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GREAT LAKES FISHERY RESEARCH BY THE MICHIGAN DEPARTMENT OF CONSERVATION, 1960

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Michigan's fishery research on the Great Lakes and their immediate tributary waters again in 1960 was directed principally toward the study of various aspects of the life history of the sea lamprey (particularly the distribution and abundance of ammocoetes in the State's waters). Considerable attention was given also to the collection of eggs from lake trout in a hatchery and in inland lakes (to aid in the rehabilitation of lake trout in the Great Lakes), and to disease problems associated with the rearing of lake trout to sexual maturity. Progress was made in a number of other studies. A highly significant development during the year was the transfer to the Conservation Commission, by the State Legislature, of authority for regulation of the Great Lakes commercial fisheries (effective March 19, 1960). This action was followed in less than 3 months by the development of the State's first commercial trawling operation (in southern Lake Michigan).

The accounts which follow are based on information provided by the staff members who were principally responsible for the respective activities discussed. Some of the results given are based on preliminary tabulations of data collected during the year and are therefore subject to revision. Portions of this report appear in the minutes of the 1960 meetings of the Great Lakes Fishery Commission (Cleveland, Ohio, December 1-2) and of the Upper Great Lakes Fishery Committee (Toronto, Ontario, December 4).

Sea lamprey research

Michigan's sea lamprey research program is under the direct supervision of T. M. Stauffer and is carried out principally from the Marquette Office of the Institute for Fisheries Research. Staff members assigned to the work include two other fishery biologists, a technician, a secretary, and five seasonal employees. The $47,531 allotment for the 1960-61 fiscal year is an earmarked item in the Institute budget. In 1960 the work was concerned principally with various studies of sea lamprey ammocoetes, with particular reference to their occurrence and distribution in streams in the northwestern Lower Peninsula and in certain lakes and bays; an estimate of their abundance in East Bay (near the mouth of the Sucker River, Alger County); duration of the ammocoete stage; and seasonal progress of metamorphosis.

Distribution and abundance of ammocoetes in streams.--Field collections with a direct-current shocker were continued to determine the distribution and abundance of sea lamprey ammocoetes in State of Michigan tributaries of the Upper Great Lakes and thus facilitate the later application of selective toxicants by the U. S. Bureau of Commercial Fisheries. During 1960, surveys for ammocoetes were conducted in streams in the northwestern Lower Peninsula

which are tributaries of Lake Michigan or of large inland lakes in this region of the State. The numbers of stream systems surveyed in the six-county area were as follows (number of collections in parentheses): Emmet--2 (14); Charlevoix--13 (64); Antrim--4 (5); Grand Traverse--1 (5); Leelanau--14 (23); and Benzie--3 (6). Laboratory examination of the collections has not been completed.

A paper entitled "Distribution of sea lamprey ammocoetes in Lake Michigan tributaries of the Upper Peninsula of Michigan, 1955-1959," by Thomas M. Stauffer, was published in January, 1961 as Miscellaneous Publication No. 14 of the Institute for Fisheries Research.

Sea lamprey ammocoetes in East Bay, Alger County.--Collections of ammocoetes in the Sucker River, Alger County, by an Institute stream survey party in July and August of 1955 and 1956 indicated that it was one of the largest producers of sea lampreys among the State of Michigan tributaries of Lake Superior.[1] The stream was treated by the U. S. Bureau of Commercial Fisheries with the sodium salt of 3-trifluormethyl-4-nitrophenol on August 4, 1959, and a post-treatment survey of 8,800 square feet of the stream on the following September 2 revealed no sea lamprey ammocoetes.[2] It seemed likely, however, that some sea lamprey larvae remained in East Bay, a 78-acre lake at the mouth of the stream. Their presence was confirmed by a preliminary survey by the Institute on May 10-12, 1960. A detailed population study was undertaken from July 22 to September 1, 1960.

In planning the population study, the bay was divided into 13 subdivisions, based on the estimated density of ammocoetes suggested by the preliminary survey. Seven of these subdivisions were located along the shore, where the substrate was generally sand, and six were in relatively deep water (mostly over 20 feet) where the substrate was predominantly silt. In each subarea, stations were selected randomly and the substrate was sampled with an orange-peel dredge (5,525 lifts at 299 stations), or with a metal enclosure (21 samples at 7 stations) into which a larvicide was introduced. Enclosures were used only in shallow water where aquatic vegetation interfered with the operation of the dredge.

A total of 227 sea lamprey ammocoetes were collected during the sampling (average total length, 3.5 inches; range, 1.5-5.4). The preliminary estimate of the number of sea lamprey ammocoetes in East Bay was 97,000 (±20,000), of which 62,000 (±8,500) were in the deep-water areas. The estimate is believed to be minimal because a limited amount of comparative sampling with the dredge and the enclosures in shallow water (in the Ogontz River, Delta County) suggested that the dredge brought up only about one-third of the ammocoetes actually present; also, some ammocoetes probably escaped from the dredge while it was being lifted from deep water.

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[1] "Distribution of sea lamprey ammocoetes in Michigan tributaries of Lake Superior, 1955-1957," by Thomas M. Stauffer and Martin J. Hansen. 1958. Mich. Dept. Cons., Inst. Fish. Res. Misc. Publ. No. 11, 25 pp.

[2] Programs and Progress, 1959. U. S. Dept. of Int., Bur. Comm. Fish., Great Lakes Biological Laboratory, 62 pp.

Sea lamprey ammocoetes in other lentic environments.--In addition to the population study in East Bay, shallow-water areas in three other inland lakes tributary to the Great Lakes and at four locations in the Great Lakes were sampled with a direct-current shocker to determine whether ammocoetes were also common in these waters. The areas studied were as follows (hours of collecting effort in parentheses): Au Train Lake, Alger County, an 830-acre warm-water lake (10); Saux Head Lake, Marquette County, a warm-water lake under 300 acres (2); Otter Lake, Houghton County, an 890-acre warm-water lake (7); Marquette Harbor, Marquette County, a protected harbor in Lake Superior (2); Huron Bay, Baraga County, a protected bay in Lake Superior (9); West Neebish Cut, Chippewa County, a ship channel in the St. Marys River (1); and Portage Bay, Delta County, a nearly enclosed bay in Lake Michigan (1).

Streams tributary to Au Train Lake, Saux Head Lake, Otter Lake and Huron Bay have supported sea lamprey ammocoete populations (all tributaries with known populations were treated with larvicide by the U. S. Bureau of Commercial Fisheries in 1958-1960), but there was no known source of ammocoetes near Marquette Harbor, West Neebish Cut, or Portage Bay. Twenty-nine sea lamprey larvae were collected in Au Train Lake and three in Huron Bay, but none at the other locations. All larvae collected were 3.0 inches long or longer.

Duration of the ammocoete stage.--The operation of an inclined-plane ("Wolf") trap (which captures downstream-migrating ammocoetes and newly transformed adults and is also a barrier to upstream-migrating adults) near the mouth of Carp Lake River, Emmet County, and of a weir near the stream's source (at Paradise Lake) continued in 1960. The annual midsummer inspection of the spawning area above the barrier for the possible presence of sea lamprey redds and the semiannual collections of ammocoetes in the stream above the barrier, with a direct-current shocker, were also continued.

The inclined trap took 2,369 sea lamprey ammocoetes and 2,147 newly transformed adults during the 1960 migration season.[3] As in previous years, no lampreys were caught in the weir at the stream's source. The catch in the inclined trap was lower than for 1959 and considerably below the average for 1949-1959 (Table 1). The data are not strictly comparable for the different years, however, because of varying amounts of escapement during high-water periods in most of the years.

Annual observations of the spawning areas in July and semiannual collections of larvae in the stream above the inclined trap in 1955-1960 indicated that no recruitment occurred during those years. It is also doubtful that recruitment occurred in 1954, since no sea lamprey ammocoetes less than 2.2 inches in length were found among 731 ammocoetes collected in 1955 (although a single 2.1-inch larva was found among 147 taken in July, 1956).

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[3] Although most migration occurred between October and June, a migration season was arbitrarily considered to correspond to the fiscal year. Thus, the 1960 season extended from July 1, 1959 to June 30, 1960.

Table 1.--Numbers of lampreys caught in an inclined-plane trap in the Carp Lake River, 1949-1960

Migration season	Recently transformed sea lampreys	Lamprey larvae[1]
1949	7,969	492
1950	16,235	8,403
1951	15,103	12,647
1952	4,069	1,414
1953	6,861	2,838
1954	10,238	14,827
1955	3,893	3,725
1956	2,401	22,822
1957	2,640	4,884
1958	4,796	561
1959	4,796	5,640
1960	2,147	2,522
Total	81,148	80,775
Average	6,762	6,731

[1] Although larvae of all species are included, sea lampreys are believed to represent 94 to 96 percent of the total (based on identification of representative samples of ammocoetes in 1956-1957 and on identification of the entire catch in 1958-1960).

The observations at Carp Lake River strongly indicate that the minimum age of the ammocoetes remaining above the inclined trap is not less than 7 years (1953 year class), and may be 11 years (1949 year class[4]) or more if the inclined trap was an effective barrier to adult sea lampreys in 1950-1953. The progressive upward trend in size and downward trend in abundance of ammocoetes in semiannual collections at three stations in the Carp Lake River between 1955 and 1960 suggest, however, that the sea lamprey population above the inclined trap is now nearing extinction (Table 2).

Metamorphosis of sea lampreys.--In early July, 1960, 406 sea lamprey ammocoetes (average length, 5.5 inches; range, 3.9 to 6.5) were collected from Carp Lake River, Emmet County, and divided randomly between two hatchery troughs that contained a layer of silt about 4 inches thick. From July 12 to November 1, 1960, the average daily minimum and maximum water temperatures in the troughs were 50° and 57° F., respectively.

Initiation of external metamorphosis was visible on approximately 4 percent of the specimens at the beginning of the experiment. The ammocoetes were left undisturbed in the one ("control") trough (observations only on July 7 or 11, and November 1). In the second ("experimental") trough, all lampreys were examined at periodic intervals for evidence of metamorphosis (July 7 or 11, which were the installation dates; August 1

[4] Although the inclined trap was operated in 1949, it was not an effective barrier to upstream migrating adult sea lampreys during that year.

Table 2.--Number and length of sea lamprey ammocoetes collected with a direct-current shocker, upstream from an inclined-plane trap, Carp Lake River, July 7-10, 1955 and October 3-4, 1960

Station number[1]	Year	Length (inches)		Number taken per hour of shocking	Percentage of sea lampreys among ammocoetes collected[2]
		Average	Minimum		
1	1955	4.6	2.2	336	79
	1960	5.6	5.1	5	8
2	1955	3.6	2.6	118	56
	1960	5.4	5.2	1	12
3	1955	4.2	3.2	47	51
	1960	4.8[3]	4.1[3]	0	0

[1] Stations 1, 2 and 3 are located upstream from the inclined trap, at distances of 1/2, 1 1/2, and 4 1/2 miles, respectively.

[2] Other species of lampreys collected were Lampetra lamottei and Ichthyomyzon spp.

[3] Length data are for 1958, the last year during which significant numbers of ammocoetes were collected at Station 3.

and 16; September 6 and 30; and November 1). Briefly, in the experimental trough, more than half of the transforming ammocoetes had shown the following changes on the dates given: beginning of development of the eyes and teeth and reduction of the oral hood by August 1; fusion of the oral hood with the lower lip by August 16; elongation of the snout and enlargement of the oral hood by September 30.

In the experimental and control troughs, only 60 and 70 percent, respectively, of the larvae transformed although it is nearly certain that all were 7 years old or older (see preceding section). Metamorphosis of only a few individuals was complete by November 1 in either the experimental or control trough. In contrast, external metamorphosis of 26 ammocoetes collected from Carp Lake River on October 3 was nearly complete, suggesting that transformation may have been retarded by the relatively low water temperatures in the hatchery troughs.

On November 1, metamorphosing lampreys in the experimental trough averaged 5.5 inches in length and the non-metamorphosing ones, 5.3 inches; for lampreys in the control trough these measurements were 5.7 and 5.4 inches. The longer average length of transforming individuals may have been due partially to elongation of the snout; however, in the

experimental trough, the average length of metamorphosing specimens before lengthening of the snout had occurred was 5.4 inches, as compared to 5.3 inches for non-transforming specimens. The data suggest that larger ammocoetes were more likely to metamorphose than smaller ones.

The reliability of external examination to detect dye-marked ammocoetes.--In June and July, 1958 a total of 2,187 sea lamprey larvae were collected from Carp Lake River, Emmet County, with a direct-current shocker, marked by subcutaneous injections of mercuric and cadmium sulfide, and released near the point of capture. During the 1959 migration season 5,365 ammocoetes and 4,796 newly transformed adults were caught in the inclined trap near the mouth of the river. The inspection (two observers) of the exterior of these lampreys showed that 54 ammocoetes and 87 newly transformed adults were marked. It was suspected, however, that some marks may have been obscured by skin and/or pigment. To determine whether this was true, a random sample of 2,347 ammocoetes and 1,692 newly transformed adults were cross-sectioned and examined internally for marks. No marked ammocoetes and only one marked adult were found. Assuming that no marks were missed by the internal examination, the results indicated that (at the 95 percent confidence level) no more than two marked ammocoetes or more than six marked adults were missed by the external examination.

A pumping device as a method of collecting larval lampreys.--A bottom-sampling device (essentially a modified "sandsucker") was tested to determine its value for quantitative sampling of ammocoetes in deep water (4 to 60 feet). The working parts of the sandsucker (mounted on a 6- by 12-foot raft) were a 10,000-gallon-per-hour-capacity centrifugal pump; an airtight 55-gallon barrel; and an inverted funnel or "cup" (8 inches in diameter) which was connected to the barrel and pump by hose and pipe. In operation, the cup was lowered momentarily to the substrate, and the bottom material under the cup was sucked up through the connecting pipes into a screened cylinder inside the barrel. Water and fine sediments washed through the screened cylinder into the pump, and were discharged through an outlet pipe. Larger materials and ammocoetes were retained in the cylinder.

In the form used, the sandsucker did not prove to be an efficient collecting tool because the barrel and lines clogged frequently when a substrate that contained a large proportion of woody debris, weeds, and clam shells was sampled; operation in water over 20 feet in depth was not possible because of the excessive weight of the hose and pipe (2-inch galvanized) required to reach bottom; and the gear was not quickly adjustable for sampling at different depths.

Certain modifications in the barrel and its pipe connections may reduce the frequency of clogging, and the substitution of aluminum pipe for iron pipe would facilitate sampling in deep water and at different depths. In the form in which it was tested, however, the sandsucker was inferior to the orange-peel dredge for sampling in deep water.

Lake trout

Collection of lake trout eggs.--The Fish Division continued experimental fishing in three large inland lakes during the 1960 spawning season for the purpose of collecting lake trout eggs. Efforts were concentrated in Higgins Lake, Roscommon County, and Elk Lake, Antrim and Grand Traverse counties, which had produced the largest numbers of eggs per unit of effort during two previous years of experimental operation in five lakes of the northern Lower Peninsula. In addition, exploratory netting was carried out in Walloon Lake, Charlevoix County (not previously netted during egg-taking operations), to try to locate spawning areas and determine lake trout abundance. A total of 315,745 green eggs were collected between October 17 and November 8 (48,528 from Elk Lake; 190,857 from Higgins Lake; and 76,360 from Walloon Lake).[5]

Although the total egg-collecting effort in inland lakes was reduced from 1958 and 1959 (when 695,399 and 429,339 eggs, respectively, were taken), it is apparent after 3 years that collection of lake trout eggs in these lakes is costly and difficult. The operation probably will be abandoned soon, if the production of lake trout eggs by hatchery brood stock increases at the expected rate.

Eggs again were collected in 1960 by Supt. Russell Robertson from brood-stock lake trout which are being reared at the Marquette Hatchery. Brood fish from four age groups were stripped in the collection of 2,450,580 green eggs (Table 3).

Table 3.--Number of green eggs collected from brood lake trout at the Marquette Hatchery, 1960

Age	Source	Number of females stripped	Total number of eggs	Eggs per female
XI	Lake Superior	46	142,072	3,089
VII	Lake Superior	210	578,456	2,755
VII	Lake Superior[1]	137	398,412	2,835
VI	Lake Superior	495	673,488	1,360
V	Lake Superior	472	520,872	1,103
V	Domestic[2]	150	137,280	915
Total or average		1,510	2,450,580	1,623

[1] "Lean" x siscowet cross.

[2] Eggs taken in 1954 from the brood fish of age-group XI.

[5] Data provided by Regional Fisheries Supervisor Max A. Hunt.

As might be expected, the fish produced increasing numbers of eggs with increasing size and age. The 11-year-old fish are the oldest lake trout which have ever been developed for hatchery brood stock. A summary of lengths, weights, and egg production of this group of fish from 1954 (the first year in which any females ripened) to 1960 is shown in Table 4. The average production of eggs per female has increased each year (except for a slight drop in 1959) from 1,007 at age V to 3,089 at age XI.

Table 4.--Lengths, weights, and number of green eggs produced by the 1949 year class of brood lake trout reared at Marquette Hatchery, 1954-1960

Year	Age of fish	Mature females			Mature males			Number of green eggs produced[1]	
		Number	Average length (inches)	Average weight (pounds)	Number	Average length (inches)	Average weight (pounds)	Total	Average per female[2]
1954	V	18	20.2	2.3	31	20.8	2.6	18,120	1,007
1955	VI	52	21.4	3.0	146	21.3	3.0	90,720	1,890
1956	VII	49	22.0	3.4	113	22.8	3.8	94,176	2,093
1957	VIII	54	22.8	3.6	78	24.2	4.5	138,888	2,621
1958	IX	50	23.6	4.2	78	24.5	4.7	148,176	2,964
1959	X	51	24.3	4.5	72	26.0	5.7	126,222	2,475
1960	XI	46	24.9	4.9	68	26.6	6.2	142,072	3,089

[1] Numbers based on counts of 240 eggs per ounce in 1954, 216 in 1955-1959, and 172 in 1960.

[2] Mature females which were found to be spent at the time of stripping (4 in 1955, 4 in 1956, and 1 in 1957) were not included in the computation of the averages.

Marking of hatchery brood fish.--In 1957, No. 3 Monel strap tags were applied to the upper jaw of all lake trout of the 1949 year class (age-group XI of Table 3) being held at the Marquette Hatchery. In 1958, No. 4 strap tags were placed on the lower jaw of both lots of fish of the 1953 year class (age-group VII of Table 3). Neither tag proved satisfactory because of excessive tearing of jaws and loss of tags; in addition, tags which remained intact required careful cleaning (a time-consuming burden during spawn-taking operations) before the tag number could be read. Results of limited branding experiments have not been particularly promising. A fully satisfactory method for individual identification of brood lake trout is not yet available.

Disease problems.--Lake trout for stocking inland lakes have been reared in Michigan for many years, from eggs collected by Great Lakes commercial fishermen from fish caught for the market. The resulting young fish were generally held at hatcheries for only about 2 years before they were planted. Although they grew slowly compared to other species of trout, and a better diet was sought, there were no particular disease problems. The retention of lake trout in hatcheries for a much longer period, to develop a brood stock, brought with it, however, two rather

serious disorders which have been apparent to some degree ever since this program began, and which are currently being studied by Fish Pathologist Leonard N. Allison. One of these is cauditis (erosion of the caudal fin) of about 15 percent of the 3- to 5-year-old fish, and the other is the development of cataract or other eye damage among about 30 to 40 percent of the fish of these and older year classes. Inquiry as to the possible cause of these two conditions was made of various hatchery supervisors in the United States and Canada, but none had reared large numbers of lake trout to brood-stock age or had had experience with the diseases concerned.

Cauditis affects lake trout from 3 to 6 years old. It typically begins along the dorsal surface of the caudal fin and gradually progresses around the edge until the entire fin is affected. The fin rays eventually disintegrate, leaving a raw lesion in place of the caudal fin. This condition was noted first at Marquette Hatchery, and later at Pendills Creek Hatchery and to a lesser degree at Harrietta Hatchery. All attempts to control the lesions by chemical treatment have failed.

It was noted that a considerable number of hatchery-reared lake trout 3 years old or older were blind in one or both eyes. The examination of several thousand fish disclosed that about 40 percent of the 4-year-old lake trout had either cataract or corneal damage.

Both the eye disorders and cauditis were suspected to be deficiency diseases, so various diets were tested. One group of diets was tested for 8 months on 1,200 fish, and another group for a full year on 1,400 fish. The eyes and tail of each fish were examined at monthly intervals. None of the diets resulted in the amelioration or cure of either condition.

Since lake trout normally live in deep water, it was suspected that high light intensity might be a cause of cataract. To check this possibility, 3,464 yearling fish from cement tanks at Marquette, that had never been exposed to direct sunlight, were divided into eight groups and held for 3 months in light intensities varying between those found in covered cement tanks indoors and in open raceways outdoors; at Harrietta, 2,000 3-year-old lake trout were divided into four equal groups, two of which were held in open outdoor raceways and two in covered raceways. After 3 months, there was little difference in the percentage of cataract among the groups of yearlings at Marquette or among the 3-year-old fish at Harrietta. These tests are being continued until May, 1961 when a final check will be made.

In another diet test, twenty 3-year-old lake trout with incipient cataract in both eyes were divided into two groups and held in aquaria. Fish of both groups were fed beef liver, but one group was injected daily with four times the normal daily requirement of riboflavin. After 6 weeks there was no difference between the groups insofar as development and progress of cataract were concerned.

Nothing that has been tried to date has been effective in controlling either cauditis or cataract. Further diet tests are planned.

Commercial production of lake trout in Lake Superior.--Commercial lake trout production in State of Michigan waters of Lake Superior during 1960 declined by about 57 percent from production in 1959 (Table 5). The precipitous drop in catch carries with it the strong implication that the once extensive lake trout fishery, which has been in jeopardy ever since the invasion of the sea lamprey, may soon vanish until such time as the lamprey is brought under control and the lake trout is rehabilitated.

Table 5.--Monthly commercial catch (pounds) of lake trout in State of Michigan waters of Lake Superior, 1959 and 1960[1]

Month	1959	1960[2]
January	17,462	12,777
February	1,378	2,010
March	5,725	15,090
April	89,972	49,313
May	168,821	64,010
June	102,810	48,741
July	83,047	24,734
August	65,902	14,903
September	70,432	18,201
October	7,329	4,957
November	18,293	22,835
December	40,630	7,316
Total	671,801	284,887

[1] Data provided by S. M. Bower.

[2] Tentative totals, based on reports received by January 30, 1961.

Stocking of rainbow trout in the Upper Great Lakes

Anglers reported additional returns during 1960 from the more than 100,000 jaw-tagged, legal-size rainbow trout which were stocked (in the spring) near the mouths of tributaries of the Upper Great Lakes in 1955-1959.[6] The primary objective of the study is to determine whether spring and fall runs of "steelheads" into these streams can be materially augmented by the planting of hatchery-reared fish. The year of planting and the number of recoveries reported during the 1960 trout season were as follows: 1955, 0; 1956, 0; 1957, 7; 1958, 50; and 1959, 102.

[6] This study is under the immediate supervision of M. J. Hansen.

In general, the voluntary reports of recaptures of marked rainbow trout continued to follow the pattern set by returns in 1955-1959. Approximately 3 percent of the tagged fish have been recovered to date, of which only about half showed the rapid growth increment of lake-run fish (many were caught within a few weeks after planting); straying of fish from the planting site was extensive (fish commonly were recovered more than 100 miles away); and relatively few fish were recovered more than 2 years after planting.

Plantings of rainbow trout in 1957-1959 included fish of three different origins: "domestic" (reared from eggs taken from hatchery brood stock); "Michigan wild" (eggs from Great-Lakes-run rainbow trout, taken during their spawning migration); and "West Coast" (eggs from sea-run rainbow trout, supplied by the State of Washington). To date the percentage return of lake-run trout has not been significantly greater for West Coast fish than for fish of the other two strains.

Walleyes in Lake Michigan

A joint study (with the U. S. Bureau of Commercial Fisheries) of the walleye population in the Bay de Noc area of northern Lake Michigan, begun in 1957, was advanced during the year by the tagging of 1,022 walleyes on April 19-May 5, near the mouth of the Tacoosh and Whitefish rivers.[7] Of 4,690 walleyes tagged in this general area in 1957-1960, 411 (8.8 percent) had been recovered by anglers or commercial fishermen by November 1, 1960. Although anglers reported 69.8 percent of the total returns and commercial fishermen 30.2 percent, these percentages were almost exactly reversed when the comparison was restricted to fish recaptured in areas which were accessible to both sport and commercial fishing. (The portion of northern Green Bay in which most of the fish were tagged is closed to commercial fishing; the marked fish become available to commercial operators only when they are outside of this restricted area.) The percentage recovery (by all methods, including renetting during years subsequent to tagging) of fish marked with No. 3 Monel strap tags on the upper jaw and with spaghetti dart tags (the two principal types used in the Green Bay study) was nearly identical (12.6 and 12.8 percent of 2,689 jaw and 1,886 spaghetti tags, respectively). Walleye "homing" to identical spawning grounds during successive years was clearly demonstrated by the marking experiment in northern Green Bay (most tagging has been done during the spawning season); of 66 recoveries of tagged fish during the netting in 1960 (64 tagged in 1959 and 2 in 1958), 64 were recovered at or very near the original release point, and all were caught in the stream in which they had been tagged. The pattern of tag recoveries continues to indicate that the walleye population of northern Green Bay is composed of several distinct subpopulations, all of which apparently restrict their range to this general portion of Lake Michigan. Of the 411 recaptures in 1957-1960, only 5 were outside the vicinity of Bay de Noc; these were caught in southern or central Green Bay (within 110 miles from the point of release).

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[7] Walter R. Crowe is representing the Institute for Fisheries Research in this study.

The annual transfer of sizable numbers of Lake Michigan walleyes (of a subpopulation which tends to be restricted to the southeastern portion of the lake) from the Muskegon River to upstream impoundments, during the spring spawning run, provides an opportunity for Department employees to determine the incidence of lamprey scarring and lymphocystis. Of 8,382 walleyes examined on April 8-23, 1960, 1.1 percent were scarred (slightly less than the 1954-1959 average of about 2.0 percent) and lymphocystis was observed in 3.4 percent (as compared to 7.4 percent in 1959, and an average of 4.9 in 1954-1959).[8]

Muskellunge in Lake St. Clair[9]

Lake St. Clair, the various channels near the mouth of the St. Clair River, and the Detroit River, have long been outstanding fishing grounds for the Great Lakes muskellunge. Field observations in 1954-1956 and the collection of fishing records from boat liverymen and others in 1939-1960 have provided a limited amount of information on the life history of the species and on the sport fishery in these waters.

Spawning season.--Reports by anglers indicated that most ripe (spawning) muskellunge were caught in Lake St. Clair in May or June. This was confirmed by the dissection of 222 muskellunge caught by anglers on May 21-June 17, 1954; 35 caught on May 14-June 5, 1955; and 32 taken on May 19-June 10, 1956. Although nearly all mature males examined during these periods were ripe, the condition of the ovaries of mature females indicated that muskellunge spawning may have been nearly completed by June 9, 1954; May 14, 1955; and June 2, 1956. General observations in these years suggested that the time of spawning was related more directly to water temperature than to calendar dates (weather during May was cool in 1954 and 1956, but unusually warm in 1955). During each of the 3 years, some mature females were seen with large, fibrous, purplish ovaries which contained eggs attached to the ovarian tissue, rather than with the yellowish ovaries and loose eggs associated with ripe females. The suggestion was that these were spent females with large numbers of residual eggs.

A total of 128 net nights of fishing with 3-foot trap nets and a 4-foot fyke net between May 21 and June 17, 1954, yielded no muskellunge, although the nets were set in habitats where most fish were being taken by anglers (channels, marshes, mouths of tributary streams, weed beds in protected coves, and open bays). High water and heavy boat traffic interfered materially with the netting operations.

Age and growth.--The examination of scales from 126 muskellunge (34 of which were less than the minimum legal length of 30 inches) taken in Lake St. Clair in 1951-1960 suggested that muskellunge usually reach legal size during their fourth or fifth year of life. Males may become sexually mature at an age of 3 years and a length of 26.5 inches; females at 5 years and 34 inches. Male muskellunge seldom exceed 41 inches in length and 16 pounds in weight in Lake St. Clair, whereas the faster growing, longer lived females commonly reach a length of 52 inches and a weight of 30 pounds.

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[8] Data provided by District Fisheries Supervisor Edward H. Andersen.

[9] Information provided by John E. Williams. Inasmuch as previous annual reports on Michigan's Great Lakes research (I. F. R. Reports No. 1559 and 1612) did not include material on muskellunge research, data collected in 1954-1960 are summarized here.

Catch by anglers.--An indication of the number and size of muskellunge caught in Lake St. Clair is provided by records supplied by Gasow's Boat Livery, Mt. Clemens, for 1939-1951 and 1954 (Table 6) and by Tommy's Boat Livery, Detroit, for 1956-1960 (Table 7). Most of the fish recorded at Gasow's Livery were caught in May and June in the northern part of Lake St. Clair, whereas those registered at Tommy's Boat Livery were caught principally in southern Lake St. Clair during the summer (mostly after mid-June). Neither set of records reveals a consistent trend in average length and weight of fish caught during the different years.

Table 6.--Number and average size of muskellunge recorded at Gasow's Boat Livery, Mt. Clemens, 1939-1951 and 1954

Year[1]	Number of fish	Average total length (inches)	Average weight (pounds)
1939	51	38.5	13.9
1940	70	37.8	12.9
1941	87	38.9	13.5
1942	56	39.2	14.5
1943	14	39.1	14.1
1944	66	40.4	15.5
1945	23	41.1	16.8
1946	82	41.0	17.5
1947	54	40.7	15.5
1948	134	39.9	13.9
1949	130	42.2	16.5
1950	110	...	17.7
1951	110	...	16.2
1954	169	39.0	13.2
Total or average	1,156	39.9	15.1

[1] No length records for 1950 and 1951; no records for 1952 and 1953.

The length-frequency distributions of 1,469 muskellunge caught by anglers in northern Lake St. Clair in 1939-1960, and 1,904 from the southern part of the lake in 1956-1960 are given in Table 8. Data for fish of known sex suggested that females were uniformly heavier than males of the same length. As a general average, fish 30 inches long weighed about 6 pounds; 40 inches--14 pounds; and 50 inches--27 pounds. Fish less than 34 inches in length were rather poorly represented in the northern part of the lake, where fishing was largely over a spawning population, and where some emphasis may have been placed on the larger fish (the fish were entered in annual fishing contests, but anglers and guides were encouraged to register fish of all sizes), but were heavily

Table 7.--Number and average size of muskellunge recorded at Tommy's Boat Livery, Detroit, 1956-1960

Year	Number of fish	Average total length (inches)	Average weight (pounds)
1956	277	36.9	11.9
1957	356	36.4	11.4
1958	466	35.8	10.8
1959	452	35.5	10.2
1960	370	35.8	11.0
Total or average	1,921	36.0	10.9

represented in the summer fishery in southern Lake St. Clair. Although more muskellunge records were obtained by Gasow's and Tommy's boat liveries than by others, the annual catch of muskellunge in Michigan waters of Lake St. Clair is believed to range up to several thousand during some years.

Fishing records kept by guides, boat liverymen, and individual anglers in 1955 and 1956 suggested that experienced fishermen and anglers with guides averaged about one muskellunge per 25 hours of fishing in Lake St. Clair; others required an average of more than 200 hours to boat one fish.

Transfer of authority for regulation of Great Lakes fisheries

The responsibility for regulation of Michigan's Great Lakes commercial fishery was transferred from the State Legislature to the Conservation Commission, effective March 19, 1960. Act 154, P. A. 1959, granted the Commission discretionary power to suspend, abridge, extend or modify the provisions of any statute governing commercial fishing, except provisions relating to penalties, forfeitures or license fees, whenever such action is necessary for better protection, preservation, maintenance and harvest of fish. Work related to the new authority was assigned to the Fish Management Section of the Fish Division. Although not concerned primarily with research, the shift of regulatory authority will expedite the application of research findings insofar as they apply to fisheries regulations, and will facilitate the State's participation in any steps which may be taken toward the establishment of uniform fishing regulations among the Great Lakes states and Ontario.

Between May 3 and May 26, 1960, meetings were called by the Department at 10 localities (Holland, Traverse City, Alpena, Port Sanilac, Bay City, Monroe, Newberry, Wetmore, Hancock, and Escanaba) to bring together commercial fishermen and representatives of the Fish and Field Administration

Table 8.--Total length (inches) and weight (pounds) of muskellunge caught by anglers during the spring in northern Lake St. Clair, 1939-1960, and during the summer in southern Lake St. Clair, 1956-1960

Length[1]	North						South	
	Female		Male		All fish			
	Number of fish	Average weight	Number of fish	Average weight	Number of fish	Average weight	Number of fish	Average weight
30	...	...	...	...	7	6.0	127	5.9
31	...	...	6	6.8	33	7.0	191	6.4
32	...	...	2	7.0	43	7.3	198	7.1
33	1	8.5	4	7.7	45	7.7	180	7.8
34	2	9.2	9	8.1	77	8.4	175	8.6
35	...	...	3	9.2	90	9.2	153	9.5
36	3	10.8	11	9.5	124	10.1	139	10.4
37	2	11.9	6	10.4	103	10.5	125	11.3
38	5	13.4	9	10.7	134	11.9	114	12.3
39	2	13.1	3	12.7	82	12.6	79	13.2
40	5	13.9	2	12.5	88	13.6	85	14.4
41	6	15.2	4	13.5	91	14.6	58	15.6
42	4	15.7	...	...	78	16.0	55	16.7
43	6	18.0	...	...	69	17.2	46	17.6
44	9	19.5	...	...	53	18.6	28	19.2
45	5	21.3	...	...	57	20.6	31	20.2
46	3	21.5	...	...	52	21.3	41	21.4
47	1	21.7	...	...	36	22.9	24	22.3
48	3	24.8	...	...	56	24.8	23	23.7
49	2	28.6	...	...	45	26.0	16	24.8
50	1	28.0	...	...	38	27.3	7	24.8
51	3	26.2	...	...	23	28.4	4	30.8
52	1	36.0	...	...	18	29.9	4	25.6
53	2	32.7	...	...	14	30.9	...	...
54	1	30.0	...	...	8	31.1	...	...
55	...	...	...	...	2	31.9	1	38.1
56	...	...	...	...	2	33.7	...	...
57	...	...	...	...	...	...	...	...
58	...	...	...	...	1	29.2	...	...
Total or average	67	18.6	59	9.6	1,469	15.0	1,904	10.9

[1] 30 = 29.5-30.4 inches; 31 = 30.5-31.4 inches, etc.

divisions of the Department and of the U. S. Bureau of Commercial Fisheries. Details of the new regulatory authority were explained to the fishermen at each meeting, and changes in regulations which had been proposed by the Michigan Fish Producers Association, or by others, were discussed. Of some 15 changes considered, 6 subsequently became law. Four of these concerned

duration of closed seasons or minimum size for certain species in certain areas; one (effective June 12, 1960) empowered the director of conservation to issue special permits for and to regulate the use of trawls for taking chubs, herring, alewives, smelt, and other designated species; and one (effective September 11, 1960) authorized the issuance of permits for the use of gill nets with meshes less than 2 1/2 inches (extension measure) for taking the same species allowed in the trawl fishery. Fourteen permits were issued by the Department for the use of trawls, and 18 for the use of small-mesh gill nets. Both types of gear were restricted to southern Lake Michigan.

Commercial production of fish by trawling[10]

Of 14 commercial fishermen who applied to the Department for permits to trawl in southern Lake Michigan in 1960, only 6 (all from Holland or Saugatuck) actually operated this gear; 8 permits were surrendered or cancelled, or expired because of failure to engage in trawling within 90 days of the date of issue. Weekly reports on fishing effort and catch (required under terms of the permits) showed that 1,281 hauls (2,041 hours of trawling) during the first 4 months of operation (June-September) yielded a total of 947,000 pounds of fish. The catch included 919,000 pounds of chubs (842,000 pounds of animal food and 77,000 of human food), 19,000 pounds of smelt, and 9,000 pounds of alewives.

Other studies

Red worm of perch.--Additional reports of red worm (Philometra cylindracea: Nematoda) in yellow perch from the Great Lakes were received from anglers in 1960, but all of the infected fish were caught within the range previously reported (Brest Bay in Lake Erie; Lake St. Clair; and Saginaw Bay, Tawas Bay, and near Alpena in Lake Huron). No red worms were found in two samples of 100 perch from Lake Huron, one collected near Cedarville and the other near Cheboygan. Fish Pathologist L. N. Allison would appreciate assistance in obtaining samples of 100 or more perch for inclusion in this study, from any locality in Lake Michigan west of the Straits of Mackinac.

Hydrographic survey of Saginaw Bay.--Progress was made during the year in the analysis of bottom fauna samples collected in Saginaw Bay, Lake Huron, during four synoptic cruises in 1956-1957, as part of a hydrographic survey which is being completed jointly with the Great Lakes Laboratory of the U. S. Bureau of Commercial Fisheries.[11] Semi-monthly samples collected at selected sites in the Bay by the Bureau's research vessel Cisco during the summer and fall of 1956 are being included in the study. Considerable effort was expended during the year in taxonomic work on the bottom invertebrates (especially the midges).

Smallmouth bass.--Of 248 smallmouth bass tagged in Big Bay de Noc and 123 tagged in Little Bay de Noc in September 1957, 24 had been returned by anglers by November 1960. The difference in percentage return in the two areas (3.6 in Big Bay and 12.2 in Little Bay de Noc) probably

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[10] Data provided by M. J. DeBoer.

[11] Frank F. Hooper represents the Institute for Fisheries Research in this study.

reflects a difference in fishing pressure in the two bays. One of the bass had moved 25 miles between the date of release and recovery, two had traveled 10 miles, and the others were caught within 5 miles from the locality of release.

A paper entitled "The life history of the smallmouth bass, Micropterus d. dolomieui, at Waugoshance Point, Lake Michigan," by William C. Latta, is expected to be published in 1961 as Bulletin No. 5 of the Institute for Fisheries Research.

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