Seasonal Depth Distributions of Landlocked Atlantic Salmon, Brook Trout, Landlocked Alewives, and American Smelt in a Small Lake

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Seasonal depth distributions of landlocked Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), landlocked alewives (*Alosa pseudoharengus*), and American smelt (*Osmerus mordax*) were determined monthly in Echo Lake, Maine, using vertical and horizontal gillnets.

Salmon were wide-ranging fish, but generally not captured in very shallow or very deep water. Brook trout were primarily an inshore species, not often captured in water deeper than 25 ft, and nearly always found close to the lake bottom. The majority of captured alewives were taken from shallow to middepths (0–30 ft) in summer and fall and in deep water during winter and spring. Smelts were widely distributed, but the majority were captured in water deeper than 30 ft every month.

No clear temperature or dissolved oxygen preference could be shown for any of the four species.

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FEW SEASONAL DEPTH DISTRIBUTIONS of fish species have been intensively studied. One technique to determine depth distribution is the use of vertical gillnets. Tibbles (MS, 1956) used this method with success to study the distribution of yellow perch (*Perca flavescens*) in Lake Mendota, Wisconsin. Horak and Tanner (1964) reported the results of vertical gillnetting in a Colorado reservoir to determine the summer distributions of rainbow trout (*Salmo gairdneri*), kokanee (*Oncorhynchus nerka*), white sucker (*Catostomus commersoni*), and yellow perch (*P. flavescens*). The distributions of white catfish (*Ictalurus catus*) and rainbow trout were determined with vertical gillnets by von Geldern (MS, 1964) for a California lake.

The purpose of this study was to determine seasonal depth distributions of four fish species inhabiting Echo Lake, Maine, from June 1967 to May 1968, using both vertical and horizontal gillnetting. Water temperature and dissolved oxygen were measured to evaluate their effect on fish distribution.

Study area — Echo Lake, located on Mount Desert Island, Maine, is partially in Acadia National Park. Surface area is approximately 237 acres (96 ha) and the maximum depth is 63 ft (19.2 m). The lake is oligotrophic and of glacial origin (Fig. 1).

Landlocked salmon were introduced in 1965 as age 0+ fall fingerlings. Brook trout were stocked periodically as fingerlings (age 0+). Adult land-

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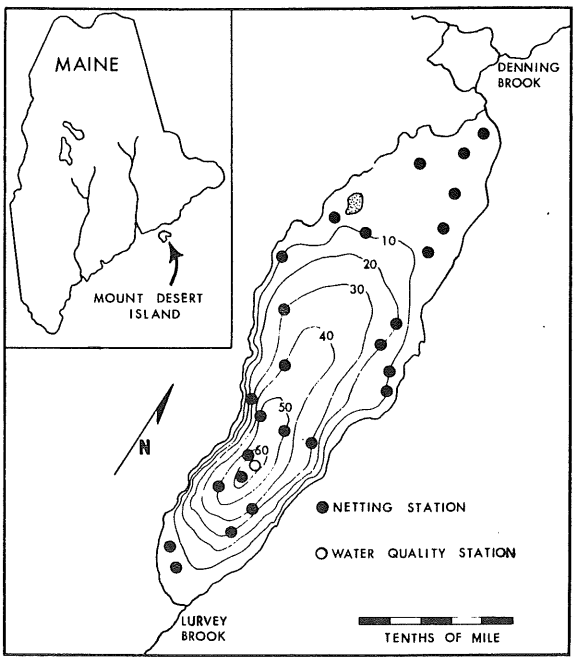

FIG. 1. Echo Lake, Mount Desert Island, Maine, showing depth contours in feet and sampling stations.

locked alewives from Cayuga Lake, New York, were introduced in June 1966, and successfully spawned that summer and each summer since. A smelt population was maintained by natural reproduction.

Materials and methods — Small-meshed vertical gillnets (02 and 03 filament nylon with $\frac{1}{4}$- and $\frac{1}{2}$-inch bar mesh, respectively) were designed and built (Lackey, 1968) to determine the depth distributions of small fish in Echo Lake. Six lengths of nets were used. The numbers of $\frac{1}{4}$- and $\frac{1}{2}$-inch mesh of each length were as follows:

	Length (*ft*)					
	10	20	30	40	50	60
$\frac{1}{4}$-inch	3	3	1	1	1	1
$\frac{1}{2}$-inch	3	3	1	1	1	1

Twenty-six sampling stations (Fig. 1) were selected at depths corresponding to the above six net lengths. The number of stations at each depth was roughly proportional to the lake surface over that depth. Selection of sampling stations was affected by several considerations, including their proximity to swimming and boating areas. Each station was marked by two large rock anchors separated by a distance twice the depth (Lackey, 1968).

During summer months, 14–19 nets were set for 48 consecutive hr each week. Each net was cleared of fish at least every 12 hr and usually more frequently. Captured fish were recorded by species, length, and depth of capture.

During winter sampling, ice was cut with a chain saw to permit placement of gillnets or, if ice was thick, with a gasoline-powered ice auger. Sampling during these months was limited to once or twice per month.

Although a few salmon and trout were captured in vertical gillnets, concurrent sampling with horizontal gillnets was necessary for more accurate estimates of the distributions of these species. Two 500-ft gangs, each composed of five 100-ft sections (8 ft deep) of different mesh sizes ($1\frac{1}{2}$-, 2-, $2\frac{1}{2}$-, 3-, and $4\frac{1}{2}$-inch stretch mesh), were used to determine depth distributions. To estimate depth of capture with these nets, it was necessary to make sets with a fathometer or in areas of known depth. By setting both gangs perpendicular to shore, it was possible to sample all depths simultaneously. Usually both nets were moved to another location during the second 24 hr of the 48-hr sampling period.

Water temperature profiles were taken with a custom-made electric resistance thermometer. Dissolved oxygen was determined by the Alsterberg modification of the Winkler method (American Public Health Association, 1965). Determinations were made at 10-ft intervals during each sampling period.

Results — Distribution data show landlocked salmon to be a wide-ranging fish (Table 1). During most of the year it was observed that salmon were not captured near the lake bottom. The exceptions to this were shallow-water catches in October and deep-water catches in April and May. There is also a distinct increase in depth of capture as summer progresses.

Brook trout in Echo Lake are generally residents of the upper 25 ft of water, but not limited to this range (Table 1). This species was most commonly captured in the lower several feet of gillnet at a given station. It was also observed that captures were highest at stations nearest shore. As with salmon, there is a distinct increase in depth of capture in August.

Alewives were usually captured in nets set in deep water. In summer and fall, alewives occupy the upper depths of the lake, mainly away from shore and bottom (Table 1). With the onset of winter, there is a marked movement to deeper waters, where the species remains until the following summer.

Smelt depth distribution followed no clear pattern (Table 1), except for an increase in depth of capture as summer progressed.

Temperature and dissolved oxygen preferences could not be shown for any of the four species.

Discussion — Landlocked salmon, unlike brook trout, are a wide-ranging fish and favor open water, away from the lake bottom. Feeding habits of salmon (Lackey, 1969) in Echo Lake also indicate a distinctly pelagic existence. Salmon in Echo Lake tended to move to deeper water as summer progressed. Similar movement of salmon has been shown in two Newfoundland ponds (Leggett and Power, 1969).

Brook trout in Echo Lake are generally near the lake bottom when captured, as reported by Flick and Webster (1962) in a New York lake and Chapman et al. (1967) in an Oregon lake. Further, food habits indicate much inshore bottom foraging (Lackey, 1969).

Depth distribution of alewives in Echo Lake follows the general patterns previously described (Galligan, 1962; Gross, 1953, MS, 1959; Reigle, 1969), but differs somewhat in timing. Seasonal differences account for this. In summer and fall, alewives occupy the upper depths of the lake, mainly areas away

TABLE 1. Depth distributions of landlocked Atlantic salmon, brook trout, landlocked alewives, and American smelt based on combined vertical and horizontal gillnetting in Echo Lake, 1967–68.

	1967							1968				
Depth (*ft*)	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Landlocked Atlantic Salmon												
0–5		1	1		22			1				1
5–10	1	2		2	5					1		1
10–15				2	2			1				
15–20			1									
20–25	2		2			2						
25–30	1	1	1	1		4						
30–35	1	4	2									
35–40	1	7	4	1								
40–45		1										1
45–50			1									1
50–55			3	2								3
55–60			1	1							5	9
Brook Trout												
0–5		1			3			6			2	3
5–10		3		1				6	1		1	2
10–15		3		1	1			1				
15–20		4										
20–25			4			3						
25–30				1		2						
30–35			1									
35–40												1
40–45												1
45–50												
50–55			1									
55–60			1									2
Landlocked Alewives												
0–5		2	10			3				3		
5–10	34	97	6							3		
10–15	23	32	13	1		200				4		
15–20	35	15	1		3					3		
20–25	21	5	6		1					5	4	
25–30	10		4				1			5	4	
30–35		2		1	1					22		
35–40		5	1	2				15		21		
40–45								38		69		
45–50					1			38		68		
50–55	1							39		69	1	2
55–60								40		71	57	3
American Smelt												
0–5					2							1
5–10	4	16	3		2							
10–15	7	2			1							
15–20	8	3	2	3	2							
20–25	11	1	1		2							
25–30	16	6	5		2	4						
30–35	35	49	22		7							
35–40	38	69	26	1	4							
40–45	4	3	18	2	8							
45–50	5	10	30	3	5							
50–55	1		9		1						1	
55–60			11								2	1

from shore and bottom. With the onset of winter, there is marked movement to deeper waters, where the species remains until the following summer.

Galligan (1962) studied the distribution of alewives in Cayuga Lake, and reported a pronounced inshore movement in late June and July associated with shallow-water spawning habits. During late summer and fall, Cayuga Lake alewives moved to deeper water. Galligan hypothesized that alewives took up a pelagic distribution in winter. Gross (1953, MS, 1959) reported similar findings in Lake Hopatcong, New Jersey.

Reigle (1969) studied alewife distribution in southern Lake Michigan with a bottom trawl. His results are similar to those reported here even though sampling methods were different. From January to April, alewives were captured in the deeper water of Lake Michigan (35 fath or deeper). In April and May alewives were taken over a wide range of depths. During spawning season (mid-May through June), alewives were found only in shallow water. Trawl catches decreased during July, August, and September, which indicated a vertical scattering of alewives. Trawling later in the year showed alewives in water 0–35 fath. Reigle reported a pronounced movement into deep water in December and January.

None of the four species studied showed a clear preference for any particular temperature, although temperature preference was difficult to evaluate because of an extreme annual range. The only consistent trend that might be associated with temperature was the progressively greater average depth of capture as summer progressed, then a rise in depth of capture in early fall.

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