollution now obstruct most of the tributaries once utilized (i.e., Cuyahoga River, Grand River, Raisin River) (Langlois, 1954). Major spawning areas presently include only offshore reefs of southwestern Lake Erie and the Sandusky River and Maumee River (Regier et al., 1969).

Actual spawning probably occurs only incidentally in the nearshore zone as delineated in this report, but spawning runs of walleye must traverse and concentrate in the nearshore zone enroute to the Sandusky and Maumee Rivers. Walleye spawning areas in the Eastern Basin are not recorded in the literature. Spawning areas consisted of rock and rubble, and the spawning season began as early as March 31 and as late as April 15, depending on water temperature. However, spawning normally began during the second week of April and peaked during the third week of that month (Van Vooren, 1978).

After spawning, adult walleye in the Western Basin were thought to move gradually offshore and eastward along the northern and southern shores of Lake Erie, (Ferguson and Derksen, 1971). However, contrary data indicated that significant numbers of post-spawning adults moved westward into the Detroit River, Lake St. Clair, and the St. Clair River (Van Vooren, 1978; Ohio Department of Natural Resources, 1971a; Wolfert, 1963). Juvenile walleyes moving out of spawning areas showed a tendency to concentrate along the lakeshore between Maumee Bay and Sandusky Bay and between the Raisin River and the mouth of the Detroit River (Parsons, 1972). There was also a tendency for Age 0 - Age I walleyes to move westward from spawning areas in the Western Basin toward the Michigan shore and into the Detroit River, Lake St. Clair, and St. Clair River (Wolfert, 1963). Some juveniles found in the Western Basin apparently originated from the Thames River spawning ground in Ontario (Lake St. Clair drainage) and gradually returned to the Thames at maturity (Ferguson and Derksen, 1971; Wolfert, 1903; Van Vooren, 1978). The nearshore zone functions as a migration corridor, spawning concentration area, nursery area, spawning ground of indeterminate significance, and as adult habitat of walleyes.

Nearshore-Specific Studies

The Ohio Department of Natural Resources maintains nearshore trawling and gill netting stations in the Western and Central Basins for annual stock assessments of walleye and other species (Van Vooren et al., 1978, 1977, 1976, 1975; Van Vooren and Davies, 1974). These stations are shown in Figure 2. Few studies have been targetted specifically at relationships of the walleye to the nearshore zone, although the spawning and migration studies of Van Vooren (1978), Parsons (1972), Ferguson and Derksen (1971), Ohio Department of Natural Resources (1971a, 1971b), and Wolfert (1963) are generally applicable to the nearshore zone.

SAUGER

Importance and Status

Sauger were relatively abundant in western Lake Erie prior to 1900, although they did not become important in commercial landings until 1915 (Deason, 1933; Trautman, 1957; Van Meter and Trautman, 1970; Hartman, 1973). Thereafter a steady decline in commercial production occurred until the species was commercially extinct by 1960 (Hartman, 1973; Regier et al., 1969). Overfishing, siltation of spawning areas, damming of streams used for spawning, and cultural pollution are the major factors thought to have contributed to the decline, and introgressive hybridization with the numerically dominant walleye may ultimately have eliminated the pure sauger strain from Lake Erie. The sauger also furnished an important sport fishery until 1963 (Doan, 1944; Keller, 1964). The Ohio Department of Natural Resources is attempting to reestablish the sauger in the Western Basin (Rawson and Scholl, 1978).

Life History Literature Sources for Lake Erie

Langlois (1954): general life history

Deason (1933): growth (native sauger)

Dechtiar (1972): parasites (native sauger)

Doan (1944): recreational fishery (native sauger)

Doan (1941, 1942): abundance related to meterological and limnological variables (native sauger)

Ewers (1933): food habits (native sauger)

Langlois (1954): general life history

Rawson and Scholl (1978): distribution, growth, food habits, fecundity, spawning areas, movements, recreational harvest, interactions with walleye (introduced sauger)

Relationship to the Nearshore Zone

Native sauger were most abundant in the Western Basin of Lake Erie, preferring shallower and more turbid waters than the walleye (Trautman, 1957). Recently introduced sauger, released as fry and fingerlings into lower Sandusky Bay between 1974 and 1976, became distributed along the entire shore of the Western Basin, particularly along the shoreline between Sandusky Bay and Monroe, Michigan. Areas of apparent heaviest concentration included Sandusky Bay, the Sandusky River, Maumee Bay, and the vicinity of Locust Point (Ottawa County, Ohio). Spawning concentrations of mature sauger occurred in late March and early April along shale ridges and sand-gravel substrates in the Sandusky River and along cobble-boulder riffles in the Maumee River. Bottom areas composed predominantly of mud were apparently not utilized for spawning. Saugers apparently matured at two years, and growth rates surpassed those of native sauger. Sauger remained in the more turbid nearshore areas of the Western Basin after spawning, and were apparently segregated from walleye except in the two river spawning areas. Successful natural reproduction has been documented by the capture of 1977 year class sauger. Angler harvest of saugers was heaviest in Sandusky Bay, the Sandusky River, and the Maumee River (Rawson and Scholl, 1978). The sauger is evidently more nearshore-oriented and prefers more turbid waters than the walleye, although it is numerically inferior to the walleye in the nearshore zone.

Nearshore-Specific Studies

Beyond distribution records, no nearshore-specific studies of sauger in Lake Erie were located. However, Rawson and Scholl's (1978) report is primarily applicable to the nearshore zone.

FRESHWATER DRUM

Importance and Status

The freshwater drum is abundant and widespread throughout Lake Erie, and it is believed to be increasing in abundance (Van Meter and Trautman, 1957). Although traditionally held in low esteem by sport and commercial fishermen in Lake Erie, the value of the drum as a commercial species is increasing. Between 97 and 99 percent of Great Lakes drum landings are from Lake Erie (Metcalf, 1978).

Life History Literature Sources for Lake Erie

Bangham (1972): parasites

Daiber (1950, 1952, 1953): age, growth, maturity, spawning, food habits

Dechtiar (1972): parasites

Edsall (1967): age, growth, maturity, spawning

Foell (1974): age and growth

Griswold and Tubb (1977): food habits

Hartley and Herdendorf (1975): food habits (same in Hartley, 1975)

Langlois (1954): general life history

Larmoyeux (1951): age and growth

Metcalf (1978): live-hauling experiments

Price (1963): food habits

Trautman (1957): general life history

Tubb (1973): food habits

Van Oosten (1938): age and growth

Relationship to the Nearshore Zone

The adult freshwater drum inhabits a wide range of depths and bottom types in Lake Erie, but it is especially common in the shallower waters of the Western Basin. It is common along the entire shoreline and in almost all embayments and river mouths (Trautman, 1957). The drum inhabits both clear and turbid waters (Trautman, 1957; Daiber, 1950). The exact habitats and locations where spawning occurs are unknown, but spawning in Lake Erie is thought to occur in diverse habitats including bays, tributaries, and in the open lake over sand or mud bottoms to a depth of about 2 m (Daiber, 1953). Pelagic eggs are produced. The spawning period in Lake Erie has been placed from early June to mid-September (Daiber, 1953; Edsall, 1967). Young-of-the-year are ubiquitous in distribution, being found in bays and tributaries as well as in the deeper waters of the open lake.

Nearshore-Specific Studies

Food habits of freshwater drum in Sandusky Bay were studied by Tubb (1973) and Griswold and Tubb (1977) and Hartley and Herdendorf (1975). Freshwater drum in the bay fed primarily on dipteran larvae, oligochaetes, zooplankton, and small fish. Some of the drum examined in the studies of Daiber (1950, 1952, 1953) were collected in the nearshore zone, specifically from the mouths of Sandusky Bay and the Portage River. Foell (1974) used drum from the nearshore zone at Cleveland for age and growth studies, and Metcalf's (1978) live-hauling study was conducted in Sandusky Bay.

GENERAL

The preceeding species accounts have dealt with species for which some detailed life history data exists relative to Lake Erie. Other species found regularly in the nearshore zone of Lake Erie (Table 1) have not been intensively studied in the Lake Erie basin. In general, the only data available pertaining to these species in Lake Erie are distribution records and estimates of relative abundance. Such data, along with general descriptive life histories, were compiled by Langlois (1954), Trautman (1957), Van Meter and Trautman (1970), and Scott and Crossman (1973). The following discussions summarize available information on habitat associations, interspecific relationships, and endangered and threatened species, as pertains to the nearshore zone of Lake Erie.

Habitat Associations of Fishes in the Nearshore Zone

The distribution and abundance of fishes in the nearshore zone is not uniform. Rather, certain species or assemblages of species are restricted to one or more distinct habitat types, while other species or assemblages of species are relatively ubiquitous. The habitat preferences of most species in Lake Erie are generally well known, so that the occurrence and relative abundance of most species in a previously unsampled area can be predicted with some confidence.

The principal division of habitat types in the nearshore zone is sheltered habitats versus unsheltered habitats in relation to wave action. Unsheltered habitats generally consist of beach or bluff areas subject to direct impact of waves from the open lake, whether on a constant or intermittent basis. Few coastal areas in Lake Erie are entirely sheltered from lake waves, the exceptions being narrow inlets, estuaries, artificial harbors, and areas protected by barrier reefs or bars. Nearshore areas in the vicinity of projecting peninsulas, points, or artificial structures may lie to leeward of prevailing winds and thus be sheltered most of the time, although shifts in wind direction may intermittently expose them. Although unsheltered nearshore areas are extensive, they are relatively unstructured habitats and do not support a diverse fish fauna. Cover is generally minimal, vegetation usually absent, and bottoms are composed of hard substrates such as bedrock, cobbles, boulders, gravel, sand, or hard clay. Species which are currently common to abundant in the most exposed of such habitats include alewife, gizzard shad, coho salmon (locally), chinook salmon (locally), rainbow (steelhead) trout (locally), rainbow smelt, emerald shiner, spottail shiner, longnose dace (locally), white sucker, shorthead redhorse, longnose sucker (locally), channel catfish, stonecat, burbot, trout-perch, white bass, logperch, yellow perch, walleye, freshwater drum, and mottled sculpin. In addition to the above species, several species are common to abundant in generally unsheltered areas provided a certain amount of structure (e.g., reefs, boulder fields, rip-rap shore, or land projections to windward) is present to provide cover and interrupt waves. Such species include sand shiner, mimic shiner, brindled madtom, rock bass, green sunfish, smallmouth bass, johnny darter, and brook silverside, all of which are also common in swiftly-flowing streams. Several other species were also common in unsheltered nearshore habitats but are now depleted due to overfishing or siltation of clean sand or gravel bottoms. These species included silver lamprey, lake sturgeon, lake herring, lake whitefish, lake trout (Eastern Basin), mooneye, silver chub, eastern sand darter, channel darter, and sauger (Langlois, 1954; Trautman, 1957; Van Meter and Trautman, 1970; Nash, 1950; Horner, 1958).

Sheltered nearshore habitats include inlets, estuaries, artificial harbors, wetlands, and areas protected by barrier bars. Most such areas are located in the Western Basin. Although the extent of such areas is limited on a lakewide basin, the diversity of habitats and species in these areas is great. Sheltered nearshore habitats can be classified as vegetated or unvegetated, hard-bottom or soft-bottom, and lentic or lotic. Most species found in unsheltered nearshore habitats are also found either perennially or seasonally in sheltered nearshore waters. Most seasonal species are present in greatest abundance during spring and early summer, when they seek sheltered waters for spawning. These seasonal species include silver lamprey, lake sturgeon (rare), alewife, lake herring (rare), lake whitefish (rare), coho salmon (locally), chinook salmon (locally), rainbow (steelhead) trout (locally), rainbow smelt, longnose sucker, shorthead redhorse, channel catfish, white bass, sauger, walleye, yellow perch, and freshwater drum. However, channel catfish, white bass, yellow perch, and freshwater drum generally remain common in sheltered waters throughout the year, while the abundance of the other species is highly seasonal (Langlois, 1954; Trautman, 1957; Nash, 1950; Harner, 1958).

Among the species perennially common in sheltered nearshore habitats are those which are generally associated with aquatic vegetation. Vegetation-dependent species which require clean sand or gravel bottoms include lake chubsucker and tadpole madtom. Vegetation-dependent species which tolerate a variety of bottom types as long as turbidity is minimal include spotted gar, longnose gar, bowfin, central mudminnow, grass pickerel, northern pike, muskellunge, chain pickerel, goldenshiner, pugnose shiner, pugnose minnow, blackchin shiner, blacknose shiner, yellow bullhead, brown bullhead, banded killifish, brook stickleback, pumpkinseed, black crappie, and Iowa darter. Several species are not largely dependent on vegetation but are extremely common in shallow, turbid waters with soft bottoms and abundant aquatic vegetation. These species include carp, goldfish, gizzard shad, white sucker, black bullhead, and white crappie. Several other species are also not dependent on vegetation but are often associated with aquatic vegetation in clear, shallow waters with sand or gravel bottoms. These species include white sucker, stonecat, rock bass, smallmouth bass, green sunfish, eastern sand darter, johnny darter, logperch, and yellow perch (Langlois, 1954; Trautman, 1957; Nash, 1950).

Sheltered, unvegetated nearshore waters also support a variety of species. Several species, including white sucker, carp, goldfish, gizzard shad, bluntnose minnow, emerald shiner, spottail shiner, quillback, black bullhead, channel catfish, white crappie, and freshwater drum are tolerant of a variety of bottom types and turbidity levels, so that they are common in almost all sheltered areas. Other species, such as sand shiner, mimic shiner, silver redhorse, golden redhorse, black redhorse, spotted sucker, stonecat, trout-perch, white bass, rock bass, green sunfish, bluegill, smallmouth bass, largemouth bass, eastern sand darter, greenside darter, fantail darter, johnny darter, yellow perch, logperch, and brook silverside, prefer relatively clear waters and hard bottoms of sand, gravel, or clay. These species may occur in both lentic and lotic waters. Softer bottoms of mud or muck are generally preferred by carp, goldfish, bigmouth buffalo, black bullhead, and flathead catfish (Langlois, 1954; Trautman, 1957; Nahs, 1950).

Many species are relatively ubiquitous in both sheltered and unsheltered waters of the nearshore zone and are generally abundant. These include white sucker, gizzard shad, emerald shiner, spottail shiner, white bass, yellow perch, and freshwater drum. All other species generally occur only in one or two specific habitats. However, it should not be misconstrued that the general outline of habitat associations provided above is strictly definitive. Many species occupy a wide range of habitats and reach their greatest abundance in only one or two. Most species will probably be encountered at some time in habitats to which they are not normally ascribed.

Interspecific Relationships of Nearshore Fishes

Research in the area of interspecific relationships of nearshore fishes is scant. Although habitat associations of nearshore fishes are known and general assemblages of species in particular areas or habitats are identifiable, such data constitute only a general knowledge of associations and not necessarily interactive relationships among species. Food habit studies comprise one type of interactive study (i.e., predation), but these are generally not of sufficient intensity or duration to identify actual relationships. Nash's (1950) and Horner's (1958) studies emphasized statistical evaluation of co-occurrence of species in tributary, nearshore, and offshore habitats and did not investigate actual interrelationships.

Threatened and Endangered Species

Several species listed in Table 1 are officially protected by law in Michigan, Ohio, and Pennsylvania. No fishes listed as threatened or endangered by New York or the U.S. Department of the Interior are generally found in the nearshore zone of Lake Erie. No official list of threatened or endangered fishes has been compiled for Lake Erie by Ontario or the Canadian federal government. However, the same species listed in Michigan, Ohio and Pennsylvania may be unofficially considered threatened or endangered in Canadian waters of Lake Erie. All the threatened and endangered species found in the nearshore zone are generally rare lakewide, except the burbot. Van Meter and Trautman (1970) considered the burbot relatively common in the deeper waters of the Central and Eastern Basins, but it is protected in Ohio because it is infrequently encountered in the shallower waters of that state. The causes of depletion of threatened and endangered fishes are varied. However, siltation, wetland diking and draining, tributary obstruction, and overfishing are considered the principal contributing factors. Species such as the muskellunge, blacknose shiner, pugnose minnow, banded killifish, and Iowa darter are extremely dependent on clear waters and abundant aquatic vegetation, whereas lakerun species such as the silver lamprey, lake sturgeon, and longnose sucker were dependent on clear water and unobstructed tributaries for spawning. Since lists of threatened and endangered species are periodically revised, the Michigan Department of Natural Resources, Ohio Department of Natural Resources, Pennsylvania Fish Commission, and New York State Department of Environmental Conservation should be consulted for current listings if work involving such species is being contemplated.

SITE-SPECIFIC STUDIES

A few areas in the nearshore zone of Lake Erie have been intensively studied with respect to fishes from a site-specific rather than a population-specific standpoint. Most of these studies have been of a general survey nature with specific short-term objectives, such as biological impact assessment of intake impingement and entrainment, heated water discharges, harbor maintenance activities, and construction and operation of coastal facilities such as power plants, marinas, or factories.

The objectives of this areal analysis are (a) an inventory of nearshore-specific fishery studies and in U.S. waters the types of data generated by these studies and (b) a brief discussion of the significance of these data with respect to the nearshore zone fish communities in general. The inventory will proceed westward around the lake beginning at Erie County, New York. A discussion of studies will follow the inventory for each coastal county, group of counties, or area of particular significance (e.g., Sandusky Bay, Maumee Bay), depending on the number of studies within such areas.

ERIE AND CHAUTAUQUA COUNTIES, NEW YORK

Inventory of Studies

The major source of information regarding fish and fisheries in the nearshore zone of Erie County and Chautauqua County, New York, is the general survey of Greeley (1929). This survey provided lists of species utilizing different habitats in the nearshore zone, relative abundance of species, and a discussion of sport and commercial fishing in the nearshore waters. Recent nearshore studies in this area are scarce, although unpublished test-netting data of the New York State Department of Environmental Conservation at Olean may provide some information. Also, unpublished ichthyological collection data of the New York State Museum and the Buffalo Society of Natural Sciences may be consulted to determine species composition and abundance in certain nearshore areas. Exploratory fishing reports of Sand and Gordon (1960), Carr (1964), and Bowman (1974) and ichthyoplankton surveys of Fish (1932) were not specific to the nearshore zone but included nearshore stations and are applicable in determining general composition and species abundance of fish communities in shallow waters of the Eastern Basin of Lake Erie. These surveys are reviewed at the end of this section under the heading "General Surveys". Recent nearshore-specific publications pertaining to fish in New York nearshore waters of Lake Erie include only environmental impact statements regarding dredging and harbor maintenance at Buffalo (U.S. Army Corps of Engineers, 1972) and Dunkirk (U.S. Army Corps of Engineers, 1975d). No direct discussion of fishes was provided in the Buffalo report. Salmonids are stocked in several tributaries and nearshore areas (Table 2) and are seasonally common in the nearshore zone. The above study locations are shown in Figure 3.

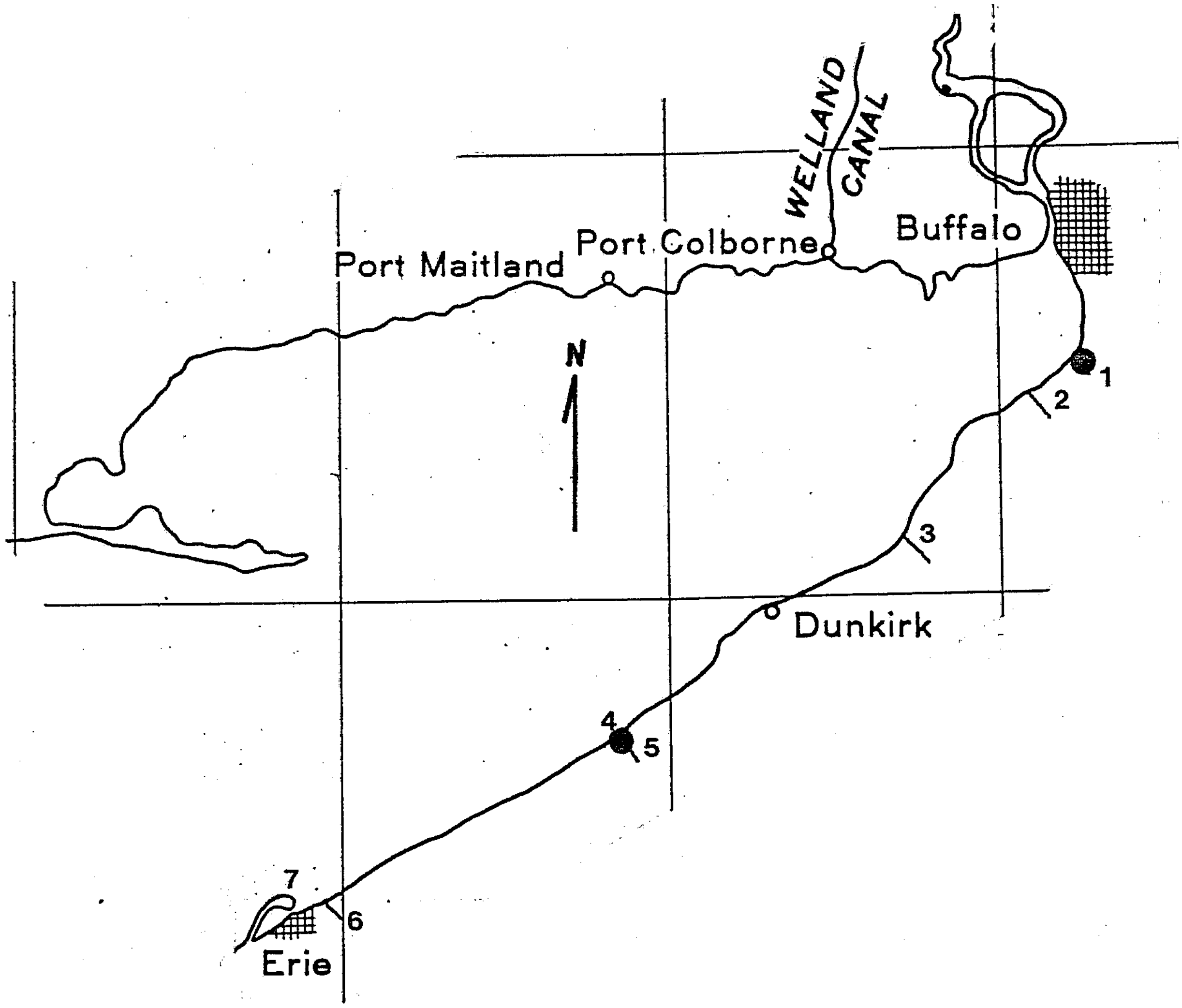

FIGURE 3. LOCATION MAP FOR NEARSHORE-SPECIFIC FISH STUDIES IN THE EASTERN BASIN OF LAKE ERIE (Key follows Figure 5)

Analysis

This two-county area comprises most of the U.S. nearshore zone of the Eastern Basin. Published information regarding the nearshore fish community of the area is scarce, and the most extensive report (Greeley, 1929) is dated. Both published and unpublished data are of a general survey nature and provide information pertaining to species composition and relative abundance in the nearshore zone, but detailed data pertaining to population or community ecology and dynamics in the nearshore zone appear to be lacking. The effects of environmental change on the nearshore fish community have not been documented. However, comparison of current unpublished data with those of Greeley (1929) would make such an evaluation possible.

Early in this century (Greeley, 1929) lake trout, lake whitefish, lake herring, spottail shiner, trout-perch, walleye, yellow perch, white bass and freshwater drum were the numerically dominant species in unsheltered nearshore habitats along Erie and Chautauqua counties. At present, yellow perch, rainbow smelt, alewife, freshwater drum, carp, gizzard shad, and white bass appear to be the numerically dominant species in such habitats (Bowman, 1974). Also, early in this century (Greeley, 1929) the following species were common to abundant in sheltered nearshore habitats of the area: lognose gar, quillback, white sucker, golden redhorse, shorthead redhorse, carp, goldfish, spottail shiner, sand shiner, goldenshiner, bluntnose minnow, channel catfish, brown bullhead, stonecat, northern pike, white bass, trout-perch, yellow perch, walleye, sauger, johnny darter, largemouth bass, smallmouth bass, pumpkinseed, rock bass, and freshwater drum. At present, published data on the fishes of sheltered habitats is lacking, except for Dunkirk Harbor. The latter is a highly impacted area and is probably not typical of less heavily utilized estuaries and embayments. The numerically dominant species in Dunkirk Harbor were carp, gizzard shad, white sucker, and walleye (probably seasonal). Also present were lesser numbers of northern pike, muskellunge, redhorse (unidentified), bullhead (unidentified), channel catfish, coho salmon, brown trout, rainbow trout, yellow perch, rock bass, smallmouth bass, white bass, and freshwater drum (U.S. Army Corps of Engineers, 1975d).

ERIE COUNTY, PENNSYLVANIA

Inventory of Studies

The only published nearshore-specific fish study that was located for Erie County, Pennsylvania was Baker (1974), in which a qualitative list of species from the Presque Isle vicinity was provided. Unpublished test-netting data of the Pennsylvania Fish Commission in Fairview may be consulted for information on species composition and relative abundance in Lake Erie nearshore waters of the state. Several ichthyoplankton sampling stations of Fish(1932) and exploratory trawling stations of Sand and Gordon (1960), Carr (1964), and Bowman (1974) were located in the nearshore zone of Erie County, Pennsylvania, but the discussions of results of these surveys were not nearshore-specific. The above locations are shown in Figure 4. Salmonids are stocked in several tributaries in Erie County and seasonally common in adjacent nearshore areas (Table 2).

Analysis

Historical data regarding fish communities in the nearshore zone of Erie County, Pennsylvania is lacking. At present, the unsheltered beach areas of the nearshore zone are probably dominated by rainbow smelt, yellow perch, freshwater drum, and alewife (Carr, 1964; Bowman, 1974). Salmonids are stocked in several nearshore areas (Table 2) and are seasonally common in the nearshore zone. Estuaries probably support a more diverse fish fauna than unsheltered areas, but documentation is lacking for such areas. Fishes found in the Presque Isle vicinity included gizzard shad, alewife, rainbow trout, coho salmon, chinook salmon, rainbow smelt, spottail shiner, emerald shiner, carp, goldfish, bluntnose minnow, quillback, white sucker, shorthead redhorse, channel catfish, brown bullhead, stonecat, trout-perch, bluegill, pumpkinseed, rock bass, largemouth bass, smallmouth bass, johnny darter, logperch, yellow perch, walleye, and freshwater drum (Baker, 1974).

ASHTABULA COUNTY, OHIO

Inventory of Studies

Trautman (1957) provided general distributional information for fishes in coastal waters of Ashtabula County. Recent site-specific fishery studies in the nearshore zone of Ashtabula County include only a survey of fishes in Conneaut Harbor and vicinity for the U.S. Steel Lakefront Plant (Aquatic Ecology Associates, 1977, 1978), cursory comments on the fishes and fishery of Ashtabula Harbor in relation to harbor dredging (U.S. Army Corps of Engineers, 1975b, 1975c), and impingement and entrainment studies at the Ashtabula A, B, and C Plants operated by the Cleveland Electric Illuminating Company (Applied Biology, Inc., 1977). These sites are shown in Figure 4. Sources of unpublished data for this area include the Ohio Department of Natural Resources, Division of Wildlife, at Akron and Sandusky, the Ohio State University Museum of Zoology, and John Carroll University Department of Biology. Salmonids are stocked in several tributaries and nearshore areas (Table 2) and are seasonally common in such areas.

Analysis

Recent aquatic ecological surveys for the United States Steel Lakefront Plant at Conneaut indicated the presence of adults of the following fish species in the harbor and adjacent nearshore waters: longnose gar, gizzard shad, alewife, mooneye, rainbow trout, brown trout, coho salmon, chinook salmon, rainbow smelt, white sucker, golden redhorse, shorthead redhorse, black redhorse, northern hogsucker, quillback, carp, goldfish, emerald shiner, spottail shiner, striped shiner, mimic shiner, sand shiner, longnose dace, rosyface shiner, bluntnose minnow, fathead minnow, brook silverside, channel catfish, stonecat, trout-perch, white bass, rock bass, smallmouth bass, white crappie, yellow perch, walleye, logperch, and mottled sculpin. The most abundant species were yellow perch, freshwater drum, spottail shiner, emerald shiner, rainbow smelt, trout-perch, gizzard shad, and white bass. Data relevant to age and growth, spatial distribution, seasonal abundance, maturity and sex ratios, and food habits were collected during the survey. However, the survey is not completed and detailed analysis of these data is not yet possible. Ichthyoplankton were also surveyed, and the species collected as larvae or eggs included gizzard shad, rainbow smelt, carp, longnose dace, white sucker, channel catfish, trout-perch, rock bass, smallmouth bass, greenside darter, rainbow darter, yellow perch, logperch, freshwater drum, and unidentified specimens of minnow, bullhead, sucker, sunfish, crappie, darter, and sculpin. Many ichthyoplankton found in nearshore waters originated in Conneaut Creek, Turkey Creek, and Raccoon Creek. The most abundant ichthyoplankton in the nearshore zone were freshwater drum, gizzard shad rainbow smelt, unidentified minnow, logperch, and trout-perch. In general, eggs were more numerous at the surface in both day and night collections, while larvae were more abundant at the surface during the day and at bottom during the night. Larvae increased in abundance during spring to a peak in late June. However, the ichthyoplankton survey is not completed and detailed analysis of these data is not yet possible (Aquatic Ecology Associates, 1977, 1978).

There have been no extensive fishery studies in Ashtabula Harbor, although Dr. Andrew M. White, John Carroll University, Cleveland, has surveyed the area. A list of fishes expected to be present in Ashtabula Harbor, but not actually documented, was presented by the U.S. Army Corps of Engineers (1975b). Local fishermen reported catches of yellow perch, freshwater drum, channel catfish, coho salmon, and minnows in the harbor area (U.S. Army Corps of Engineers, 1975c).

Impingement and entrainment of fish has been monitored at the Ashtabula A, B, and C power plants operated by the Cleveland Electric Illuminating Company. Results at each plant were similar. Major species impinged were rainbow smelt, freshwater drum, emerald shiner, spottail shiner, and trout-perch. Other species impinged included longnose gar, gizzard shad, coho salmon, carp, goldfish, fathead minnow, quillback, white sucker, channel catfish, black bullhead, brown bullhead, yellow bullhead, stonecat, white bass, largemouth bass, smallmouth bass, green sunfish, pumpkinseed, bluegill, rock bass, yellow perch, and logperch. Impingement was greatest during spring, supposedly due to inshore movement of fish for spawning. Entrainment of larvae was greatest during June-July, and the major species entrained were freshwater drum, rainbow smelt, carp, spottail shiner, and emerald shiner. Species entrained in minor numbers included gizzard shad, unidentified clupeids, unidentified suckers, logperch, trout-perch, crappies (generic), yellow perch, mottled sculpin, gizzard shad, and alewife. Impingement and entrainment were relatively low (Applied Biology, Inc., 1977).

LAKE COUNTY, OHIO

Inventory of Studies

Trautman (1957) provided general discussions of distribution, abundance, and life histories of fishes found in the nearshore zone of Lake County. The lakewide exploratory fishery surveys of Carr (1964), Sand and Gordon (1960), and Bowman (1974) were confined primarily to offshore sites, but Carr included several nearshore sites in Lake County. Sources of unpublished data documenting the fish fauna in this area include the Ohio Department of Natural Resources, Division of Wildlife, at Sandusky and Akron, the Cleveland Museum of Natural History, the John Carroll University Department of Biology, and the Ohio State University Museum of Zoology. Nearshore-specific fish studies in Lake County included the site survey for a proposed nuclear power plant near Perry (Cleveland Electric Illuminating Company, 1973), a diked disposal impact assessment for Fairport Harbor (U.S. Army Corps of Engineers, 1975a), and fishery survey to assess the biological effects of operating the Eastlake Electric Generating Station of the Cleveland Electric Illuminating Company (Aquatic Ecology Associates, 1976). These sites are shown in Figure 4. Salmonids have been stocked in the Chagrin River and are seasonally abundant in that vicinity (Table 2).

Analysis

The most abundant fish species in the unsheltered nearshore area of Lake County appear to be alewife, gizzard shad, carp, white sucker, trout-perch, spottail shiner, yellow perch, walleye, white bass, and freshwater drum. At least 13 other species occurred and were listed by Aquatic Ecology Associates (1976) and Cleveland Electric Illuminating Company (1973). Data regarding community diversity, biomass, age, and growth of fishes in the Eastlake vicinity were presented by Aquatic Ecology Associates (1976). Within Fairport Harbor moderate to heavy sport fishing occurs from boats and shore. The principal species taken by anglers were yellow perch, walleye, white bass, freshwater drum, rainbow (steelhead) trout, and coho salmon (U.S. Army Corps of Engineers, 1975a). Specific sites of disturbance which may have impacts on the nearshore fish community are the intake and discharge of the Eastlake Electric Generating Station and harbor dredging in Fairport Harbor. Aquatic Ecology Associates (1976) reported that the thermal plume of the Eastlake Electric Generating Station crossed the mouth of the Chagrin River, but that the heated waters were confined to the surface and probably had little effect on fish migrations into and out of the Chagrin River. The restriction of harbor maintenance activities to time periods other than the spring spawning period was believed to minimize the impact of such activities on spawning runs of fishes into the Grand River via Fairport Harbor (U.S. Army Corps of Engineers, 1976a). Other impact areas of less apparent consequence exist in the nearshore zone of Lake County but have not been reported in the literature.

CUYAHOGA COUNTY, OHIO

Inventory of Studies

Trautman (1957) provided general discussions of distribution, abundance, and life histories of fishes found in the nearshore zone of Cuyahoga County. Carr (1964) included one nearshore site in the vicinity of Cleveland in his report of lakewide exploratory fishing surveys. Sources of unpublished data documenting the fish fauna in this area are the same as those listed for Lake County. Impingement and entrainment of fishes are monitored at the Lakeshore Electric Generating Plant of the Cleveland Electric Illuminating Company (Applied Biology, Inc., 1977). White et al. (1975) conducted an extensive survey of fishes in the Cleveland vicinity, including both tributaries and nearshore waters. The fishes of Cleveland Harbor have been discussed by the

U.S. Army Corps of Engineers (1976a, 1976b), in conjunction with harbor maintenance, dredging, and modification activities, and by the New York State University College at Buffalo (1975), in connection with proposed construction of an airport in the harbor area. These locations are shown in Figure 4. Salmonids have been stocked in the Cuyahoga River, although that stocking site has not been utilized recently (Table 2).

Analysis

Fishes of the nearshore waters of Lake Erie in the vicinity of Cleveland have been relatively well-surveyed. Impingement and entrainment of fish has been monitored at the Lakeshore Electric Generating Plant in Euclid, operated by the Cleveland Electric Illuminating Company. The most abundant species impinged at the plant were rainbow smelt, freshwater drum, trout-perch, shiners (emerald and spottail), gizzard shad, white bass, and yellow perch. All other species collected comprised less than 0.3% by number and included coho salmon, carp, goldfish, channel catfish, pumpkinseed, bluegill, rock bass, black crappie, white crappie, walleye, and logperch. The greatest numbers of fish were impinged during spring, supposedly due to inshore movement of fish for spawning. Entrainment of larvae was consistently low, with entrainment of eggs being higher and peaking in May-June. Carp and gizzard shad predominated as both eggs and larvae in entrainment samples. Other larvae entrained included trout-perch, shiners (emerald or spottail), and logperch (Applied Biology, Inc., 1977).

An extensive survey of fishes by White et al. (1975) in the Cleveland vicinity, including both nearshore waters and tributaries, cannot be reviewed in detail here. In summary, at least 48 species are encountered in the nearshore waters in the Cleveland area (Table 3). Twenty-five species are presently common to abundant in the area, although most of the species were at one time more abundant than at present. Changing environmental conditions in the Cleveland area, together with overfishing of some species, have caused declines of many species. Factors affecting local fish populations were (a) stream obstructions, (b) elimination of wetlands by draining and ditching, (c) siltation, (d) organic pollutants, (e) inorganic pollutants, (f) nutrient enrichment, (g) litter, (h) over-exploitation of fish populations, and (i) introduction of exotic species. These factors are common to most areas of Lake Erie and have been discussed in detail by Trautman (1957) and Hartman (1973). Three principal nursery areas occurred along the Lake Erie shoreline in the Cleveland area, the most important of which was the lower Rocky River and adjacent shoreline, followed by the mouth and adjacent shoreline of the Chagrin River and Cleveland Harbor and adjacent marinas. Young-of-the-year of many species were collected in these areas and were listed in the report. Goldfish, pumpkinseed, largemouth bass, and yellow perch were documented spawning in Cleveland Harbor during 1972-1974 . Yellow perch was the most abundant commercial and game species in the Cleveland nearshore area (White et al., 1975).

The Cleveland Harbor is divided into the outer lakefront harbor and the inner Cuyahoga River harbor. In general, the inner harbor is affected by severely polluted Cuyahoga River waters and few species utilize the area, the only permanent residents being the goldfish and spottail shiner (U.S. Army Corps of Engineers, 1976b). The outer harbor supports a greater diversity of fishes. The numerically dominant species in the outer harbor were

TABLE 3

FISHES COLLECTED IN NEARSHORE WATERS OF LAKE ERIE IN THE CLEVELAND VICINITY[1]

Family and Common Name	Status
Petromyzontidae	
silver lamprey	rare
sea lamprey	rare
Lepisosteidae	
longnose gar	uncommon
Amiidae	
bowfin	uncommon
Clupeidae	
alewife	common
gizzard shad	extremely abundant
Salmonidae	
chinook salmon	seasonally common
coho salmon	seasonally common
rainbow trout	uncommon
Osmeridae	
rainbow smelt	seasonally abundant
Percopsidae	
trout-perch	seasonally abundant
Gadidae	
burbot	rare
Percichthyidae	
white bass	abundant
Centrar hidae	
white crappie	common
black crappie	uncommon
rock bass	common
smallmouth bass	uncommon
largemouth bass	common
bluegill	common
pumpkinseed	abundant
Esocidae	
northern pike	rare
Cyprinidae	
carp	abundant
goldfish	abundant
goldenshiner	locally common
longnose dace	rare
pugnose minnow	rare
emerald shiner	abundant
spottail shiner	uncommon
sand shiner	uncommon
mimic shiner	rare
bluntnose minnow	abundant
quillback	rare
golden redhorse	common
shorthead redhorse	rare
white sucker	abundant
Ictaluridae	
channel catfish	uncommon
yellow bullhead	common
brown bullhead	common
black bullhead	common
stonecat	common
Atherinidae	
brook silverside	rare
Sciaenidae	
freshwater drum	abundant
Percidae	
walleye	rare
yellow perch	abundant
log perch	rare
johnny darter	rare
greenside darter	rare
Cottidae	
mottled sculpin	rare

[1] White et al. (1975)

TABLE 4

COMPARISON OF FISH SPECIES ABUNDANCE IN SANDUSKY BAY, 1830-1975

1830[1]	1940[2]	1975[3]
(Species listed in decreasing abundance)		
White Bass	White crappie	Gizzard shad
Walleye	White bass	Yellow perch
Northern pike	Gizzard shad	White bass
Channel catfish	Carp and Goldfish	Carp and Goldfish
Largemouth bass	Bullheads	White crappie
Muskellunge	Freshwater drum	Bullheads
	Channel catfish	Freshwater drum
	Black crappie	Channel catfish
		Walleye

1 Klippart (1877)
2 Edminster (1940)
3 Hartley and Herdendorf (1975)

alewife, gizzard shad, goldfish, spottail shiner, bluntnose minnow, emerald shiner, goldenshiner, white sucker, rainbow smelt, trout-perch, pumpkinseed, yellow perch, and freshwater drum. Other less abundant species were listed, and seasonal abundance, larvae distribution, spawning areas, food habits, sport fishing, and commercial fishing have been discussed (New York State University College at Buffalo, 1975; U.S. Army Corps of Engineers, 1976a).

LORAIN COUNTY, OHIO

Inventory of Studies

Trautman (1957) and McCormick (1890, 1892) provided general discussions of distribution, abundance, and life histories of fishes found in the nearshore zone of Lorain County. The lakewide exploratory fishing surveys of Fish (1932), Carr (1964), Bowman (1974), and Sand and Gordon (1960) were confined primarily to offshore sites, but their data from shallower stations adjacent to Lorain County may apply to the nearshore fish community. Sources of unpublished data documenting the fish fauna in this area include the Ohio Department of Natural Resources, Division of Wildlife, at Sandusky and Akron, the Cleveland Museum of Natural History, the John Carroll University Department of Biology, the Ohio State University Museum of Zoology, and the U.S. Fish and Wildlife Service Lake Erie Laboratory in Sandusky. Nearshore-specific fish studies (Figure 4) in Lorain County included only a survey of the nearshore zone in the vicinity of the Avon Lake Electric Generating Station, operated by the Cleveland Electric Illuminating Company (Applied Biology, Inc., 1977; Aquatic Ecology Associates, 1976).

Analysis

The most abundant species in the unsheltered nearshore beach areas of Lorain County, as extrapolated from the surveys of Avon Lake, appear to be gizzard shad, alewife, emerald shiner, spottail shiner, carp, yellow perch, walleye, freshwater drum, white bass, stonecat, and coho salmon. The sea lamprey, chinook salmon, rainbow smelt, northern pike, goldfish, fathead minnow, goldenshiner, creek chub, quillback, white sucker, shorthead redhorse, golden redhorse, yellow bullhead, channel catfish, trout-perch, rock bass, black crappie, white crappie, smallmouth bass, green sunfish, bluegill, and mottled sculpin are also present in lesser numbers. Data regarding community diversity, biomass, age, and growth of several species were also collected in the Avon Lake surveys. It was believed that the thermal discharge of the power plant had no adverse effects on the nearshore fish community. Several species were impinged in the power plant intake: rainbow smelt, freshwater drum, emerald shiner, spottail shiner, and several other species comprising less than ten percent of the number of fish impinged. Major species entrained as larvae were shiners (unidentified emerald or spottail shiners) and clupeids (unidentified alewife or gizzard shad). Impingement and entrainment results were preliminary, and no assessment of the impacts on the fish community was made (Applied Biology, Inc., 1977; Aquatic Ecology Associates, 1976).

ERIE COUNTY, OHIO (EXCLUSIVE OF SANDUSKY BAY)

Inventory of Studies

Trautman (1957) provided general discussions of distribution, abundance, and life histories of fishes found in the nearshore zone of Erie County. The lakewide exploratory fishing surveys of Carr (1964), Bowman (1974), and Sand and Gordon (1960) were confined primarily to offshore sites, but their data from shallower stations adjacent to Erie County may apply to the nearshore fish community. Sources of unpublished data documenting the fish fauna of this area include the Ohio Department of Natural Resources, Division of Wildlife, at Sandusky and Findlay, the Ohio State University Museum of Zoology, and the U.S. Fish and Wildlife Service Lake Erie Laboratory in Sandusky. Nearshore-specific fish studies in Erie County included the site survey and environmental impact statement for a proposed Erie Nuclear Power Plant (U.S. Nuclear Regulatory Commission, 1977), and environmental impact statements pertaining to harbor maintenance and navigation in Huron Harbor (U.S. Army Corps of Engineers, 1974, 1975e). These locations are shown in Figure 4. Salmonids have been stocked in the Huron River (Table 2).

Analysis

Unsheltered nearshore habitats in Erie County are apparently dominated (i.e. greater than ten percent combined catch of seines, trout, and gillnets) by alewife, gizzard shad, carp, emerald shiner, white bass, yellow perch, and freshwater drum. Other less numerous species in these unsheltered areas include sea lamprey, lake sturgeon, bowfin, coho salmon, chinook salmon, rainbow smelt, goldfish, carp x goldfish hybrids, spotfin shiner, silver chub, spottail shiner, sand shiner, silverjaw minnow, quillback, white sucker, northern hogsucker, golden redhorse, shorthead redhorse, channel catfish, stonecat, trout-perch, brook silverside, rock bass, bluegill, white crappie, black crappie, smallmouth bass, walleye, and logperch. Spatial distribution of adult fish at 5-m and 8-m depths was compared, indicating in general a greater abundance of spottail shiner, gizzard shad, white bass, and channel catfish at 5-m than at 8-m and a greater abundance of yellow perch and freshwater drum at 8-m than 5-m. Yellow perch and spottail shiner were more abundant in the nearshore zone during April and May as a result of inshore spawning movements, as were alewives during June and July. Rainbow smelt were more abundant during spring and fall. Icthyoplankton was also sampled in the area. Eggs of two unidentified cyprinids and freshwater drum were most abundant in the area during June and July. All other eggs comprised less than ten percent of the collections and were largely unidentified. The most numerous fish larvae in the area were emerald shiner and unidentified cyprinids. All other larvae comprised less than ten percent of the collections and included, in order of abundance, rainbow smelt, alewife, gizzard shad, clupeids (unidentified alewife or gizzard shad), yellow perch, spottail shiner, carp, logperch, trout-perch, unidentified *Coregonus* sp., white bass, bluegill, unidentified peroids, channel catfish, unidentified suckers, crappies (black and white combined), freshwater drum, and several totally unidentified species. Spawning activity of fishes in the area began in late April and concluded in late August. Peak spawning activity and ichthyoplankton densities occurred in June and July (U.S. Nuclear Regulatory Commission, 1977; U.S. Fish and Wildlife Service, 1977).

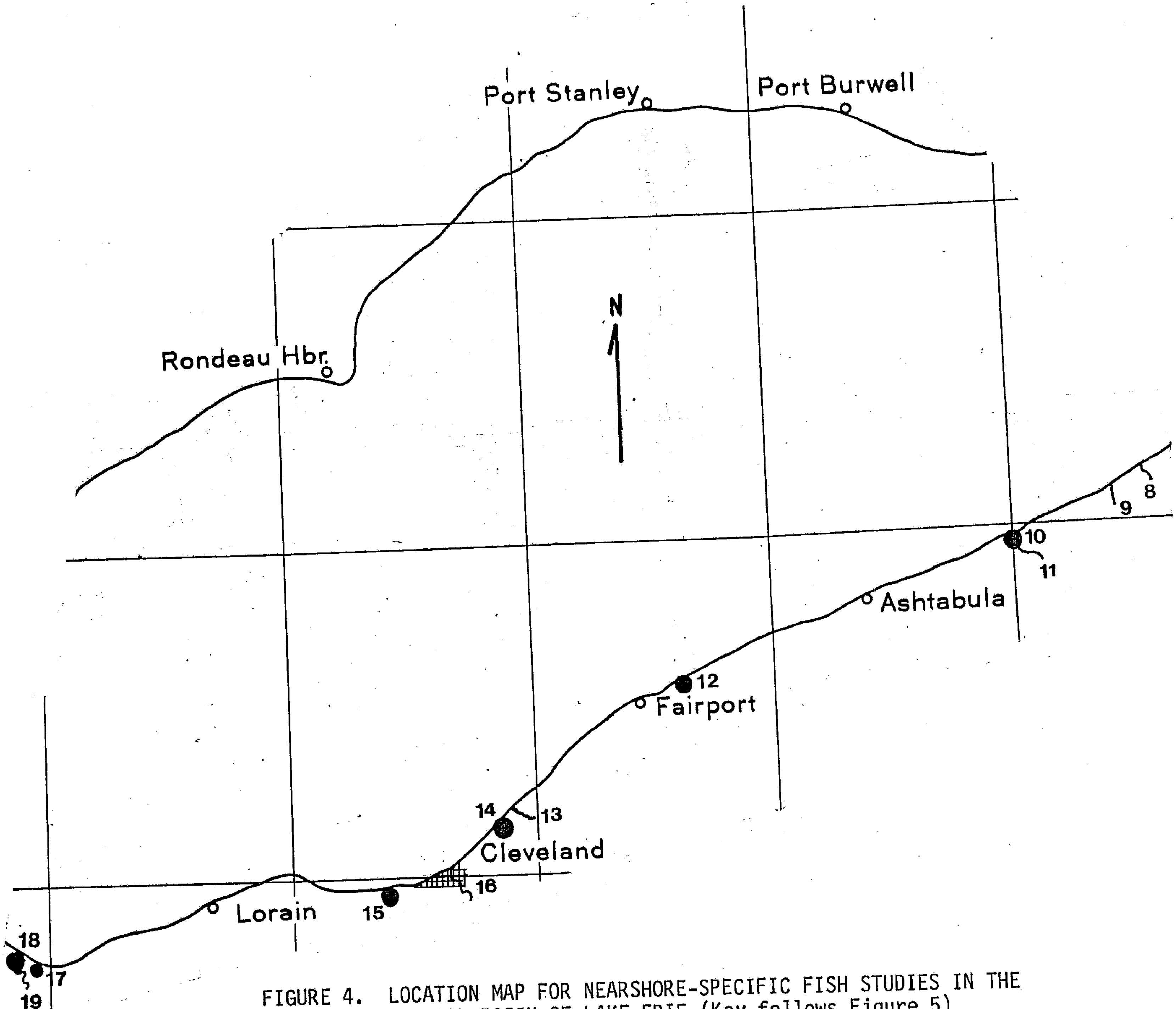

FIGURE 4. LOCATION MAP FOR NEARSHORE-SPECIFIC FISH STUDIES IN THE CENTRAL BASIN OF LAKE ERIE (Key follows Figure 5)

The only sheltered nearshore habitat sampled for fishes, as documented in the literature, has been Huron Harbor. The most abundant species in Huron Harbor were gizzard shad and emerald shiner. Other less abundant species included yellow perch, white bass, freshwater drum, carp x goldfish hybrids, brook silverside northern pike, black crappie, white crappie, spottail shiner, bluegill, pumpkinseed, and stonecat. The fish habitat in Huron Harbor was uniform and generally poor. Little cover existed, and the bottom consisted primarily of mud and silty sand. A limited amount of cover existed adjacent to the east breakwall and was thought suitable for use by yellow perch and centrarchids. The Huron River, Mud Brook, and extensive marshes upstream of the harbor were productive fish habitats and most of the fishes in the harbor were probably feeding or spawning migrants from upstream or the open lake (U.S. Army Corps of Engineers, 1974, 1975e).

SANDUSKY BAY, OHIO

Inventory of Studies

Trautman (1975) and Langlois (1954) provided general discussions of distribution, abundance, and life histories of fishes in Sandusky Bay. The Ohio Department of Natural Resources, Division of Wildlife, annually samples fish by trawl and gill net at index stations in the bay (Van Vooren and Davies, 1974; Van Vooren et al., 1975, 1976, 1977, 1978). The fish and fisheries of Sandusky Bay were reviewed by Hartley (1975) and Hartley and Herdendorf (1975). Previous fishery studies specific to Sandusky Bay were reported by Klippart (1877), Edmister (1940), Chapman (1955), Tubb (1973), Willis (1974), Center for Lake Erie Area Research (1974), and Griswold and Tubb (1977). Sources of unpublished data documenting the fish fauna of Sandusky Bay include the Ohio Department of Natural Resources, Division of Wildlife, in Sandusky and Findlay, the Ohio State University Museum of Zoology, and the U.S. Fish and Wildlife Lake Erie Laboratory in Sandusky. Sandusky Bay is shown in Figure 5.

Analysis

The fish fauna of Sandusky Bay has changed dramatically during historical times in response to the following factors: (a) siltation due to negligent agricultural practices and deforestation, (b) diking and drainage of adjacent wetlands, (c) construction of dams on tributaries, (d) intensified commercial fishing, and (e) introduction of exotic species. The relative abundance of major species in the bay in 1830, 1940, and 1975 is shown in Table 4, and a composite list of all species recorded from the bay and their historical trends in abundance is provided in Table 5 (Hartley and Herdendorf, 1975).

Northern pike (Esox lucius) and muskellunge (Esox masquinongy), once abundant in the bay, were severely depleted by 1900 due to overfishing and blockage or drainage of spawning marshes. Also once abundant in the bay, the largemouth bass (Micropterus salmoides) and smallmouth bass (Micropterus dolomieui) were initially depleted by overfishing. The largemouth bass, which is more tolerant of silty water and a muddy bottom than is the smallmouth bass, is currently common in the bay, whereas the smallmouth bass is uncommon. The walleye (Stizostedion vitreum) was one of the more abundant species in the bay in 1830, but resident walleyes are now uncommon due to the siltation problem. Walleye are seasonally abundant in the bay during the spring spawning run to the Sandusky River. The white bass (Morone chrysops) has always been and

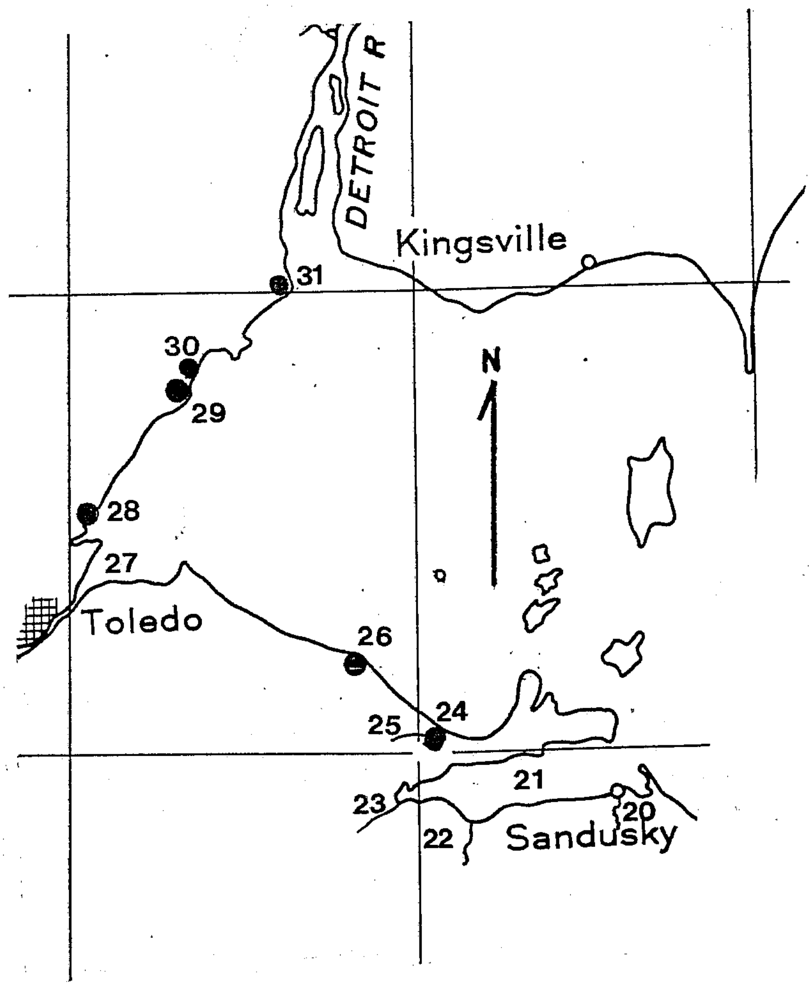

FIGURE 5. LOCATION MAP FOR NEARSHORE-SPECIFIC FISH STUDIES IN THE WESTERN BASIN OF LAKE ERIE (Key follows this Figure)

KEY TO FIGURES 3, 4, AND 5

1. Hamburg Beach
2. Eighteenmile Creek
3. Cattaraugas Creek
4. Barcelona Beach
5. Chautauqua Creek
6. Sixmile Creek
7. Presque Isle
8. Walnut Creek
9. Trout Run
10. Conneaut
11. Conneaut Creek
12. Perry Nuclear Power Plant Site
13. Chagrin River
14. Eastlake
15. Avon Lake
16. Cuyahoga River
17. Erie Nuclear Power Plant Site
18. Huron
19. Huron River
20. Cold Creek
21. Sandusky Bay
22. Pickerel Creek
23. Sandusky River
24. Port Clinton
25. Portage River
26. Locust Point, Davis-Besse Nuclear Power Plant
27. Maumee Bay
28. North Maumee Bay, Erie Shooting Club, J. R. Whiting Power Plant
29. Monroe
30. Sterling State Park
31. Pointe Mouillee

remains among the more abundant species in the bay. Although it prefers clearer waters and a firm bottom, the white bass is apparently favored in the bay by an abundance of forage fishes and the scarcity of larger predators such as the walleye, northern pike, and muskellunge. Similarly, the channel catfish (Ictalurus punctatus), freshwater drum (Aplodinotus grunniens), and yellow perch (Perca flavescens), which prefer clearer waters but are moderately tolerant to siltation, have remained abundant in the bay throughout historical times. The yellow perch and channel catfish are seasonal in abundance in the bay, the former being more abundant during fall, winter, and spring and the latter mainly during spring. The absence of large predators in the bay may offset the disadvantageous effects of siltation on these three species. The carp (Cyprinus carpio) and goldfish (Carassius auratus), two species which prefer muddy waters, have increased rapidly in the bay since their introduction in the late 1900's, and both are now abundant. The gizzard shad (Dorosoma cepedianum) also prefers turbid conditions with abundant plankton and has increased dramatically in the bay from initial scarcity. The scarcity of large predators may also favor gizzard shad in the bay. The brown bullhead (Ictalurus nebulosus) and black bullhead (Ictalurus melas) are also relatively abundant in the bay, both preferring more turbid conditions and probably benefiting from the scarcity of larger predators. The remaining species listed in Table 5 are not as common as the species discussed above. Many, such as the stoneroller (Campostoma anomalum), northern hogsucker (Hypentelium nigricans), and greenside darter (Etheostoma blennioides), are primarily stream species which were never of major importance in the bay. Most of the uncommon and rare species have been virtually extirpated owing to their dependence of clear water, sand or gravel bottom, or abundant aquatic vegetation (Edmister, 1940; Klippart, 1877; Chapman, 1955; Trautman, 1957; Hartley and Herdendorf, 1975).

Discussions of commercial fishing in Sandusky Bay were provided by Edmister (1940), Chapman (1955), Klippart (1877), Hartley and Herdendorf (1975), and, to a limited extent, by Smith and Snell (1887). The major current commercial species, taken primarily by shore seine, include carp, goldfish, freshwater drum, miscellaneous suckers (Catostomidae), channel catfish, yellow perch, and white bass. Historically, northern pike, walleye, sauger, muskellunge, largemouth bass, and smallmouth bass were important until depleted.

Recent surveys of fish and fisheries in Sandusky Bay were conducted by Hartley and Herdendorf (1975), Tubb (1973), and Griswold and Tubb (1977). Hartley and Herdendorf (1975) determined relative abundance of fishes (adults and fry) and food habits. Fry collected in the bay included gizzard shad, white bass, emerald shiner (Notropis stramineus), freshwater drum, yellow perch, goldfish, and smallmouth bass, in decreasing order of abundance (Table 5). Tubb (1973) and Griswold and Tubb (1977) discussed food habits of freshwater drum, yellow perch, white bass, and channel catfish in the bay. Hartley and Herdendorf (1975) also discussed food habits of several species in the bay. The findings of these authors are reviewed in connection with each species under SPECIES BACKGROUNDS AND RELATIONSHIPS TO THE NEARSHORE ZONE.

TABLE 5

COMPLETE LIST OF FISH SPECIES PRESENT IN SANDUSKY BAY[1]

		TREND
ABUNDANT		
Gizzard shad	*Dorosoma cepedianum*	Increasing
Goldfish	*Carassius auratus*	
Carp	*Cyprinus carpio*	
Emerald shiner	*Notropis atherinoides*	
Spottail shiner	*Notropis hudsonius*	Increasing
Spotfin shiner	*Notropis spilopterus*	Increasing
Bluntnose minnow	*Pimephales notatus*	
Channel catfish	*Ictalurus punctatus*	
White bass	*Morone chrysops*	Increasing
White crappie	*Pomoxis annularis*	
Yellow perch	*Perca flavescens*	
Freshwater drum	*Aplodinotus grunniens*	
COMMON		
Longnose gar	*Lepisosteus osseus*	Decreasing
Alewife	*Alosa pseudoharengus*	
Rainbow smelt	*Osmerus mordax*	Decreasing
Golden shiner	*Notemigonus crysoleucas*	Decreasing
Mimic shiner	*Notropis volucellus*	Decreasing
White sucker	*Catostomus commersoni*	
Shorthead redhorse	*Moxostoma macrolepidotum*	Decreasing
Black bullhead	*Ictalurus melas*	
Yellow bullhead	*Ictalurus natalis*	Decreasing
Brown bullhead	*Ictalurus nebulosus*	
Stonecat	*Noturus flavus*	Decreasing
Trout-perch	*Percopsis omiscomaycus*	Decreasing
Brook silverside	*Labidesthes sicculus*	Decreasing
Rock bass	*Ambloplites rupestris*	
Green sunfish	*Lepomis cyanellus*	
Pumpkinseed	*Lepomis gibbosus*	
Orangespotted sunfish	*Lepomis humilis*	Increasing
Bluegill	*Lepomis macrochirus*	
Largemouth bass	*Micropterus salmoides*	
Black crappie	*Pomoxis nigromaculatus*	Decreasing
Logperch	*Percina caprodes*	Decreasing
UNCOMMON		
Sea lamprey	*Petromyzon marinus*	
Bowfin	*Amia calva*	Decreasing
Coho salmon	*Onchorhynchus kisutch*	
Chinook Salmon	*Onchorhynchus tshawytsha*	
Central mudminnow	*Umbra limi*	Decreasing
Grass pickerel	*Esox americanus vermiculatus*	Decreasing
Stoneroller	*Campostoma anomalum*	
Common shiner	*Notropis cornutus*	
Sand shiner	*Notropis stramineus*	

TABLE 5 (Con't.)

COMPLETE LIST OF FISH SPECIES PRESENT IN SANDUSKY BAY[1]

		TREND
UNCOMMON		
Fathead minnow	*Pimephales promelas*	Increasing
Quillback	*Carpiodes cyprinus*	Decreasing
Northern hog sucker	*Hypentelium nigricans*	
Bigmouth buffalo	*Ictiobus cyprinellus*	Decreasing
Spotted sucker	*Minytrema melanops*	Decreasing
Golden redhorse	*Moxostoma erythrurum*	Decreasing
Tadpole madtom	*Noturus gyrinus*	Decreasing
Brindled madtom	*Noturus miurus*	Decreasing
Banded killifish	*Fundulus diaphanus*	Decreasing
Smallmouth bass	*Micropterus dolomieui*	
Greenside darter	*Etheostoma blennioides*	
Johnny darter	*Etheostoma nigrum*	Decreasing
Walleye	*Stizostedion v. vitreum*	Increasing
RARE		
Silver lamprey	*Ichthyomyzon unicuspis*	Decreasing
Lake sturgeon	*Acipenser fulvescens*	Decreasing
Spotted gar	*Lepisosteus oculatus*	Decreasing
Mooneye	*Hiodon tergisus*	Decreasing
Lake whitefish	*Coregonus clupeaformis*	Decreasing
Northern pike	*Esox lucius*	Decreasing
Muskellunge	*Esox masquinongy*	Decreasing
Silver chub	*Hybopsis storeriana*	Decreasing
Blackchin shiner	*Notropis heterodon*	Decreasing
Blacknose shiner	*Notropis heterolepis*	Decreasing
Lake chubsucker	*Erimyzon sucetta*	Decreasing
Silver redhorse	*Moxostoma anisurum*	Decreasing
Burbot	*Lota lota*	
Longear sunfish	*Lepomis megalotis*	
Warmouth sunfish	*Lepomis gulosus*	
Iowa darter	*Etheostoma exile*	Decreasing
Channel darter	*Percina copelandi*	
Blackside darter	*Percina maculata*	
Sauger	*Stizostedion canadense*	Decreasing
Blue walleye	*Stizostedion vitreum glaucum*	Decreasing

OTTAWA AND LUCAS COUNTIES, OHIO (EXCLUSIVE OF MAUMEE BAY)

Inventory of Studies

Trautman (1957) and Langlois (1954) provided general discussions of distribution, abundance, and life histories of fishes found in the nearshore zone of Ottawa and Lucas counties. The Ohio Department of Natural Resources, Division of Wildlife, annually samples fish by trawl and gill net at index stations in the area. Only two published nearshore-specific studies of fishes in the area exist: an environmental impact statement pertaining to the effects of maintenance dredging on fishes in Port Clinton harbor (U.S. Army Corps of Engineers, 1977) and an environmental assessment of the effects of the intake and discharge of the Davis-Besse Nuclear Power Station at Locust Point (Reutter, Herdendorf, Barnes, 1979). These locations are shown in Figure 5. Sources of unpublished data documenting the fish fauna in the area include the Ohio Department of Natural Resources, Division of Wildlife, at Sandusky and Findlay, the U.S. Fish and Wildlife Service Lake Erie Laboratory at Sandusky, and the Ohio State University Museum of Zoology.

Analysis

Unsheltered nearshore habitats in Ottawa and Lucas counties, as evidenced by ten years of monitoring at the Davis-Besse Nuclear Power Station,are apparently dominated by gizzard shad, alewife, spottail shiner, emerald shiner, white bass, yellow perch, and freshwater drum. Other species found in lesser abundance included bowfin, brook silverside, quillback, white sucker, spotted sucker, golden redhorse, bigmouth buffalo, shorthead redhorse, northern hogsucker, rock bass, green sunfish, pumpkinseed, oranges spotted sunfish, bluegill, redear sunfish, smallmouth bass, largemouth bass, white crappie, black crappie, goldfish, carp, goldfish carp hybrids, silver chub, goldenshiner, spotfin shiner, mimic shiner, fathead minnow, northern pike, muskellunge, black bullhead, yellow bullhead, brown bullhead, channel catfish, stonecat, longnose gar, rainbow smelt, johnny darter, logperch, sauger, walleye, trout-perch, sea lamprey, and coho salmon. The greatest abundance of fishes in the area occurred between May and August, as most species concentrated nearshore for spawning. The fish fauna was characterized by populations of highly pelagic and benthipelagic schooling species. No significant effect in either attraction or repulsion of fish in the intake or discharge area of the power plant was observed, nor was impingement of larger fish considered significant. Fish eggs larvae were most abundant in the area from April to June. Gizzard shad, yellow perch, and emerald shiners were the most abundant larvae collected by fry nets. Entrainment of larvae in the power plant intake was considered insignificant. The relatively low density of fishes in the nearshore area, the location of the intake 3,000 ft. offshore, and low intake/discharge volume due to operation of a cooling tower were considered the principal factors contributing to minimal impact of the Davis-Besse Nuclear Power Station on fish populations in the area (Reutter et al., 1979)

Although sheltered habitats in the nearshore zone of Ottawa and Lucas counties are abundant in the form of extensive coastal wetlands, estuaries, and embayments, little effort has been focused on surveying the fish communities of these areas and publishing the information. Although published information on the fishes of Port Clinton harbor is available, this information is rudimentary and cannot be considered representative of the extensive and diverse sheltered habitats in the area. In the inner harbor gizzard shad (*Dorosoma cepedianum*), carp (*Cyprinus carpio*), and white bass (*Morone chrysops*) were most abundant. In or near the approach channel, freshwater drum (*Aplodinotus grunniens*) and gizzard shad were most abundant, while yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), carp, and channel catfish (*Ictalurus punctatus*) were present but less abundant. Gizzard shad and yellow perch were the most abundant species in the nearshore waters of Lake Erie around Port Clinton. Species documented in Port Clinton harbor are listed in Table 6. A limited amount of length data for some of these species was available (U.S. Army Corps of Engineers, 1977).

MAUMEE BAY, OHIO AND MICHIGAN

Inventory of Studies

Trautman (1957) and Langlois (1954) provided general discussions of distribution, abundance, and life histories of fishes in Maumee Bay. Environmental impact statements dealing with the effects of harbor dredging on fishes in the bay were prepared by the U.S. Army Corps of Engineers (1972, 1974, 1976) and Herdendorf et al. (1975). Summaries of the fish community composition and migrations in Maumee Bay were presented by Fraleigh et al. (1974, 1977), Fraleigh (1977), and Pinsak and Meyer (1976). Impingement and entrainment of fishes at the intake of the Bayshore Power Plants, operated by Toledo Edison Company, were assessed by Reutter et al. (1978, 1979), while heated water discharge effects of these plants were assessed by Wapora, Inc. (1977). Sources of unpublished data documenting the fish fauna of Maumee Bay include the Ohio Department of Natural Resources, Division of Wildlife, at Sandusky and Findlay, the U.S. Fish and Wildlife Service Laboratory at Sandusky, the Ohio State University Museum of Zoology, and the University of Toledo, Department of Biology.

Analysis

The fish fauna of Maumee Bay has changed considerably during historical times in response to the following factors: (a) siltation, (b) blockage of spawning grounds by dams or dikes and destruction of spawning grounds (e.g. siltation of sand or gravel bottoms and drainage of marshes), (c) increasing concentration of industrial waste, (d) intense commercial fishing, and (e) introduction of exotic species, (e.g. carp), which competed successfully with native species under changing environmental conditions. The relative abundances of species in the bay before and after 1957 are compared in Table 7.

In general, changes in the fish community composition of Maumee Bay were similar to those that occurred in Sandusky Bay, in response to similar environmental changes. Maumee Bay was a major lake whitefish spawning area until the early 1900's and was considered the most prolific fish spawning area in Lake Erie. The factors listed above led to declines in abundance of such formerly abundant species as northern pike, muskellunge, largemouth bass, smallmouth

TABLE 6

FISH SPECIES FOUND IN PORT CLINTON HARBOR[1]

Family and Common Name	Family and Common Name
Petromyzontidae	**Cyprinidae**
silver lamprey	carp
	goldfish
Lepisosteidae	emerald shiner
longnose gar	spottail shiner
	golden shiner
Amiidae	common shiner
bowfin	spotfin shiner
	sand shiner
Clupeidae	mimic shiner
alewife	fathead minnow
gizzard shad	bluntnose minnow
Hiodontidae	**Ictaluridae**
mooneye	channel catfish
	black bullhead
Salmonidae	brown bullhead
coho salmon	yellow bullhead
rainbow trout	stonecat
	tadpole madtom
Osmeridae	**Percopsidae**
rainbow smelt	trout-perch
Esocidae	**Cyprinodontidae**
northern pike	blockstripe topminnow
Catostomidae	**Percichthyidae**
white sucker	white bass
northern hogsucker	**Centrarchidae**
quillback	smallmouth bass
bigmouth buffalo	largemouth bass
golden redhorse	rock bass
spotted sucker	black crappie
	white crappie
	bluegill
	green sunfish
	longear sunfish
	orangespotted sunfish

TABLE 6 (Con't.)

FISH SPECIES FOUND IN PORT CLINTON HARBOR[1]

Family and Common Name	Family and Common Name
Percidae	
yellow perch	
walleye	
logperch	
johnny darter	
Sciaenida	
freshwater drum	

1 Source: Ohio Department of Natural Resources as reported by U.S. Army Corps of Engineers (1977)

TABLE 7

RELATIVE ABUNDANCE OF FISHES IN MAUMEE BAY BEFORE AND AFTER 1957[1]

Family/Common Name	Status Before 1957	Status After 1957
Acipenseridae		
lake sturgeon	abundant before 1916, declined 1916-1950	probably absent
Lepisosteidae		
spotted gar	common before 1901, declined 1901-1950	probably absent
longnose gar	common	common but declining
Amiidae		
bowfin	common	uncommon
Esocidae		
northern pike	abundant before 1910, declined 1910-1950	uncommon
muskellunge	abundant before 1900, declined thereafter	rare
Hiodontidae		
mooneye	common before 1901, declined 1901-1950	rare
Clupeidae		
gizzard shad	common	abundant
alewife	rare	common seasonally
Salmonidae		
lake whitefish	abundant before 1900 sharp decline thereafter	rare
Catostomidae		
bigmouth buffalo	common	common
silver redhorse	common	uncommon

TABLE 7 (Con't.)

RELATIVE ABUNDANCE OF FISHES IN MAUMEE BAY BEFORE AND AFTER 1957[1]

Family/Common Name	Status Before 1957	Status After 1957
Catostomidae		
shorthead redhorse	abundant before 1925	common
golden redhorse	common	common
greater redhorse	common before 1900	uncommon to rare
quillback	occasional	common
white sucker	common	common
Cyprinidae		
carp	increased after 1880	abundant
goldfish	increased after 1880	common
goldenshiner	common	decreasing
silver chub	common	rare
emerald shiner	common	common
redfin shiner	common	rare
spottail shiner	common	common
spotfin shiner	common	occasional
sand shiner	common	uncommon
bluntnose minnow	common	common
Ictaluridae		
channel catfish	common	common
brown bullhead	common	common
black bullhead	common	common
stonecat	common	occasional
Anguillidae		
American eel	occasional	occasional
Gadidae		
burbot	occasional	occasional
Percopsidae		
trout-perch	common	common
Atherinidae		
brook silverside	common	occasional

TABLE 7 (Con't.)

RELATIVE ABUNDANCE OF FISHES IN MAUMEE BAY BEFORE AND AFTER 1957[1]

Family/Common Name	Status Before 1957	Status After 1957
Percichthyidae		
white bass	abundant	common
Centrarchidae		
white crappie	common	common
black crappie	common	uncommon
smallmouth bass	abundant	uncommon
largemouth bass	abundant	common
green sunfish	common	common
bluegill	common	common
pumpkinseed	common	common
Percidae		
sauger	common	rare
walleye	abundant	common
yellow perch	abundant	common
channel darter	common before 1924, declined 1924-1952	rare
logperch	common	common
johnny darter	common	common
Sciaenidae		
freshwater drum	common	abundant

1 Based on Pinsak and Meyer (1976)

bass, and lake whitefish. Other formerly abundant species such as white bass, channel catfish, yellow perch, and freshwater drum remained abundant due to their tolerance of turbidity and silted bottoms. The carp and gizzard shad have benefitted by the increases of siltation and lack of larger predators in the bay and are now abundant. The walleye is seasonally abundant in the bay during its spring spawning run up the Maumee River (Pinsak and Meyer, 1976; Fraleigh et al., 1974, 1977).

Unlike Sandusky Bay, Maumee Bay is a major commercial port and is almost entirely surrounded by urban/industrial development. Diverse sourves of municipal and industrial pollution exist, but the principal factors affecting the fisheries of the bay aside from siltation appear to be dredging for channel maintenance and commercial gravel removal and the intake and discharge activities of the Bayshore Power Plant. The dredging operations do not appear to have had any but localized effects on the suspension of silt in the bay, although the deepening of the bay and river mouth and removal of gravel and sand has eliminated some spawning area. The construction of a diked disposal facility near the heated water discharge of the Bayshore Plant has apparently had some blocking effect of the white bass spawning run but has had no obervable impact on the walleye run (Pinsak and Meyer, 1976; Fraleigh et al., 1974, 1977). The thermal discharge of the Bayshore Plant was expected to have no significant effect on movements or survival of fishes in the bay (Wapora, Inc., 1977). However, the intake operations of the plant resulted in impingement or entrainment of large numbers of fish. Heavy impingement was seasonal only and consisted primarily of gizzard shad, with impingement and entrainment loss of game and commercial species being considered insignificant compared to total sport and commercial harvest of these species in Ohio waters of Lake Erie (Reutter et al., 1979).

MONROE COUNTY, MICHIGAN (EXCLUSIVE OF MAUMEE BAY)

Inventory of Studies

Langlois (1954) provided general discussions of distribution, abundance, and life histories of fishes in the coastal waters of Monroe County. Cole et al. (1978) and Waybrant and Shauver (1977) surveyed larval fishes in the area. Environmental impact statements dealing with harbor dredging and maintenance activities at Monroe provided some information on fishes of that area. The ecology of the Erie Shooting Club marsh has been extensively studied, with information pertaining to fishes summarized by King and Hunt (1967) and Hunt and Mickelson (1976). The fishes in the marsh and nearshore waters at Pointe Mouillee were studied by McDonald (1951) and the U.S. Army Corps of Engineers (1973), and the fishes associated with the marsh and nearshore waters at Sterling State Park were surveyed by Jaworski and Raphael (1976). Most of the information on fishes of the Monroe County nearshore zone has been accumulated during surveys to assess thermal discharge and impingement and entrainment effects at the three major coastal power plants of the area: Whiting (Zeitoun et al., 1978), Monroe (Parkhurst, 1971; Cole, 1978; Goodyear, 1978), and Enrico Fermi (U.S. Atomic Energy Commission, 1972). Sources of unpublished data pertaining to the fishes of the nearshore zone of Monroe County include the Michigan Department of Natural Resources at Lansing, the U.S. Fish and

Wildlife Service Lake Erie Laboratory at Sandusky, Ohio, and Great Lakes Laboratory at Ann Arbor, Michigan, the University of Michigan Museum of Zoology, at Ann Arbor, Michigan State University at Lansing, and Eastern Michigan University at Ypsilanti.

Analysis

Unsheltered nearshore habitats in Monroe County are dominated by yellow perch, white bass, spottail shiner, emerald shiner, alewife, and gizzard shad. Other species found in the area included freshwater drum, carp, carp x goldfish hybrids, white crappie, channel catfish, yellow bullhead, walleye, silver chub, rainbow smelt, *Moxostoma* spp., logperch, quillback, pumpkinseed, trout-perch, rock bass, brown bullhead. Age and growth data on two of these species, carp and yellow perch, were provided by Parkhurst (1971) during a study of the thermal discharge of the Monroe Power Plant. The occurrence of larval and juvenile fishes in the nearshore zone of Monroe County was synopsized by Waybrant and Shauver (1977) and Cole et al. (1978). In decreasing order of relative abundance immature fishes found included yellow perch, clupeids (including both alewife and gizzard shad,rainbow smelt, white bass, *Notropis* spp. (including both spottail and emerald shiners), freshwater drum, unidentified cyprinids (including goldfish, carp, silver chub, spottail shiner, and emerald shiner) logperch, carp, unidentified catostomids (including quillback, white sucker, and Moxostoma spp.), pumpkinseed, channel catfish, emerald shiner, unidentified centrarchids (including rock bass, pumpkinseed, bluegill, largemouth bass, and smallmouth bass), goldfish, walleye, trout-perch, spottail shiner, unidentified *Micropterus* species (including largemouth and smallmouth bass), white crappie, unidentified Etheostoma species (primarily johnny darter), smallmouth bass, brook silverside, gizzard shad, northern pike, white sucker, rock bass, longnose gar, coho salmon, chinook salmon, rainbow trout, black bullhead, yellow bullhead, brown bullhead, stonecat, burbot, white perch, largemouth bass, and johnny darter.

Sheltered nearshore habitats in Monroe County for which published information on fishes is available include the Erie Shooting Club marsh, North Maumee Bay at the J.R. Whiting Power Plant, Monroe Harbor, Sterling State Park, and Pointe Mouillee marsh. Ecological studies conducted to aid in management of Erie Shooting Club marsh for waterfowl production revealed the presence of bowfin (*Amia calva*), carp (*Cyprinus carpio*), yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), largemouth bass (*Micropteru salmoides*), smallmouth bass (*Micropterus dolomieu*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), white bass (*Morone chrysops*), gizzard shad (*Dorosoma cepedianum*), shiners (*Notropis* spp.), and yellow bullhead (*Ictalurus natalis*)in the marsh and adjacent waters. Northern pike (*Esox lucius*), black crappie, and brook trout (*Salvelinus fontinalis*) have been stocked in the marsh (King and Hunt, 1967; Hunt and Mickelson, 1976.

Carp have been troublesome in the marsh, eliminating many kinds of vegetation needed by water fowl. Vegetation was destroyed by consumption and by increased turbidity due to rooting activity of the carp. Carp in the marsh were largely herbivorous, consuming large quantities of *Chara* spp., whereas pondweeds (Potamogeton spp.) were destroyed largely by rooting. Carp spawning in the marsh begins in late April and lasts until early June. The exclusion and removal of carp from the marsh has been accomplished by screens, weirs, and successive poisonings. After removal, carp generally gained access through open weirs and broken screens, and carp surviving the poisoning reproduced, resulting in eventual repopulation of the marsh. Following removal of carp on 9 June 1964, vegetation recovered very well within two months. Vegetation was most susceptible to destruction by carp early in the growing season, when shoots were young and tender. During summer, dense vegetation and warm water temperatures apparently restricted carp activity (King and Hunt, 1967; Hunt and Mickelson, 1976).

The intake of the J.R. Whiting Power Plant, operated by Consumers Power Company, is located in extreme North Maumee Bay. Fishes collected by impingement, entrainment, or gill netting in the intake area are listed in Table 8. The larvae entrained in greatest abundance were clupeids, yellow perch, white bass, freshwater drum, walleye, and spottail shiner. Impinged fish included primarily emerald shiner, spottail shiner, yellow perch, carp, goldfish, gizzard shad, freshwater drum, and white bass. Fish gill netted in the vicinity included alewife, gizzard shad, bowfin, longnose gar, coho salmon, goldfish, carp, bigmouth buffalo, quillback, black bullhead, brown bullhead, channel catfish, white bass, yellow perch, walleye, and freshwater drum. Impingement and entrainment studies are incomplete and analysis of the impact of these factors on the fish community of North Maumee Bay has not yet been analyzed (Zeitoun et al., 1978).

The most extensively studied sheltered nearshore habitat in Monroe County has been the River Raisin estuary and Monroe Harbor, primarily in connection with harbor dredging and alteration (U.S. Army Corps of Engineers, 1976, 1977) and intake/discharge effects of the Monroe Power Plant, operated by Detroit Edison (Cole, 1978; Goodyear, 1978; Parkhurst, 1971). Adult fishes found in the harbor and adjacent discharge canal are listed in Table 9.

Fish species present in the Sandy Creek estuary and the wetlands of Sterling State Park include carp, yellow perch, white crappie, smallmouth bass, unidentified bullheads, and carp-goldfish hybrids. These species support a sport fishery in the area. Fish larvae collected in the same waters included white bass, white crappie, unidentified sunfishes, logperch, brook silverside, gizzard shad, alewife, and unidentified shiners. Larval gizzard shad and shiners dominated numerically (Jaworski and Raphael, 1976).

Species present in Pointe Mouillee Marsh included sea lamprey, longnose gar, bowfin, gizzard shad, carp, goldfish, spottail shiner, black bullhead, grass pickerel, northern pike, yellow perch, walleye, largemouth bass, pumpkin seed, bluegill, rock bass, brook silverside, and freshwater drum. Carp were most abundant (McDonald, 1951). Angling opportunity existed for largemouth bass, northern pike, and a variety of panfish (U.S. Army Corps of Engineers, 1973).

TABLE 8

FISHES IMPINGED, ENTRAINED, OR GILL NETTED AT THE J.R. WHITING PLANT, MONROE COUNTY, MICHIGAN, DURING 1978[1]

Family and Common Name	Family and Common Name
Clupeidae	Percopsidae
alewife	trout-perch
gizzard shad	
	Percichthyidae
Salmonidae	white bass
coho salmon	
	Centrarchidae
Osmeridae	rock bass
rainbow smelt	green sunfish
	pumpkinseed
Esocidae	orange spotted sunfish
northern pike	bluegill
	largemouth bass
Cyprinidae	white crappie
goldfish	black crappie
carp	
emerald shiner	Percidae
blacknose shiner	yellow perch
spottail shiner	logperch
fathead minnow	walleye
Catostomidae	Sciaenidae
white sucker	freshwater drum
quillback	
shorthead redhorse	
bigmouth buffalo	
Ictaluridae	
black bullhead	
yellow bullhead	
brown bullhead	
channel catfish	
tadpole madtom	

1 Zeitoun et al. (1978)

TABLE 9

RELATIVE ABUNDANCE OF ADULT FISHES IN THE MONROE HARBOR VICINITY[1]

Family and Common Name	Relative Abundance
Lepisosteidae	
longnose gar	occasional
Clupeidae	
gizzard shad	abundant
alewife	occasional
Esocidae	
northern pike	occasional
Salmonidae	
coho salmon	occasional
chinook salmon	occasional
Osmeridae	
rainbow smelt	uncommon
Cyprinidae	
carp	common
goldfish	occasional
carp x goldfish hybrids	occasional
spottail shiner	common
emerald shiner	common
silver chub	rare
Catostomidae	
quillback	occasional
Moxostoma spp.	occasional
white sucker	occasional
Ictaluridae	
channel catfish	common
yellow bullhead	common
brown bullhead	uncommon
black bullhead	common

TABLE 9 (CONT.)

RELATIVE ABUNDANCE OF ADULT FISHES IN THE MONROE HARBOR VICINITY[1]

Family and Common Name	Relative Abundance
Percopsidae	
trout-perch	common
Percichthyidae	
white bass	abundant
Centrarchidae	
white crappie	common
pumpkinseed	occasional
rock bass	occasional
smallmouth bass	occasional
largemouth bass	occasional
Percidae	
yellow perch	abundant
walleye	common
logperch	common
Sciaenidae	
freshwater drum	abundant

1 Parkhurst (1971), U.S. Army Corps of Engineers (1976), Goodyear (1978).

OVERVIEW AND RECOMMENDATIONS

This report has been an attempt to assemble and review the published literature dealing with the fish communities in the nearshore zone of Lake Erie and some of the effects of environmental change and cultural activities on these communities. In general, the fish communities of the nearshore zone can be classified as either of two types: those characteristic of open, unsheltered nearshore waters (e.g. beaches, bluffs, etc.) and those characteristic of sheltered nearshore habitats (e.g., bays, estuaries, leeward shores). The unsheltered habitats are dominated by gizzard shad, alewife, white bass, yellow perch, spottail shiner, emerald shiner, freshwater drum, walleye, and channel catfish. Sheltered habitats, depending on bottom type and the presence or absence of vegetation, generally support fish communities of greater density and diversity than unsheltered habitats. Most of the species common in unsheltered habitats also occur commonly in sheltered habitats, together with various cyprinids, ictalurids, catostomids, centrarchids, and percids not common in the unsheltered habitats. Sheltered habitats are also seasonally important as spawning migration routes and nursery areas for many species.

In general, sheltered habitats appear to be more severely affected by environmental change and cultural activities than unsheltered habitats. Most such areas provide natural harbors and protected sites for urban/industrial development, with its need of water for consumption, transportation, and disposal of wastes. Moreover, sheltered nearshore habitats are generally associated with tributaries and are thus exposed to cultural effects originating far upstream. The more common problems in such areas are industrial pollution, municipal waste disposal, agricultural silt and pesticide loading, dredging and harbor maintenance, and thermal intake-discharge effects of power plants and industries.

Although this report has dealt with environmental impacts of cultural activities in certain nearshore areas, the assessments of these impacts have been based on those in technical reports prepared by public amd private agencies whose conclusions cannot be considered wholly unbiased. Given the current data base regarding nearshore fish communities as exists in the literature reviewed for this report, an adequate assessment of the impacts of various cultural activities on nearshore fishes in Lake Erie is not possible. Most previous assessments have been short-term in duration and extremely localized in area. Generally, the intensity of sampling is insufficient to achieve definitive results, and the distribution and availability of results in the form of technical reports is limited.

Aside from the evaluation of cultural impacts, the amount of scientifically acquired information regarding nearshore fish communities was surprisingly sparse. Most previous studies have dealt with offshore commercial and game fish populations, and little effort has been devoted to study of the distribution, seasonal abundance, migrations, spawning sites and interspecific relationships of fishes in the actual nearshore zone. The following areas of interest have been largely neglected:

(a) Spawning areas in the nearshore zone are largely unknown. Most statements regarding spawning in the nearshore zone are based on indirect knowledge of spawning requirements of certain species and the availability of suitable habitat in the nearshore zone.

(b) The seasonality, distribution, and abundance of fish eggs and larvae in the nearshore zone are likewise poorly documented.

(c) The seasonal abundance and distribution of adult fishes in the nearshore zone, and their interspecific relationships, are only partially documented.

Extensive field surveys are required to adequately document the above areas. However, considerable useful data is buried in museum records, unpublished data files, and technical reports of limited circulation. Although this report has been an attempt to inventory and review such sources, no attempt has been made to extract and evaluate data and to assemble it into a cohesive, detailed treatment of nearshore zone fish communities. Such an attempt is recommended and may facilitate future field investigations.

LITERATURE CITED

Adamstone, F.B. 1922. Rates of growth of the blue and yellow pike perch. Univ. Toronto Stud., No. 20 (Publ. Ontario Fish. Res. Lab., I-IX): 77-86.

Applegate, V.C., and H.D. Van Meter. 1970. A brief history of commercial fishing in Lake Erie. U.S. Fish. Wildl. Serv., Fish. Leafl. 630. 28 pp.

Applied Biology, Inc. 1977. Section 316(B), Intake monitoring program, Ashtabula A and B Plant. Interim Progress Report, Cleveland Electric Illuminating Company, Cleveland, Ohio. 64 pp.

Applied Biology, Inc. 1977. Section 316(B), Intake monitoring program, Ashtabula C Plant. Cleveland Electric Illuminating Co., Interim Prog. Rpt. 52 pp.

Applied Biology, Inc. 1977. Section 316(B), ntake monitoring program, Cleveland Electric Illuminating Company, Avon Lake Plant. Interim Progress Rpt., Cleveland Electric Illuminating Company, Cleveland, Ohio. 102 pp.

Applied Biology, Inc. 1977. Section 316(b), Intake monitoring program, Cleveland Electric Illuminating Company, Lakeshore Plant. Interim Progress Rpt., Cleveland Electric Illuminating Company, Cleveland, OH. 57 pp.

Aquatic Ecology Associates. 1976. An aquatic ecological study of the inshore area of Lake Erie in the vicinity of the Avon Lake Stream Electric Generating Station, Avon Lake, Ohio. Cleveland Electric Illuminating Company, Cleveland, Ohio. 380 pp.

Aquatic Ecology Associates. 1976. An aquatic ecological study of the inshore area of Lake Erie in the vicinity of the Eastlake Steam Electric Generating Station, Eastlake, Ohio. Cleveland Electric Illuminating Company, Cleveland, Ohio. 354 pp.

Aquatic Ecology Associates. 1977. Aquatic and terrestrial ecology studies, Lake Front Plant, Conneaut, Ohio. Summary Rpt., May 21, 1977 to June 15, 1977, United States Steel Corporation, Pittsburgh, PA. 74 pp.

Aquatic Ecology Associates. 1977. Aquatic ecology study, Lake Front Plant, Conneaut, Ohio. Summary Rpt., August 16, 1977 to November 15, 1977, United States Steel Corporation, Pittsburgh, PA. 196 pp.

Aquatic Ecology Associates. 1978. Aquatic ecology study, Lakefront Plant, Conneaut, Ohio. Suppl. Ichthyoplankton Rpt., June 1 through July 9, 1977, United States Steel Corporation, Pittsburgh, PA. 54 pp.

Aquatic Ecology Associates. 1978. Aquatic ecology study, Lakefront Plant, Conneaut, Ohio. Summary Rpt., November 16, 1977 to December 31, 1977, United States Steel Corporation, Pittsburgh, PA.

Aquatic Ecology Associates. 1978. Aquatic ecology study, Lakefront Plant, Conneaut, Ohio. Summary Rpt., January 1, 1978 to April 30, 1978, United States Steel Corporation, Pittsburgh, PA. 95 pp.

Bailey, R.M., J.E. Fitch, E.S. Herald, E.A. Lachner, C.C. Lindsey, C.R. Robins, and W.B. Scott. 1970. A list of common and scientific names of fishes from the United States and Canada. Am. Fish. Soc., Spec. Publ. No. 6. 150 pp.

Baker, Michael, Jr., Inc. 1974. Presque Isle environmental study, study of environmental implications involved in construction of an east access bridge to Presque Isle, Erie, Pennsylvania. General State Authority, Commonwealth of Pennsylvania, Harrisburg. 194 pp.

Baldwin, N.S. and R.W. Saalfeld. 1962. Commercial fish production in the Great Lakes, 1867-1960. Great Lakes Fish. Comm., Tech. Rpt. No. 3. 166 pp.

Baldwin, N.S., and R.W. Saalfeld. 1970. Commercial fish production in the Great Lakes, 1867-1960, supplement covering the years from 1961 to 1968. Great Lakes Fish. Comm., Tech. Rpt. No. 3 (supplement). No pagination.

Bangham, R.V. 1972. A resurvey of the fish parasites of Lake Erie. Ohio Biol. Surv. Bull. 4(2). 20 pp.

Bodola, A. 1966. Life history of the gizzard shad, Dorosoma cepedianum (Le Sueur), in western Lake Erie. U.S. Fish and Wildl. Serv., Fish. Bull. 65(2): 391-425.

Boesel, M.W. 1938. The food of nine species of fish from the western end of Lake Erie. Trans. Am. Fish. Soc. 67:215-23.

Bowman, E.W. 1974. Lake Erie bottom trawl explorations, 1962-66. U.S. Dept. Commerce, NOAA Tech. Rpt. NMFS SSRF-674. 21 pp.

Brown, E.H., Jr., and C.F. Clark. 1965. Length-weight relationship of northern pike, Esox lucius, from East Harbor, Ohio. Trans. Am. Fish. Soc. 94:404-405.

Carr, I.A. 1964. Lake Erie fisheries explorations, May-November 1960. Commer. Fish. Rev. 26(4):1-8.

Center for Lake Erie Area Research. 1974. Aquatic ecology of a proposed nuclear power plant site on Sandusky Bay, Ohio. Center for Lake Erie Area Research, Ohio State Univ., Columbus. Unpaginated.

Chapman, C.R. 1955. Sandusky Bay report. Ohio Dept. Nat. Resour., Div. Wildl. 84 pp.

Chen, M., and G. Power. 1972. Infection of American smelt in Lake Ontario and Lake Erie with the microsporidian parasite _Glugea hertwigi_ (Weissenberg). Canadian J. Zool. 50:1183-88.

Clark, C.F. 1950. Observations on the spawning habits of the northern pike, _Esox lucius_, in northwestern Ohio. Copeia 1950. 285-88.

Clark, D.F., and F. Steinbach. 1959. Observations on the age and growth of the northern pike, _Esox lucius_ L., in East Harbor, Ohio. Ohio J. Sci. 59:129-134.

Clemens, H.P. 1951a. The growth of the burbot _Lota lota maculosa_ (Le Sueur) in Lake Erie. Trans. Am. Fish. Soc. 80:163-73.

Clemens, H.P. 1951b. The food of the burbot _Lota lota maculosa_ (Le Sueur) in Lake Erie. Trans. Am. Fish. Soc. 80:56-66.

Clemens, W.A. 1922. A study of the ciscoes of Lake Erie. Univ. Toronto Stud., Biol. Ser., No. 20 (Publ. Ontario Fish. Res. Lab. 1-9):27-37.

Clemens, W.A., and N.K. Bigelow. 1922. The food of ciscoes (_Leucichthys_) in Lake Erie. Univ. Toronto Stud., Biol. Ser., No. 20 (Publ. Ontario Fish. Res. Lab. 1-9):41-53.

Cleveland Electric Illuminating Company. 1973. Environmental report, Perry Nuclear Power Plant, Units 1 and 2, construction permit stage, volume 2. Cleveland Electric Illuminating Company, Cleveland, OH.

Cole, R.A. 1978. Entrainment at a once-through cooling system on western Lake Erie, volume 1. U.S. Environmental Protection Agency, Environmental Protection Agency, Environmental Res. Lab., Duluth, MN, Rpt. No. 600/3-78-070. 139 pp.

Cole, R.A., J. Schaeffer, and J. Werther, and N.V. Wagner. 1978. The occurrence of young fishes in the Michigan coastal waters of the Great Lakes. Michigan Dept. Nat. Resour., Fish. Div., Tech. Rpt. No. 78-1. 247 pp.

Cooper, C.L. 1979. CLEAR Tech. Rpt. No. 112. Water quality of the nearshore zone of L. Erie: A historical analysis and delineation of nearshore characteristics of the U.S. waters. 342 pp.

Couch, J.H. 1922. The rate of growth of the white fish (_coregonus albus_) in Lake Erie. Univ. Toronto Stud., Biol. Ser., No. 20 (Publ. Ontario Fish. Res. Lab., 1-9): 99-107.

Daiber, F.C. 1950. The life history and ecology of the sheepshead, Aplodinotus grunniens Rafinesque, in western Lake Erie. Ph.D. Dissertation, Ohio State University, Columbus. 150 pp.

Daiber, F.C. 1952. The food and feeding relationships of the freshwater drum, Aplodinotus grunniens Rafinesque, in western Lake Erie. Ohio J. Sci. 52: 35-46.

Daiber, F.C. 1953. Notes on the spawning population of the freshwater drum (Aplodinotus grunniens Rafinesque) in western Lake Erie. Am. Midl. Nat. 50:159-71.

Deason, H.J. 1933. Preliminary report on the growth rate, dominance and maturity of the pike-perches (Stizostedion) of Lake Erie. Trans. Am. Fish. Soc. 63:348-60.

Dechtiar, A.O. 1972. New parasite records for Lake Erie fish. Great Lakes Fish. Comm., Tech. Rpt. No. 17. 20 pp.

DeRoth, G.C. 1965. Age and growth studies of channel catfish in western Lake Erie. J. Wildl. Mgmt. 29:280-86.

Doan, K.H. 1940. Studies of the smallmouth bass. J. Wildl. Mgmt. 4:241-266.

Doan, K.H. 1941. Relation of sauger catch to turbidity in Lake Erie. Ohio J. Sci. 41:449-52.

Doan, K.H. 1942. Some meteorological and limnological conditions as factors in the abundance of certain fishes in Lake Erie. Ecol. Managr. 12: 294-314.

Doan, K.H. 1944. The winter fishery in western Lake Erie with a census of the 1942 catch. Ohio J. Sci. 44:69-74.

Downing, S.W. 1923. Are we maintaining the supply of whitefish in Lake Erie? Trans. Am. Fish. Soc. 53:62-64.

Edmister, J.O. 1940. The fish and fisheries of Sandusky Bay. M.S. Thesis, Ohio State University, Columbus. 60 pp.

Edsall, T.A. 1967. Biology of the freshwater drum in western Lake Erie. Ohio J. Sci. 67:321-40.

Ewers, L.A. 1933. Summary report of the Crustacea used as food by the fishes of the western end of Lake Erie. Trans. Am. Fish. Soc. 63:379-90.

Ferguson, R.G. 1965. Bathymetric distribution of American smelt, Osmerus mordax, in Lake Erie. Proc. Conf. Great Lakes Res., Great Lakes Res. Div., Univ. Michigan, Publ. 13:47-60.

Ferguson, R.G., and A.J. Derksen. 1971. Migrations of adult and juvenile walleyes (Stizostedion vitreum vitreum) in southern Lake Huron, Lake St. Clair, Lake Erie, and connecting waters. J. Fish. Res. Bd. Canada 28: 1133-42.

Fish, M.P. 1930. Contributions to the natural history of the burbot, Lota maculosa (Le Sueur). Bull. Buffalo Soc. Nat. Sci. 15(1):1-20.

Fish, M.P. 1932. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. U.S. Bur. Fish., Bull. 10:293-398.

Foell, E.J. 1974. The age and growth of freshwater drum (Aplodinotus grunniens Rafinesque) from Lake Erie near Cleveland, Ohio. M.S. Thesis, John Carroll University, Cleveland. 95 pp.

Fraleigh, P.C. 1974. Maumee Bay environmental quality study. Final Rpt., Toledo-Lucas County Port Authority Environmental Advisory Committee, Toledo, Ohio. 289 pp + app.

Fraleigh, P.C. 1977. Maumee Bay environmental quality study. Final Rpt., Toledo-Lucas County Port Authority Environmental Advisory Committee, Toledo, Ohio. 246 pp. + app.

Fraleigh, P.C., and E.J. Tramer. 1974. Maumee Bay environmental quality study, fish study. Univ. Toledo, Biology Dept., Toledo, Ohio. 19 pp.

Goodyear, C.D. 1978. Evaluation of 316(B) demonstration, Detroit Edison's Monroe Power Plant. Final Rpt., U.S. Fish and Wildl. Serv., Office of Ecol. Serv., Great Lakes Area Office, Ann Arbor, Michigan. 245 pp.

Greeley, J.R. 1929. Fishes of the Erie-Niagara watershed, pp. 150-79. In New York State Conservation Department, A Biological Survey of the Erie-Niagara System, Supplement to Eighteenth Annual Report, 1928. J.B. Lyon Company, Albany.

Griswold, B.L., and R.A. Tubb. 1977. Food of yellow perch, white bass, freshwater drum, and channel catfish in Sandusky Bay, Lake Erie. Ohio J. Sci. 77:43-47.

Hair, D.E. 1978. Lake Erie smallmouth bass survey. Ohio Dept. Nat. Resour., Div. Wildl., Wildl. In-Service Note 392. 19 pp.

Harkness, W.J.K. 1922. The rate of growth of the yellow perch (Perca flavescens) in Lake Erie. Univ. Toronto Stud., No. 20 (Publ. Ontario Fish. Res. Lab., I-IX):89-95.

Harner, W.H. 1958. Interspecific association studies of some fishes of the western basin of Lake Erie, the shore waters, and tributary streams. M.S. thesis, Ohio State University, Columbus. 44 pp.

Harrison, E.J. 1978. Comparative ecologic life histories of sympatric populations of Esox lucius and Esox masquinongy of the upper Niagara River and its local watershed. Ph.D. Dissertation, State Univ. of New York, Buffalo. 303 pp.

Hartley, S.M. 1975. Limnological analysis of Sandusky Bay, Lake Erie, Ohio. M.S. Thesis, Ohio State University, Columbus. 127 pp.

Hartley, S.M., and C.E. Herdendorf. 1975. Abundance and population trends of Sandusky Bay fishes, pp. 381-422. In:Proceedings, Sandusky River Basin Symposium, May 1975, International Joint Commission, Windsor, Ontario.

Hartman, W.L. 1973. Effects of exploitation, evnironmental changes, and new species on the fish habitats and resources of Lake Erie. Great Lakes Fish. Comm., Tech. Rpt. No. 22. 43 pp.

Herdendorf, C.E., C.L. Cooper, S.M. Hartley, and W.E. Carey. 1975. Environmental impact assessment of commercial sand and gravel dredging in Maumee River and Maumee Bay of Lake Erie. Ohio State Univ., Ctr. Lake Erie Area Res., Columbus, Tech. Rpt. No. 41. 380 pp.

Hohn, M.H. 1966. Analysis of plankton ingested by Stizostedion vitreum vitreum (Mitchill) fry and concurrent vertical plankton tows from southwestern Lake Erie, May 1961 and May 1962. Ohio J. Sci. 66:193-97.

Hunt, G.S., and P.G. Mickelson. 1976. Ecological studies at the Erie Shooting and Fishing Club Marsh and their management implications, Monroe County, Michigan. Erie Res. Comm. and N. Am. Wildl. Found., Washington, D.C. 70 pp.

Jaworski, E., and C.N. Raphael. 1978. Existing and potential value of wetlands and bottomlands in the Sterling State Park Area, Monroe County, Michigan. U.S. Environ. Protection Ag., Reg. 5, Chicago. 37 pp.

Jobes, F.W. 1933. Preliminary report on the age and growth of the yellow perch (Perca flavescens Mitchill) from Lake Erie, as determined from a study of its scales. Pap. Mich. Acad. Sci., Arts, and Letters 17: 643-52.

Jobes, F.W. 1952. Age, growth, and production of yellow perch in Lake Erie. U.S. Fish Wildl. Serv., Fish. Bull. 52:205-266.

Johnson, G.H. 1951. An investigation of the mooneye (Hiodon tergisus). Tech. Session Res. Council of Ontario 5 (Abstracts):16.

Keller, M. 1964. Lake Erie sport fishing survey. Ohio Dept. Nat. Resour., Div. Wildl., Publ. 316. 19 pp.

King, D.R., and G.S. Hunt. 1967. Effect of carp on vegetation in a Lake Erie marsh. J. Wildl. Mgmt. 31:181-88.

Klippart, J.H. 1877. History of Toledo and Sandusky fisheries. Ohio State Fish and Game Comm., Ann. Rpt. (1875-1876) 1:32-42.

Langlois, T.H. 1945. Water, fishes, and cropland management. Trans. 10th North Am. Wildl. Conf.:190-96.

Langlois, T.H. 1954. The western end of Lake Erie and its ecology. J.W. Edwards, Publisher, Inc., Ann Arbor, Michigan. 479 pp.

Larmoyeux, J.D. 1951. Further investigation of the age and growth of the sheepshead, *Aplodinotus grunniens* Rafinesque, in Lake Erie. M.S. Thesis, University of Michigan, Ann Arbor. 21 pp.

Lawler, G.H. 1948. Preliminary population studies of five species of Lake Erie fishes. M.S. Thesis, Univ. Western Ontario, London. 101 pp.

Lawler, G.H. 1965. Fluctuations in the success of year-classes of whitefish populations with special reference to Lake Erie. J. Fish. Res. Bd. Canada 22:1197-1227.

Leach, G.C. 1928. Artificial propagation of pike perch, yellow perch, and pikes. Rpt. U.S. Comm. Fish. (1927), App. I:27 pp.

MacCallum, W.R., and H.A. Regier. 1970. Distribution of smelt, *Osmerus mordax*, and the smelt fishery in Lake Erie in the early 1960's. J. Fish. Res. Bd. Canada 27:1823-46.

McCormick, L.M. 1890. List of fishes of Lorain County, Ohio. J. Cincinnati Soc. Nat. Hist. 12(4):126-28.

McCormick, L.M. 1892. Descriptive list of the fishes of Lorain County, Ohio. Oberlin Col. Lab. Bull. No. 2. 32 pp + 14 plates.

McDonald, M.E. 1951. The ecology of Pointe Mouillee marsh, Michigan, with special reference to the biology of the cat-tail (*Typha*). PhD. dissertation, University of Michigan, Ann Arbor. 243 pp.

Metcalf, M.T. 1978. Delayed mortality following transport of Lake Erie freshwater drum captured in shore seines. M.S. thesis, Ohio State University, Columbus. 64 pp.

Miller, R.R. 1957. Origin and dispersal of the alewife, *Alosa pseudoharengus*, and the gizzard shad, *Dorosoma cepedianum*, in the Great Lakes. Trans. Am. Fish. Soc. 86:97-111.

Miller, R.R. 1972. Threatened freshwater fishes of the United States. Trans. Am. Fish. Soc. 101:239-52.

Nash, C.B. 1950. Associations between fish species in tributaries and shore waters of western Lake Erie. Ecology 31:561-66.

Nepszy, S.J., and A.O. Dechtiar. 1972. Occurrence of *Glugea hertwigi* in Lake Erie rainbow smelt (*Osmerus mordax*) and associated mortality of adult smelt. J. Fish. Res. Bd. Canada 29:1639-41.

New York State University College. 1975. Airport feasibility study for the Lake Erie Regional Transportation Authority. New York State Univ. Coll., Great Lakes Lab., Buffalo, New York. 278 pp.

Ohio Department of Natural Resources. 1971a. Walleye spawning area study in western Lake Erie. Final Rpt., Federal Aid Proj. F-35-R, Job No. 1. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 24 pp.

Ohio Department of Natural Resources. 1971b. Walleye sampling. Job Completion Rpt., Proj. No. F-35-R, Job No. 2. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 16 pp.

Ohio Department of Natural Resources. 1971c. Coho salmon sampling. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 25 pp.

Ohio Department of Natural Resources. 1975. Status of Ohio Lake Erie fisheries. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Res. Unit, Sandusky. 14 pp.

Ohio Department of Natural Resources. 1976. Status of Ohio's Lake Erie fisheries. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Res. Unit, Sandusky. 20 pp.

Ohio Department of Natural Resources. 1977. Status of Ohio's Lake Erie fisheries. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Res. Unit, Sandusky. 20 pp.

Ohio Department of Natural Resources. 1978. Status of Ohio's Lake Erie fisheries. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Res. Unit, Sandusky. 20 pp.

Parkhurst, B.R. 1971. An ecological evaluation of a thermal discharge. Part V:The distribution and growth of the fish populations along the western shore of Lake Erie at Monroe, Michigan. Michigan State Univ., Inst. Water Res., Thermal Discharge Series, Tech. Rpt. No. 17. 71 pp.

Parsons, J.W. 1970. Walleye fishery of Lake Erie in 1943-62 with emphasis on contributions of the 1942-61 year-classes. J. Fish. Res. Bd. Canada 27:1475-89.

Parsons, J.W. 1971. Selective food preference of walleyes of the 1959 year class in Lake Erie. Trans. Am. Fish. Soc. 100:474-85.

Parsons, J.W. 1972. Life history and production of walleyes of the 1959 year-class in western Lake Erie, 1959-62. Trans. Am. Fish. Soc. 101:655-61.

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

Pinsak, A.P., and T.L. Meyer. 1976. Environmental baseline for Maumee Bay. Maumee River Basin Level B Study, Comprehensive Water and Related Land Resources Planning, Great Lakes Basin Comm., MRB Series No. 9. 164 pp.

Price, J.W. 1963. A study of the food habits of some Lake Erie fish. Ohio Biol. Surv. Bull. 2(1). 89 pp.

Rawson, M.R., and R.L. Scholl. 1978. Reestablishment of the sauger, *Stizostedion canadense*, in western Lake Erie. Ohio Dept. Nat. Resour., Div. Wildl., Wildl. In-Service Note 387. 9 pp.

Regier, H.A., V.C. Applegate, and R.A. Ryder. 1969. The ecology and management of the walleye in western Lake Erie. Great Lakes Fish. Comm., Tech. Rpt. No. 15. 101 pp.

Reutter, J.M., C.E. Herdendorf, M.D. Barnes, W.E. Carey. 1979. Response of fish and invertebrates to the heated discharge from the Davis-Besse reactor, Lake Erie, Ohio. Ann. Perform. Rpt., Federal Aid in Sport Fish Restoration, Proj. No. F-41-R-10. Ohio State Univ., Ctr. Lake Erie Area Res., Columbus. 164 pp.

Reutter, J.M., C.E. Herdendorf, G.W. Sturm. 1978. Impingement and entrainment studies at the Bay Shore Power Station, Toledo Edison Company, 316(B) Program, Task II. Ohio State Univ., Ctr. Lake Erie Area Res., Columbus, Tech. Rpt. No. 78b. 160 pp.

Sand, R.F., and W.G. Gordon. 1960. Exploratory fishing in Lake Erie. September 1958-November 1959. Commer. Fish. Rev. 22:1-12.

Scott, D.C. 1955. Activity patterns of perch, Perca flavescens, in Rondeau Bay of Lake Erie. Ecology 36:320-27.

Scott, W.B. 1951. Fluctuations in abundance of the Lake Erie cisco (Leucichthys artedi) population. Contrib. Roy. Ont. Mus. Zool. 32. 41 pp.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. Canada, Bull. 184. 966 pp.

Scott, W.B., and S.H. Smith. 1962. The occurrence of the longjaw cisco, Leucichthys alpenae, in Lake Erie. J. Fish. Res. Bd. Canada 19:1013-23.

Smith, H.M., and M.M. Snell. 1887. Review of the fisheries of the Great Lakes in 1885, pp. 1-333. In: U.S. Comm. Fish and Fisheries, Rpt. of the Comm. for 1887.

Stone, U.B., D.G. Pasko, and R.M. Roecker. 1954. Study of Lake Ontario-St. Lawrence River smallmouth bass. N.Y. Fish and Game J. 1:1-26.

Sztramki, L., and G.C. Teleki. 1977. Annual variations in the fecundity of yellow perch from Long Point Bay, Lake Erie. Trans. Am. Fish. Soc. 106:578-582.

Thomasson, R.D. 1963. Some observations on the American smelt, Osmerus mordax (Mitchill), in the central basin of Lake Erie. M.S.A. Thesis, Univ. Toronto, Toronto, Ont. 124 pp.

Trautman, M.B. 1957. The fishes of Ohio. Ohio State University Press, Columbus. 683 pp.

Tubb, R.A. 1973. Food habits of the fishes in Sandusky Bay. Final Rpt., Contract No. 14-16-0003-13,657, U.S. Dept. of the Interior, Bur. Sport Fish. and Wildl., Twin Cities, Minn. 18 pp.

Turner, C.L. 1920. Distribution, food, and fish associates of young perch in the Bass Island region of Lake Erie. Ohio J. Sci. 20:137-52.

U.S. Army Corps of Engineers. 1972. Draft environmental statement, confined disposal facility for Toledo Harbor, Ohio. U.S. Army Engineer District, Detroit. 39 pp.

U.S. Army Corps of Engineers. 1972. Final environmental statement, Buffalo Harbor, New York (maintenance). U.S. Army Engineer District, Buffalo. 15 pp.

U.S. Army Corps of Engineers. 1973. Draft environmental statement, confined disposal facility at Pointe Mouillee for Detroit and Rouge Rivers. U.S. Army Engineer District, Detroit. 104 pp.

U.S. Army Corps of Engineers. 1974. Draft environmental impact statement, maintenance dredging of the polluted sediments in Toledo Harbor, Michigan. U.S. Army Engineer District, Detroit. 24 pp.

U.S. Army Corps of Engineers. 1974. Final environmental statement, navigation project, Huron Harbor, Erie County, Huron, Ohio U.S. Army Engineer District, Buffalo. 141 pp.

U.S. Army Corps of Engineers. 1975a. Draft environmental statement, diked disposal facility, Site No. 1, Lake Erie, Fairport Harbor, Ohio. U.S. Army Engineer District, Buffalo, New York. 79 pp. + app.

U.S. Army Corps of Engineers. 1975b. Final environmental impact statement, operation and maintenance, Ashtabula Harbor, Ashtabula County, Ohio. U.S. Army Engineer District, Buffalo, New York. 128 pp. + app.

U.S. Army Corps of Engineers. 1975c. Draft environmental statement, diked disposal facility, Site No. 3, Lake Erie, Ashtabula Harbor, Ashtabula, Ohio. 83 pp. + app.

U.S. Army Corps of Engineers. 1975d. Final environmental impact statement, operation and maintenance, Dunkirk Harbor, Chautauqua County, New York. U.S. Army Engineer District, Buffalo. 123 pp. + app.

U.S. Army Corps of Engineers. 1975e. Final environmental statement, operations and maintenance project, Huron Harbor, Erie County, Huron, Ohio. U.S. Army Engineer District, Buffalo. 122 pp.

U.S. Army Corps of Engineers. 1976. Draft environmental statement, Ottawa River Harbor, Michigan and Ohio. U.S. Army Engineer District, Detroit. 35 pp. + app.

U.S. Army Corps of Engineers. 1976. Final environmental statement, maintenance dredging of the federal navigation channel at Monroe Harbor, Michigan. U.S. Army Engineer District, Detroit. 118 pp. + app.

U.S. Army Corps of Engineers. 1976a. Fisheries investigations, Cleveland Harbor, Ohio. U.S. Army Engineer District, Buffalo, New York. 51 pp.

U.S. Army Corps of Engineers. 1976b. Cleveland Harbor, Ohio, draft feasibility report for harbor modification. U.S. Army Engineer District, Buffalo, New York. 121 pp.

U.S. Army Corps of Engineers. 1977. Draft environmental statement, Port Clinton Harbor, Ohio, maintenance operations. U.S. Army Engineer District, Detroit, Michigan. 68 pp. + app.

U.S. Army Corps of Engineers. 1977. Preliminary feasibility report on modifications to Monroe Harbor, Michigan. U.S. Army Engineer District, Detroit. 46 pp. + app.

U.S. Atomic Energy Commission. 1972. Final environmental statement related to operation of Enrico Fermi Atomic Power Plant, Unit 2, Detroit Edison Company. U.S. Atomic Energy Comm., Directorate of Licensing, Washington, D.C. 133 pp. + app.

U.S. Fish and Wildlife Service. 1977.

U.S. Nuclear Regulatory Commission. 1977. Draft environmental statement related to construction of Erie Nuclear Plant, Units 1 and 2, Ohio Edison Company, et. al. U.S. Nuclear Regulatory Comm., Off. of Nuclear Reactor Regulation, Washington, D.C. 290 pp.

Van Meter, H.D., and M.B. Trautman. 1970. An annotated list of the fishes of Lake Erie and its tributary waters exclusive of the Detroit River. Ohio J. Sci. 70(2):65-78.

Van Oosten, J. 1930. The disappearance of the Lake Erie cisco - a preliminary report. Trans. Am. Fish. Soc. 60:204-14.

Van Oosten, J. 1936. The dispersal of smelt, _Osmerus mordax_ (Mitchell), in the Great Lakes region. Trans. Am. Fish. Soc. 66:160-71.

Van Oosten, J. 1938. The age and growth of the Lake Erie sheepshead, _Aplodinotus grunniens_ Rafinesque. Pap. Mich. Acad. Sci., Arts and Letters 23:651-68.

Van Oosten, J. 1942. The age and growth of the Lake Erie white bass, _Lepibema chrysops_ (Rafinesque). Pap. Mich. Acad. Sci., Arts and Letters 27: 307-34.

Van Oosten, J.V. 1961. Records, ages, and growth of the mooneye, _Hiodon tergisus_, of the Great Lakes. Trans. Am. Fish. Soc. 90:170-74.

Van Oosten, J., and R. Hile. 1947. Age and growth of the lake whitefish, _Coregonus clupeaformis_ (Mitchill), in Lake Erie. Trans. Am. Fish. Soc. 77: 178-249.

Van Vooren, A.R. 1978. Characteristics of walleye spawning stocks. Final Rpt., Federal Aid Project F-35-R, Study No. 4. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 28 pp.

Van Vooren, A.R., and D.H. Davies. 1974. Survey of fish species in Ohio waters of Lake Erie. Performance Rpt., Federal Aid Project F-35-R, Study No. 2, Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 69 pp.

Van Vooren, A.R., D.H. Davies, G.A. Emond. 1976. Survey of fish species in Ohio waters of Lake Erie. Performance Rpt., Federal Aid Project F-35-R, Study No. 2. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 63 pp.

Van Vooren, A.R., D.H. Davies, G.A. Emond. 1975. Survey of fish species in Ohio waters of Lake Erie. Performance Rpt., Federal Aid Project F-35-R, Study No. 2. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 65 pp.

Van Vooren, A.R., D.H. Davies, G.A. Emond. 1978. Survey of fish species in Ohio waters of Lake Erie. Performance Rpt., Federal Aid Project F-35-R, Study No. 2. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 55 pp.

Van Vooren, A.R., D.H. Davies, G.A. Emond. 1977. Survey of fish species in Ohio waters of Lake Erie. Performance Rpt., Federal Aid Project F-35-R, Study No. 2. Ohio Dept. Nat. Resour., Div. Wildl., Lake Erie Fish. Res. Unit, Sandusky. 61 pp.

Wapora, Inc. 1977. 316(A) Demonstration, Bay Shore Station, Toledo Edison Company. Toledo Edison Co., Toledo, Ohio. 135 pp.

Waybrant, R.C., and J.M. Shauver. 1977. A survey of larval fish in Michigan waters of Lake Erie, 1975 and 1976. U.S. Environmental Protection Agency, Environmental Res. Lab., Duluth, Minnesota. 52 pp.

Wells, L., and R. Howe. 1974. Life history of the spottail shiner (Notropis hudsonius) in southeastern Lake Michigan, the Kalamazoo River, and western Lake Erie. U.S. Bur. Sport Fish and Wildl., Res. Rpt. 78. 10 pp.

White, A.M., M.B. Trautman, E.J. Foell, M.P. Kelty, and R. Gaby. 1975. Water quality baseline assessment for the Cleveland area - Lake Erie. Volume II. The fishes of the Cleveland metropolitan area including the Lake Erie shoreline. U.S. Environ. Protection Ag., Chicago, Project G005107, Sec. 108a Program. 181 pp.

Wickliff, E.L. 1920. Food of young smallmouth black bass in Lake Erie. Trans. Am. Fish. Soc. 50:364-371.

Willis, C.F. 1974. Fish population of Sandusky Bay inferred from museum records. Center for Lake Erie Area Res., Tech. Rpt. No. 16. 11 pp.

Wolfert, D.R. 1963. The movements of walleye tagged as yearlings in Lake Erie. Trans. Am. Fish. Soc. 92:414-20.

Wolfert, D.R. 1969. Maturity and fecundity of walleyes from the eastern and western basins of Lake Erie. J. Fish. Res. Bd. Canada 26:1877-88.

Wolfert, D.R. 1977. Age and growth of the walleye in Lake Erie, 1963-1968. Trans. Am. Fish. Soc. 106:569-77.

Wolfert, D.R., V.C. Applegate, and L.N. Allison. 1967. Infection of the walleye, Stizostedion v. vitreum, of western Lake Erie with Bothriocephalus cuspidatus (Cooper). Pap. Michigan Acad. Sci., Arts and Letters 52:105-14.

Zeitoun, I.H., J.A. Gulvas, J.E. Schaeffer, N.C. Van Wagner. 1978. Progress report of the 1978 impingement and entrainment studies at the J.R. Whiting Plant. Consumers Power Company, Dept. of Environmental Services, Jackson, Michigan, Tech. Rpt. No. 13.