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HISTORY OF THE WALLEYE FISHERIES OF SAGINAW BAY, LAKE HURON [1]

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Abstract

The walleye population in Saginaw Bay once supported four commercial fisheries: a seine fishery in or near certain rivers, a fyke net fishery in rivers, an angling fishery through the ice on the inner part of the Bay, and a fishery using mostly trap nets and pound nets offshore. All had collapsed by the late 1940's. The final decline was traced to a series of year class failures beginning in 1944. Modest-sized year classes in the 1950's were not adequate to arrest the downward trend in the stock. The Bay and its tributaries have had a long history of water quality problems. Circumstantial evidence is presented that poor recruitment was primarily related to increased turbidity which presumably smothered eggs on the inner-bay spawning reefs. Commercial fishing, while not the primary factor initiating the decline, became relatively more intense as walleye abundance fell. Sea lamprey, rainbow smelt, and alewife probably were not primarily responsible for the decline in walleyes but smelt and alewife may suppress recovery.

[1] Contribution from Dingell-Johnson Project F-35-R, Michigan

Introduction

Saginaw Bay supported the second largest walleye (Stizostedion v. vitreum) fishery on the Great Lakes until a precipitous decline occurred in the 1940's (Fig. 1). Most of the catch was made during the spawning migration into the shallow, inner part of the Bay, but some smaller walleyes were taken during a fall migration. All evidence indicates that the inner part of the Bay and its tributaries served as the major spawning and nursery grounds; the outer part of the Bay and the adjacent waters of Lake Huron were the summer home of adult and subadult walleyes. Evidence was presented by Schneider and Leach (1978) that this population contributed to fisheries as far away as Thunder Bay.

Types of fisheries

Fisheries were established in the Saginaw Bay area in the 1830's (Lanman 1839). Four types of commercial fisheries for walleye eventually developed: a seine fishery in or near certain rivers, a fyke net fishery in the Saginaw River and its tributaries, an angling fishery through the ice on the inner part of the Bay, and an offshore fishery. Only the offshore fishery was important in the 1900's.

The seine fishery was directed at concentrations of spawning walleyes found principally in the lower end of the Saginaw River. The magnitude of the Saginaw River run in the 1800's is illustrated by reports that numerous fishermen were taking as many as 1,000 barrels (109 metric tons) in 1858 (Fox 1858), and that walleyes were caught at the rate of several tons per seine haul in 1871 (Milner 1874). This fishery had dwindled by the turn of the century, and it can be inferred from reports by conservation officers and the Bay City Hatchery (the latter now in State of Michigan Archives) that only a small run remained by the late 1920's. According to detailed records on commercial fishing gathered by the Michigan State Board of Fish Commissioners (MSBFC), 1891-1908 (now in State of Michigan Archives), seine fisheries also existed

in or near the Pine and Rifle rivers, Arenac County. Large quantities of walleyes were also taken at the mouth of the Kawkawlin River (which means "place of the pickerel") at least as far back as 1843 (Butterfield 1918). Between 1887 and 1891, the Michigan State Board of Fish Commissioners obtained ripe walleyes from commercial netters operating within 2 miles of the Saginaw and Kawkawlin rivers (MSBFC 1890, 1893).

In 1864, a fall and winter fishery was initiated on the Saginaw and Shiawassee rivers which, by the end of the 1860's, was averaging 68 metric tons of yellow perch (Perca flavescens), northern pike (Esox lucius), black bass (Micropterus), and walleyes per year (Fox 1868). Reports to the Michigan State Board of Fish Commissioners (MSBFC 1887, 1893, 1897) and the United States Commission of Fish and Fisheries (Kumlien and True 1887; Smith 1894) supply additional information. These fish reportedly moved up into the rivers during storms on the Bay. The walleyes were tiny--averaging only 4 ounces--and many were wasted because they were too small to be used. By 1879 this fishery was reputedly declining because of sawmill pollution. A size limit was finally imposed in 1894 but undersized fish were still being taken 10 years later (Gansser 1905). This fishery dwindled and was closed in 1908, but as late as 1940 fingerling perch still migrated up the Saginaw and Cass rivers to Frankenmuth (Michigan Department of Conservation 1940?). The decline of the fyke and seine fisheries in the Saginaw River was probably due to overexploitation and a reduction in water quality.

The ice fishery on Saginaw Bay was once very important. In January 1875, 300 or 400 shanties were located off the mouth of the Saginaw River where the water was 3-5 m deep (Smith and Snell 1891). (The water must have been relatively transparent then because walleyes were taken with spears.) Kumlien (1887) reported than in 1877 over 1,000 fishermen took more than 25 pounds (11.3 kg) per day each. (If that rate continued for 3 months a record high catch--over 1,000 MT--would have been made by just this one method!) The fishery was small in 1885 (Smith and Snell 1891) but at the turn of the century Gansser (1905) noted that 500 to 2,000 fishermen and unemployed workers still "go out on

the ice in the bay, erect huts and live for several months luring the finny tribe from the clear blue waters."

The offshore fishery had become the most prominent walleye fishery several decades before the population crashed. Pound nets and trap nets were the most effective gear. The best fishing grounds were along both edges of the inner bay up to a distance of 20 miles from the Saginaw River mouth, and on the Coreyon Reef, a shallow bar extending from the mouth of the Saginaw River to the Charity Islands (Anonymous 1883; MSBFC 1890). Large catches were made during the spawning migration, and smaller catches during a fall migration into the Bay (Hile and Buettner 1959). Some walleyes were taken from the outer bay during the summer, especially after the introduction of the deep-water trap net (Van Oosten et al. 1946).

Spawning grounds

The breeding grounds for the Saginaw Bay walleye stock can be deduced from descriptions of fisheries, records of hatchery operations and memories of commercial fishermen. The Saginaw River system (and probably other tributaries which supported fisheries) were once important, but eventually offshore reefs had to sustain the entire walleye stock. Spawning occurred in many areas of the inner bay as late as the 1930's. Ripe eggs were collected for the Bay City Hatchery by fishermen as far away as Caseville and Point Au Gres but the prime spawning areas seemed to be off the mouth of the Saginaw River, along the shore between Quanicassee and Fish Point, along the outer edge of the islands between Sebewaing and Bay Port, and on the Coreyon Reef out from Bay Port. Some spawning also took place along the west shore between Rifle Bar and Nayanquing Point, and some may have occurred around the Charity Islands because they became an important fishing area after the stock declined.

Changes in the fish population

The commercial statistics (Baldwin and Saalfeld 1962), which combine catches of the various walleye fisheries, show that the catch from Saginaw Bay fluctuated, but without a long-term trend, up until the mid-1920's (Fig. 1). From a low point then, catches increased to an all time high of 930 MT in 1942, declined abruptly, stabilized at a low level in 1949-64, then collapsed. Walleye fishing was prohibited after 1969.

An abrupt increase in the sauger (Stizostedion canadense) population in the 1920's and 1930's was the first indication of changes in the Bay. It may have been a response to the low levels of walleye and perch at that time, or to eutrophication of the Bay. Growth of yearling and older walleye began to increase in the early 1930's and continued to do so irrespective of increases, and later decreases, in walleye abundance (Hile 1954; and U.S. Great Lakes Fishery Laboratory unpublished data). The improved growth of walleye coincided with the initial buildup of the smelt population (Fig. 1), as reconstructed from the observations of Van Oosten (1937), and was probably due, in part, to utilization of smelt for food.

The relatively high commercial catch of walleyes in 1932-43 resulted from a combination of three factors: high walleye abundance, improved growth, and reduced minimum size limits. The last two factors made a greater proportion of the stock available to commercial fishing. The minimum size limit was reduced from 680 g (approximately 432 mm) to 419 mm in 1933, then to 404 mm in 1939.

The combination of faster growth and lower size limit surely resulted in increased harvest of immature walleyes (Schneider and Leach 1978); but the subsequent collapse of the stock was probably not initiated by overfishing. The size structure of the population during the 1940's was skewed toward large walleyes and does not suggest that overfishing was taking place then (Table 1). Also, fishing effort remained stable from 1929 to 1943 (Fig. 1) and catch-effort did not increase significantly when the size limits were reduced (see Appendix Table 3 of Hile and Buettner 1959). However, commercial fishing placed added stress on the population after the decline began: by 1950, catch had dropped 96% but effort only 62%. This

heavy exploitation, coupled with very poor recruitment, caused the stock (and its reproductive potential) to decline rapidly.

Hile and Buettner (1959) noted the similarity in the decline of the walleye to that of the lake trout (Salvelinus namaycush) and postulated that sea lamprey (Petromyzon marinus) predation was the primary cause of both. The sea lamprey population of Lake Huron exploded in the 1940's, according to Smith's (1968) data for the adult run at the Ocqueoc River weir, in the northern part of the lake (Fig. 1). Lamprey scarring appears to have been very low on walleye, however (Shetter 1949; and M. Keller and H. J. Buettner personal communication), and the size structure of the population did not become truncated (Table 1), as would occur if lamprey were selectively killing the larger walleyes. On the contrary, larger walleyes predominated during the late 1940's when the sea lamprey was at its peak and the lamprey's primary food, the lake trout, had already been exterminated.

Rather than lamprey predation, the size structure reflects poor recruitment. After the strong year classes in 1940 and 1943, only modest-sized year classes in 1950 and 1954 (and possibly one or two others in the late 1950's) interrupted the downward trend. The strong year class in 1943 was hatched in the spring following the massive die-off of rainbow smelt (Osmerus mordax) (Van Oosten 1947); on the other hand, only weak year classes were produced the next 6 years even though smelt remained sparse (Fig. 1). Smelt returned to high abundance in the 1950's.

The decline in the walleye was accompanied by an increase in yellow perch, suckers (Catostomus) and especially, carp (Cyprinus carpio) (Hile and Buettner 1959). Actually, the increase in perch biomass was greater than the catch-effort index of Hile and Buettner suggests because declining growth was reducing the proportion of the perch population available to the fishery (El Zarka 1959). The abundance of catfish (Ictalurus spp.) increased also, but it began during the 1930's (Hile and Buettner 1959)--possibly as an early response to changes in water quality. The alewife first reached a significant level in Saginaw Bay in the early 1950's and soon became very abundant (Fig. 1). (The graph of their abundance was patterned after that of Aron and Smith [1971] based on the descriptions of Miller [1957].) It is

suspected that alewives and smelt may have hindered walleye recruitment in recent years but that they were not the primary cause for the decline (Schneider and Leach 1978). An attempt to aid the remnant walleye population by planting 50 million fry in 1972 and again in 1973 failed (R. Haas personal communication).

Changes in water quality

Fishermen claimed that pollution via the Saginaw River and other tributaries was responsible for the decline of the Saginaw Bay walleye fishery. This view was supported by Beeton (1969) and is supported here. The importance of water quality in the Saginaw River to the spawning areas in the inner bay can be appreciated from the fact that the river discharges a volume of water equal to the volume of the inner bay (the area southwest of a line from Sand Point to Point Lookout) in 2.4 years (calculated from data of Beeton et al. 1967).

As pointed out earlier, sawmills were affecting the Saginaw River fisheries as far back as 1879 (True 1887). The lumbering boom was over by the turn of the century but other kinds of pollution have increased through the years. A siltation problem in the river (and to a lesser extent in the Bay), initiated by logging, was surely aggravated by intensive agricultural practices--including ditching and tiling--and by the sluggish current. Nutrients contributed by the rich soils, fertilizers and domestic sewage, increased substantially as the Saginaw Valley developed. Populations in the four major cities in the watershed (Bay City, Flint, Saginaw, and Midland) expanded from 85,000 in 1900, to 322,000 in 1950. Bay City and Saginaw did not install primary sewage treatment plants until the early 1950's.

The Saginaw River Basin has also been subjected to severe pollution from chemical, petroleum, heavy manufacturing, sugar refining, and canning industries. Biennial Reports by the Michigan Stream Control Commission trace the history of the problem. Pollution increased in severity after World War I and by the mid-1920's the Third Biennial Report of the Michigan Department of Conservation (1926?) stated: "The fishery

interests of Saginaw Bay have suffered losses definitely traceable to the pollution of the Saginaw River and its tributaries." In 1930, the City of Saginaw requested relief from the effects of brine, chemical plant wastes and sugar beet wastes on its water supply which was drawn from the Saginaw River. A study in 1935-36 (Adams 1937) dealt mainly with water quality in the river but included some data on chlorides in the Bay. While brine itself is not very toxic to fish life, its distribution pattern showed that polluted river water was usually concentrated in the areas used by spawning walleyes and that the dilution rate was reduced under ice cover.

Phenolic wastes had an obvious impact on the fishery. Data in the report by Adams (1937) indicated that the concentration of phenols in the Saginaw River peaked (maximum of 0.2 ppm by Gibbs' method) during the winter months when biodegradation was low. The result was a tainting of walleye and other fish in the Bay during winter and early spring. The tainting problem began about the time of World War I, became acute by the late 1930's, then gradually improved. Unfortunately there is no information on the concentration of phenols in Bay water or sediments. In a letter from W. E. Mason to R. S. Marks on December 27, 1948 (Michigan Department of Natural Resources files), it was noted that phenols seemed to be released when the sediments were roiled by storms. Phenolic waste treatment facilities were expanded periodically through the years but the improvements may have been offset by increased production and by new sources.

World War II disrupted the pollution control program for the Saginaw Valley, and also, the reports by the Stream Control Commission. The last reports, in the early 1940's, tell of oil discharges, fish kills in tributary streams caused by cannery wastes, and the return of phenol discharges to high levels. It is probable that even more serious pollutants went unobserved.

Measurements made by employees of the Bay City water treatment plant show that turbidity of the Bay increased greatly during the 1940's (Fig. 1). Silt as well as plankton, may have contributed to the turbidity because the levels were always highest in the weeks following the loss of the protective cover of ice--the time when walleyes deposited their eggs. At

least as far back as 1950, fishermen (M. Keller personal communication) recall scrubbing "slime" off their nets every few days and noticing that "mud" was accumulating on once-clean substrates. A thick layer of organic sediment was reportedly encountered in 1952 when Bay City was compelled to move its water intake out to cleaner water. Until recent years, strong northeast winds washed this material up on the beach of the Bay City State Park in amounts so large it had to be trucked away. When analyzed in 1961, this material consisted of the remains of ostracods, cladocerans, higher aquatic plants, the algae Fragillaria and Cladophora, as well as general organic detritus (letter in Michigan Department of Natural Resources files from C. M. Fetterolf to R. W. Parker and F. D. Frost, August 31, 1961). The turbidity problem may have been aggravated by the re-dredging of the Saginaw River channel in 1942 and the dumping of the spoils in the Bay. The dumping ground was located off the Saginaw River, near a major walleye spawning ground, in water so shallow that the loose spoils could be dispersed by wave action. Major dredging operations also took place in 1865-67, 1884-85, 1910-14, 1932-33, and 1961-64; minor amounts were dredged nearly every year (Butterfield 1918; and data from Army Corps of Engineers).

It seems likely that pollutants which altered the substrate on the spawning grounds were the most detrimental to the walleye population. The report on Lake Huron by the U.S. Fish and Wildlife Service (1969) supports this opinion. It should be noted that the Bay City Hatchery successfully incubated walleye eggs in inshore water (obtained from the Bay City intake line) through 1944. The hatchery was permanently closed the following year because insufficient numbers of walleye eggs were obtained.[1] Few eggs were taken in 1945 because an early spring had stimulated spawning before commercial fishing was permitted and, probably, because of the collapse of the walleye fisheries off the Saginaw River mouth. In 1932, 60 boats docked in the Saginaw River were supplying eggs to the hatchery; by 1938, this number had dropped to 32, and during the 1940's that fishery disappeared. Significantly, the last walleye fishing ground to decline was the one furthest away from the influence of the Saginaw River.

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[1] The possibility that releases of walleye fry from the hatchery had been sustaining the walleye stock of Saginaw Bay was discounted by Hile and Buettner (1959) and Dymond (1957).

Intensive studies in the 1950's documented the adverse effect of Saginaw River water on the benthos of the inner bay (Schneider et al. 1969). The burrowing mayfly, Hexagenia, was still present then (although perhaps less abundantly than before), but was greatly reduced in 1955 or 1956 and became sparse by 1965. Depletion of dissolved oxygen in the bottom waters of the inner bay, serious enough to kill perch confined in trap nets, was first observed in the early 1970's during mid-summer calms 2 or 3 days long (R. Manor personal communication), but undoubtedly began years earlier.

Conclusions

Saginaw Bay and its fisheries have undergone dramatic changes since the 1830's, and especially since the 1940's. The quality of the water in the Saginaw River system and the inner bay was steadily degraded by a wide variety of domestic and industrial pollutants. The rate of degradation increased in the 1920's and levels critical to some fish were reached in the 1940's. The fish community shifted from high-value species (especially walleye) to low-value species (such as carp, catfish, perch, smelt, and alewife).

The inner bay and its tributaries contained major spawning grounds for walleyes and supported large and diverse walleye fisheries. Gradually, the most important fisheries shifted from those oriented to spawning runs in or near tributaries, to those exploiting spawning runs on offshore reefs; however, total commercial catch remained relatively stable until the 1940's. A succession of weak year classes, beginning in 1944, initiated a population decline, and only a remnant stock remains now. The causes of the decline appear to have been, primarily, fouling of the substrates used for incubating eggs by the accumulation of organic materials (and possibly toxins) and, secondarily, an intensive fishery which reduced the resiliency of the population.

Restoration of the walleye in Saginaw Bay will depend on (1) rehabilitation of the spawning substrates through pollution control

and the cleansing action of currents, (2) reestablishment of a brood stock through the planting of fingerling walleyes, and (3) the ability of walleye fry to survive in the altered fish community.

Table 1.--Length-frequency distributions (percent) of walleyes in the catch of Saginaw Bay (Bay Port) commercial fishermen during spawning runs, 1927-58 (T = <0.5%).[a]

Total length (mm)	Year and (in parentheses) number of fish													
	1927 (131)	1929 (604)	1943 (288)	1948 (427)	1949 (210)	1950 (262)	1951 (363)	1952 (185)	1953 (180)	1954 (119)	1955 (130)	1956 (236)	1957 (350)	1958 (385)
173-241	--	--	--	--	--	--	48	--	--	--	--	--	--	1
242-272	--	--	--	--	--	--	11	--	2	--	2	2	--	1
273-307	--	--	--	--	--	--	2	--	T	--	1	14	1	T
308-338	--	--	--	--	--	2	5	1	T	--	11	19	7	T
339-373	1	--	1	1	--	3	6	13	2	8	35	8	35	5
374-406	3	T	12	1	1	14	6	39	13	2	--	6	30	15
407-439	21	18	42	3	10	11	7	24	12	7	1	14	17	27
440-472	27	14	21	4	8	7	2	10	29	8	8	14	5	22
473-503	18	22	9	7	4	4	3	7	29	13	4	6	1	17
504-533	11	13	4	13	6	3	1	2	4	23	7	3	2	7
534-564	8	13	5	30	13	7	1	--	2	22	9	4	1	1
565-597	2	8	4	30	18	10	1	1	1	12	7	3	1	1
598-632	5	5	1	4	26	15	2	--	T	--	11	1	T	1
633-665	--	4	--	1	8	11	2	1	2	1	2	6	T	1
666-699	3	3	1	4	2	6	2	--	T	1	--	--	--	--
> 699	1	T	T	2	4	7	1	2	3	3	2	T	--	1

[a] Data for 1927, 1929 and 1943 from Hile (1954); unpublished data for other years courtesy of U.S. Fish and Wildlife Service, Great Lakes Fishery Laboratory, Ann Arbor, Michigan

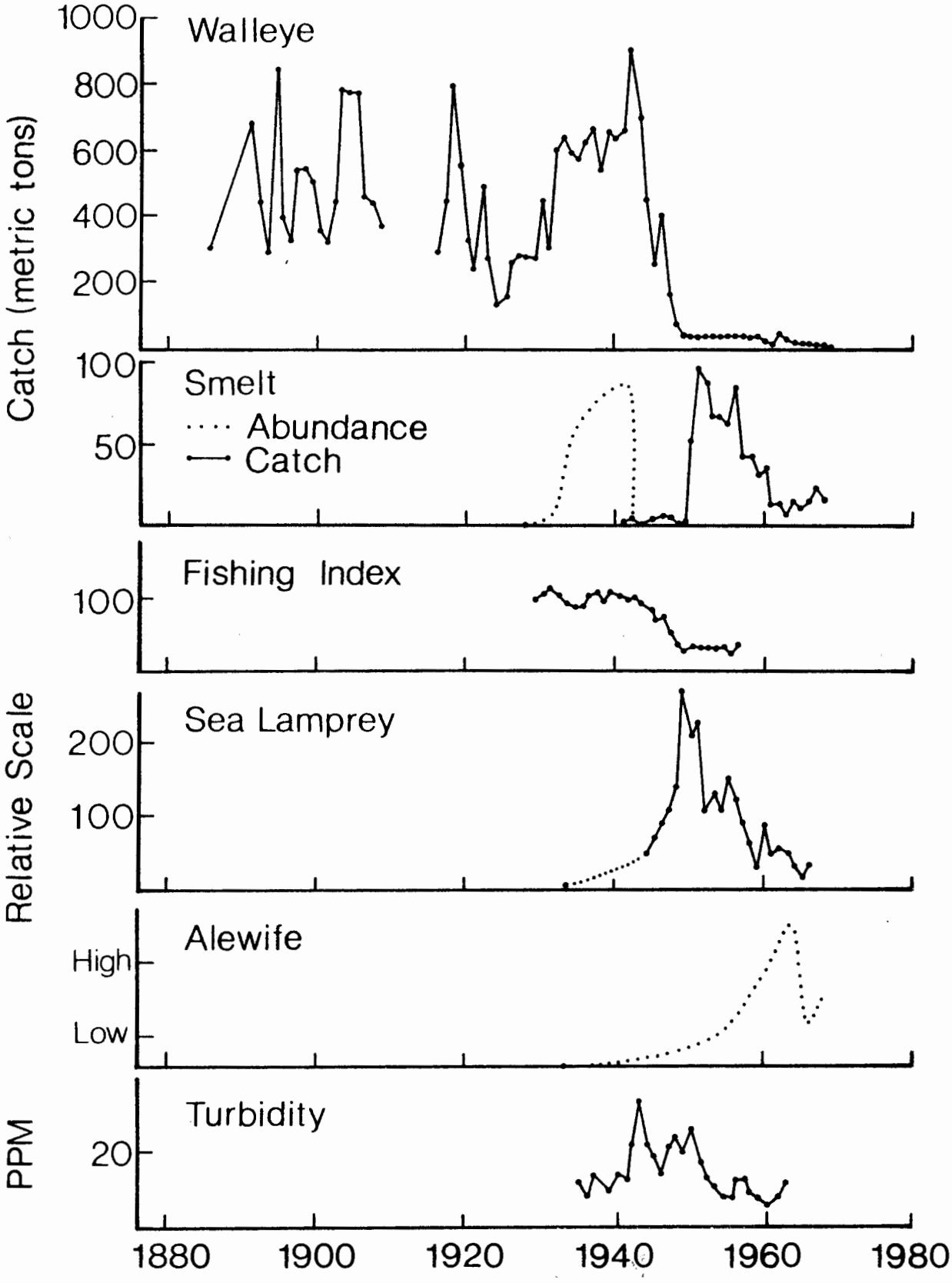

Figure 1.--For Saginaw Bay, Lake Huron: commercial catches of walleyes, 1885-1969; probable relative abundance (dotted line) of rainbow smelt (Van Oosten 1937, 1947) and commercial catches (solid line), 1928-68; commercial fishing intensity index (percentages of 1929-43 mean) for walleyes, 1929-56 (Hile and Buettner 1959); abundance indices (percentages of mean number of upstream migrating adults counted at the Ocqueoc River weir) for sea lampreys, 1944-66 (Smith 1968); probable relative abundance of alewives, 1933-58 (Miller 1957; Aron and Smith 1971); and turbidity (parts per million) of bay water, 1935-58 (Bay City Water Treatment Plant, unpublished data).

Literature cited

Adams, Milton P. 1937. Saginaw Valley report. Michigan Stream Control Commission, 154 pp.

Anonymous. 1883. History of Bay County, Michigan, with illustrations and biographical sketches of some of its prominent men and pioneers. H. R. Page & Co., Chicago, 281 pp.

Aron, William I., and Stanford H. Smith. 1971. Ship canals and aquatic ecosystems. Science 174: 13-20.

Baldwin, Norman S., and Robert W. Saalfeld. 1962. Commercial fish production in the Great Lakes 1867-1960. Great Lakes Fishery Commission Tech. Rep. 3, 166 pp. + supplements.

Beeton, A. M. 1969. Changes in the environment and biota of the Great Lakes. Pages 150-187 in Eutrophication: causes, consequences, correctives. Proceedings, Symposium, National Academy of Sciences, Washington, D.C.

Beeton, Alfred M., Stanford H. Smith, and Frank F. Hooper. 1967. Physical limnology of Saginaw Bay, Lake Huron. Great Lakes Fish. Comm. Tech. Rep. 12, 56 pp.

Butterfield, George E. (ed) 1918. Bay County, past and present, compiled by the pupils and teachers of the sixth grade geography classes, Bay City Public Schools. C. and J. Gregory, Bay City, Michigan, 212 pp.

Dymond, J. R. 1957. Artificial propagation in the management of Great Lakes fisheries. Trans. Amer. Fish. Soc., 86(1956): 384-392.

El-Zarka, Salah El-Din. 1959. Fluctuations in the population of yellow perch, Perca flavescens (Mitchill), in Saginaw Bay, Lake Huron. U.S. Fish Wildl. Serv. Fish. Bull. 151: 365-415.

Fox, Truman B. 1858. History of Saginaw County, from year 1819 down to present time. Printed in East Saginaw, 78 pp.

Fox, Truman B. 1868. History of Saginaw Valley, its resources, progress and business interests. East Saginaw, Michigan, 80 pp.

Gansser, Capt. Augustus H. 1905. History of Bay County, Michigan. Richmond S. Arnold, Chicago, 726 pp.

Hile, Ralph. 1954. Fluctuations in growth and year-class strength of the walleye in Saginaw Bay. U.S. Fish Wildl. Serv. Fish. Bull. 56: 7-59.

Hile, Ralph, and Howard J. Buettner. 1959. Fluctuations in the commercial fisheries of Saginaw Bay 1885-1956. U.S. Fish Wildl. Serv. Res. Rep. 51, 38 pp.

Kumlien, Ludwig. 1887. The fisheries of the Great Lakes. Pages 757-769 in History and methods of the fisheries. The fish and fisheries of the United States, Sect. V, G. Brown Goode (ed.). U.S. Government Printing Office, Washington, D.C.

Kumlien, Ludwig, and Frederick W. True. 1887. The fishing grounds of the Great Lakes. Pages 117-132 in the fishing grounds of North America. The fish and fisheries of the United States, Sect. III. G. Brown Goode (ed.). U.S. Government Printing Office, Washington, D.C.

Lanman, James 1839. History of Michigan: Civil and topographical in a compendius form with a view of surrounding lakes. E. French, New York, 397 pp.

Michigan Department of Conservation. Lansing.
1926? Third biennial report for 1925-1926. 425 pp.
1940? Tenth biennial report for 1934-1940. 331 pp.

Michigan State Board of Fish Commissioners. Lansing.
1887. Seventh biennial report, 1884-1886. 80 pp.
1890. Ninth biennial report, 1888-1890. 92 pp.
1893. Tenth biennial report, 1890-1892. 89 pp.
1897. Twelfth biennial report, 1894-1896. 129 pp.

Michigan Stream Control Commission. Biennial reports, 1931-32 to 1941-42. Lansing.

Miller, Robert Rush. 1957. Origin and dispersal of the alewife, Alosa pseudoharengus, and the gizzard shad, Dorosoma cepedianum, in the Great Lakes. Trans. Am. Fish. Soc. 86(1956): 97-111.

Milner, James W. 1874. Report on the fisheries of the Great Lakes; the result of inquiries prosecuted in 1871 and 1872. U.S. Comm. Fish., Rep. for 1872-73 (part 2): 1-78.

Schneider, James C., Frank F. Hooper, and Alfred M. Beeton. 1969. The distribution and abundance of benthic fauna in Saginaw Bay, Lake Huron. Proc. 12th Conf. Great Lakes Research, Internat. Assoc. Great Lakes Research, pp. 80-90.

Schneider, J. C., and J. H. Leach. 1978. Walleye stocks in the Great Lakes 1800-1975: Fluctuations and possible causes. Great Lakes Fish. Comm. Tech. Rep. No. 29.

Shetter, David S. 1949. A brief history of the sea lamprey problem in Michigan waters. Trans. Am. Fish. Soc. 76(1946): 160-176.

Smith, H. M., and M. P. Snell. 1891. Review of the fisheries of the Great Lakes in 1885. U.S. Fish Comm., Ann. Rep. for 1887, pp. 3-333.

Smith, Hugh M. 1894. The fyke nets and fyke-net fisheries of the United States, with notes on the fyke nets of other countries. Pages 299-355 in U.S. Fish. Comm. Bull. 12(1892).

Smith, S. H. 1968. Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Board Can. 25: 667-693.

True, Frederick W. 1887. The fisheries of the Great Lakes. Pages 631-673 in A georgraphical review of the fisheries industries and fishing communities for the year 1880. The fish and fisheries of the United States, Sect. II, G. Brown Goode (ed.). U.S. Government Printing Office, Washington, D.C.

U.S. Fish and Wildlife Service. 1969. Fish and wildlife as related to water quality of the Lake Huron basin. A special report on fish and wildlife resources, 1969. Report of the Regional Directors, Bureau of Commercial Fisheries and Bureau of Sport Fisheries and Wildlife, 134 pp.

Van Oosten, John. 1937. The dispersal of smelt, Osmerus mordax (Mitchill), in the Great Lakes region. Trans. Am. Fish. Soc. 66(1936): 160-171.

Van Oosten, John. 1947. Mortality of smelt, Osmerus mordax (Mitchill), in lakes Huron and Michigan during the fall and winter of 1942-43. Trans. Am. Fish. Soc. 74(1944): 310-337.

Van Oosten, John, Ralph Hile, and Frank Jobes. 1946. The whitefish fishery of lakes Huron and Michigan with special reference to the deep-trap-net fishery. U.S. Fish Wildl. Serv. Fishery Bull. 40: 297-394.

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