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INTRODUCTION OF EXOTIC FISH INTO MICHIGAN[1/]

by

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The program of introducing exotic species of fish into Michigan was a major, early function of the Michigan State Board of Fish Commissioners--often referred to as the Michigan Fish Commission. The United States Fish Commission usually provided the eggs.

The North American Fish Policy adopted by the American Fisheries Society in 1954 contains the following: "The introduction of exotic species is proper where adequate biological investigation has demonstrated the need and the suitability of the environment including the possible effects on contiguous waters." (Hazzard, 1955).

The Committee has dealt mainly with species that are suitable for sport fishing in its consideration of future introductions. A short resume of natural range, description, life history, and habitat is given for each species. The brook trout is included with introductions of the past because its original range was so limited in Michigan. Probably some other native species occurred only in a few localities before stocking

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1/ Contribution from Dingell-Johnson Project F-27-R-2.

distributed them widely. On the other hand, the lake whitefish was planted in a number of waters by the Fish Commission without success.

The names of fishes used in this report conform to those given in American Fisheries Society Special Publication No. 2.

Unsuccessful introductions

American eel--Anguilla rostrata (LeSueur)

The American eel is found in eastern North America, rarely in northern South America, from southern Greenland and Labrador to Brazil; in the Mississippi Valley it occurs as far inland as South Dakota, Minnesota, Wisconsin, Illinois, Indiana, Ohio, and Pennsylvania. It is not native to the Great Lakes region above Niagara Falls, but was introduced into numerous landlocked lakes many years ago; it appears very rarely in lakes Huron and Erie, reached no doubt via canals (Hubbs and Lagler, 1947). There is at least one record of its presence in Lake Michigan.

The eel is easily distinguished from all other northern freshwater fishes by its long, cylindrical form. Although it superficially resembles the lampreys, the eel has jaws, scales, and pectoral fins; the lampreys have none of these characters. Eels may reach a length of 6 feet, but most of them are less than half this long. The larger ones are females; males seldom exceed a length of 2 feet.

The reproductive cycle of the eel is most interesting. All eels spawn in the sea, in an area southwest of Bermuda. Spawning has not

been observed, but the smallest specimens have been captured in this area. It is generally believed that adults die after spawning. The very small eels, called leptocephali, are flat, ribbon-shaped, transparent, and lack pigment except in the eyes. About 2 years after hatching and when they have reached fresh water, the leptocephali undergo metamorphosis and assume the cylindrical shape of the adult. At this stage the eels usually are found along the north Atlantic coast during winter. In late March or April they become pigmented and swim up streams in vast numbers. They are predacious in fresh water. The mature eels migrate downstream, usually in the late summer or fall, and make the long journey to the spawning area in the vicinity of the Bermudas.

The eel feeds on almost any kind of animal life which it can capture. Eggs of various fish are commonly found in its stomach, and it eats many species of fish as well as numerous invertebrates. It is especially active at night.

Jerome (1879) reports that in May and June 1877 a crew from the Michigan State Board of Fish Commissioners captured 243,700 American eels in the Hudson River just below the dam at Troy, New York. Between June 7 and 13, 1877, a total of 265,000 eels were stocked in 23 Michigan ponds and lakes and in 11 streams. In 1878 an additional 460,000 were deposited in 60 lakes and ponds and 10 rivers. The total planting in 5 additional years between 1877 and 1891 amounted to 2,211,000 eels (Holcomb, 1964).[2]

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[2] Holcomb, Dennis E. 1964. A history of intentional introductions of exotic fishes in Michigan. M.S. thesis, University of Michigan, 33 p.

American shad--Alosa sapidissima (Wilson)

The American shad is native to the Atlantic Ocean, occurs from Labrador to Florida, develops in the sea, but ascends streams to spawn. In the Great Lakes region it is confined to the Lake Ontario Basin. It has been successfully introduced into the Pacific Ocean where it ranges from southern California to southern Alaska (Hubbs and Lagler, 1947).

This fish belongs to the herring family. Its cheeks are deeper than those of the alewife. The upper jaw is terminal, and the jaws are toothless in adults. There is a conspicuous, dark spot on the shoulder, which frequently is followed by smaller spots.

The following summary of the life history of the American shad was condensed from Wise Fishermen's Encyclopedia (1951). The maximum weight is about 12 pounds. The average female is about 22 inches long and weighs 6 1/2 pounds. The average male in the Chesapeake Bay region is 19 inches long and weighs 4 pounds. Little is known of the habits of the shad while in the ocean. However, its habits are well known in the Atlantic coastal rivers. The shad runs begin in the Southeast in February and March. In Chesapeake Bay most of the shad begin entering the rivers in late March and most have left the Bay by early June. Occasionally there are small fall runs in the Bay. Spawning occurs soon after the shad reach fresh water. Shallow spots in rivers near the mouths of creeks are preferred spawning grounds. The fish are said to pair off and swim side by side during spawning. The eggs are broadcast and quickly sink to the bottom where they adhere to the first object they touch. The number of

eggs produced by a single female varies from 25,000 to 30,000 although there is a record of 150,000 eggs taken from one fish. The eggs hatch in about 6 days. The young forage in the river their first summer, then migrate downstream and go to sea. Males mature and return to a stream after 3 or 4 years, and the females return to spawn beginning at the age of 4 years. The adults do not die after spawning but return to the sea.

Jerome (1875) listed the stocking of 210,000 shad fry in June 1873 in the Grand, Detroit, Flint, Raisin, and St. Joseph rivers, and in Long Lake, Kalamazoo County. About half of the fry were obtained at Camp Green, on the Hudson River, and the remainder at South Hadley Falls, Massachusetts. In June 1874, 80,000 shad were planted in the Shiawassee River near Corunna, and on July 31, 1874, 75,000 were stocked in the Detroit River at Detroit. No additional plantings are recorded in the Reports of the Michigan State Board of Fish Commissioners.

Chinook salmon--Oncorhynchus tshawytscha (Walbaum)

The chinook salmon occurs in the north Pacific, south to Japan and southern California. The heaviest runs usually occur in the larger rivers. The chinook is the least common but the largest (averaging more than 20 pounds) of the five species of Pacific salmon in North America. Because of its large size and high quality, this species has always commanded the highest market price. The greater portion of the catch is sold fresh or used for mild cure (Rounsefell and Kelez, 1938). Clemens and Wilby (1946) describe the fish as having numerous, black, small,

irregular spots on its back, dorsal fin, and both lobes of the caudal fin, 15 or more anal rays, 140 to 185 pyloric caeca, and loose conical teeth. The young are readily recognized by the strongly developed parr marks.

Rounsefell and Kelez (1938) state that chinooks usually spawn in deeper, faster water than do the other species of salmon, possibly because of their greater size and strength. The races which spawn far up in the small headwater streams usually appear during the spring months, whereas the races which spawn in the lower tributaries, or in the main stream, do not appear until summer or early fall. The following is quoted from Wise Fishermen's Encyclopedia: "Young fish may go to sea as fry or fingerlings or remain in streams until yearlings. Yearling mature males of five to six inches may be taken in headwater streams as ripe fish which have never gone to sea. Two to seven years of sea growth occurs. Two- and three-year-old mature males are known as 'jacks'." Fraser (1921) reported that generally those individuals which had entered the sea shortly after hatching were younger when they returned to spawn than those that had migrated after a considerable time in fresh water. Young salmon feed on worms, insects and crustaceans. In the sea they eat herring, sand-lance squid, and shrimp. They seldom feed during the spawning migration.

Eyed chinook salmon eggs from the McCloud River, California, were obtained by the Michigan Fish Commission from the United States Fish Commission. This service continued from 1873 to 1878. Plantings were made in 35 counties. Jerome (1875) records that in December 1873

a total of 45, 200 chinook salmon fry were released in four streams and two lakes in the southern part of the State. Early in 1874 some 28, 330 chinooks were planted in two ponds and two streams in southern Michigan. All of these fish originated from 80, 000 eggs sent to the Niles State Hatchery, but hatched at a private facility of Jackson Couch near Jackson. Additional plantings of chinook salmon were made by both federal and state hatcheries. Holcomb (1964)[2] reports that, "Michigan records indicate at least 1, 332, 576 fish were planted as California, or Chinook salmon, between 1873 and 1917."

The latest stocking of chinook salmon in Michigan was done at Deep Lake, Oakland County, on March 27, 1945, when 2, 230 fingerlings that averaged 2 inches were stocked with 185 chum and 775 coho. Only a few chinooks were caught subsequently by Institute for Fisheries Research personnel.

Reviews of past attempts to introduce Pacific salmon outside their native range have been made by Davidson and Hutchinson (1938) and Huntsman and Dymond (1940). The latter authors concluded that the only fully documented success has been the transplanting of chinook salmon to New Zealand. Ricker (1954) states, "Considering that the chinook is the least common salmon in the Pacific and, apart from the sockeye, the most 'choosy' one in respect to the streams it ascends, it is perhaps not surprising that these efforts failed."

Atlantic salmon--Salmo salar Linnaeus

The original range of the Atlantic salmon was the North Atlantic Ocean on the American side, from southern Greenland and Labrador, south to the Hudson River and occasionally to the Delaware River, and in the Lake Ontario Basin. At present the range extends south to Maine, but the fish is extinct in the Lake Ontario Basin. Landlocked salmon are found in certain cold lakes of New England and the Maritime Provinces (Hubbs and Lagler, 1947).

Adults of both the ocean and landlocked fish have dark X-shaped spots irregularly scattered over the top half of the body, a slender caudal peduncle, and brownish coloration on the back (Clemens and Wilby, 1946).

The landlocked salmon spawns in streams in October and November, and the young fish remain in the stream for some time before entering a lake. Some males mature at 3 years of age, and females at 4 and 5 years. Young salmon feed largely on aquatic insects while in the stream. Adult salmon are mainly fish eaters, feeding extensively on smelt or minnows.

The first 40,000 Atlantic salmon eggs were presented to Michigan by the U. S. Fishery Commission in the spring of 1873. The eggs were hatched at the private fishery of N. W. Clark near Clarkston. The first introductions were made in three lakes in Oakland County on May 14, 1873, and consisted of 1,250 fry (Jerome, 1875). That month a total of 21,250 fry were planted in eight inland lakes and seven streams. Some 139,000 fry were stocked in 1874. On March 6, 1875, boxes containing 320,000

eggs arrived at Niles and were moved to the Pokagon Hatchery. This lot of eggs was in very poor condition, and the few fry that hatched and survived were released in Dowagiac Creek, which flowed by the hatchery (Jerome, 1876). These plantings are the only records of Atlantic salmon in the Reports of the Michigan Fish Commission.

Landlocked salmon were first planted on June 20, 1874, into Dowagiac Creek at the State Hatchery (Jerome, 1875). Records of the Michigan Fish Commission and Department of Conservation list 774,829 Atlantic and landlocked salmon planted, in 31 years between 1873 and 1932 (Holcomb, 1964).[2]

Neither of the two forms of the Atlantic salmon have become established in Michigan from the numerous plantings. It appears unlikely that plantings in the future would be any more successful. Attempts of reestablishing this species in the Lake Ontario Basin have failed.

Cutthroat trout--Salmo clarki Richardson

The various subspecies of the cutthroat trout occur in coastal streams from Alaska to northern California, throughout the Intermountain Area, and east to the upper Missouri, Platte, Colorado, and Rio Grande drainages (Sigler and Miller, 1963). The cutthroat may be resident or sea-run; non-migratory fish tend to stay in the headwaters of the coastal streams. Sigler and Miller (1963) describe this species as follows: "The back and sides of the cutthroat trout are frequently steel gray and covered with spots. These spots are larger, more regular in size and shape, and

more restricted than are those on brown or rainbow trout. A slash mark, usually red or orange in adults, runs along each branch of the lower jaw. The tips of dorsal, pelvic, and anal fins may be plain, dusky, rose, or red. The tail is slightly forked."

Cutthroat trout spawn in the spring in clear, shallow riffles of small streams when the water temperature approaches 50 F. Egg production amounts to about 1,000 eggs per pound of female fish. Young cutthroats feed on invertebrates such as small crustaceans and insects. Later they eat larger invertebrates and small fish. Fish is the sole diet of large adults. In Utah this species reaches 8 to 12 inches and sexual maturity in 3 to 4 years.

The various subspecies seem to prosper only in their native areas. Thousands of intermountain cutthroat trout were stocked in lakes and streams of the Oregon coast but without success. In Utah and Nevada the original range of the cutthroat has been severely reduced (Sigler and Miller, 1963 and LaRivers, 1962). Agricultural and industrial pollution, dams and other barriers are factors cited for this reduction of range. Competition from other species and the cutthroat's inability to withstand heavy fishing pressure are also involved. The cutthroat trout does not compete so well with the rainbow trout, and is even less successful in holding its own with the brown trout. It has a strong tendency to hybridize with other species of Salmo, especially rainbow trout. The difficulty and high cost of rearing cutthroat prohibit their use for "put and take" stocking.

The Michigan Fish Commission made its first planting of cutthroat trout (8,000) into waters of Newaygo County in 1895 (Anon., 1897). Michigan plantings of this species totaled 105,000 fish from 1895 to 1940 (Holcomb, 1964).[2]

Arctic grayling--Thymallus arcticus (Pallas)

Hubbs and Lagler (1947) give the original range of the grayling in Michigan as the Otter River of the Lake Superior drainage and the streams of the Lower Peninsula from the Jordan River to the Muskegon and from the Cheboygan River to the Rifle. The Michigan, Montana, and Arctic graylings now are considered a single species. The adjectives "Michigan" and "Montana" will be used herein not to denote subspecies but to differentiate the locality of origin.

The grayling can be distinguished by its large, flaglike dorsal fin, with more than 15 soft rays. The habitat of this fish in Michigan was essentially similar to that of the brook trout. However, it spawned in the spring, in the main channel of streams, and not in the headwaters as does the brook trout. The eggs were laid in the shallows over sand and fine gravel. Aquatic insects and other invertebrates were its principal foods. Three primary causes have been given for the extermination of this species in Michigan: (1) the floating of logs during the spawning season, which gouged out the eggs and fry; (2) the fish were unable to withstand fishing pressure because they were so easily caught; (3) they were unable to withstand competition from the introduced brook and rainbow trout.

Hazen L. Miller devotes an informative chapter to the Michigan grayling in The Old Au Sable. Its last stand was in the Otter River where it became extinct in the late 1930's. Grayling had received year-round protection in the State since about 1919.

Various attempts were made to extend the natural range of the Michigan grayling. On May 18, 1877, a lot of 300 grayling, caught by hook and line from the Manistee River near Grayling, were planted in three streams and one lake in the southern part of the State. The Pokagon State Hatchery received 1, 200 of these fish for brood stock, but they produced no young. In 1880 Dowagiac Creek was stocked with 60 adults, and Mill Creek, a branch of the Paw Paw River, was stocked with 32 adults. In September 1925 a hundred grayling taken from the Otter River were planted in a tributary of the Tittabawassee River on the Gladwin State Game Refuge, and 22 were delivered to the Grayling State Hatchery. Earlier experience was repeated when little, if any, reproduction occurred and the parent stock dwindled to a remnant in 3 years.

The Montana grayling was introduced into Michigan in 1903. The reports of the Michigan Fish Commission record plantings made in 1903, 1904, 1905, 1906, 1913, and 1914, including one of 25, 000 fish deposited in the Otter River, Houghton County on May 16, 1914. Thousands of Montana grayling have been stocked by the Department of Conservation. There is little information on the results of these plantings except for gill-netting records from O'Brien Lake, Alcona County and Manganese Lake, Keweenaw County, and several published papers by Dr. J. W.

Leonard on the food habits of Montana grayling in Ford Lake, Otsego County. The latest attempts to reintroduce the grayling in this State were made at Manganese Lake in 1958 and 1959.

There seems to be no prospect that a grayling fishery can be restored here. But if such a fishery could be developed, the grayling probably would offer little enticement for anglers except for the promise of an unusual catch.

Successful introductions

Pink salmon, Oncorhynchus gorbuscha (Walbaum)

The pink salmon is an extremely important commercial species of the Pacific Ocean, particularly in Asia and Alaska. Pink salmon grow rapidly. They attain an average weight of slightly more than 4 pounds in 2 years (Neave, 1963). They may be identified by their deeply forked caudal fin, relatively large spots on the back, large rectangular spots on the upper part of the caudal fin, and fine scales (more than 200 on the lateral line). During the spawning period, males are distinctly humped anterior to the dorsal fin (LaMonte, 1945) and possess hooked jaws.

In the eastern portions of the Pacific, pink salmon occur from California to Alaska (LaMonte, 1945). Except for Lake Superior, no fresh-water populations are known (Rounsefell, 1958), although some attempts apparently have been made to introduce these species into several fresh-water environments.

Pink salmon mature, spawn, and die in their second year (Neave, 1963). Spawning occurs in late September through October. It is the

least migratory salmon, generally spawning only a few miles from the ocean (LaMonte, 1945). Important characteristics of a spawning stream are good volume of flow and velocity, unobstructed entry into the lake or ocean, and suitable gravel beds and water temperatures (Hale, personal communication). After hatching, the fry drift downstream into the ocean, spending two summers there before they return to streams to spawn and complete their life cycle (Neave, 1963). Studies in Alaska indicate that when the fry enter estuarine waters they are preyed upon extensively by herring (Thorsteinson, 1962). Pink salmon exhibit a phenomenon called "cyclic dominance" (Ward, personal communication). One of the two year classes composing a stock is very much more abundant than the other. The year class maturing in odd-numbered years is generally abundant, whereas there are few fish in the even-year class.

Analyses of stomach contents have shown that pinks feed on a wide variety of marine plankters. Pteropods, euphausids, and copepods are common food items (Ward, personal communication).

Prior to the establishment of a small population in Lake Superior, salmon experts believed that of the six species of Pacific salmon, the pinks were the least likely to succeed in fresh water (Rounsefell, 1958). It is thought that pink salmon were introduced accidentally in Lake Superior in 1956 from a Canadian fish hatchery located on the shore of the lake (Schumacher and Eddy, 1960). Following these escapements, small spawning populations have been observed in Minnesota streams in 1959 and 1961 (Schumacher and Hale, 1962) and 1963 (Hale, personal communication). In addition, captures of pink salmon were made in Ontario and

Michigan waters of Lake Superior. It is possible that the pink salmon will become firmly established in Lake Superior (Schumacher and Hale, 1962), but time alone will tell. Additional releases at suitable locations might promote the buildup of a permanent population. Apparently a number of streams along the Michigan border of Lake Superior contain spawning facilities similar to those in Minnesota streams.

The pink salmon could be a valuable addition to both the sport and commercial fisheries of Lake Superior. Its fast growth and short life cycle may enable it to compete more successfully with the sea lamprey than other salmonids. Because it is in the spawning streams only a short time, it probably would not compete with native trout for food.

American smelt--Osmerus mordax (Mitchill)

The natural range of the American smelt is given by Hubbs and Lagler (1947) as from Labrador, to the vicinity of New York along the Atlantic Coast, and in the basins of Lake Champlain, the St. Lawrence River and Lake Ontario. It is now established through introductions in all the other Great Lakes and in some inland lakes.

All the smelt eggs deposited by the Michigan State Board of Fish Commissioners were obtained from the United States Bureau of Fisheries. The Bureau operated a smelt hatchery at Green Lake, Maine which carried a native freshwater race of the American smelt. The first eggs received in Michigan arrived at the Soo Hatchery in 1906 and were deposited in the St. Mary's River. The Commissioner's Reports of the

U. S. Bureau of Fisheries for 1909, 1912, 1914, 1915, 1916, and 1921 record the Michigan Fish Commission as receiver of large numbers of smelt eggs. Of these, only two plantings are recorded in the Reports of the Michigan State Board of Fish Commissioners, and both are for 1912. On April 4, Torch Lake, Antrim County, was stocked with 6,000,000 eggs, and on the 6th, 16,400,000 eggs were placed in Crystal Lake, Benzie County.

Creaser (1926) gives good evidence to substantiate the claim that the stocking in Crystal Lake was responsible for the spread of smelt into most of the upper Great Lakes. Van Oosten (1937) records the phenomenal spread of this fish throughout the Great Lakes region.

Today the smelt provide recreation and succulent food for thousands of fishermen who net them during the spawning migrations into tributaries of the Great Lakes. Some inland lakes now also contain populations, from which good catches are taken in winter. Fish Lake, Barry County, was stocked with a total of 15,300 adult smelt in 1958 to 1960. Other plantings were made elsewhere in 1950, 1953, and 1954. Reports indicate that Gull Lake, Kalamazoo County, Ford Lake, Mason County, and Lake Fifteen, Montmorency County produced smelt fishing last winter.

Brook trout--Salvelinus fontinalis

The range of the brook trout is from Labrador southward along the Appalachians to Carolina and Georgia; in the interior to the Great Lakes basin, and in a few northern headwaters of the upper Mississippi

River system; also in southeastern Minnesota and northeastern Iowa. In Michigan it was native to Lake Superior and tributaries, to the northern tip of the Lower Peninsula (Hubbs and Lagler, 1947).

The distinguishing characters of this species are the vermiculations on the back and the successive white and black stripes along the fore edge of each of the lower fins. Brook trout are voracious feeders. They eat insects throughout their life but also consume worms, mollusks, crustaceans, and fish. They attain greatest abundance in clear, spring-fed streams. They spawn in the fall over gravel bottom.

The first plantings of brook trout in Michigan were made in southern Michigan streams. In 1879 a total of 11,500 fry were deposited in streams in Cass, Berrien, and Kalamazoo counties from the State Hatchery at Pokagon. The following year 50,400 fry were stocked in 47 localities in 14 counties. The brook trout has been the fish most extensively planted in the inland waters of the State, and no doubt will continue to be stocked in certain waters.

Brown trout--Salmo trutta Linnaeus

The brown trout, which is native to Europe, has been introduced in many places of the Great Lakes drainage area. The brown trout has yellowish pectoral fins, a tinge of red or orange on the adipose fin and few spots on the caudal fin.

A lot of 5,000 eggs was received at the Northville federal hatchery on February 18, 1883, and 4,900 fry were planted in a branch of the Pere Marquette River on April 11, 1883 (Clark, 1885). This is

believed to be the first stocking of brown trout in Michigan. The first recorded planting of this species by the State Board of Fish Commissioners was made on April 11, 1885 at Coldspring Lake, Clare County, when 8,000 fry were released. During 1885 and 1896 some 1,794,000 fry were stocked by the Fish Commission. It discontinued the stocking of brown trout in 1897 because members of the Commission had come to believe that the brown trout was inferior in every respect to either the brook or rainbow trout. However, in February 1903 the Commission planted 60,000 brown trout fry in five creeks in Kent County. Then there was another abandonment of this species until March 1909, when regular releases were resumed. Presently the Department of Conservation plants large numbers of these fish, mainly in streams.

Rainbow trout--Salmo gairdneri Richardson

The rainbow trout is native to the Pacific Ocean, from southern Alaska to southern California, ascending coastwise streams to spawn (Hubbs and Lagler, 1947). Today it is present in many of the trout waters of North America.

The rainbow trout has a red or pink stripe along the middle of each side, which is most pronounced during the breeding season; the stripe is faint or absent in young. Small black or brown spots appear on the back and sides and on the dorsal and caudal fins; a few spots also appear on the black-margined adipose fin. The small and medium-sized fish feed on invertebrates, plant material, and small fish; large

rainbow trout are mainly piscivorous. This species spawns in the early spring over gravel bottom in streams.

Mr. Daniel C. Fitzhugh, Jr. of Bay City is said to have brought the first rainbow trout eggs to Michigan, in 1876 (Smedley, 1938). The fry were deposited in the Au Sable River. The first eggs received by the Fish Commission were from McCloud River, California, and arrived at the Pokagon Hatchery on April 14, 1880. The 2,000 eggs produced 1,800 fish, 600 of which were released in the north branch of the Paw Paw River, 600 in Boyne River, and 600 were kept at the hatchery for brood stock. From the hatch of 1884, 6,000 rainbows were planted in Beaver Creek, Ottawa County. In June 1885, 25,000 were released in the South Branch of the Pere Marquette River. Because of over-crowding in the hatchery ponds, 210 adults were deposited in the Muskegon River in 1886. Rainbow trout have been planted almost every year in Michigan since stocking began in 1880, and this program doubtless will continue.

Undesirable introductions and invaders

Carp--Cyprinus carpio Linnaeus

Pond culture, one of the oldest agricultural practices, is inextricably linked with the world-wide range of the carp. The husbandry of fish ponds as a practical and economical means of raising food had its origin in Asia. The practice spread to Europe in the mid 14th century, centering primarily in Czechoslovakia and

and later in Germany (Neess, 1946), where carp became an accepted source of protein and an item of export.

The carp was introduced into this country just before the turn of the century, about 1877 (Sigler, 1958). Its culture and distribution began in the midwest around 1880 (Harland and Speaker, 1956), and by the early 1900's stock from Germany had been introduced into many eastern waters (Neess, 1949). While carp were generally raised in artificial ponds, small natural ponds were frequently utilized also. Finally, they were introduced into natural lakes and streams. Following extensive stocking, the highly adaptable carp became dispersed throughout many of the 48 states. Iowa initiated steps as early as 1909 to control their numbers in one body of water (Harlan and Speaker, 1956).

The carp did not fulfill its intended role in this country. Because of the abundance of other foods and fish, this species did not achieve the acceptance and economic importance that it attained in Europe. Americans favored the rearing and planting of carnivorous sport species. In this country the carp generally is thought to be detrimental to game species. However, in some areas it is considered a sport fish and also is of some commercial importance.

Sea lamprey--Petromyzon marinus Linnaeus

The sea lamprey is a scaleless, eel-like fish with a sucking, disc-shaped mouth. Its original distribution was in the north Atlantic

Ocean and tributaries, from Iceland, Northern Europe, and the Gulf of St. Lawrence to northwestern Africa and northern Florida. It is also native to Lake Ontario and the Finger Lakes of New York State (Hubbs and Lagler, 1947). It has recently extended its range to all the Great Lakes and at least five inland lakes in Michigan (Guard, 1953). Sea lampreys gained entry into the upper Great Lakes through the Welland Canal which was constructed in 1829 to bypass Niagara Falls (Applegate, 1950). They passed through Lake Erie, where conditions were not suitable for them, and reached lakes Huron and Michigan in the 1930's. They were first reported in Lake Superior in 1946 (Applegate, 1950).

The sea lamprey spawns in streams in the spring. Nests are constructed in the gravel beds, and the adults die after spawning. After hatching the larvae drift downstream and burrow into soft bottom, where they remain for 5 to 8 years before they transform into parasitic organisms and migrate to the ocean or a lake. The larvae feed on microscopic plant and animal materials. During the adult, parasitic stage of its life in fresh waters, the sea lamprey inhabits the deeper areas of lakes, feeding on the blood and body fluids of trout, whitefish, and other deep-water fish. It has been well established that the lamprey caused the sudden decline of the lake trout fishery in the Great Lakes.

There obviously is little good to be said about the sea lamprey. Although it is reported that northern Europeans consider lamprey flesh a delicacy, Americans have yet to develop a taste for it. The application of larvicides to streams in which spawning occurs holds good promise of eventually controlling this pest in the Great Lakes region.

Introductions not adequately tested

Redear sunfish--Lepomis microlophus (Günther)

This is a southern fish that has occurred in Illinois, Indiana, and Ohio to some extent. It ranges southeastward to west Florida and southwestward to the Rio Grande (Forbes and Richardson, 1920). Lopinot (1961) states that the redear sunfish can now be found throughout most of Illinois. Gerking (1945) states that the original range of the redear sunfish in Indiana has been obscured by propagation and stocking by the state fish hatcheries since 1932. Although this fish has been planted in both lakes and streams in Indiana, it has thrived only in the lakes. Trautman (1957) claims that the redear sunfish was not native to Ohio and that where it has been introduced north of its original range, it generally inhabits non-flowing waters which are relatively clear and which contain some vegetation. Redear sunfish congregate about brush, stumps, and logs, hence their colloquial name of "Stumpknocker." They are mostly bottom feeders and do not rise readily to flies on the surface.

The redear sunfish has three anal-fin spines and large scales (53 or fewer in lateral line); teeth are lacking on tongue; the pectoral fins are very long and pointed at tip; the gill-rakers are short, blunt, and often crooked; the opercle has a broad scarlet margin (Hubbs and Lagler, 1947).

Krumholz (1950a) states that redear sunfish placed in ponds by themselves will grow rapidly until they produce young, after which the growth rate declines. In Indiana the redear sunfish is recommended over the bluegill as it is not so prolific as the bluegill and has a more restricted spawning period (Krumholz, 1952). In Illinois the redear has been recommended for stocking in place of the bluegill because it grows faster and produces fewer young (Lopinot, 1961). Ball (1952) moved redear sunfish to central Michigan where they apparently can withstand winter conditions and reproduce in ponds. They appear to be less prolific than bluegills, and have not become overly abundant when stocked with largemouth bass.

The earliest collection of redear sunfish from Michigan recorded in the Institute for Fisheries Research files was made by R. M. Bailey, G. P. Cooper, and R. Gibbs on July 11, 1947. A total of 103 redears, which ranged from 3.7 to 7.5 inches, were caught in a 30-foot seine at Silver Lake, Branch County. The netting record mentions that this species was abundant. It is believed that these fish originated from plantings made by the Indiana Conservation Department in Lake George, which is located in both Indiana and Michigan. The redear had apparently moved into Silver Lake via a stream that connects with Lake George. Ball (personal communication) recalls that C. Troy Yoder and he caught redear sunfish by nets at Silver Lake and transplanted about a dozen of them in two ponds at the Wolf Lake Hatchery. They grew rapidly, and some reached a weight of 1 3/4 pounds.

The following comments constitute a resume of a thesis by Cole (1951):[3] Adult redear sunfish obtained during 1949 spawned in ponds, and the first fry were seen about the first of August. Laboratory studies indicated that this species was inactive and refused to eat at water temperatures below 44 F. On the basis of this experiment, the redear would be seldom caught by ice fishermen. A nest was noted about July 24, 1950 in Pond 8 at Hastings, and small fry were seen as late as September 1. The nest was in the midst of aquatic plants in about 3 feet of water, and was similar in size to that of a pumpkinseed nest. These spawning fish were in their second growing season. Redear sunfish and largemouth bass stocked together grew very well. Redear sunfish eat many mollusks and hard-bodied insects, such as snails, fingernail clams, water-boatman, and aquatic beetles.

The redear sunfish has been stocked in a few natural waters of the State. Although the plantings have not been checked very thoroughly, it appears that most (if not all) of them have failed.

Ball (personal communication) states that after a winterkill at North Twin Lake, Cheboygan County, he saw two redear sunfish, and their growth had been very good. He notes that the spawning temperature for the redear has been determined to be about 74 F. However, M. H. Patriarche (personal communication) mentions that excellent reproduction occurred in a pond where temperatures declined to 63°-69° during the spawning period.

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[3] Cole, Vernon, Walter. 1951. Contributions to the life history of the redear sunfish (Lepomis microlophus) in Michigan waters. Masters thesis, Michigan State College, 54 p.

Dr. Ball does not believe that there is any evidence anywhere that the redear ever becomes excessively abundant, and he sees no possibility of over-abundance in Michigan waters.

A personal communication from Mr. M. H. Patriarche states: "As far as I know the redear populations at the Rifle River Recreation Area are extinct. A planting of 1,000 two-year-old fish (mean length 2.5 inches) from Wolf Lake Hatchery was made in Jewett Lake in 1954. A similar planting was made again in 1956. These plantings were made at a time when there were large numbers of bluegills in addition to other species of fish in the lake. Under these circumstances the species didn't get a fair test. Growth was excellent for the 16 survivors of the 1954 stock which were caught in trap nets in 1956 and 1957 but reproduction was poor. In 1959 there were only an estimated 78 redears in the lake (mostly progeny of the 1954 parent stock). None of the 1956 planting, which were in poor condition when planted, survived. By the fall of 1962, when the lake was treated with toxaphene, only 3 redears remained in the lake.

"A few adult redears were transplanted to Devils Washbasin pond after it was reclaimed in 1957. Excellent reproduction occurred in June of 1958, 1959, and 1961 at temperatures as low as 63-69 F. but the populations were decimated twice by winterkills. Of the 228 fingerlings transplanted to Grousehaven Lake in 1959, none were caught by anglers and no follow-up was made with netting gear. The maximum exploitation rate for the Jewett Lake redears was 23 percent in 1960."

The Committee recommends that the redear sunfish be stocked with largemouth bass in some southern Michigan lakes following reclamation or winterkill.

Splake--Brook trout x lake trout hybrids

"Splake" is a common name for the fish that results from breeding a male brook trout with a female lake trout. In recent years this fish has attracted much public attention, so it is surprising that there is little information on its evaluation. The history of this hybrid has been reviewed by Scott (1956). New York and Pennsylvania stocked large numbers of these fish in the 1800's.

Martin and Baldwin (1960) state, "More recently interest in the hybrid was revived by the experimental work in Alberta in 1946 (Stenton, 1950, 1952). Plantings of hybrids have been made in 1950 in Alberta (Cuerrier, 1954), in 1954 in Pennsylvania (G. L. Trembley, personal communication) and New York (R. G. Zilliox, personal communication), in 1955 in Wyoming (Sowards, 1959), California (Shapovalov, Dill, and Cordone, 1959), New Hampshire (R. B. Knowlton, personal communication) and Manitoba (B. Kooyman, personal communication), in 1956 in Michigan (Kmiotek and Oehmcke, 1959), in 1957 in Quebec (L. R. Seguin, personal communication) and Minnesota (R. E. Schumaker, personal communication), and in 1958 in Colorado (Tanner, 1959) and Wisconsin (Kmiotek and Oehmcke, 1959)."

Stenton (1952) described the general color of the first-generation hybrid when 3 years old as follows: ". . . the back is dark olive-green with numerous pale vermiculations; the sides are bluish-silver and the belly white. There are numerous lemon-yellow and pale pink spots along the sides above and below the lateral line. The leading edges of the paired fins and of the anal fin are white, and the remainder of these fins are pale orange in colour, with the pectoral fins being dusky towards the forward edge. The dorsal fin is dark and heavily spotted. The tail is truncate as in the brook trout, but the body is elongated as in the lake trout. From the foregoing it becomes apparent that both parent species have left undeniable marks on the coloration and form of their progeny. The red spots and blue halos common to the brook trout are absent."

The paper by Martin and Baldwin (1960) is condensed in the following six paragraphs.

The recovery of splake by anglers has been less than 2% of the fish stocked in some lakes of Algonquin Park, Ontario. However, when marked lake trout, brook trout, and splake have been planted together, the recovery of hybrids has generally been higher. In four lakes, returns from angling have been higher for splake than with brook trout. Recovery from the first planting of 700 splake yearlings in Jack Lake in 1954 was extremely high; anglers caught 65% of these fish during 1956 and 1957, and experimental nets captured an additional 10%. In 1956 the catch of splake in this lake was 0.92 fish per boat-hour. In comparison, the catch of brook trout per boat-hour for Redrock Lake has ranged from 2.0 to 0.68

annually. Lake trout catches vary from 0.5 to 1.5 fish per boat-hour in most Algonquin Park lakes. Most anglers who sought splake used spinning tackle and either trolled along the shore or cast over shoal areas. Best results were obtained when live minnows were added to spinners or spoons. Short bursts of remarkable success were achieved when schools of splake moved over shoal areas where fishermen were congregated. These periods of activity, which lasted about one half hour, occurred once in the late morning and once in the late afternoon. When on the hook, the reaction of most of the splake was similar to that of a brook trout, but some possessed the dogged, sounding tactics of the lake trout. Anglers who have caught the splake generally claim that it is equal to brook trout as a game fish.

Splake frequent shallow waters in the spring and fall. Most of them are in the region of the thermocline during the summer stratification. Field observations indicate that the preferred temperature of the hybrid trout is closer to that of the brook trout, although the reverse was noted in laboratory studies. Gill-net catches of splake in Jack Lake afford further evidence of the strong schooling behavior which has been noted by anglers.

There was considerable variety in the diet of splake taken from Jack Lake in the spring months. A majority of the stomachs contained insects, especially mayfly nymphs. Other organisms these fish ate were leeches, crayfish, blue-spotted salamanders, fish, plankton, amphipods, frogs, and mice. Almost one-fourth of the stomachs collected during

the summer were empty; the remainder contained crayfish, plankton, insects, fish, and leeches. In the fall, mayfly nymphs were again prominent. Minnows and crayfish were dominant in the small winter sample.

The splake grow relatively fast in lakes of Algonquin Park. At age III they average 1 to 3 inches longer than brook trout that have been planted in the small lakes; they are 4 to 6 inches longer than native brook trout in the larger lakes; and they are 8 to 10 inches longer than native lake trout. Their growth between ages I and II is particularly rapid. Females grow slightly faster than males. A splake planted in Jack Lake in May 1954 had reached a length of 21.8 inches by May 1958. An age IV hybrid taken in Redrock Lake in the summer of 1959 was 20.6 inches long.

Splake in Jack Lake are heavier for their lengths than native brook trout, but much less robust than brook trout planted in small lakes. In general the length-weight relationship of splake is similar to that of the lake trout. Splake planted in May 1954 had attained a maximum weight of 4.4 pounds by May 1958.

In Jack Lake the first indication of spawning was noted on October 14, 1959. Female splake showed little color, but the abdominal region of the males was a deep pink and the fins of many, including the caudal, were almost entirely orange, and the paired fins had striking, white leading edges. Many of the males had light backs and dark, lustrous bands along the sides. Splake were observed cleaning the

bottom on the talus slope and sandy areas, usually with the snout, in a manner similar to the lake trout. The male courted the female by nudging her side or by brushing her vent with his back and dorsal fin. There was some pairing of the sexes, but because of the rocky bottom on the talus slope and sandy nature of the other area, no nest was built. One pair defended a particular area on the rock spawning bed from other hybrids. Individuals were observed on the bed, night and day, for a period of at least 2 weeks. Splake showed no avoidance to lights at night and could be watched for an indefinite period, whereas lake trout will disperse from an illuminated area. Immature splake were seen attempting to pick up eggs from the bottom. One 13-inch splake, taken near the sandy spawning area, had 70 splake eggs in its mouth and stomach. On November 3, divers collected fertilized eggs on the talus slope but failed to find eggs in the two sandy areas. The spawning activity covered the latter part of October and the first half of November. Water temperature ranged from 44 to 47 F during the peak of spawning. Some eggs had hatched by April 28; this represents an incubation period of about 6 months.

A check of Michigan planting reports shows that splake were first planted in 1957 in two lakes in Marquette County; the initial plantings consisted of 2,000 sublegals in Lake Arfelin and 1,000 in Tilden Lake. The next stocking was done in 1961 when 8,000 sublegals were planted in Squaw Lake, Marquette County, and 2,450 legals in Imp Lake, Gogebic County. In 1962, Squaw Lake received 3,400 sublegal splake. Beatons

Lake, Gogebic County, was stocked with 10,000 sublegals and Imp Lake with 3,000 in 1963, to complete the plantings to date.

Apparently no detailed effort has been made to evaluate the stocking of splake in Michigan. Gill netting has provided some records. Nets set in Lake Arfelin on May 26, 1959, caught 42 splake (7.5-11.5 inches), and on September 21 a single splake (18.8 inches) was taken. In Squaw Lake, gill nets set on May 29, 1962 caught 83 splake (7.7-13.3 inches). Eight nylon gill nets set June 14, 1963, in Imp Lake caught 12 splake that averaged 14.1 inches and ranged from 10.3 to 16.4 inches.

The Committee recommends that greater effort be made to evaluate future stocking of splake in Michigan. Most of the states that have planted this fish have not yet published their results.

Channel catfish--Ictalurus punctatus (Rafinesque)

According to Hubbs and Lagler (1947), the northern channel catfish is native to Michigan, and in some of the Great Lakes probably intergrades with the southern channel catfish. The southern form is an important game and commercial species in the Mississippi drainage area. In the Great Lakes area, management of the channel catfish has mostly involved limited stocking in farm ponds and artificial lakes. An introductory planting of 500 9-inch, yearling channel catfish obtained from Illinois, was made in Sanford Lake (Midland County), an impoundment on the Tittabawassee River, in November 1949. Anglers have

occasionally reported captures since then, but the introduction apparently did not establish a substantial fishery. In 1963, this lake received another planting of catfish (75,000), and three other impoundments on the Tittabawassee River were stocked also with 1-inch fingerlings (Secord Lake, 30,000; Smallwood Lake, 20,000; Wixom Lake, 101,500). These fish were provided by the U. S. Fish and Wildlife Service. Hodenpyle Backwaters, Wexford County, was planted with 25,000 fingerlings in 1962, and with 25,000 catfish of larger size (5.4-inch average) in September 1963.

Perhaps this species could be utilized to some advantage in Michigan if it were stocked in natural (rehabilitated) lakes to fill the niche now commonly (and often undesirably) occupied by bullheads, to provide a larger and more desirable fish.

Possible introductions

Kokanee--Oncorhynchus nerka (Walbaum)

The kokanee salmon is native to a few landlocked drainages along the Pacific Coast, in British Columbia, Idaho, Montana, and Washington. It has never been introduced into the waters of Michigan. Kokanee have been transplanted successfully to Arizona, California, Connecticut, Colorado, Maine, Minnesota, New York, North Dakota, Oregon, Pennsylvania, and Wyoming.

The kokanee has a dark blue back and silvery sides. The anal fin has at least 13 rays, a characteristic which separates this salmon

from the trout. As the spawning season approaches, both the male and female turn a deep red.

Kokanee live for 2 to 7 years. They thrive in cold, large lakes, and spend much of their life in very deep water except at twilight when they may feed near the surface. Smaller lakes with an abundance of plankton may also be suited for them. These fish eat plankton primarily, and they generally feed from sundown until dark. They often travel in large schools (Sigler and Miller, 1963).

The following comments summarize a report by Seeley and McCammon (1963) on the kokanee in California: There are two groups of spawners in California: one spawning from August to October; the other, from late October to February. Early spawning and a higher percentage of 2-year-old spawners are associated with the British Columbia strain; this strain is less desirable in California. Kokanee spawn and reproduce successfully in streams or in spring areas along lake shores. The growth rate is quite rapid. They have not provided forage for trout. Evidence suggests that kokanee compete with trout for food and are not adequately harvested in small, lightly fished lakes. Stocking them in small lakes with natural trout populations, or those containing fingerlings, is highly questionable. Kokanee introduced as "swimup" fry have been used to supplement plantings of "catchable-size" trout in some heavily fished waters at little cost. Stocking of 175,000 fry in 1961 in a "two-story" lake produced fairly good kokanee fishing over an extended period in 1963.

Liberal regulations are required in the management of a kokanee fishery since the fish usually are short-lived and are available to anglers for only a brief time. Everhart (personal communication) states that kokanee could not be harvested in Maine because they never reached the 14-inch legal limit for salmon. At Lake Pend Orville, Idaho, this fish is taken by commercial fishermen by angling. Trembley and Wilde (personal communications) and Greene (1958) mention that few anglers succeed in catching kokanee and that it may take a while for them to learn how to harvest these fish. Catching them presents no great problem to fishermen in Washington, Oregon, and Idaho. Jelliffe (1958) explains his method of catching kokanee in the lakes of New York. He trolls a Sebago spinner before three size 6 or 8 hooks baited with pieces of red worm.

New York has had good success stocking 2-inch (spring) fingerlings in oligotrophic lakes that contain bass, perch, and other warm-water fish. The annual stocking rate in East Twin Lake, Connecticut is approximately 20,000 May fingerlings (advanced fry), and the annual angling catch has been about 500 to 700 fish that average 18 inches. An additional 300 to 500 adult fish are taken in the fall for egg taking purposes. Kokanee enter the fishery only in their fourth year in Connecticut. At the present time, six lakes are stocked. The entire program costs about $1,000 per year and the annual harvest exceeds 2,000 fish, which average about two pounds.

An inquiry on kokanee programs was sent to Maine, New York, North Dakota, and Pennsylvania. Only the answer from Dale L. Heneger, North Dakota, discourages experimental plantings of this fish in Michigan.

The Committee believes that the kokanee should be tried experimentally in Michigan. Large plantings should be made for at least 4 years in the chosen lake. All of the planting should be done with one race.

Dolly Varden--Salvelinus malma (Walbaum)

The Dolly Varden is a western cousin of the brook trout which it generally resembles in color and form. However, it is more slender and lacks the vermiculations that are characteristic of the brook trout. The olive to brown back is flecked with pale yellow spots, and numerous small, red spots appear on the sides. This fish may attain a length of 3 feet and a weight to 20 pounds. It ranges from California to Alaska. In northern California it is restricted to the upper tributaries of the Sacramento River (Snyder, 1940). It is more plentiful in Oregon, Washington, British Columbia, and Alaska (Wales, 1957). While fluvial in derivation, Dolly Varden are often anadromous. In British Columbia it is widely distributed in both fresh and salt water, achieving a greater marine abundance to the northward (Clemens and Wilby, 1946). Spawning occurs in streams in the fall. In many areas seaward migrations take place in the spring (April-June), and upstream movement occurs in the fall (July-September). According to Clemens and Wilby (Op. cit.), Roos

(1959), and Lagler and Wright (1962), its food consists primarily of insects, fishes, and crustaceans. While not ranked as high as the steelhead and the cutthroat trouts, it nevertheless is rated a fine sport fish.

Since the Dolly Varden is a boreal species, in Michigan the cold-water areas of the northern part of the State would be best suited for it. Two aspects of this fish lead to suggestions on how it might be handled if it were introduced here. It is rather predacious, and in this respect it would be of special concern to fish culturists. Its vulnerability to angling, similar to that of the rainbow trout, lies between that of the easily caught brook trout and the wary brown trout. Because of its highly predatory habits, the Dolly Varden might utilize fish more as food in two-story lakes than the rainbow trout does. In small, reclaimed lakes, it might be stocked experimentally at sublegal or legal size along with a forage species. Being less susceptible to capture, it could be expected to provide fishing over a longer period of the season than the brook trout.

Its preference for cold water and its anadromous nature suggest that the Dolly Varden could be stocked experimentally in tributaries of Lake Superior. According to Rounsefell (1958), the season and duration of marine life in its northern range appears to be influenced by latitude, sea and stream temperatures, and the size and physical characteristics of the particular stream it frequents. In many of Upper Peninsula streams Dolly Vardens conceivably could compete for food with young trout of other species. They undoubtedly would prey on rainbow and brook trout to some extent. The degree of their anadromy probably

would largely determine their overall effect upon the other trout in streams. If this trout spent most of its life in streams, then it likely would be detrimental to the presently established trouts.

Hybrid sunfishes

Several species of the sunfishes hybridize naturally in Michigan, mainly the bluegill with the pumpkinseed. Hubbs and Hubbs (1931, 1932, and 1933) reported on laboratory studies on hybridization of sunfishes. They noted that green sunfish x bluegill and green sunfish x pumpkinseed hybrids grew more rapidly than the parent species. In both aquarium-reared and natural hybrids, green sunfish x pumpkinseed, green sunfish x bluegill, and green sunfish x longear sunfish are predominantly males (81 to 95 percent). They also state many reasons that indicate that these hybrids are sterile.

Luce (1937) produced hybrid sunfish by stripping eggs and milt into fingerbowls containing small amounts of water. He raised them to sexual maturity in aquaria. Ricker (1948) and Krumholz (1950b) produced large numbers of hybrids by placing male bluegills and female redear sunfish in ponds that contained no other fish. In ponds with no other fish, Lagler and Steinmetz (1957) produced hybrids by introducing ripe pumpkinseed males with bluegill females and bluegill males with pumpkinseed females.

A summary of the paper by Childers and Bennett (1961) follows: Six possible P_1 crosses were made with bluegills, redear sunfish, and

green sunfish. Large numbers of F_1 hybrid fry developed normally from each of these crosses. The fry were released in outdoor ponds, where they grew to sexual maturity. No direct genetic isolation appeared between the three species. Attempts to produce hybrids naturally resulted in large numbers of F_1 hybrids only from the green sunfish male x bluegill female and redear sunfish male x green sunfish crosses. Of the six kinds of F_1 hybrids produced, only the green sunfish male x redear sunfish female reproduction had an approximate 50:50 sex ratio. When placed in ponds that contained no other fish, redear male x green female F_1 and green male x bluegill female F_1 produced large numbers of F_2 hybrids; green male x redear female F_1 produced a few F_2 hybrids. The other hybrids failed to produce an F_2 generation. Bluegill male x green female F_1 progeny grew in length at approximately the same rate as pure green sunfish. Under high population densities, the hybrid sunfish might grow faster than the parent type because of a superior ability to compete for food and space. Apparently in uncrowded ponds there is little difference in growth rates of hybrid sunfish and their parent species.

Ball (personal communication) believes that hybrid F_1 fish from the green sunfish male x redear sunfish female cross are very promising for use in farm ponds in Michigan. This hybrid appears satisfactory since it inherits aggressive behavior of the green sunfish and generally retains the growth pattern of the redear sunfish.

Bailey (personal communication) has informed the writer that largemouth bass x bluegill hybrids have occurred naturally in Hawaii. Perhaps experiments with this cross would be in order.

Exotic species of less promise

Tilapia--*Tilapia mossambica*

This cichlid is a major pondfish throughout much of the world (Swingle, 1960). Although adults reach weights of 5 pounds or more in tropical countries, most of the production is composed of fish in the 2- to 5-inch groups (ibid.). Tilapias are good to eat, easy to raise, produce well, and grow fast. They were first used in pond culture in Java in 1938-1939, and since then have been introduced into at least 16 tropical or semi-tropical countries (ibid.).

The tilapia lives only in the warmer climates. It is a mouth-breeder. A female produces between 100 and 300 fish per hatch, and new broods occur every 30 to 40 days. The nests are constructed in a sandy substrate. The young fish feed on crustaceans and unicellular algae, and older fish subsist on filamentous algae and non-living organic material.

In the tropical countries into which it has been introduced, the tilapia may eventually replace the carp in pond culture (Swingle, 1960). It has been introduced successfully in Alabama, but its value as a sport fish has not been proved. It is extremely doubtful that tilapia would succeed in Michigan because even the most hardy species die when water temperatures are 50 F or lower for prolonged periods (Swingle, personal communication). These fish may have some value as bait.

Striped bass--Roccus saxatilis (Walbaum)

The striped bass ranges along the eastern coast of North America from the St. Lawrence River to the Tchefuncta River, Louisiana. It was introduced in 1879 on the Pacific coast, in San Francisco Bay, and has spread to the Columbia River to the north, and south to Los Angeles County, California (Pearson, 1938). The favorite haunts of this species are the fresh and brackish rivers and coastal estuaries. The fish range freely along the coast, but they very rarely are caught in the open sea. Landlocked striped bass are found in at least two localities--the Santee-Cooper Reservoir, South Carolina, and Kerr Reservoir, Virginia.

This species is carnivorous, predacious, a very active feeder, and consumes many kinds of fishes and crustaceans. Striped bass spawn in coastal rivers that have strong rapids and rock-strewn bottom, and the spawning season extends from late April to early June. Water temperature is the principal factor that controls the time of spawning. The lowest temperature at which spawning occurs is about 58 F. Peak activity occurs at 60-65 F. The eggs are semibuoyant, and hatch in 48 hours at about 65 F, or in 36 hours at 71 F. Albrecht (1964) in laboratory studies found that eggs kept suspended by agitation of the water by air bubbles hatched better than those allowed to rest on the substrate. The current velocity required to insure egg suspension in fresh water is apparently about 1 foot-per-second. Since eggs normally take 2 days to

hatch, about 30 miles of water flowing at this rate would be required to suspend eggs throughout development. Eggs and larvae can survive under fluctuations of water temperatures between 55 and 75 F. Mansueti (1958) believes starvation is the principal cause of mortality among larvae.

Scruggs and Fuller (1955) reported on the first striped bass population developed in a fresh-water environment. The origin of this population was believed to be from fish trapped upstream at the time Wilson Dam was completed and some recruitment that occurred by migration upstream through the lock from Cooper River. Scruggs (1957) wrote on the reproduction of striped bass in Santee-Cooper Reservoir. Kerr Reservoir, an impoundment of the Roanoke River was stocked with 3 million striped bass from Albermarle Sound stock during 1953-1955. There is a possibility that some striped bass were trapped in the stream when the dam was completed in 1952. The population has become large enough to support a substantial sport fishery (Beitch, 1963). Bowers (personal communication) states that Kentucky Lake, in Kentucky and Tennessee, has been stocked with 1,361 striped bass since 1958. There has been no evidence of a successful hatch, although the introduced fish are living and growing well in Kentucky Lake. He mentions that this species is a very desirable game fish, but it is quite difficult to obtain stock. Massmann (personal communication) states that South Carolina has a law which prohibits the collection of fish for out-of-state use. This regulation would make it difficult to obtain striped bass from the Santee-Cooper Reservoir. Martin (personal communication) writes as follows:

"We feel [in Virginia] this species has tremendous potential in certain of our large hydro- and flood-control impoundments. Our preliminary data suggests that this species requires long stretches, up to 40 miles, of unimpeded feeder streams in which to spawn successfully. The eggs are semi-buoyant and the streams must have sufficient flow to keep the eggs in motion during the 36-72 hour hatching period. If you have similar physical conditions in Michigan I feel you should try this species by all means."

The Committee is of the opinion that in Michigan there are no large impoundments with enough miles of unimpeded feeder streams required for the reproduction of the striped bass. It appears that only the Great Lakes might have the necessary spawning requirement. However, the water temperature of the streams may be a limiting factor.

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