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# POPULATIONS OF SEA LAMPREY LARVAE IN OGONTZ BAY AND OGONTZ RIVER, DELTA COUNTY, MICHIGAN

by

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## Introduction

Sea lampreys (<u>Petromyzon</u> <u>marinus</u>) have been assumed to spend the larval stage in streams. Larval sea lampreys, however, have been recorded at five locations along the north shore of Lake Michigan by Stauffer and Hansen[2] and in Lake Superior by Thomas (1960). The proximity of these collection locations to sea lamprey spawning streams, the occurrence of an annual downstream movement of sea lamprey larvae,[2] and the lack of evidence that sea lampreys spawn in the Great Lakes, all strongly suggest that these lake populations originated from streams.

If substantial populations of larvae[3] exist in the Great Lakes, it is important to know their nature and origin. The routine use of larvicides, which are effective against ammocoetes in streams,[4] may control the lake populations also, providing the larvae first spend considerable time

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[2] Thomas M. Stauffer and Martin J. Hansen, 1958. A preliminary report on the migration of sea lamprey ammocoetes in Michigan. Mich. Dept. Cons., Inst. Fish. Res. Rept. No. 1565.

[3] The terms larva and ammocoete refer to the sea lamprey unless stated otherwise.

[4] Programs and Progress, 1959. Mimeographed report of Great Lakes Fisheries Investigations, Bureau of Commercial Fisheries, Fish and Wildlife Service, U. S. Dept. of Interior.

in streams. However, if lake populations are virtually independent of those in streams, it may be necessary to employ different methods of control.

This investigation compared lake and stream populations of ammocoetes found in a portion of a Lake Michigan bay and in the "parent" stream. Ogontz Bay (in the northern portion of Green Bay, Lake Michigan) and the Ogontz River, which drains into the north end of Ogontz Bay, were selected for study because of the known presence of sea lamprey ammocoetes in both bay and stream.[5] The possibility of recruitment to the bay population from other streams was slight; the nearest stream containing sea lampreys (excluding the Ogontz River) was 5 miles away. Ogontz Bay was studied in 1958-1959, and the Ogontz River in 1959.

## Ogontz Bay population

Ogontz Bay (area, 7 square miles) is relatively shallow, with a maximum depth of 14 feet and an average depth of 5 to 6 feet. In the area studied, the bottom consisted of varying proportions of sand, silt, clay, detritus, and some gravel. Near shore the bottom was generally soft, but in water over 3 feet deep the substrate was more compact, with a higher percentage of hard clay. Bulrushes (*Scirpus* sp.), the dominant form of vegetation along the swampy shoreline, were common in water depths of one to three feet; pondweed (*Potamogeton natans*) and waterweed

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[5] Larvae of the American brook lamprey (*Lampetra lamottei*) were also present in the bay and river.

(Elodea canadensis) were present in smaller amounts. Stonewort (Chara vulgaris) was predominant in water over 3 feet deep.

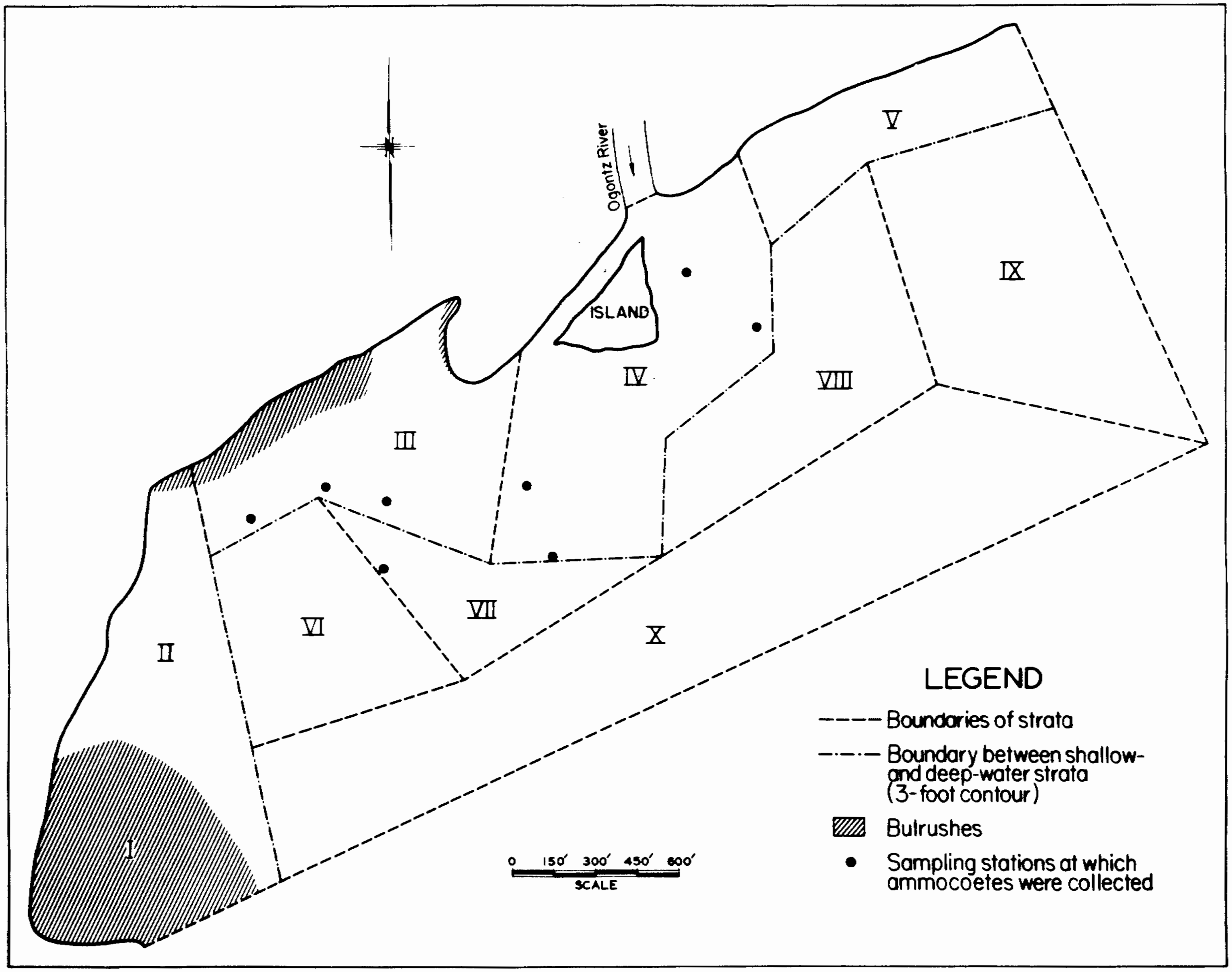
Methods.--Following exploratory sampling in 1957, larval populations in Ogontz Bay were studied intensively in 1958 and a limited study was conducted in 1959 to determine whether there was any major change from the 1958 population.

An orange-peel dredge (12 inches in diameter with the jaws closed) was used for all sampling in the bay. In deep water, the dredge was operated from a 26-foot converted lifeboat and in the shallows from a 16-foot trap-net boat. A winch and boom were used to raise the dredge; the dredged materials were then washed through a 1/8-inch wire mesh with water from a small centrifugal pump. A 1.5-horsepower gasoline engine powered both the winch and the pump.

The study area (143 acres) lay along the shoreline off the mouth of the Ogontz River. It was divided into 10 strata on the basis of bottom type and proximity to the mouth of the river (Figure 1). Strata I-V were located in shallow water (average depth, 1.5 feet) along shore, and Strata VI-X were located in relatively deep water (average depth, 4.5 feet) beyond the 3-foot contour.

It was not practical to make frequent transfers of the heavy dredging equipment from the lifeboat used in deep-water strata to the trap-net boat used in the shallow-water strata; therefore, most of the deep-water stations were sampled first (July 31-August 11, 1958), all of the shallow-water stations next (August 15-September 4), and then the remaining

Figure 1.--Study area in Ogontz Bay, Delta County, Michigan, showing strata used in sampling.



Ogontz River
ISLAND
I
II
III
IV
V
VI
VII
VIII
IX
X
0 150' 300' 450' 600'
SCALE
LEGEND
Boundaries of strata
Boundary between shallow- and deep-water strata (3-foot contour)
Bulrushes
Sampling stations at which ammocoetes were collected

deep-water stations (September 6-10). Within each of the three periods, the sequence of sampling among strata was determined at random (subject to the allocation of sampling effort) to equalize among strata any possible effect of changes in numbers.

The number of sampling stations allocated to a given stratum was proportional to the anticipated ammocoete population. Population density was expected to be greater in strata containing a predominantly soft bottom and in those located near the mouth of the river; generally this was confirmed.

Sampling stations within strata were first located at random on a large-scale map, allowing a unit of area 60 feet square for each station. Stations were then located in the field from written instructions which indicated the direction and distance to be measured from buoys of known location. In shallow water, distance was measured with a 100-foot steel tape; in deep water, it was measured as time at constant engine speed. This boat characteristic was calibrated on two standard courses several times each day to adjust for variable conditions of wind and wave.

At each station, 25 dredge lifts were made (with several exceptions). Care was taken to avoid superimposed samples. Each lift was recorded as either "good" (containing a normal amount of substrate) or "poor" (containing noticeably less than a normal amount). Dredge lifts were usually good in a soft substrate but poor in a hard bottom.

The surface area sampled by good and poor lifts was determined by calibrating the dredge on representative bottom types in the study area.

A 30-inch-square positioning device was used to lay down 1/4-inch ball bearings, 2 inches apart, in a grid pattern on the bottom. The dredge was dropped into this pattern in the normal way, and the area of surface thus sampled was determined by counting the ball bearings recovered, each representing 4 square inches. In this manner, one dredge lift was taken at each of 25 locations. The lifts classified as good averaged 0.63 square foot (range of 14 values, 0.39 to 0.81 square foot), while the poor lifts averaged 0.24 square foot (range of 11 values, 0.11 to 0.44 square foot). The total area dredged at each collecting station could then be estimated from these average values and the counts of good and poor lifts. The calculated area sampled at most stations was between 14.6 and 15.8 square feet.

In addition to calibration, a further correction for undersampling was needed. The necessity for this correction was discovered in 1959, when both the orange-peel dredge and an enclosure method (described later) were used to estimate the ammocoete population (both American brook and sea lampreys) in a sluggish portion of the Ogontz River (Stratum 2, see Table 2). Stations for both methods were selected at random; 5 enclosure stations (4 enclosures per station) were sampled on July 22 and August 17-18 and 85 dredge stations (10 lifts per station) were sampled on August 31 and September 3, 4, 8, and 9. The mean density of both species of ammocoetes obtained from the enclosures was 0.455 ±0.103 per square foot, as compared to 0.142 ±0.024 per square foot for the dredge. This difference was statistically significant

($\underline{t}$ = 2.96). The ratio of these values, 3.20 ±0.90, was used to correct all estimates based upon the orange-peel dredge. Although the dredge thus proved to be a less efficient collecting instrument than the enclosures, it was the most practical and effective deep-water device available.

There is no good evidence that the dredge was selective of age or size, although it is impossible to test the point precisely. A question is appropriate because some lampreys must have escaped.

Those captured cannot be assumed to be independent samples in either method because lampreys here were taken in lots (clusters) as they occurred on the randomly sampled areas. Statistical independence would mean no correlation within clusters, i.e., no real differences among clusters, an assumption which cannot be made. Because specimens from separate clusters were field-preserved in a common jar and measured later, cluster means are not known; only the records as pooled in the field for stations above and below the lamprey weir (see Figure 2). Pooled data show that 8 of 40 lampreys taken in the dredge and 2 of the 23 taken in enclosures had begun to metamorphose. The average length (and number of lampreys in the sample) for various categories is given below (standard deviation within category: ±0.84 for sea lampreys and ±1.50 for American brook lampreys).

| | Taken above weir | Taken below weir | Total |
|---|---|---|---|
| Sea lamprey | | | |
| Enclosure | 2.53(6) | 4.65(17) | 4.10(23) |
| Dredge | 4.72(5) | 4.70(35) | 4.70(40) |
| American brook lamprey | | | |
| Enclosure | -- | -- | 4.66(20) |
| Dredge | -- | -- | 4.60(24) |

The population in each stratum was estimated as the product of the mean number of ammocoetes collected per square foot, the stratum area, and the correction factor (3.20). A ratio estimate and variance (Cochran, 1953) were calculated for the mean number of ammocoetes per square foot (mean number per station divided by mean station area); the stratum area was accepted as an absolute measurement made on the map; and the correction factor carried its own variance. The totals and variances for individual strata were summed to estimate the total and variance for the entire area.

Results.--The total ammocoete population of Ogontz Bay in 1958 was estimate to be 30,100 ±12,200, most of which (81 percent) were in shallow water (Table 1). The larger number in shallow water was probably due to a more suitable bottom type and proximity to the mouth of the river.

The length distribution is shown in Figure 4 for all 17 ammocoetes taken from the bay (3 collected in 1957, 9 in 1958, and 5 in 1959). The mean length was 4.79 inches (range 4.0-5.3) with a standard deviation of ±0.37. Six of the 17 had begun to metamorphose.

Some 2,900 larvae of the American brook lamprey were also estimated to be present in 1958.

Limited random sampling was undertaken in 1959 to determine whether any major population changes had occurred since the previous summer. On July 30 and 31, 1959, 12 stations in Stratum III and 15 in Stratum IV were sampled in the same manner as in 1958. In 1959, the combined

Table 1.--Estimates of sea lamprey ammocoete populations in Ogontz Bay, 1958

| Stratum number | Area of stratum in acres[1] | Number of sampling stations[2] | Number of ammocoetes collected | Population estimate | |
|---|---|---|---|---|---|
| | | | | Number of ammocoetes | Standard error |
| Shallow water | | | | | |
| I | 10.0 | 8 | 0 | 0 | .. |
| II | 10.6 | 9 | 0 | 0 | .. |
| III | 14.0 | 38 | 3 | 9,700 | 6,100 |
| IV | 18.4 | 58 | 5 | 14,600 | 8,600 |
| V | 7.7 | 16 | 0 | 0 | .. |
| Subtotal | 60.7 | 129 | 8 | 24,300 | 10,500 |
| Deep water | | | | | |
| VI | 10.6 | 10 | 0 | 0 | .. |
| VII | 6.2 | 10 | 1 | 5,800 | 6,100 |
| VIII | 13.7 | 41 | 0 | 0 | .. |
| IX | 18.6 | 22 | 0 | 0 | .. |
| X | 36.0 | 20 | 0 | 0 | .. |
| Subtotal | 85.1 | 103 | 1 | 5,800 | 6,100 |
| Total | 145.8 | 232 | 9 | 30,100 | 12,200 |

[1] Area was determined by planimeter from a plane-table map.

[2] With several exceptions, 25 dredge lifts were taken at each sampling station.

population estimate for both strata (based on the collection of one ammocoete in Stratum IV and none in Stratum III) was 11, 200 ± 11, 600. Although the 1958 estimate was 24, 300 ± 10, 500, the difference was within expected sampling fluctuation.

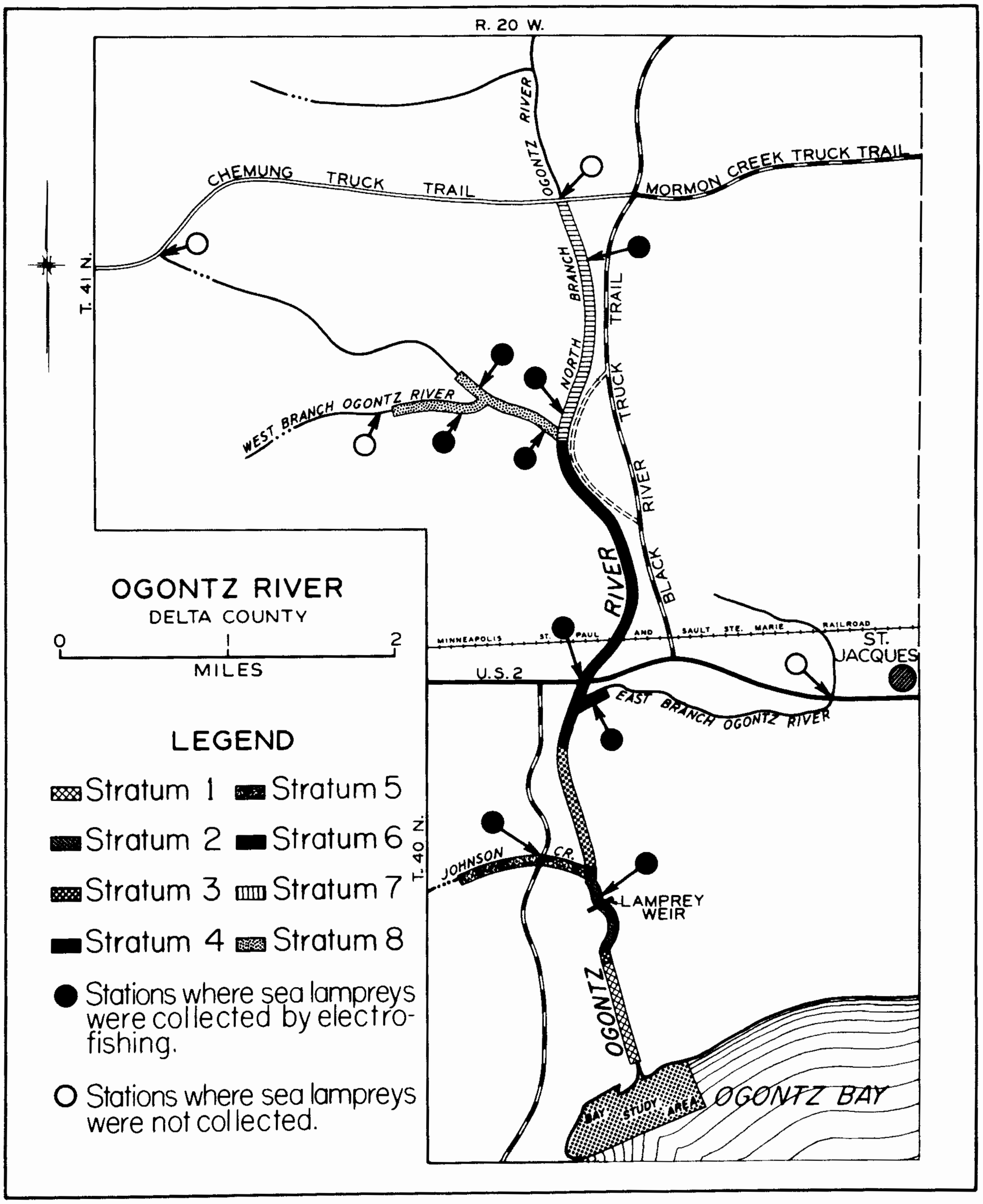
Nonrandom sampling, at a location judged most likely to yield ammocoetes (in Stratum IV), also revealed no evidence of important changes in the bay population from 1958 to 1959. None of the 360 lifts of the orange-peel dredge on September 11, 1958 contained ammocoetes, while 4 of the 460 lifts on July 16, 1959 did contain larvae (4 ammocoetes were collected). Even if the dredge lifts are considered independent trials (they were not), the difference was not significant ("Fisher exact" test, Siegel, 1956).

The studies thus showed that appreciable numbers of ammocoetes were present in the bay, and since they were found in each of 3 years their presence was not sporadic. With no evidence of marked population changes from 1958 to 1959, it seems reasonable to compare the bay population of 1958 with that of the Ogontz River in 1959.

## Ogontz River population

The Ogontz River, a small stream (approximate discharge, 5 cubic feet per second) in Delta County, Michigan, empties into the northwest corner of Ogontz Bay (Figure 2). The main stream and its four tributaries drain a watershed of about 30 square miles. In 1959, summer water temperatures (recorded in the course of field work) ranged between 58° and

Figure 2.--Ogontz River, Delta County, Michigan, showing sampling strata of 1959 and the stations used in exploratory electrofishing in 1957-1959. The portion of Ogontz Bay in which the population study was made in 1958 (see Figure 1) is also shown.


R. 20 W.
T. 41 N.
T. 40 N.
CHEMUNG TRUCK TRAIL
MORMON CREEK TRUCK TRAIL
OGONTZ RIVER
NORTH BRANCH
TRUCK TRAIL
BLACK RIVER
WEST BRANCH OGONTZ RIVER
RIVER
MINNEAPOLIS ST. PAUL AND SAULT STE. MARIE RAILROAD
ST. JACQUES
U.S. 2
EAST BRANCH OGONTZ RIVER
JOHNSON CR.
LAMPREY WEIR
OGONTZ
BAY STUDY AREA
OGONTZ BAY
OGONTZ RIVER
DELTA COUNTY
0 1 2
MILES
LEGEND
Stratum 1
Stratum 2
Stratum 3
Stratum 4
Stratum 5
Stratum 6
Stratum 7
Stratum 8
Stations where sea lampreys were collected by electro-fishing.
Stations where sea lampreys were not collected.

78° F., with an average of 64° F. During the study, water levels were below normal. The water was typically tea colored; large deposits of clay in the stream banks caused the water to become extremely turbid after rains. With the exception of a bedrock area in the lower river, larval habitat was present throughout the system; the major spawning area was in the upper portion of the stream.

An electro-mechanical barrier to upstream-migrating adult sea lampreys (Applegate, Smith and Nielson, 1952) was operated by the U. S. Bureau of Commercial Fisheries near the mouth of the river in 1958 and 1959. It is unlikely that the ammocoete population of the stream had been reduced materially by 1959, however, because of the relative recency of installation of the weir, and the known escapement of adults past the barrier during the spawning migration of 1958[6] (larvae of the 1959 year class were not included in the population estimate).

Methods.--The study area selected was that part of the Ogontz River system where ammocoetes were found in exploratory electrofishing (13 collections were made with a direct-current shocker in 1957-1959); this area included 9.6 miles, or most of the river system. The study area was divided into eight strata according to physical characteristics (Figure 2 and Table 2). These divisions were: the lower main stream (Stratum 1); a sluggish section of the main stream, separated from Stratum

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[6] Programs and Progress, 1958. Mimeographed report of Great Lakes Fisheries Investigations, Bureau of Commercial Fisheries, Fish and Wildlife Service, U. S. Department of Interior.

Table 2.--Physical features of different strata sampled for sea lamprey ammocoetes in the Ogontz River

[Depth, width, and volume of flow were measured at the place and time of sampling]

| Stratum number | Length (feet) | Depth (feet) | | Width (feet) | | Velocity[1] | Volume (cubic feet per second) | Bottom type[2] |
|---|---|---|---|---|---|---|---|---|
| | | Average | Maximum | Average ± standard error | Range | | | |
| 1 | 4,200 | 2.5 | 4.0 | 44.8 ± 0.92 | 25-72 | S | 5.2 | SS;G, R, C |
| 2 | 2,700 | 1.5 | 4.0 | 29.1 ± 0.49 | 19-36 | GS | 5.2 | SS |
| 3 | 6,400 | 0.3 | 0.8 | 24.5 ± 1.00 | 19-33 | R | 5.0 | B |
| 4 | 15,250 | 0.7 | 4.0 | 15.1 ± 0.98 | 6-30 | GR | 5.0 | SS;G, R, C |
| 5 | 4,200 | 0.5 | 2.0 | 8.[illegible] ± 0.10 | 6-11 | GS | 0.2 | SS;G, R, C |
| 6 | 1,200 | 0.5 | 1.5 | 10.9 ± 1.90 | 8-18 | GS | 0.5 | SS;G, C |
| 7 | 10,930 | 0.6 | 2.0 | 8.7 ± 0.42 | 6-12 | R | 2.5 | SS;G, C |
| 8 | 6,000 | 0.6 | 2.5 | 10.1 ± 1.12 | 6-14 | GR | 1.5 | SS;G, C |

[1] S = sluggish (velocity less than 0.5 feet per second); R = rapid (velocity greater than 0.5 feet per second); GS = generally sluggish (stream in most of stratum sluggish, with some sections of faster water); GR = generally rapid.

[2] SS = silty sand; G = gravel; R = rubble; C = clay; B = bedrock.

1 by a short rapids (Stratum 2); two bedrock areas in the main stream (Stratum 3); the upper half of the main stream (Stratum 4); Johnson Creek upstream from the mouth to a point where it became intermittent (Stratum 5); the East Branch to an extensive series of beaver dams and impoundments (Stratum 6); the North Branch to the Chemung Truck Trail (Stratum 7); and the West Branch to a large beaver dam impoundment on the south fork and to a point where the flow was almost nil on the north fork (Stratum 8).

Stratum 1 was sampled from July 6 to 15, and Strata 2-8 from July 20 to September 10, 1959. Although it would have been desirable to sample in a random sequence among strata (to compensate for population changes or movement of ammocoetes between strata), this was not possible because of limited time. Although migrations over short distances probably occurred during the study period and a downstream migration of some distance presumably had taken place in April and May (see footnote 2), it was assumed that the ammocoete population was relatively sedentary at the time of study.

Stratum 1 was 1,400 yards long. It was necessary to use the orange-peel dredge here because of deep water. Ten lifts were made at each of the 147 stations. Stream width was recorded at every third or fourth station. The stations were located by first selecting points at random along the stream length, and then choosing the exact locations at random across the stream at the designated points. Where stream width is variable, this method gives bottom areas where the stream is narrower a greater probability of being selected, but this bias disappears when stream width approaches uniformity. Therefore, to reduce the bias, the population estimates were calculated here for three subsections of Stratum 1, within which width was less variable. This move also reduced the effect of a slight variability, up and down stream, in the proportion of stations where width was measured.

In Stratum 1, the population was estimated as the product of four factors: (1) the number of ammocoetes per square foot with its variance as calculated by the same ratio-estimation method used in the bay; (2) the mean width of the stream with its variance as found by sampling; (3) the length of the stratum, taken to be absolute as measured; and (4) the same correction factor (3.20) and variance as were used in the bay.

In Strata 2-8, ammocoetes were collected with a cylindrical enclosure of sheet aluminum (24-gauge) that was 2.5 feet in diameter and 24 or 36 inches high (Figure 3). In use, the cylinder was set over the area selected for sampling, and the lower edge was pushed a few inches into the substrate. A larvicide (3-trifluormethyl-4-nitrophenol, described by Applegate, Howell, and Smith [1958]) was added to the enclosed water, to a concentration of 40 to 60 p.p.m. Most of the ammocoetes soon emerged from their burrows and could be collected. The enclosure was routinely allowed to stand about 1.5 hours. Then the enclosed substrate was excavated to a depth of several inches and washed through a 1/8-inch wire mesh screen to recover any remaining larvae; 21 sea and brook lamprey ammocoetes of various sizes (4.3 percent of

Figure 3.--Enclosures of sheet aluminum, 2.5 feet in diameter, used in collecting ammocoetes in the Ogontz River. Here the substrate is being screened to insure collection of all lampreys killed by the larvicide.

the total collected) were recovered by this screening. In turbid water, an underwater viewer and a scap net were used in collecting. At several turbid-water stations, the water in the enclosure was pumped out and passed through the 1/8-inch screen.

The primary sampling units with the enclosure method were 100-yard-long sections of stream. One of the first field operations was the measurement of the length of stream where ammocoetes were present. During the measurement, the 100-yard sections were identified with numbered stakes. The strata were designated next on the basis of observations of habitat types made while measuring the stream. Within a stratum, the sections to be sampled were selected at random. In the selected sampling sections, lampreys were collected from four enclosures, each set at a point randomly selected in the manner described for Stratum 1.[7] Stream width was measured at each enclosure.

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[7] This use of multiple measurements, or subsampling, of the sample sections was dictated by considerations of cost. The fixed charge of access to a section was about 210 minutes; this included travel on foot to the section, the wait for the toxicant to act at the first enclosure, and the return travel. To locate the sample point, set up an enclosure, apply the toxicant, and later collect ammocoetes took about 27 minutes per station. Such information on time costs allows a belated calculation of the best number of enclosures to use per section, provided there is a measure of the variability both between enclosures in the same section, and between sections. Data on such variability were recorded only at eight sections in Stratum 4. Here the variance between sections was estimated to be 0.34, and variance between enclosures was 3.07 (unit of measurement--ammocoetes per enclosure). If we accept these estimates (in spite of there being no evidence

(footnote continued at bottom of next page)

In Strata 2-8, populations were estimated as the product of three factors: (1) the mean number of ammocoetes per square foot, and its variance as calculated from sample section values (each of which was an average of four enclosure determinations); (2) the mean width of stream and its variance, similarly calculated; and (3) length of the stratum as measured. Population estimates and variances for the separate strata were summed to estimate the total ammocoete population in the Ogontz River.

The enclosure is clearly superior to the orange-peel dredge as a sampling device in areas where it can be used. Nevertheless, certain systematic errors are suspected and each of these would result in an underestimate of ammocoete numbers. These are:

1. Ammocoetes under 1 inch long (1959 year class) were not included in the estimate because of uncertainty of identification. Even though these small larvae were probably less likely to be captured than the larger ones, they still comprised 8 percent of all larvae (both species) collected.
2. Previous experience suggested that a substrate containing woody litter was especially productive of ammocoetes. Because the enclosures could not be used at stations

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7 (continued)

of a significant difference among sections) then the balance between variances and costs indicates the best information would have been attained by using five, instead of four, enclos res per section (Cochran 1953; p. 225).

containing an excess of woody litter, the substitution of nearby locations (which may have contained fewer ammocoetes) was occasionally necessary.

3. It is possible, though unlikely, that some dead ammocoetes were not collected in turbid water.

4. Small populations in headwaters may have escaped detection in the preliminary survey and thus have been excluded from the study area.

Results.--The ammocoete population of the stream system was estimated to be 136,800 ±29,700; most (84 percent) were in the main stream (Table 3). On the basis of certain characteristics of the ammocoete population, the stream may be divided into an upper region (Strata 4, 6, 7, and 8) and a lower region (Strata 1, 2, and 5), divided by the apparently sterile mile of shallow water flowing over bedrock in Stratum 3. The upper region had the larger ammocoete population, at generally higher densities; the larvae were smaller in average size, and proportionately fewer were metamorphosing (Tables 3 and 4; Figure 4). All four differences seem greater than it is reasonable to expect from sampling. An approximate test yielded $t$ values of 2.7 and 2.3 for number and density, respectively. The clumped nature of sampling renders doubtful an exact interpretation of the tests for mean length or proportion metamorphosing ($t$ = 11.2, chi-square = 10.5, respectively), but the indication of a difference seems strong.

Table 3.--Estimates of sea lamprey ammocoete populations in the Ogontz River, 1959[1]

| Stratum number | Area of stratum (acres) and standard error | Sample size[2] | Number of ammocoetes collected | Population estimate | |
|---|---|---|---|---|---|
| | | | | Number of ammocoetes | Standard error |
| 1 | 4.3 ±0.23 | 147 | 12 | 9,400 | 3,900 |
| 2 | 1.8 ±0.03 | 5 | 23[3] | 19,000 | 7,700 |
| 3 | 3.6 ±0.38 | 2 | 0 | - | - |
| 4 | 5.3 ±0.86 | 22 | 162 | 86,300 | 27,200 |
| 5 | 0.8 ±0.02 | 2 | 0[4] | - | - |
| 6 | 0.3 ±0.14 | 2 | 1 | 300 | 300 |
| 7 | 2.2 ±0.28 | 8 | 18 | 11,300 | 6,300 |
| 8 | 1.4 ±0.40 | 5 | 17 | 10,500 | 5,300 |
| Total | 19.7 ±1.11 | 193 | 233 | 136,800 | 29,700 |

[1] Ammocoetes under 1 inch in length were not included.

[2] In Stratum 1, the unit of the sample was the station, where 10 dredge lifts were taken. In Strata 2-8, the unit was the 100-yard stream section, in each of which four enclosure determinations were made (except that only three enclosures were used in one of the sample sections in each of Strata 2 and 7).

[3] Dredging took 40 ammocoetes. Population estimates were based only on the 23 ammocoetes taken in enclosures.

[4] Although one ammocoete was collected in Stratum 5 during the exploratory electrofishing, none were taken in the enclosures.

Table 4.--Population density, mean length, and maturity of sea lamprey ammocoetes in Ogontz Bay and Ogontz River

| Part of drainage system[1] | Number of ammocoetes per 100 square feet | Mean length (inches) and standard error | Percentage of ammocoetes metamorphosing |
|---|---|---|---|
| Bay | 0.5 | 4.79 ±0.09[2] | 35 |
| Lower main stream (1) | 5.0 | 4.37 ±0.37 | 0 |
| Lower main stream (2) | 23.4 | 4.48 ±0.13[3] | 16[3] |
| Bedrock area (3) | none | - | - |
| Upper main stream (4) | 37.5 | 2.81 ±0.08 | 3 |
| Tributaries (5-8) | 10.8 | 3.06 ±0.18[4] | 3[4] |

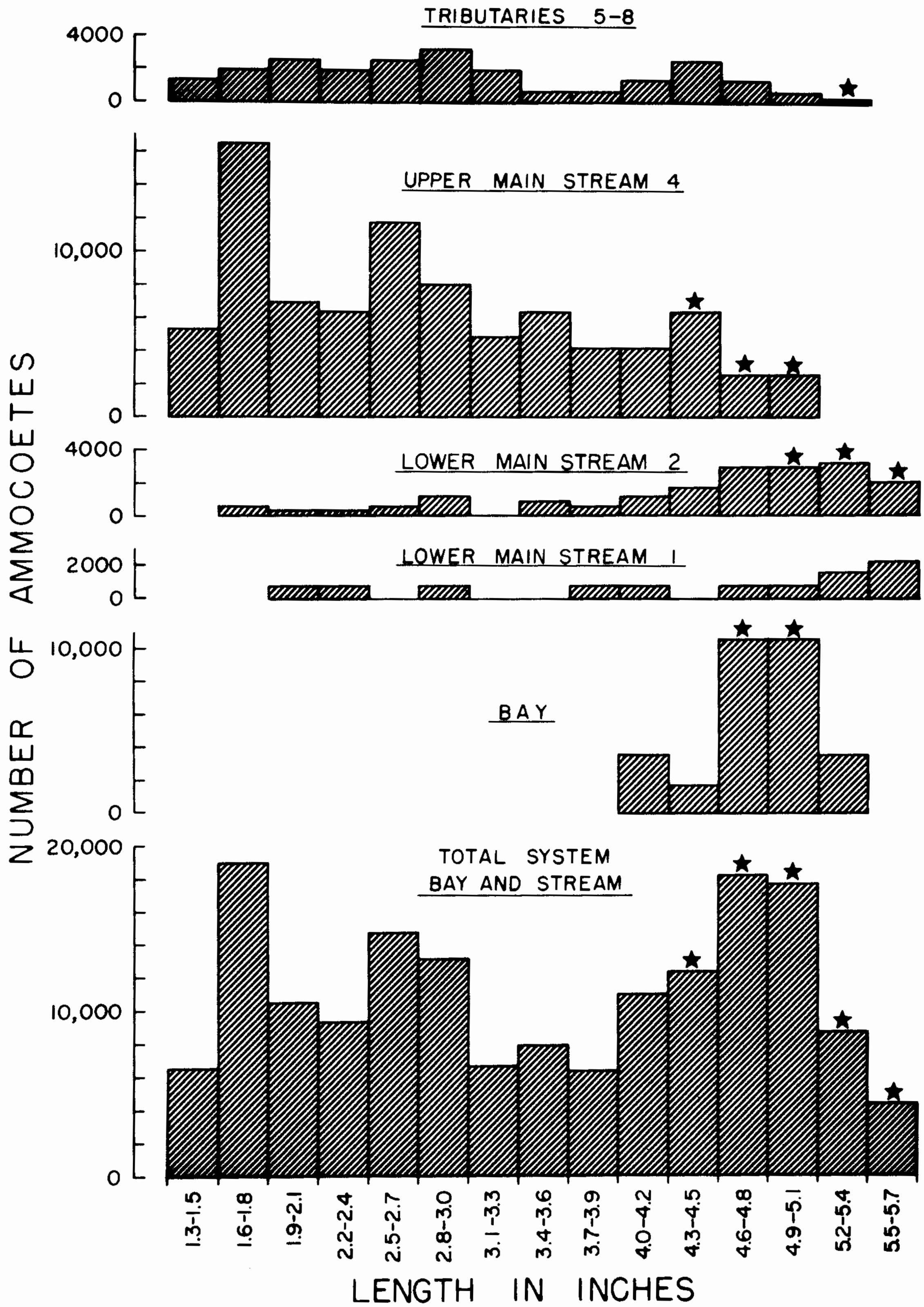
[1] Stratum number in parentheses.

[2] Computed from all ammocoetes collected in 1957, 1958, and 1959.

[3] Computed from collections made with both dredge and enclosure.

[4] Apply only to Strata 6-8.

Figure 4.--Estimated length distribution of sea lamprey ammocoete populations in Ogontz Bay and Ogontz River. Frequencies were calculated by proportion from the respective sample length distribution and population estimate. A star indicates presence of metamorphosing lampreys.



TRIBUTARIES 5-8
4000
0
UPPER MAIN STREAM 4
10,000
0
LOWER MAIN STREAM 2
4000
0
LOWER MAIN STREAM 1
2000
0
BAY
10,000
0
TOTAL SYSTEM
BAY AND STREAM
20,000
10,000
0
NUMBER OF AMMOCOETES
1.3-1.5
1.6-1.8
1.9-2.1
2.2-2.4
2.5-2.7
2.8-3.0
3.1-3.3
3.4-3.6
3.7-3.9
4.0-4.2
4.3-4.5
4.6-4.8
4.9-5.1
5.2-5.4
5.5-5.7
LENGTH IN INCHES

The greater population density in the upper region confirms field observation that the major spawning areas were in this part of the river. Presumably the population in the lower region was supported mainly by recruitment from upstream. However, the observed differences in size and proportion metamorphosing would imply differential migration (or survival) rates according to these characteristics. In fact, this hypothesis is supported elsewhere by observations of Stauffer and Hansen (footnote 2) at Carp Lake River, Emmet County, Michigan, where they reported that larger ammocoetes were more likely to migrate downstream.

Some 138,700 larvae of the American brook lamprey were also estimated to be in the river (66 percent of these were in the main stream).

## Discussion

This study indicated that appreciable numbers of ammocoetes (18 percent of the combined bay and river population) were in the bay, even though they were less numerous and more widely scattered than those in the river. A greater proportion were metamorphosing in the bay. Ammocoetes in the bay were larger on the average, and were confined to a narrow range at the upper end of the length distribution for the entire bay-river population (Figure 4). For their particular length group of 4 inches and longer, bay larvae made up 41 percent of all in the system, whereas they constituted only 18 percent of the larvae of all sizes combined.

An important question here, with reference to control of sea lampreys, is the relation of the bay population to that in the river.

Were the ammocoetes in the bay growing and surviving to metamorphose eventually into adults, or were they only a temporarily surviving segment? The first alternative would imply a far more serious control problem than would the second.

Such information as we have supports the hypothesis that the bay population was a natural extension of that in the river, even though a definitive answer cannot be provided from single years of study in the bay and in the river. This interpretation depends upon an assumption that the bay population reconstructed in Figure 4 reflects a 'standing' age structure (and not, say, the chance result of a flood). First, it seems reasonable to postulate from the size distribution that the bay population was being recruited from the stream. Ammocoetes have been demonstrated to move downstream, with the larger individuals moving more. Some selection by size was apparently occurring here, both within the stream, and from river to bay. While this selection could arise solely from the greater movement of larger lampreys, it would also be influenced by any accelerated mortality for younger animals which do move. Second, if the bay population exists by recruitment from the river, this process must be happening at a low rate, accompanied by high survival in the bay. This conclusion is reached by considering that the growth of ammocoetes is relatively slow during their multi-year larval stage (Applegate, 1950), probably too slow to allow a stream population of the magnitude found here to recruit large ammocoetes to this bay population at any rapid rate. It is obvious, however, that this conclusion would be radically altered were certain changes to be observed in the length distribution of ammocoetes for bay and stream.

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