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LARVAL LAMPREY POPULATIONS IN A LAKE HURON BAY AND TRIBUTARY [1]

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Abstract

A stratified, random sampling technique was used to estimate the number of lamprey larvae in McKay Bay and McKay Creek during 1961-63. The total number of sea lampreys (Petromyzon marinus) was 32,926; 39% in the bay and 61% in the stream. This demonstrated that lenitic populations are large enough to warrant concern. Although our estimate showed that most lenitic larvae were on or near the alluvial fan where they could be eradicated with Bayluscide, nonrandom sampling revealed a substantial population some 1,400 feet from the stream mouth. This study confirms the need for continued, frequent larvicide treatments for certain streams. The American brook lamprey (Lampetra lamottei) population in our study area of McKay Creek was estimated at 130,808 and had a biomass of 352 pounds, or 30 pounds per acre.

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Introduction

A larvicide has proved its effectiveness by virtually eradicating sea lamprey (Petromyzon marinus) ammocoetes from streams (Applegate et al., 1961). However, Hansen and Hayne (1962) and Wagner and Stauffer (1962a, 1962b) demonstrated that substantial populations of larvae exist in lenitic waters. While larvae on alluvial fans of streams can be killed by Bayluscide (Manion, 1969), the existence of widely distributed populations would pose problems in sea lamprey control. Our study provides more information on ammocoete populations in lenitic environments and on their relationship to populations in streams from which they originated. Our information was derived from population estimates of ammocoetes in McKay Bay and its only tributary, McKay Creek. A beaver pond area in the stream was of particular interest. Although ammocoetes are known to occur in impoundments, there is little information about their abundance there.

The gear used to sample sea lamprey ammocoetes also captured American brook lamprey (Lampetra lamottei). We therefore measured their population parameters because they are important members of the bottom fauna in many areas (Hansen and Hayne, 1962; Smith and McLain, 1962).

The study area is approximately 20 miles northeast of the Straits of Mackinac, on the north shore of Lake Huron (Fig. 1). Since

McKay Creek is the only tributary of McKay Bay and the nearest other stream is 5 miles away, it is the source of ammocoetes in the bay. The creek is 5 1/2 miles long and has a discharge of 5.5 cubic feet per second at normal summer flow. The soil of the watershed is underlain by limestone, and the area is generally wooded. The bay is about 1 mile long, 1/3 mile wide, and its maximum depth is 22 feet. Population estimates were made during June-September of 1961-63 (Table 1). Little migration of ammocoetes occurred during these months (Manion and McLain, 1971) and we assumed that lamprey populations did not change among years.

McKay Creek Populations

The distribution of ammocoetes in McKay Creek was determined by electrofishing for 1/2 to 1 hour at each of 16 locations (Fig. 1). Sea lamprey ammocoetes were not found in the upper portion of the mainstream or in the two tributaries. Therefore, population estimates were made only in the lower 4 miles of the mainstream. American brook lampreys, however, were abundant throughout the stream. Because of physical characteristics (Table 2) that required different methods of sampling, the study area was divided into three subareas: the estuary, the stream proper and a beaver area (Fig. 1). The gear used effectively sampled all larvae over 1 inch long and older than age 0. Some age-0 larvae no doubt escaped our gear. Thus, estimates of age-0 larvae are minimal.

Other fish collected included brook trout (Salvelinus fontinalis), mottled sculpin (Cottus bairdi), central mudminnow (Umbra limi) and fathead minnow (Pimephales promelas).

McKay Creek estuary. --The estuary was sampled during 20-28 August 1962 when water temperatures were 58-66 F. It was 1,072 feet long and averaged 86 feet wide. The current was sluggish, vegetation was common to abundant, and the bottom was sand and clay. Other physical characteristics are given in Table 2. The estuary was mapped, and it was divided into two substrata by using the 1 1/2-foot contour line. To establish station locations, grid lines were drawn at 10-foot intervals on the map. Within each stratum, each grid-line intersection was numbered and became a possible sampling station, subject to random selection. Because the estuary was deep, an orange-peel dredge was used to sample the ammocoete population. Ten dredge lifts were taken at each of 50 randomly selected stations. Mechanics of sampling were described by Wagner and Stauffer (1962a). Calibration studies made by Wagner and Stauffer (1962a) and Hansen and Hayne (1962) indicated that this dredge has varying efficiency in sampling different bottom types. The area sampled per lift in the estuary was estimated to be 0.8 square foot in soft, silty clay, and 0.3 square foot in hard clay. The areas sampled in intermediate bottom soils fell between these extremes.

The estimated number of ammocoetes in each stratum was the product of the mean number of ammocoetes collected per square foot and the total area of the stratum. A variance for the estimate was

calculated by methods given by Cochran (1959, p. 128-129). Estimated numbers of ammocoetes and their standard errors in the estuary in August 1962 were: sea lamprey, 6,399 ± 2,280 and American brook lamprey, 13,479 ± 3,425 (Table 3). Estimates in the estuary in September 1961, using similar but less sophisticated methods, gave nearly identical results. Sea lamprey and American brook lamprey ammocoete populations were 6,534 ± 1,511 and 14,706 ± 3,583, respectively.

Hansen and Hayne (1962) compared collections made with the orange-peel dredge with collections made with metal enclosures. They found that the dredge collected only about a third of the ammocoetes present. Thus, populations in McKay estuary were underestimated.

McKay Creek proper. --This study area was divided into five strata according to physical characteristics (Fig. 1 and Table 2). In upstream progression, the strata were: (1) a sluggish section just above the estuary, with clay and silt-clay bottom; (2) an area of faster water having a clay bottom with some sand, plus rubble and gravel suitable for lamprey spawning; (3) a section below a beaver area with generally rapid water and bottom of silt and silty sand; (4) a sluggish stretch above the beaver area; and (5) an area of rapid water and a considerable amount of gravel suitable for lamprey spawning. Water temperatures were closely similar in the five strata; daytime averages ranged from 59 to 63 F during July-September 1961.

Sampling stations within each stratum were randomly located by the method of Hansen and Hayne (1962). Larvae were collected with a metal 55-gallon drum from which both ends had been removed. This enclosure was placed over the area selected for sampling and pushed several inches into the substrate to provide a watertight seal. A lamprey larvicide, 3-trifluormethyl-4-nitrophenol (TFM), was introduced at a concentration of 40-60 ppm. After 1 1/2 hours, ammocoetes that had emerged from their burrows were taken from the enclosure with forceps. In turbid water, a scap net was passed repeatedly through the water to capture ammocoetes. The water was then pumped from the enclosure and poured through a 1/8-inch wire mesh screen. Finally, the substrate in all enclosures, except hard clay, was removed to a depth of several inches and worked through the screen to recover any remaining ammocoetes. Only eight larvae, all dead, were found in the substrate.

The population of each stratum was estimated as the product of the following factors: (1) mean number of ammocoetes collected per square foot, (2) mean width of the stream, and (3) length of the stratum. The variance of the mean number of ammocoetes per square foot, and of the mean width of the stream, were determined so that the variance of the estimate could be calculated. Population estimates and variances of the estimates for all strata were summed to obtain the total population. For McKay Creek proper, the estimates were 13,727 ± 2,879 sea lamprey and 107,484 ± 18,751 American brook lamprey ammocoetes (Table 3).

Beaver pond area. --The beaver pond area was 2 miles upstream from the stream mouth, and was about 1/2 mile long and 400 feet wide (Fig. 1). In 1961, there were six active beaver dams with a combined pond area of about 500,000 square feet. The dams were 200 to 550 feet apart and, progressing upstream, were identified by the letters A to F. In the spring of 1962, the beavers (Castor canadensis) were removed by trapping; thereafter the dams rapidly deteriorated. By the time population estimates were made in the summer of 1962, the pond areas had been reduced to 74,600 square feet. We made collections with a back-pack shocker (Braem and Ebel, 1961) at the same five stations both in 1961 and 1962. These collections suggested that the population of ammocoetes in areas where water remained did not change significantly between 1961 and 1962. The total population, however, must have been greater in 1961 than in 1962 because of the greater water area in 1961. The fate of ammocoetes in the drained area is unknown. Since they did not concentrate in the inundated areas that remained in 1962, numerous ammocoetes must have died or migrated out of the beaver pond area.

By the summer of 1962, three main types of habitat had resulted from deterioration of the six dams. One was that of connecting streams between the dams, where water movement was generally rapid and the bottom consisted of sand, silt and woody debris. A second was the dam channel which consisted of the upstream face of the dams and 6-20 feet of the adjacent substrate. Woody debris and silt composed the bottom here, and the flow of water was generally sluggish. A third habitat was

the residual pond water, with practically no current, and a substrate of soft silt. Daytime water temperatures during June-September 1962 were usually 56-61 F, with no great difference among the types of habitat. Each of the three types of habitat was designated as a major stratum. Substrata were established where physical differences occurred within the major strata.

Ammocoete populations in the beaver pond area in 1962 were sampled with the back-pack shocker. Sampling stations were selected by a stratified random sampling technique. The amount of sampling done in any specific part of the beaver area was in proportion to the anticipated abundance of ammocoetes as shown by exploratory collections.

Each connecting stream was designated as a substratum because of ecological differences. Approximately 25% of each stream was sampled by assigning randomly selected sampling stations, 25 feet long, to each substratum. The connecting streams were 6,479 feet long; the 1,572 feet that were sampled, produced 7 sea lamprey and 820 American brook lamprey ammocoetes.

Methods used in the dam channels were similar to those used in the streams except that some dam channels were sampled entirely. The total length of the dam channels was 2,412 feet of which 1,286 feet (53%) were sampled. Nine sea lamprey and 708 American brook lamprey ammocoetes were collected.

The area of the ponds above dams A, B and C was negligible so it was not sampled. A grid with numbered intersections was superimposed on outline maps of ponds D E and F. Each intersection was

a possible sampling station subject to random selection. The sampling stations were 5 feet wide and extended 20 feet in a randomly determined direction from the selected intersections. One station was sampled in pond D (area, 1,400 square feet) but produced no ammocoetes. Three stations were sampled in pond F (area, 5,700 square feet) where 19 American brook lamprey larvae were collected.

Pond E (67,500 square feet) was divided into upper and lower regions because of physical differences. The outline of the pond was mapped and the total area measured, but small hummocks of exposed bottom were scattered within the pond, and there were many intergradations between exposed bottom and water of sufficient depth to harbor lampreys. The mosaic was too complex, and the boundaries between the exposed and inundated substrate too poorly defined to permit mapping the inundated areas and randomly select sampling stations in these areas alone. Consequently, exposed bottom was included in the area from which sampling stations were chosen. Wherever a selected station fell on exposed bottom, the catch of ammocoetes was designated as zero. Thus, mean catch per station was representative of the total pond area which included all types of habitat. Fifteen stations produced 12 American brook lamprey ammocoetes.

Efficiency of the back-pack shocker was determined by two methods in McKay Creek beaver pond area in 1962. Subsequent reflection, plus discussion with other biologists, indicated that these calibrations were invalid. Shocker efficiency was reassessed during August 1971 in

the Yellow Dog River, Marquette County, where northern brook lamprey (Ichthyomyzon fossor) larvae were abundant. We selected 12 silty areas, each 39 to 86 square feet, that resembled the connecting streams in the beaver pond area of McKay Creek. Ammocoetes were collected from each area with the same shocker, operator and methods that were used in the McKay Creek beaver pond area. Each area was then isolated from the stream proper by earthen and log dikes. One to 3 hours after shocking was completed, the areas were treated with TFM (40 ppm) and the remaining ammocoetes were removed.

Shocker efficiency was: number collected with shocker divided by total number collected with shocker and larvicide, multiplied by 100. Efficiency among the 12 areas varied from 9 to 100% with an average and standard error of 57 ± 9%. Ammocoetes collected by shocker (mean length, 3.1 inches) were not significantly larger ($t = 1.89$, $0.05 < p < 0.10$, $df = 201$) than the larvicide collected ammocoetes (mean length, 2.9 inches).

The efficiency estimate obtained in the Yellow Dog River was only a rough approximation of actual efficiency in the McKay beaver pond area because shocker efficiency likely varies with size and species of larvae, visibility, and water conductivity. These factors were not the same in the Yellow Dog River and McKay Creek beaver pond area.

The estimated number of ammocoetes in each strata of the beaver pond area was calculated as: the mean number of ammocoetes collected per unit length (streams and channels) or unit area (ponds) multiplied by the total length or area of the strata divided by the

collecting efficiency of the shocker. The variance of the mean number of ammocoetes per unit length or area and the collecting efficiency were calculated to determine the variance of the estimates. Population estimates and their variances were summed to determine the total population.

In the beaver pond area, estimates of sea lamprey and American brook lamprey were 66 ± 31 and 9, 845 ± 1, 409, respectively (Table 3).

McKay Bay Population

McKay Bay has a surface area of 219 acres, a maximum depth of 22 feet and an average depth of 10 feet. Water temperatures at the bottom during the study ranged from 52 to 65 F. The bottom slopes gradually toward the mouth of the bay but the drop-off is abrupt along both sides. The substrate is generally sand near shore, and sand-clay or clay in the deeper areas. The shoreline is wind-swept and barren, except near the mouth of McKay Creek where bulrushes (Scirpus sp.) are present. Pondweed (Potamogeton sp.) and stonewort (Chara sp.) are common throughout the bay. The fishes predominantly taken by anglers are yellow perch (Perca flavescens) and lake herring (Coregonus artedii).

Collecting gear. --Enclosures could not be used in the deep water and the orange-peel dredge would not penetrate the hard substrate. In prior use of enclosures, we noticed that ammocoetes left their

burrows when larvicide was applied, swam to the surface of the water where they remained briefly, then swam to the bottom and died. To take advantage of this behavior, a new trap was developed to sample in McKay Bay. An inverted funnel was attached inside a 14- x 22-inch metal cylinder (15-gallon oil drum). A screened cover permitted access to the top of the trap but prevented ammocoetes from escaping. The open end of the trap was pushed into the substrate and larvicide was introduced from an attached pressure tank.[3] Larvae emerged from the substrate, swam up through the inverted funnel and were trapped in the upper end of the trap.

Three tests were made to determine the efficiency of the traps. Initial laboratory tests indicated: (1) efficiency was 80%, (2) 10 ppm of TFM was effective, (3) variations in temperature (58-72 F) had no effect on efficiency and (4) the traps were not size selective. The second testing of the traps was done in McKay Creek estuary where simultaneous estimates of lamprey populations were made with the orange-peel dredge and with the traps. Numbers of sea lampreys and American brook lampreys estimated by use of the traps were only about one-fourth those derived with the dredge; however, the differences were not significant at the 95% level. The traps were not size selective. We concluded that trap efficiency here was either very low or too few stations (20) were sampled to negate the effect of probable nonrandom distribution of larvae--we could not determine which. In a third test, we introduced 2,040 sea lamprey larvae into a 1,729-square-foot pond at randomly selected points. This pond was 2-3 feet deep with

[3] Details of the traps are available from the senior author.

a sand substrate and water temperature of 70 F. Ammocoetes were allowed to acclimate for 36 hours, after which we estimated the population by sampling 66 randomly selected stations with the traps. Trap efficiency was 74%, TFM at concentrations in the range of 4-10 ppm had no effect on efficiency and the traps were more efficient for smaller ammocoetes ($t = 3.0$, $p < 0.01$).

We believed that the third test gave the best measure of gear efficiency; accordingly trap catches in the bay were multiplied by 1.355 to correct for undersampling. Because of the low efficiency encountered in the estuary, we considered that our correction factor, if in error, would result in an underestimate of the bay population.

Selection of stations. --For the McKay Bay population study, depth, bottom type and area of emergent vegetation were recorded on a plane table map in June 1962. The bay was divided into 12 strata based on: (1) expected concentration of ammocoetes as judged by distance from the stream mouth and bottom type, (2) method of sampling and (3) aquatic vegetation (Fig. 2, Table 4). We assumed that ammocoete numbers would be higher near the stream mouth and in soft bottom types (Hansen and Hayne, 1962; Wagner and Stauffer, 1962a). Generally, sampling effort was apportioned among the strata according to their assumed population of larvae. A grid was drawn on the map of each stratum to establish collecting station locations, and the locations were chosen at random as described previously. Sequence of sampling among strata was also randomly determined to prevent bias from possible changes in abundance of ammocoetes.

Sampling procedure. --Collections at each sampling station where water was over 18 inches deep were made with six lamprey traps set in a line 1-2 feet apart. Larvicide was introduced at a concentration of 10 ppm and the traps were lifted 4 hours later. In water less than 18 inches, each station was sampled with two of the metal enclosures used in McKay Creek.

During the study, 154 stations (990 square feet) were sampled with traps and 26 stations (137 square feet) were sampled with enclosures (Table 4). Four sea lamprey ammocoetes and one American brook lamprey ammocoete were collected in the traps; none were collected in the enclosures. The sea lamprey ammocoetes were found within 500 feet of the mouth of McKay Creek and at depths less than 3 feet.

Population estimates. --The estimated number of ammocoetes in the bay was found by the same method as for beaver area ponds. The number of sea lamprey collected and estimated populations were:

Strata	Number collected	Estimated population and standard error
I	3	5,310 ± 3,954
II	1	7,424 ± 7,780
Total	4	12,734 ± 8,727

We are rather certain that the total is an underestimate because larvae were not collected in one stratum where they had been collected before. In 1961, 500 nonrandom dredge lifts in stratum VII produced five sea lamprey larvae (average length, 3.8 inches; range, 2.6 to 4.6) and a

metamorphosing sea lamprey 5.1 inches long. Also collected were six American brook lamprey larvae (average length, 5.5 inches; range, 4.1 to 6.7) and a metamorphosing American brook lamprey 6.3 inches long.

Numbers of American brook lamprey ammocoetes were not estimated because only one was caught during random sampling.

Sea Lamprey Population

Numerical distribution. --The total number and standard error of larvae in McKay Creek and McKay Bay were 32,926 ± 9,468. Numbers of larvae varied greatly among strata. Percentages of the total population in various areas were as follows: McKay Creek, above the beaver area, 8%; beaver pond area, <1%; stratum 3, 3%; strata 1 and 2, 31%; estuary, 19%; and bay, 39%. Larvae in stratum 3 and above came from the spawning area in stratum 5 (see below), and comprised only 11% of the total population. Larvae in stratum 2 and below originated from spawning in stratum 2; they made up 89% of the population. Larvae from stratum 5 may have been less numerous than those hatched in stratum 2 for a number of reasons, including fewer spawners and less extensive larval habitat.

Size distribution. --Our sampling indicated that larvae were smaller in or near the spawning areas than at greater distances, which reflected downstream drift (Stauffer, 1962; Manion and McLain, 1971). The average size of larvae hatched in stratum 5 was progressively

larger as downstream distance from the spawning area increased (Table 5 and Fig. 3). No larvae smaller than 2.7 inches were found in the beaver pond area or in stratum 3, which suggests that larvae in strata 3-5 and the beaver pond area formed a more or less discrete population from those hatched in stratum 2. Larvae that originated in stratum 2 also were larger at progressively longer distances downstream (Table 5 and Fig. 4).

Few larvae were of a length (Manion and Stauffer, 1970) at which metamorphosis occurs. No metamorphosing larvae were collected in the stream but one was collected during preliminary examination of the bay.

Biomass. --Sea lamprey larvae did not comprise an important part of the biomass in McKay Creek and McKay Bay (Table 5). Their weight was 0.4 pound per acre with the greatest weights (9.6 and 8.8) occurring in the deep water of the estuary and bay stratum I.

Comparison with other populations. --The McKay Creek sea lamprey population was low to intermediate in density (Table 6). McKay Creek larvae were smaller than those in Ogontz River and fewer (if any) were metamorphosing. In McKay Bay, total number and density were lower than that of Ogontz and East bays. Average length of McKay Bay larvae (4.0 inches) was intermediate between Ogontz Bay (4.8 inches) and East Bay (3.6 inches) larvae. Metamorphosing larvae were found in all three bays.

American Brook Lamprey Population

The number of larvae in the McKay Creek study area was estimated as 130, 808. This is a minimal estimate because preliminary surveys indicated that there were many, many more upstream from the study area plus at least some in McKay Bay. Within the study area, abundance varied greatly among strata. Percentages of the total population in various areas were as follows: above the beaver pond area (strata 4, 5) 57%; beaver pond area, 8%; stratum 3, 7%; strata 1 and 2, 18% and estuary, 10%. American brook lampreys were most abundant in or near spawning areas and in the upper part of the stream.

Size distribution. --As for sea lamprey, American brook lamprey larvae were smaller in or near spawning areas than they were at further distances downstream which reflected downstream drift (Table 5 and Fig. 6). Average size of larvae hatched in stratum 5 (or upstream) increased progressively, downstream to the beaver area. A slight decrease in average size in stratum 3 may have been due to an influx of small larvae from the West Branch which contained a small amount of spawning area. Larvae presumably hatched in stratum 2 were also progressively larger as downstream distance from the spawning grounds increased.

American brook lampreys ranged in size from 0.6 to 7.8 inches with an average length of 2.8 inches. They were exceptionally large in the beaver pond area. Six per cent of the lampreys collected were metamorphosing; they averaged 6.6 inches long and ranged from 5.3

to 7.6 inches. This range was slightly larger than that mentioned by Vladykov (1949).

Biomass. --American brook lampreys comprised a substantial portion (90%) of the lamprey biomass in McKay Creek (Table 5). For all areas combined, the estimate was 29.9 pounds per acre with extremes of 7.3 in the beaver ponds and 67.1 in stream stratum 4. The relatively large biomass in stratum 4 was probably due to its suitability as larval habitat and proximity to spawning areas in stratum 5 and upstream.

Conclusion

Distribution of sea lamprey ammocoetes in the McKay population demonstrates, as has been indicated elsewhere (Hansen and Hayne, 1962; Wagner and Stauffer, 1962a and 1962b), that lenitic populations are large enough to warrant concern. Some 12,734 individuals were in the bay or 39% of the combined stream-bay population. Larvae in the bay were relatively large (4.0 inches, average) and it seems likely that they would survive to metamorphose. However, according to the population estimate, most were on or near the alluvial fan where they would have been susceptible to Bayluscide. On the other hand, nonrandom sampling (500 dredge lifts) revealed a substantial population of sea lamprey larvae some 1,400 feet from the stream mouth. This is in agreement with Wagner and Stauffer (1962a, 1962b) and Hansen and Hayne (1962) who also found larvae at considerable

distances from the stream mouth. The present study, then, confirms the need for continued, frequent larvicide treatments for certain streams.

Few sea lampreys were in the beaver pond area. However, because the beaver pond area was mostly drained just before the estimate, we do not think that our estimates reflect a "normal" population.

American brook lampreys were abundant in McKay Creek; in one stratum their density was 54,084 per acre and biomass was 67.1 pounds per acre. In the entire stream system, they numbered 130,808 or 87% of the total lamprey numbers and comprised 90% of the lamprey biomass.

Acknowledgments

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Table 1. --Dates of lamprey population surveys in McKay Bay and McKay Creek

Location	Inclusive dates
Bay	7 August-25 September 1963
Estuary	6-12 September 1961
	20-28 August 1962
Stream	
Stratum 1	7-19 September 1961
Stratum 2	13-27 July 1961
Stratum 3	31 July-16 August 1961
Stratum 4	18-30 August 1961
Stratum 5	30 August-6 September 1961
Beaver area	
Streams	11 July-13 September 1962
Channels	13 June-9 August 1962
Ponds	14-16 August 1962

Table 2.--Physical characteristics of McKay Creek strata, 1961-62

Stratum	Length (feet)	Mean depth (inches)	Width (feet)		Area (square feet)	
			Mean	Standard error	Area	Standard error
Estuary						
Shallow	-	7.9	-	-	32,600*	-
Deep	-	38.7	-	-	59,400*	-
McKay Creek proper						
1	2,400	26.1	29.8	1.2	71,500	2,390
2	3,900	11.3	17.8	0.8	69,470	2,950
3	4,848	10.0	13.2	0.4	64,160	2,180
4	5,400	11.0	8.4	0.4	45,450	2,150
5	3,918	5.3	9.5	0.3	34,100	1,330
Beaver pond area						
Streams	6,479	5.5	6.3	0.3	41,850	1,960
Channels	2,412	11.0	7.8	0.6	18,900	1,480
Ponds	-	8.7	-	-	74,600*	-

* Measured with planimeter.

Table 3.--Area sampled, ammocoetes collected, and population estimates of ammocoetes by stratum in McKay Creek, 1961-62

Species and stratum	Percent of stratum sampled	Number collected	Population estimate		Number per acre
			Number	Standard error	
Sea lamprey					
Estuary					
Shallow	0.17	2	1,185	805	1,587
Deep	0.44	23	5,214	2,133	3,823
Total	0.34	25	6,399	2,280	3,031
McKay Creek proper					
1	0.23	6	2,580	1,015	1,571
2	0.27	20	7,518	2,303	4,712
3	0.33	3	911	676	619
4	0.31	7	2,233	1,124	2,139
5	0.21	1	485	485	568
Total	0.27	37	13,727	2,879	2,078
Beaver pond area					
Streams	23.4	7	43	19	45
Channels	53.3	9	23	24	53
Ponds	2.6	0	0	0	0
Total	15.7	16	66	31	21
American brook lamprey					
Estuary					
Shallow	-	4	2,370	1,602	3,168
Deep	-	49	11,109	3,028	8,144
Total	-	53	13,479	3,425	6,382
McKay Creek proper					
1	-	13	5,589	2,548	3,404
2	-	49	18,420	4,495	11,552
3	-	30	9,113	1,830	5,901
4	-	177	56,430	16,713	54,084
5	-	37	17,932	6,497	21,053
Total	-	306	107,484	18,751	16,275
Beaver pond area					
Streams	-	820	5,740	964	5,974
Channels	-	708	2,439	818	5,594
Ponds	-	31	1,666	622	973
Total	-	1,559	9,845	1,409	3,166

Table 4. --Sampling and physical characteristics of McKay Bay strata, 1963

Stratum	Sampling method	Number of samples	Area (acres)	Mean depth (feet)	Predominant bottom type
I	Trap	8	1.53	2.3	Sand
II	Trap	12	9.71	3.3	Sand, sand-clay
III	Trap	5	2.25	1.6	Sand
IV	Trap	9	12.92	6.6	Sand, clay
V	Trap	6	10.38	4.9	Sand, rock
VI	Trap	24	14.50	5.2	Sand-clay, clay
VII	Trap	36	34.59	6.9	Sand-clay, sand
VIII	Trap	24	39.76	9.5	Sand-clay, clay
IX	Trap	24	59.30	9.8	Clay, sand-clay
X	Trap	6	13.81	11.2	Clay, sand-clay
XI	Enclosure	12	8.18	0.8	Sand, sand-clay
XII	Enclosure	14	12.13	0.8	Sand, sand-clay

Table 5.--Average total length and biomass of ammocoetes of the sea lamprey and American brook lamprey in McKay Creek and McKay Bay, 1961-63

Stratum	Sea lamprey			American brook lamprey		
	Average length (inches)	Weight (pounds)		Average length (inches)	Weight (pounds)	
		Total	Per acre		Total	Per acre
Bay						
I	2.9	13.4	8.8	-	-	-
II	4.7	43.9	4.5	-	-	-
Total or average	4.0	57.3	0.3	-	-	-
Estuary						
Shallow	2.0	0.7	0.9	3.1	6.5	8.7
Deep	3.4	13.1	9.6	4.6	68.2	50.0
Total or average	3.2	13.8	6.5	4.3	74.7	35.4
McKay Creek proper						
1	2.8	5.1	3.1	3.7	25.3	15.4
2	2.3	10.0	6.3	2.9	50.0	31.3
3	4.9	6.0	4.1	3.7	42.3	28.7
4	1.7	1.4	1.3	2.1	70.0	67.1
5	0.5	<0.1	<0.1	1.9	15.1	19.3
Total or average	2.4	22.6	3.4	2.4	202.6	31.0
Beaver pond area						
Streams	3.7	0.2	0.2	4.6	39.8	41.4
Channels	4.6	0.1	0.3	5.2	22.4	51.5
Ponds	-	0.0	0.0	4.9	12.6	7.3
Total or average	4.0	0.3	0.1	4.8	74.8	24.0
Grand total or average	3.1	93.9	0.4	2.8	352.1	29.9

Table 6.--Population estimates of lamprey ammocoetes for various waters, summarized as number per acre

Reference	Population area and watershed	Sea lamprey		American brook lamprey	
		Lotic	Lenitic	Lotic	Lenitic
Wagner et al (this study)	McKay Creek and Bay, Lake Huron	1,718	58	11,127	-
Hansen and Hayne (1962)	Ogontz River and Bay, Lake Michigan	6,944	206	7,041	20
Wagner and Stauffer (1962a)	East Bay, Lake Superior	-	1,314	-	989
Smith and McLain (1962)	Furnace Creek Lake Superior	286	-	3,464	-
Smith and McLain (1962)	Snyder Creek Lake Michigan	105	-	1,180	-
Stauffer (1960) unpublished report	Carp Lake River Lake Michigan	17,041	-	-	-

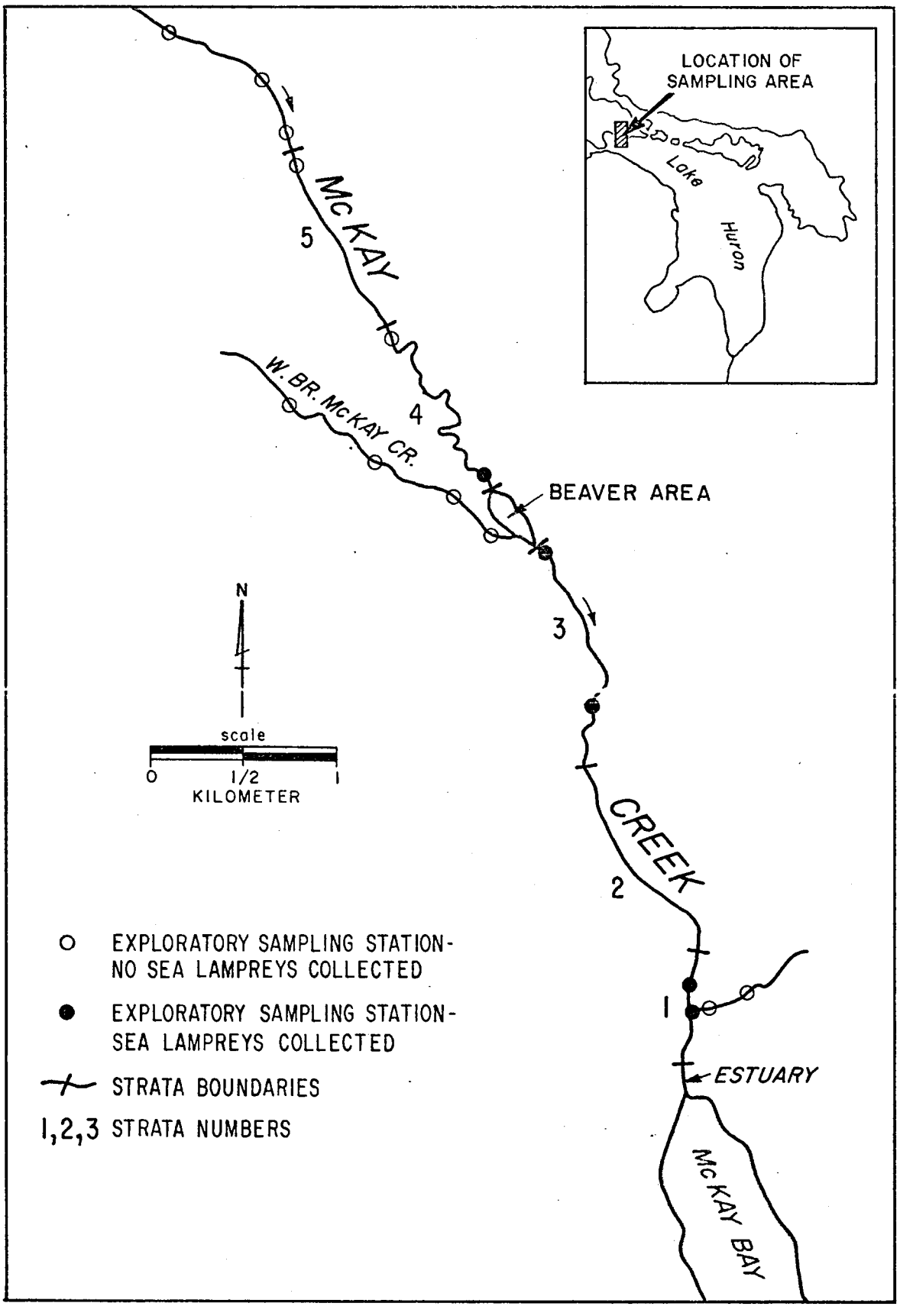

Figure 1. --McKay Creek with exploratory sampling stations and strata for population estimates.

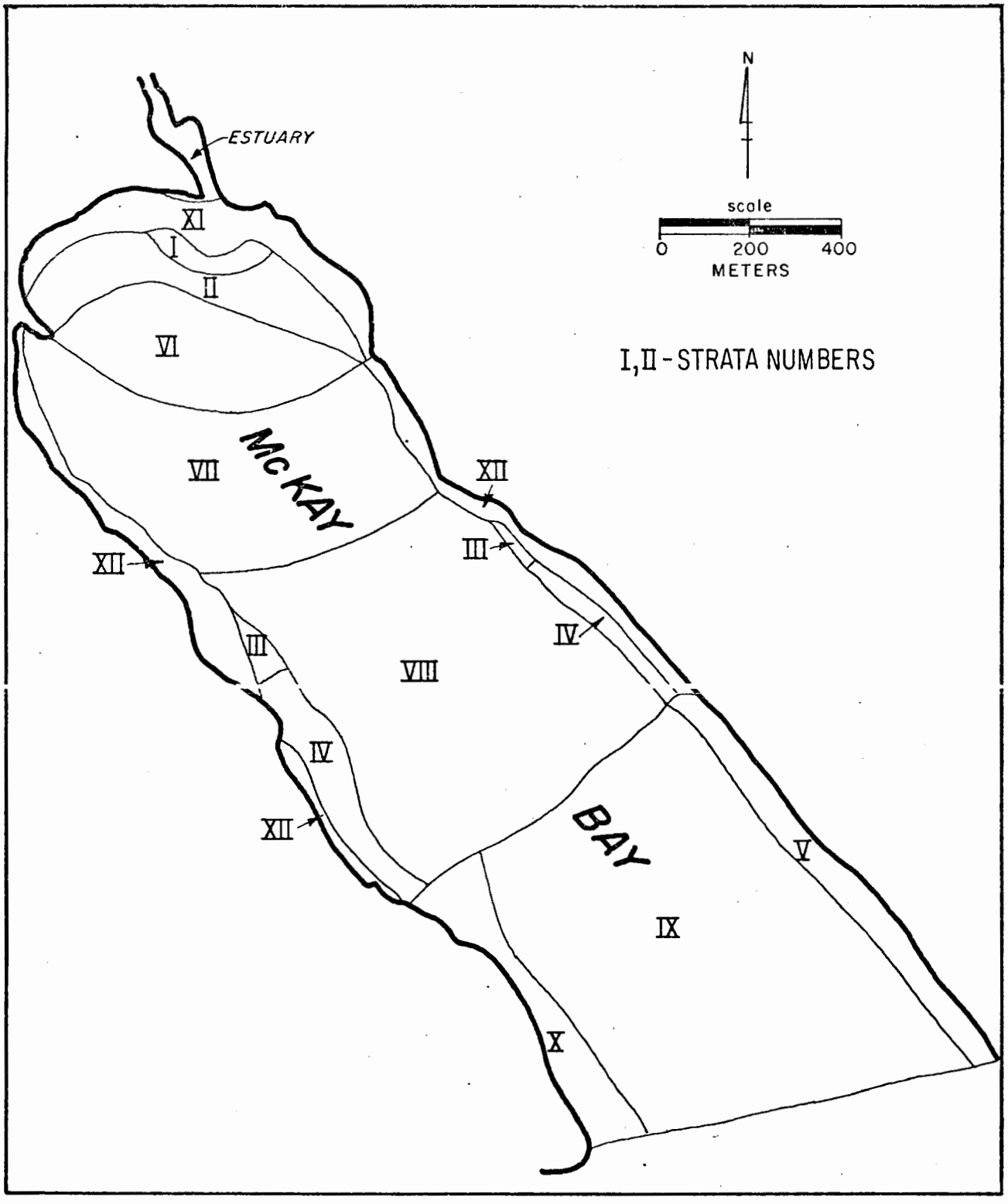

Figure 2.--McKay Bay with strata (I-XII) for population estimate.

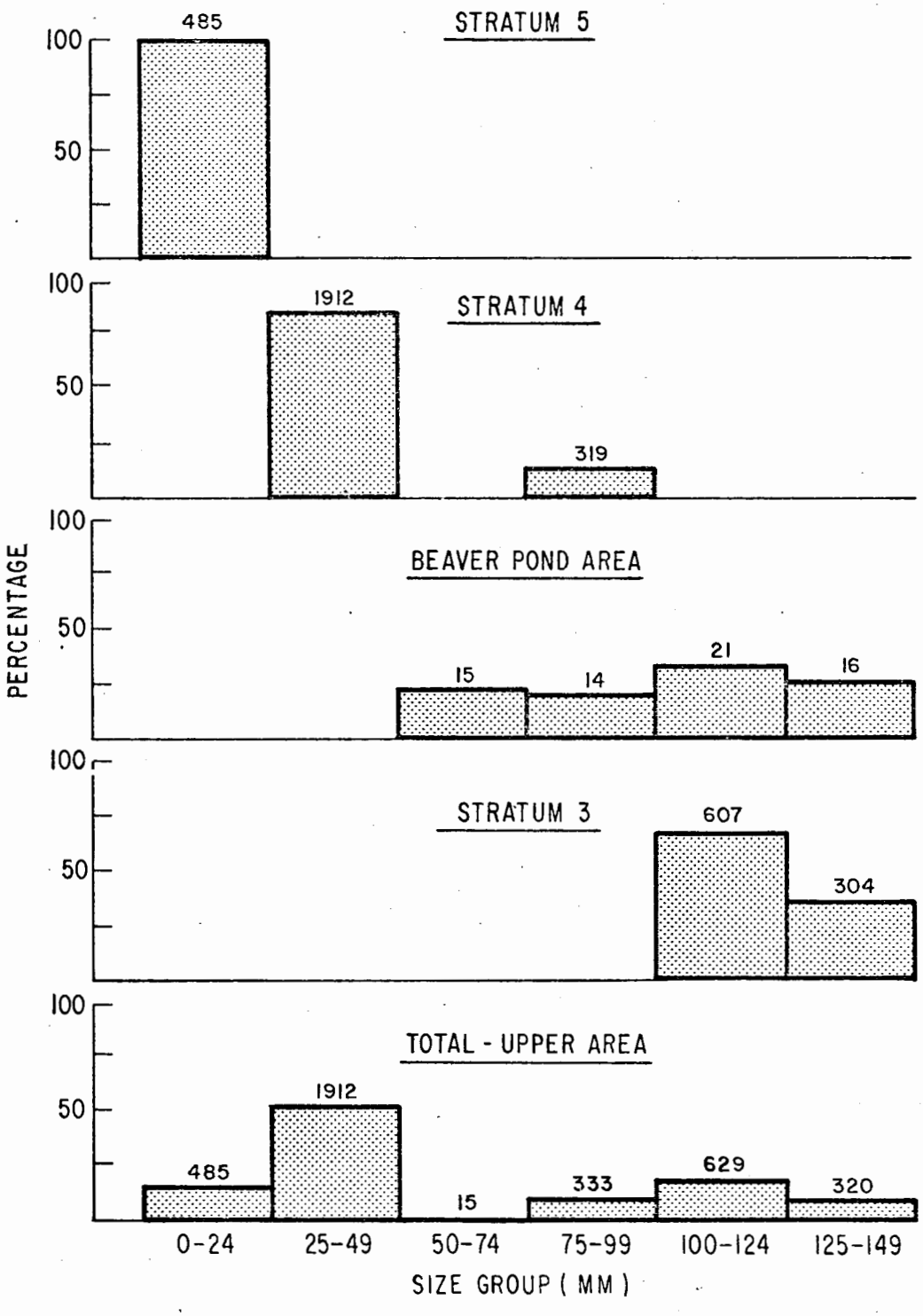

Figure 3. --Length-frequency distribution by percentages of sea lampreys in 1-inch length groups for strata in the upper area of McKay Creek. Numbers of larvae are given for each inch group.

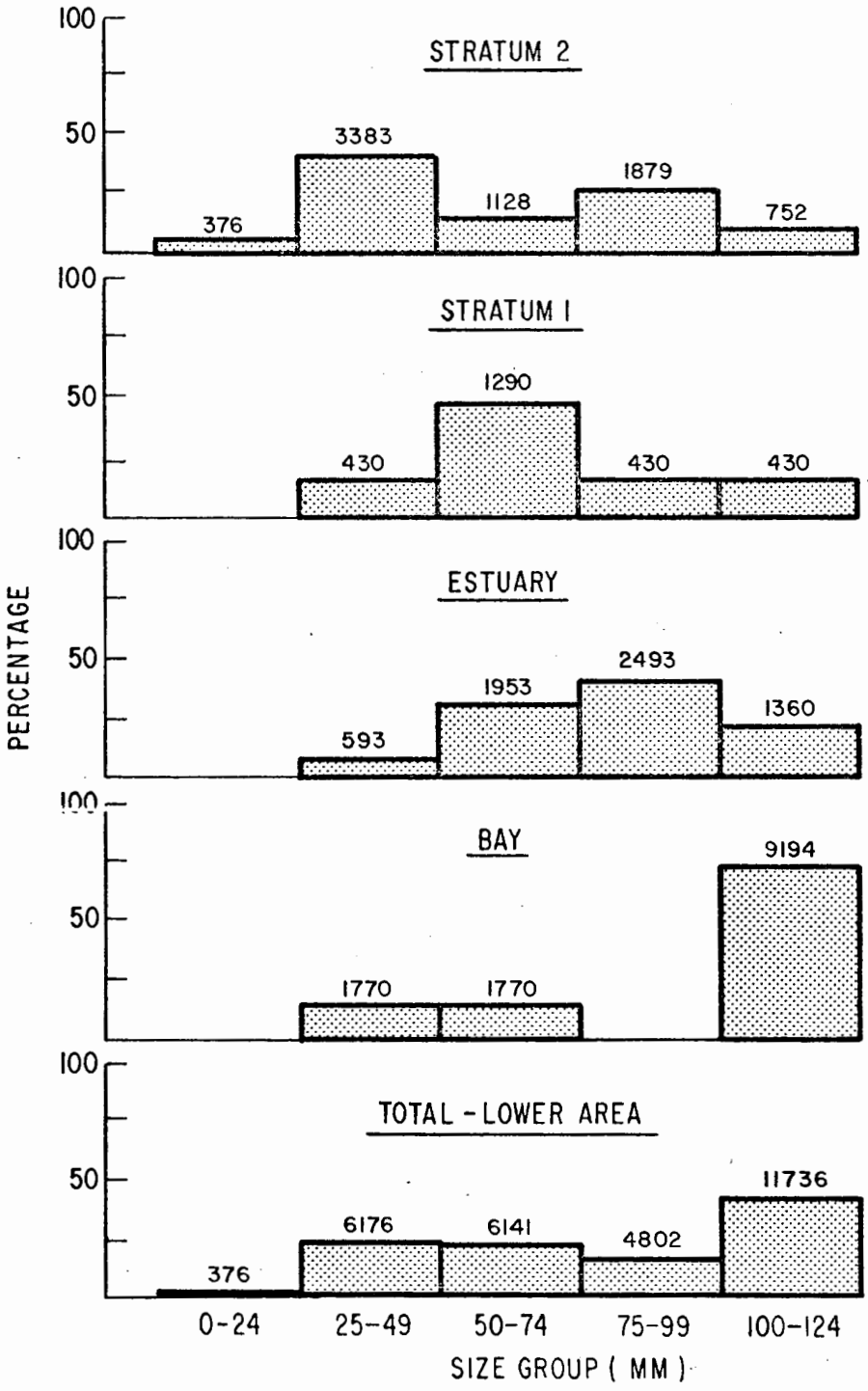

Figure 4. --Length-frequency distribution by percentages of sea lampreys in 1-inch length groups for strata in the lower area of McKay Creek and in McKay Bay. Numbers of larvae are given for each inch group.

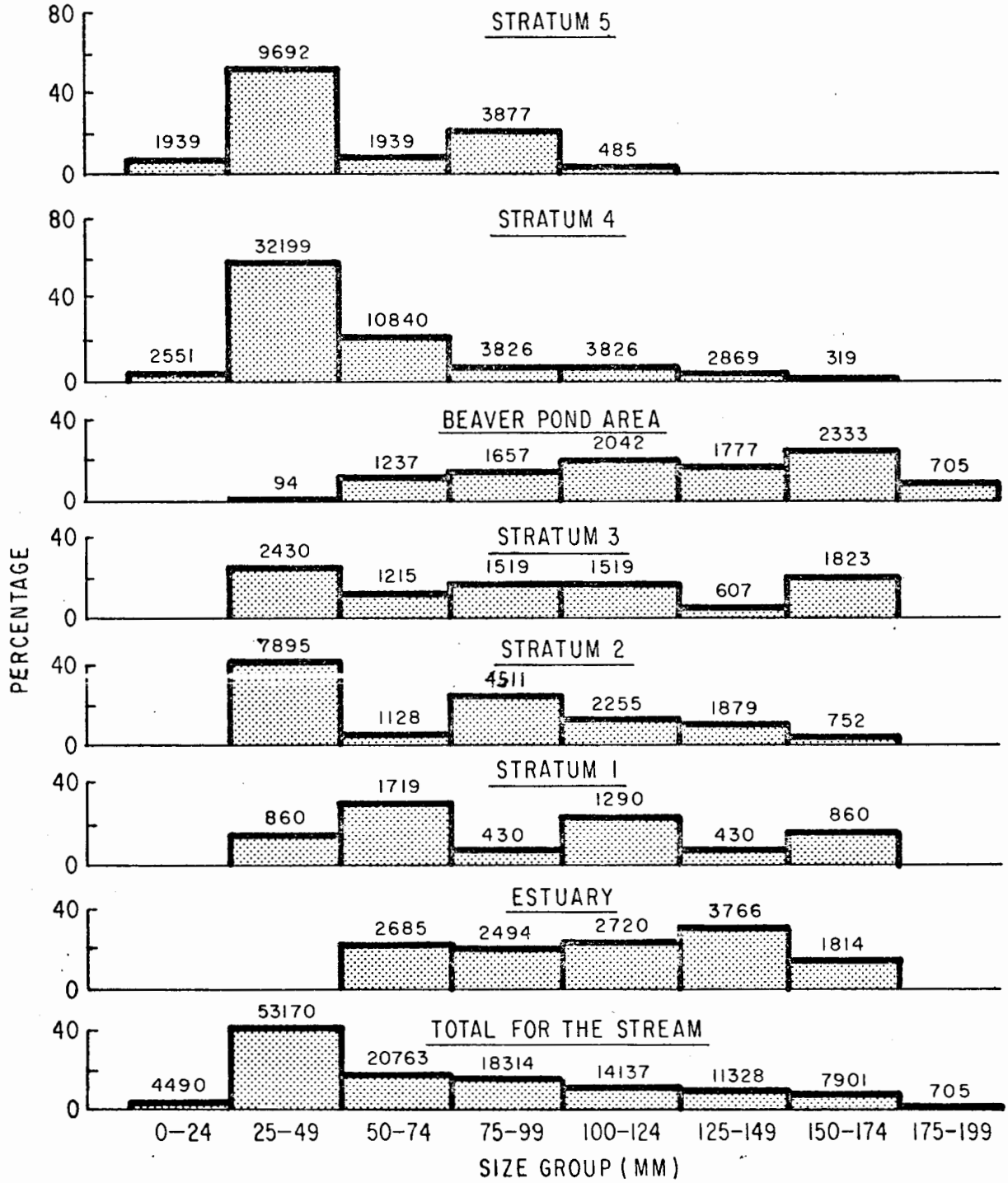

Figure 5.--Length-frequency distribution by percentages of American Brook lamprey larvae in 1-inch length groups for strata in McKay Creek. Numbers of larvae are given for each inch group.

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