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ABUNDANCE, SIZE, AND SEX RATIO OF ADULT SEA-RUN SEA LAMPREYS, *PETROMYZON MARINUS*, IN THE CONNECTICUT RIVER[1]

Populations of sea-run sea lampreys, *Petromyzon marinus*, occur in many rivers on the east coast of North America from Labrador to Florida (Bigelow and Schroeder 1953). The Connecticut River in the northeastern United States is believed to have the largest population (Beamish 1980). Although the historical, upstream range of the sea lamprey in the Connecticut River is not known, it probably was similar to American shad, *Alosa sapidissima*, which migrated 280 km upstream to Bellows Falls, VT (Moffitt et al. 1982).

Upstream migration of anadromous fish species in the Connecticut River main stem was first restricted in 1798 by the construction of Turners Falls Dam at km 197, and further in 1849 by the construction of Holyoke Dam at km 140. The first upstream fish passage facility for anadromous fish was a fish lift at Holyoke Dam that began operating in 1955. Until 1969 the sea lampreys using the fish lift were counted and either killed or thrown back. From 1969 to 1984, they have been passed upstream each year. Sea lampreys have also used the fish ladders that were completed in 1980 and 1981 at Turners Falls and Vernon Dams, respectively. With the completion of the fish ladder at Bellows Falls Dam in 1984, migrants now have access to 350 km of main-stem river and many additional tributaries (Fig. 1).

The present report summarizes the annual counts of sea lampreys from 1958 to 1984 at the two Holyoke fish lifts (a second fish lift was added in 1976). We also examined the sex ratio, total length, and weight of adults in 1981-82 and compared these characteristics with those of the population in the St. John River, New Brunswick. Beamish et al. (1979) sampled the St. John River population at km 140, at a fish lift located at Mactaquac Dam.

Methods

Sea lampreys that were lifted above the dam were counted each year from 1958 to 1984, except for the period from 1969 to 1974. From 1958 to 1968, sea lampreys were counted by personnel of the Holyoke Water Power Company (the owner of the dam), and

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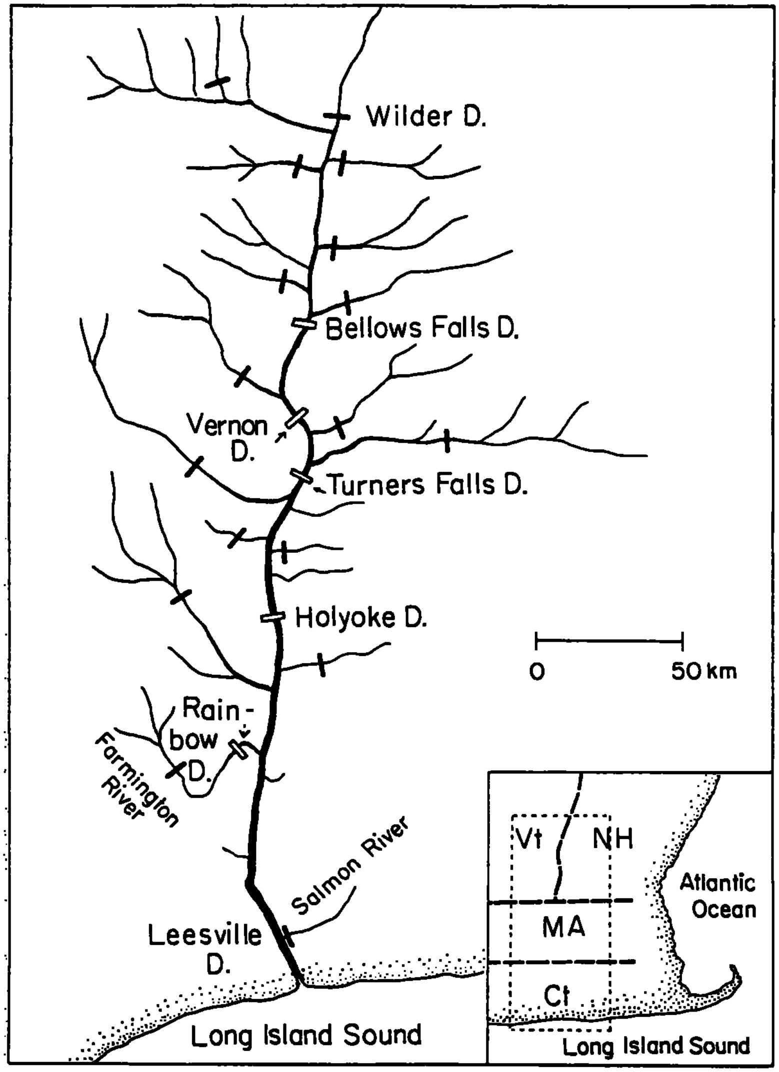

FIGURE 1.—Map of the Connecticut River showing the location of Holyoke Dam and the other dams with fishways on the lower 350 km of the main stem and major tributaries. Dams that sea lampreys can pass are designated by an open bar; dams they cannot pass are designated by a solid bar.

from 1975 to 1984, they were counted by personnel from either the Massachusetts Division of Fisheries and Wildlife or the Massachusetts Cooperative Fishery Research Unit. Until 1975, fish of all species were lifted, deposited into small carts, carried across the dam, and counted as they were released. Beginning in 1975, all fish were sluiced directly from the fish lift bucket into a large flume and were counted through a glass window in the side of the flume as they swam upstream. The accuracy of these counts has not been experimentally determined. However, the counts are probably very accurate because the sea lampreys are large and swim slowly through the flume.

We collected sea lampreys daily at the fish lift trap from 1 May to 10 June 1981, and from 10 May to 30 June 1982 for determination of total length (TL) and sex. The number of sea lampreys sampled each day was proportional to the number lifted the previous day. The number of sea lampreys lifted and (in parenthesis) the number collected follow: 0-50 (2); 51-100 (4); 101-200 (6); 201-400 (8); 401-800 (10); 801-1,000 (15); 1,001-2,000 (25); 2,001-3,000 (30); 3,001-5,000 (40); >5,000 (50). in both years, total length was measured to the nearest millimeter and sex was determined by dissection. We determined the sex ratio for each day of the run to observe changes during the migration. In 1982 each sea lamprey was also weighed to the nearest gram. Chi-square tests were used to compare the sex ratios for differences from a 1:1 frequency. Student's t-test was used to compare the males and females for mean length and weight. We compared males and females for the length-weight relationship by calculating a separate regression for each sex using the logarithmic equation: $\log w = \log a + (b)(\log 1)$ (Ricker 1975).

Results and Discussion

Abundance

The numbers of sea lampreys lifted from 1958 to 1967 were relatively few, and probably reflected the inefficiency of the fish lift rather than a small population (Fig. 2). After the flume and second lift were added in 1975 and 1976, respectively, 22,000-53,000 adults have been passed upstream each year. The 53,000 counted in 1981 was the largest number ever passed at Holyoke and the largest run documented in any river. In 1981, 59% of the total run was lifted during the week of 24-30 May; and in 1982, 68% were lifted during the week of 28 May-3 June. Beamish (1980) reported that about 8,600 sea lampreys are lifted annually in the fish lift at Mactaquac Dam. He estimated the spawning populations in other northern streams at <8,000.

The sea lampreys that reach Holyoke Dam are only a portion of the total run, because several tributaries below the dam support populations (Whitworth et al. 1976). The sea lamprey population may increase as adults gain access to additional spawning and rearing habitat in headwater streams by using fish passage facilities constructed for Atlantic salmon, *Salmo salar*, and American shad (Moffitt et al. 1982). Thus, the restoration program designed primarily for Atlantic salmon and American shad is also restoring the sea lamprey to additional habitat. Since 1975, over 20,000 sea lampreys have been passed each year at Holyoke Dam and given access to new spawning and rearing habitat. The estimated life span of sea lampreys in the St. John River is estimated at 9-12 yr (Beamish and Potter 1975). Therefore, if the Connecticut River population returns to their natal stream and has a similar life cycle, and if the strength of the year classes after 1975 was enhanced by the additional rearing habitat above Holyoke, then beginning in

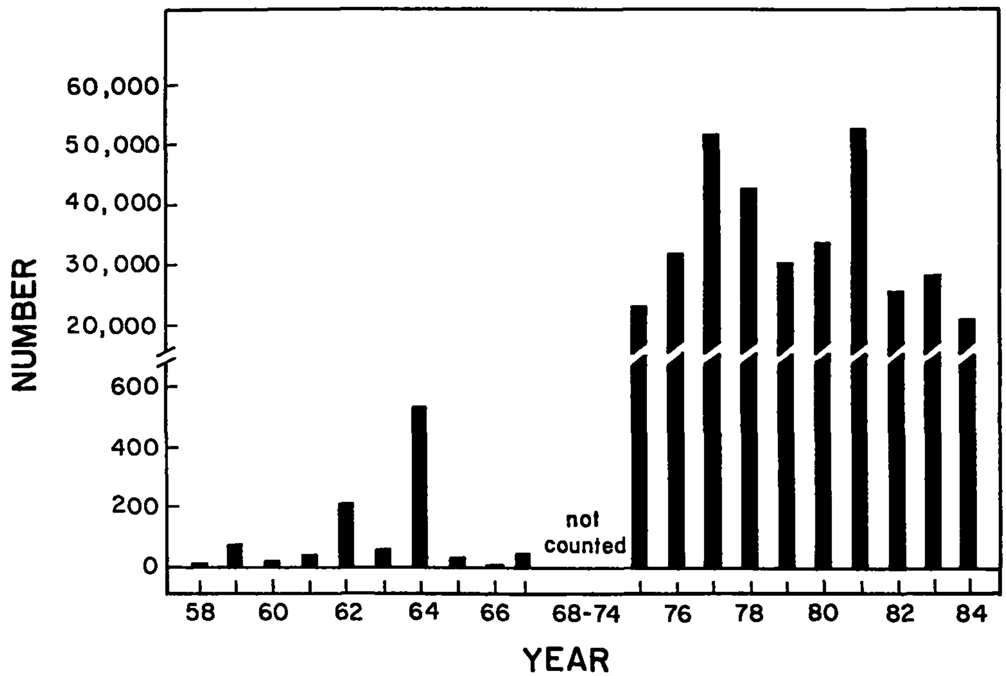

FIGURE 2.—Number of adult sea lampreys lifted in the Holyoke fish lifts each year, 1958-84.

1984 there should be increased returns of adults at Holyoke. The return of sea lampreys at Holyoke in 1984 was not a record return, but this could be due to the high discharge caused by the 50-yr flood that occurred in early June 1984, when most sea lampreys are lifted. If the sea lamprey population increases, the wound frequencies should increase on host species of marine and anadromous fish.

Sex Ratio

Sex ratios for both years were skewed from 1:1 in favor of males, but the ratio was only significant in 1982: in 1981, 56% were males (ratio: 1.3:1; $\chi^2 = 3.4$, $P > 0.05$; in 1982, 62% were males (ratio: 1.6:1; $\chi^2 = 11.6$, $P < 0.005$, Table 1). Sex ratios also changed during the spawning migration with the proportion of males increasing late in the run. The percent of males in the early and late periods were 55 and 59% in 1981 and 59 and 67% in 1982. The increase in the proportion of males was not significantly different from a 1:1 ratio in 1981, but the increase was significant in 1982 ($\chi^2 = 7.6$:$P < 0.01$). Applegate (1950) found that males in landlocked sea lamprey populations increased to about 75% in the late part of the run. The reason for this phenomenon is unknown.

Males are the most abundant sex in stable populations of sea-run and landlocked sea lampreys. Beamish et al. (1979) reported 55% males (ratio: 1.36:1) in nearly mature adults in the St. John River in 1974-77 (Table 1). Davis (1967), who collected anadromous sea lampreys for 5 yr from Barrows Stream, ME, reported a male:female ratio of 1.9:1; however, the sample size was very small ($N = 66$). Potter et al. (1974) found an excess of males in landlocked sea lamprey (ratio: 1.26:1). The sex ratio in stable populations (where males are more abundant than females) is different from the ratio in populations from the upper Great Lakes, where an excess of females is typical of populations being eradicated or controlled (Smith 1971). Sex ratios in sea lampreys also vary with cycles of abundance (Wigley 1959; Smith 1971), and temperature and nutrition may differentially affect growth and survival of male and female ammocoetes (Hardisty 1954).

TABLE 1.—Mean total length and weight (SE in parenthesis), and percent males in sea lampreys sampled at Holyoke Dam, Connecticut River, compared with samples collected from the Mactaquac Dam, St. John River.

Dam & year	N	Mean length (cm)		Mean length (cm)		Percent male
		Male	Female	Male	Female	
Holyoke						
1981	464	71.3 (2.8)	71.5 (2.9)	—	—	56
1982	404	71.4 (2.7)	71.1 (3.6)	[1]794 (8.2)	[2]806 (12.01)	62
Mactaquac[3]						
1974-77	341	72.4 (4.7)	72.9 (5.1)	868 (18.1)	885 (18.3)	55

[1]249 males were weighed.
[2]155 females were weighted.
[3]Data from Beamish et al. (1979); ± 95% confidence limits in parenthesis.

Total Length and Weight

In 1981, 464 sea lampreys (0.9% of the number lifted) were measured for total length; in 1982 the number examined was 404 (1.5% of the number lifted). There was no significant difference between the mean length of males and females during either year or for both years (Student's t-test: $P > 0.05$, Table 1). Length of females and males ranged from 60 to 85 cm in both years.

The similarity in mean total length of adults in the consecutive spawning runs of 1981-82 suggests relative stability of the sea lamprey population. This differs greatly from the unstable sea lamprey populations in the Great Lakes where body length decreased from 1950's to 1960's—changes related to decreases in food supply and changes in the environment (Smith 1971).

The mean weight of females was not significantly different from the mean weight of males (Student's t-test: $P > 0.05$, Table 1). We determined the length-weight relationship by using the regression equations: $\log w = -3.42 \pm (2.21) (\log 1)$, ($r^2 = 0.75$, $P < 0.01$) for females and $\log w = -3.11 \pm (2.10) (\log 1)$, ($r^2 = 0.76$, $P < 0.01$) for males. There was no significant difference between the slopes of the regression lines, consequently we combined males and females ($N = 404$). Using the equation $y = b + mx$ or weight = b + (slope) (length), a highly significant correlation ($r^2 = 0.76$, $P < 0.01$) was found for the regression equation: weight = 521.9 + (0.23890) (length). The length-weight relationship is linear, rather than sigmoid, as it is in most fishes. Because the body is attenuate, the weight of sea lampreys does not increase as rapidly with length as it does in most other fishes. This relationship is less evident in females, possibly because of the additional weight of their eggs.

Generally, in landlocked populations, females are slightly heavier than males because of their high fecundity (Applegate 1950). We also found this was true. Although the sea lampreys at Holyoke Dam were similar in length to those in the St. John River, the average weight of Connecticut River fish was considerably less (Table 1). The difference in average weight between sea lampreys in the two populations is not due to the difference in location of upstream sampling sites, but possibly to differences in energetic requirements, food supplies, or some aspect of the environment during the oceanic parasitic phase. A difference in weight between populations has previously been found in landlocked sea lampreys in the Great Lakes (Smith 1971).

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AN IMPROVED OTTER SURFACE SAMPLER

Field trials using a neuston sampler described by Sameoto and Jaroszynski (1969) revealed serious sampling problems associated with coastal waters of British Columbia. Due to extensive freshwater runoff in the vicinity of large rivers, sampling conditions including choppy surface waters of lowered salinity and vertically depressed distributions of near-surface larval and juvenile fishes. Under such conditions, the S-J sampler behaved erratically, throwing considerable spray, and, when adjusted to increase depth of tow, the body and control surfaces deformed at speeds in excess of 5 knots. The modifications described here reflect our objectives of improving performance, increasing durability, and ease of handling, without increasing costs other than those incurred by adding a flowmeter to provide quantitative catches. The complete unit is depicted in Figure 1.

Detailed Description

Sampler Box

Constructed of 1/8" marine aluminum, this aluminum is folded into a body with one welded seam (Fig. 2). The leading edges are reinforced with 1/4" aluminum for attaching the bridles and depressor. The square mouth opening was sized to accomodate 0.25 m^2 bongo nets having a circumference of 185 cm. Body dimensions are 46 × 46 × 60 cm.