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RESTORATION AND MANAGEMENT OF THE NEW ENGLAND ALEWIFE FISHERIES WITH SPECIAL REFERENCE TO MAINE

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INTRODUCTION

The increased demand for protein food, coupled with a decrease in the available manpower and machinery, has caused a serious shortage in the fish supply. To obtain the largest poundage from the curtailed gear and porsonnel, the fisheries are turning to species which will yield the greatest catch for the effort expended.

In April 1942, the senior author pointed out that the alewife (Pomolobus pseudoharengus) would be sought after, because it can be taken with very little labor and equipment. The fish are usually caught merely by dipping them out of the water as thousands crowd up the rivers during the spring spawning migration.

For many years the demand for alewives has been light, since they were used chiefly for salting, smoking, and as lobster bait. Their boniness restricted their use as food. However, it was learned that canning softens the bones, and several thousand cases canned in 1942 found a ready market. The bulk of the increased 1943 catch was used for commercial canning, with some being pickled and an unknown, but appreciable, quantity used for home canning.

Alewives run into fewer rivers and are far less abundant now than formerly. The production of alewives by counties throughout New England in various years from 1889-1938 is shown in table 1. It will be noted that the total catch has fallen from an average of more than 10 million pounds during the first four years in which the fisheries were canvassed, to slightly over 4 million pounds during the last three years for which statistics are available.

These figures on alewife production are not necessarily closely associated with abundance, but to a large extent reflect the demand for the species. This is illustrated by the great drop in the catch during 1933, when the prices of the more popular fishes were at extremely low levels. Because of the scattered nature and seasonal character of the alewife fisheries it is difficult for statistical agents to obtain complete records of the annual catch by the method of canvassing the fishermen once a year. For this reason, these catches should be considered as minima. However, the figures suggest great changes in the productive capacity of various localities due to the disappearance or diminution of the runs to certain rivers.

In the Connecticut River, which according to H. M. Smith (1899) was the second river in New England in the production of alewives, the catch amounted, in 1896 to 795,000 pounds or 79 percent of the total for Connecticut. This great run has almost disappeared and the total take for the state is now negligible. (Table 2)

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TABLE 1.—New England catch of alewives by years, counties and states. 1/

States and counties	Year												
	1889	1898	1902	1905	1919	1925	1929	1930	1931	1933	1935	1937	1938
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Maine													
Cumberland	776,545	45,000	33,600	40,000	4,925	8,041	17,258	. . . . .	16,980	52,586	150,600	10,600	20,600
Hancock	759,122	631,600	399,633	531,550	254,645	435,750	361,978	501,016	948,083	192,630	653,100	548,200	556,400
Kennebec	. . . . .	. . . . .	2,750	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Knox	616,750	734,925	836,850	1,099,250	553,060	380,425	1,121,000	577,716	456,298	436,240	455,200	460,800	413,900
Lincoln	1,348,550	2,382,300	659,100	768,286	364,500	714,600	759,467	750,300	675,833	581,440	1,320,000	689,400	1,052,200
Penobscot	. . . . .	8,500	. . . . .	5,000	19,000	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Sagadahoc	274,100	7,500	458,900	513,000	225,200	40,600	40,500	82,000	64,000	15,000	40,400	104,000	90,000
Waldo	148,770	125,100	37,150	31,500	7,000	. . . . .	. . . . .	6,665	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Washington	455,800	286,700	1,423,825	321,000	219,650	365,000	410,500	211,598	634,701	326,615	644,000	780,000	887,000
York	. . . . .	4,000	8,720	12,000	. . . . .	187,500	110,250	. . . . .	. . . . .	98,567	110,600	225,000	120,000
Total	4,379,637	4,225,625	3,860,528	3,321,586	1,647,980	2,131,916	2,820,947	2,129,495	2,795,895	1,703,878	3,373,900	2,818,000	3,140,100
New Hampshire													
Rockingham	140,400	325,000	475,000	122,000	. . . . .	. . . . .	58,000	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Massachusetts													
Barnstable	2,756,480	1,436,531	2,948,350	1,636,300	1,632,866	360,000	106,376	361,808	487,000	314,000	9,600	33,100	195,100
Bristol	484,300	608,744	670,292	581,000	195,596	2,667	3,866	6,848	18,504	4,506	24,900	. . . . .	. . . . .
Dukes	28,100	497,561	356,008	218,280	761,150	627,240	647,050	785,940	657,475	4,400	1,500	61,100	6,000
Essex	115,632	106,600	57,200	1,808,400	29,815	523,265	287,860	197,250	237,540	396,350	550,200	231,900	269,100
Nantucket	. . . . .	. . . . .	. . . . .	37,500	56,900	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Norfolk	. . . . .	. . . . .	. . . . .	29,800	. . . . .	32,000	25,000	22,500	15,000	20,000	. . . . .	. . . . .	. . . . .
Plymouth	526,104	321,995	599,000	624,900	426,050	601,500	. . . . .	397,500	744,800	175,000	348,000	430,400	480,700
Suffolk	. . . . .	. . . . .	. . . . .	. . . . .	800	101,300	315,700	18,000	51,700	8,800	24,500	329,400	6,900
Total	3,910,616	2,971,431	4,630,850	4,936,180	3,103,177	2,247,972	1,385,852	1,789,846	2,212,019	923,056	958,700	1,085,900	957,800
Rhode Island													
Bristol	1,000	30,750	35,120	24,670	. . . . .	. . . . .	. . . . .	. . . . .	22,176	10,000	5,000	22,500	19,000
Kent	. . . . .	1,000	9,800	150	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Newport	419,000	342,000	262,120	264,270	260,550	114,570	93,439	66,050	69,432	. . . . .	15,300	58,300	47,400
Providence	13,500	17,000	8,550	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	1,620	. . . . .	. . . . .	. . . . .	. . . . .
Washington	1,088,350	757,702	289,300	309,500	9,015	46,840	25,950	120,000	33,500	166,000	35,100	137,400	114,200
Total	1,521,850	1,148,452	704,890	598,590	269,565	161,410	119,389	186,050	126,728	176,000	55,400	218,200	180,600
Connecticut													
Fairfield	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	720	. . . . .	. . . . .	. . . . .	. . . . .
Hartford	. . . . .	583,945	1,168,468	896,980	40,161	7,020	5,050	. . . . .	20,848	. . . . .	15,000	4,680	15,900
Middlesex	41,392	227,455	247,517	255,387	98,713	2,000	2,400	. . . . .	2,000	162	. . . . .	. . . . .	. . . . .
New Haven	8,600	12,300	20,390	7,885	500	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
New London	3,280	44,700	226,778	71,775	37,776	6,660	1,800	1,000	3,916	15,000	2,600	80,000	12,400
Total	53,272	868,400	1,663,153	1,232,028	177,150	15,680	9,250	1,000	27,484	15,162	17,600	84,800	28,300
Grand total	10,005,775	9,538,908	11,334,421	10,210,384	5,197,872	4,556,978	4,393,438	4,106,391	5,162,126	2,817,296	4,405,600	4,206,900	4,306,800

1/ Figures published by the U. S. Bureau of Fisheries, including only those years in which they were given by counties.

TABLE 2. --New England alewife catch by states.[1]

Year	Maine	N.H.	Mass.	R.I.	Conn.	Total	
						Pounds	Value
1880	1,804,202	425,000	3,751,059	2,978,000	770,000	9,728,261	$103,285
1887	2,754,819	100,450	4,130,277	1,560,300	17,600	8,563,446	113,952
1888	3,079,994	146,750	6,291,936	1,739,300	25,200	11,283,180	138,130
1889	4,379,637	140,400	3,910,616	1,521,850	53,272	10,005,775	103,751
1896	3,388,326	293,671	5,356,489	2,076,960	1,001,188	12,116,634	113,420
1898	4,225,625	325,000	2,971,431	1,148,452	868,400	9,538,908	76,959
1902	3,860,528	475,000	4,630,850	704,890	1,663,153	11,334,421	89,289
1905	3,321,586	122,000	4,936,180	598,590	1,232,028	10,210,384	92,957
1908	2,525,000	121,000	4,574,000	288,000	1,026,000	8,534,000	81,200
1919	1,647,980	. . . .	3,103,177	269,565	177,150	5,197,872	121,700
1924	1,168,077	. . . .	2,592,299	405,737	116,306	4,282,419	53,229
1928	2,131,916	. . . .	2,247,972	161,410	15,680	4,556,978	51,954
1929	2,820,947	58,000	1,385,852	119,389	9,250	4,393,438	40,126
1930	2,129,495	. . . .	1,789,846	186,050	1,000	4,106,391	36,722
1931	2,795,895	. . . .	2,212,019	126,728	27,484	5,162,126	41,701
1932	2,296,287	19,800	1,164,283	72,470	19,339	3,572,179	18,739
1933	1,703,078	. . . .	923,056	176,000	15,162	2,817,296	16,837
1935	3,373,900	. . . .	958,700	55,400	17,600	4,405,600	25,467
1937	2,818,000	. . . .	1,085,900	218,200	84,800	4,206,900	21,986
1938	3,140,100	. . . .	957,800	180,600	28,300	4,306,800	19,985
1939	2,954,300	. . . .	946,000	22,600	13,800	3,936,700	27,494
1940	2,260,300	. . . .	879,000	20,200	33,900	3,193,400	19,141

1/ Figures published by the former U. S. Bureau of Fisheries and by the Fish and Wildlife Service.

In 1880 the Rhode Island catch was 2,978,000 pounds, but fell steadily to a low of 20,000 pounds in 1940. It came chiefly from a large number of small streams and brackish shore ponds. The run in the Warren (Palmer) River, which produced 161,000 pounds in 1896 has fallen to very small proportions due largely, according to Belding (1921), to lack of uniform fishing regulations between Rhode Island and Massachusetts. Until the problems of pollution, impassable dams, and stream flow have been solved, it is doubtful whether sizable alewife runs can be restored in Rhode Island.

The alewife fisheries in Massachusetts have seriously declined from their former abundance. Averaging between four and five million pounds in the period between 1880 and 1896, production has declined to an average of one million pounds in the last ten years.

David L. Belding (1921) in a report of the Division of Fisheries and Game of Massachusetts sums up investigations made between 1912 and 1920, which show that the decline in the fisheries was caused by impassable dams, pollution, overfishing, and the elimination of spawning grounds. Largely as a result of the interest aroused by the deplorable conditions brought out in Belding's report, fish ladders have been constructed over several of the dams and repairs and alterations made in many existing fishways.

Overfishing has been caused to a great extent by the practice of the towns of leasing fishing rights to the highest bidder, usually for only one season. This system of short-time leases puts a premium on exploitation, as the successful bidder has no financial interest in the future of the fishery.

Although pollution has been abated to some extent, the highly industrialized character of the coast of Massachusetts renders it doubtful whether many of the streams in congested areas can be cleared of pollution at a cost commensurate with the possible value of the alewife runs.

Extension of the alewife fisheries in Massachusetts, except for the building up of existing runs, is seriously handicapped by the elimination of many former spawning grounds. More and more ponds and lakes are being reserved for water supplies and streams have been diverted for the flooding of cranberry bogs.

The greatest opportunity for the restoration of a really large alewife run in Massachusetts is afforded by the Merrimac River. Even as late as 1896, with the river dammed at many points, it produced 472,500 pounds of alewives and thus was the fourth largest producer in New England. The present run is negligible.

At one time alewives abounded in several rivers in New Hampshire, especially the Piscataqua, Exeter, and Newmarket. However, according to Atkins (1887) in 1880 the main upper tributaries of the Piscataqua had been dammed for more than 200 years and the main river itself had more recently been obstructed. In 1896 the catches of these three rivers (Smith 1899) were Piscataqua, 24,000 pounds; Newmarket, 26,000; and Exeter, 244,000. Since then the alewife fisheries of New Hampshire have further declined until there are now no runs of commercial importance.

The alewife catch in Maine has held up better than those in any of the other New England states. In the six years for which statistics were collected between 1880 and 1898, Maine accounted for 32 percent of the average New England catch of 10,200,000 pounds. In the last six years on which figures are available, from 1933 to 1940, Maine produced 78 percent of the average catch of 3,478,000 pounds. The decrease in the Maine take between the earlier and later periods was only 17 percent, from 3,272,000 to 2,708,000 pounds. In the remainder of New England the catch fell from 6,934,000 to 770,000 pounds - a reduction of 89 percent.

The decline in abundance, and in the number, of runs in Maine has actually been far greater than would appear from the statistics, as is brought out in detail below. Because of the great possibilities for development and restoration, Maine was chosen for the first season's work on alewives.

LIFE HISTORY OF THE ALEWIFE

Adult alewives ascend the streams in the spring to spawn. As the eggs are not deposited until the water temperatures have risen to suitable levels (usually 55° to 70° F., Belding 1921), the migration in general occurs earlier in the southern part of New England. The runs south of Cape Cod make their first appearance between the last of March and the middle of April. In central Maine, they appear between the last of April and the first week of May. In most of the streams in eastern Maine alewives are not expected until after the first of May.

Alewives spawn chiefly in lakes and quiet stretches of stream. However, we have observed them spawning in a moderate current, when more suitable places were not available.

The eggs are adhesive and cling tightly to stones, sand, and other material on the bottom. The incubation period is very short, ranging from 48 to 96 hours at 72° F. (Belding 1921) to six days at 60° F. (Bigelow and Welsh 1925).

The young develop rapidly, descending to salt water when from one and one-half to four inches long. In the Pemaquid River young alewives were entering salt water on July 14, 1943, at a length of less than one and one-half inches. This, however, was exceptionally early for alewives to be descending streams in Maine. Careful inspection, at the time, revealed no young descending the two largest alewife-producing rivers in this vicinity, the St. George and Damariscotta. In 1941 the bulk of the young alewives descended the Pemaquid during August and a sample taken on August 12 averaged about one and three-quarters inches in length. It is generally reported that the bulk of the young alewives customarily migrate to salt water from late August through September.

Adults return to salt water so soon after spawning that the early spawners often pass through the last of the incoming run. Although it is generally taken for granted that the great majority of the adults survive to return to salt water, in some streams we have observed numbers of them dead. What proportion of the adults that reach the sea survive to spawn

a second time is a question. Belding (1921) is of the opinion that they probably spawn but once. Our examination of scales from the 1943 runs in the Orland and Damariscotta Rivers in Maine and the Nemasket River in Massachusetts indicated that in each river almost the entire catch was composed of one age group. This strongly suggests that very few adults, spawn more than once. This question can be settled later from analysis of the returns from stocking experiments.

The length of time that alewives spend at sea seems to vary from southern to northern New England. Belding reports from stocking experiments in Massachusetts that mature fish return to a stream three years after adults have been planted there for spawning. The U. S. Fish Commission (1874) states that when several hundred spawning alewives were placed in Keene's Pond, which had an outlet into the Calais River, Maine, adults returned to spawn four years after. We obtained scale samples from three rivers, one having its mouth south of Cape Cod (Nemasket) and two in Maine (Damariscotta and Orland). Examination of these scales showed three checks on 78 out of 83 samples from the Nemasket River. Samples from the Damariscotta River had four checks on 83 out of 88 examined, and Orland River alewife scales the same number on 25 out of 25 examined. This would indicate that returns from stocking experiments in Maine rivers may be expected in about four years.

The difference in age between the alewives from the Nemasket River and those from the Damariscotta and Orland Rivers is reflected in their size. In all three rivers the females averaged between six and nine millimeters longer than the males. Comparing fish of the same sex, the Nemasket River males averaged 258 mm., while those from Damariscotta and Orland Rivers averaged 269 and 270 mm., respectively. For females the averages are 267 mm. for Nemasket against 275 and 278 mm. for the northern rivers. The lengths and weights of these samples are summarized in table 3. It will be noted that the weight for any given length (taken from the regression curve of weight on length) is greater for Nemasket alewives than for those of the northern rivers, regardless of sex.

Although the evidence indicates that the alewives in the Damariscotta and Orland Rivers are predominantly four years of age, it is not suggested that this holds true in all Maine rivers. Alewives from certain streams are reported to average noticeably smaller than those from other streams in the same locality. It is quite possible that an earlier seaward migration of the young or a different fresh-water environment might cause the fish from some streams to mature sooner.

SUITABILITY OF MAINE RIVERS FOR ALEWIVES

The first step in a restoration and management program for the Maine alewife fisheries was to obtain detailed information on the present and former runs and on the present suitability of individual streams for the development and maintenance of commercial runs.

As a preliminary, a list was prepared, from topographical maps, of all the streams of any size emptying into salt water between Kittery and Calais. The lake and pond areas of these 115 streams, with the exception

TABLE 3. --Length and weight of alewives from three New England rivers in 1943

Item	Males			Females		
	Nemasket River	Damariscotta River	Orland River	Nemasket River	Damariscotta River	Orland River
Number of specimens	38	191	349	45	227	301
Average length in millimeters	257.8	268.9	269.7	266.9	275.0	278.2
Average weight in grams	241.3	244.7	241.0	264.1	273.4	279.3
Weight in grams from regression curve of weight on length:-						
at 225 millimeters	139 ± 15.1	173 ± 18.7	146 ± 15.3	191 ± 21.1	156 ± 16.9	162 ± 17.5
at 250 millimeters	228 ± 18.3	217 ± 22.8	197 ± 20.7	241 ± 26.0	211 ± 22.6	213 ± 23.0
at 275 millimeters	269 ± 21.5	257 ± 27.0	254 ± 26.7	299 ± 32.3	269 ± 28.8	268 ± 28.9
at 300 millimeters	314 ± 25.1	301 ± 31.6	322 ± 33.8	364 ± 39.3	339 ± 36.3	334 ± 36.1
at 325 millimeters	361 ± 28.9	349 ± 36.6	406 ± 42.6	437 ± 47.2	422 ± 45.2	411 ± 44.4
Standard error of estimate of regression curves in percent	8.0	10.5	10.5	10.8	10.7	10.8

of the St. Croix, Penobscot, Kennebec, and Androscoggin, were calculated by means of planimeter measurements, except those for which the areas have been published in the State of Maine fish survey reports. (Cooper 1939a, 1939b, 1941, 1942)

Commissioner Arthur Greenleaf of the Sea and Shore Fisheries Department sent questionnaires to the warden of each district asking for certain data on local streams. In response, more or less complete information was received for 52 streams. The authors made a personal inspection of 64 streams, paying special attention to fishways, dams, natural obstructions, stream flow, and extent of spawning areas. Photographs were taken of most of these features. Reports on other streams were received from various sources. Altogether some information was obtained on 110 streams.

The complete list of streams arranged from south to north following the coast is given in table 4. Analysis of the data presented indicates that there is a distinct relationship between the lake area accessible to alewives and the size of the run in each stream. Thus table 5 shows that no streams with less than 20-39 acres of lake have a commercial fishery and none of the rivers supporting regular fisheries have less than 320 acres (half a square mile) of lake area. Therefore in discussing the possibilities of restoration by counties the streams with less than 40 acres of lake surface have been ignored.

The number of streams in each county classified according to lake area is given in table 6. It will be noted that of the streams (72 out of 111) with more than 40 acres of lake, only 12 lie in the four southern counties, 25 in the three central counties, and 35 in the three eastern counties.

York County:--Only 6 streams in York County contain more than 40 acres of lake surface in their drainage. The warden's reports indicate poor alewife runs in the York, Mousam, Kennebunk, and Saco Rivers. The southernmost of these, the York River, has no record of ever having had a commercial run. The Mousam and Kennebunk Rivers have several dams without fishways, and therefore no commercial run can be expected. Access to most of the large lake area of the Saco River is also blocked by dams. The dams at the town of Saco are reported to be provided with fishways, but no information was obtained on their effectiveness. If these dams are passable, 343 acres of lake is accessible. As a whole the outlook for alewife restoration in York County is discouraging at present.

Cumberland County:--The only streams with over 40 acres of lake area are the Presumpscot and Royal Rivers. At one time alewives ascended the Presumpscot into Sebago Lake (Atkins 1887) but at present a series of impassable dams has eliminated it as an alewife spawning area. The Royal River is blocked close to the mouth by two dams. The first about 7 feet in height is built of concrete. The second dam is of masonry about 9 feet in height, but a ledge in the center of the stream would facilitate the construction of a fishway.

Sagadahoc County:--Nequasset Brook with 430 acres is the only stream in this county (excluding the Androscoggin River) with more than 40 acres of lake surface. The 15- to 18-foot concrete dam at tidewater has a well-designed masonry fish-ladder. The easy ascent provided by the series of

TABLE 4.--Alewife runs and lake areas on 115 Maine streams

Name of stream	Alewife run		Lake area in acres		Sources of information[1]	Remarks
	At present	Formerly	Area accessible	Total area		
York County						
Spruce Cr.	None	None	0	0	W	
Brave Boat Cr.	None	None	0	0	W	
York R.	Poor		46	46	W, F	Stream small and very brushy.
Cider Hill Cr.	?	?	?	87		Probably the "York" river reported with a poor run.
Cape Neddick R.	None	None	?	157	W	
Josias R.	None	None	0	0	W	
Ogunquit R.	None	None	3	3	W	
Webhannet R.	None	None	?	2	W	
Merriland R.	None	?	0	12	W	
Branch Br.	None	?	?	3	W	
Mousam R.	Poor	Yes	0	1,842+	W, O	Dams near mouth
Kennebunk R.	Poor		0	244	W	Dams near mouth
Batson R.	None	?	0	3	W	
Little R. or Davis Br.	None	?	3	3	W	
Saco R.	Poor	Yes	?	4,204+	W, F, O	343 acres accessible if fishways at Saco are passable
Goosefare Br.	None	None	0	0	W	
Cumberland County						
Little R.	Fair		20	20	W	
Scarboro R.	None		0	0	O	
Nonesuch R.	None		0	0	O	
Red Br.	None		?	10	O	
Stroudwater R.	None		0	0	O	
Presumpscot R.	None	Good	0	28,787+	O	Formerly entered Sebago Lake
Royal R.	None	?	0	250	F, O	
Cousins R.	None		0	0	O	
Bunganuc Cr.	None		0	0	W	
Sagadahoc County						
Androscoggin R.	None	Yes	0		O	
Whiskeag St.	Poor		15	15	W	
Winnegance St.	Fair		?	39+	W	
Nequasset Br.	Good	Good	430	430	W, F, O	
McFarlin's St.	Poor		?	6	W	
Cathance R.	?	Yes	?	16	O	
Abagadassett R.	?		0	0		

TABLE 4. (Continued)

Name of stream	Alewife run		Lake area in acres		Sources of information[1]	Remarks
	At present	Formerly	Area accessible	Total area		
Kennebec County						
Kennebec R.	None	Excellent	0		0	Formerly ascended to Norridgewock Falls.
Cobbosseecontee St.	None	Excellent	0	11,546+	0	
Nehunkeag Br.	?	Yes	?	183	0	
Lincoln County						
Eastern R.	?	Yes	?	73	0	
Sheepscot R.	Poor	Good	0	2,839+	W, F, 0	Sheepscot Pond stocked in 1943.
Dyer R.	Poor	Yes	0	576	W. F.	
Deer Meadow Br.	?		?	80		
Lily Pond St.	None	Yes	63	63	F, 0	Lily Pond Stream stocked in 1943.
Back River St.	Poor	Yes	0	64	F. 0	Used as a water supply.
West Harbor Cr.	None	Good	159	159	F	West Harbor Pond stocked in 1943.
Damariscotta R.	Very good	Excellent	4,463	4,463	W. F, 0	
Pemaquid R.	Fair	Good	50	2,803	W. F. 0	Pemaquid Pond stocked in 1943.
Muscongus Br.	Poor	Yes	253	253	W. F.	Stream partially obstructed.
Medomak R.	Poor	Good	0	809	W. F. 0	Medomak Pond stocked in 1943
Goose R.	None		?	48	0.	
Knox County						
St. George R.	Good	Excellent	1,569	5,745+	W. F.	Needs several fishways.
Oyster R.	None	?	?	110	0	
Mill R.	?	?	0	343	0.	Used as a water supply.
Tenants Harbor Marsh	None	Yes	0	10?	W	
Weskeag R.	None	Yes	0	0	W	
Goose R.	None	None	0	80	F. 0	Steep natural falls
Meguntticook R.	None	?	0	1,332+	0	
Vinalhaven St.	Poor		0	164	0	

TABLE 4. (Continued)

Name of stream	Alewife run		Lake area in acres		Sources of information[1]	Remarks
	At present	Formerly	Area accessible	Total area		
Waldo County						
Ducktrap R.	Good	Yes	816	1,040	W, F, O	
Little R.	None		0	0	F. O	Used as a water supply
Passagassawaukeag R.	Poor	Yes	0	567	W. F	
Wescot St.	None		0	50	F	
Goose R.	None		0	1,370+	F. O	
Searsport St.	Poor		0	56	F	
Marsh R. or Colson St.	?		155	155	O	
Marsh St.	None		0	156+	F. O	
Penobscot County						
Souadabscook St.	Poor		0	456	F. O	
Penobscot R.	Poor	Yes	?		F. O	
Sedgeunkedunk St.	Poor		0	1,195	O	
Mill Cr.	Poor		125	125	F	
Hancock County						
Mill St. 2/	None		0	48	W. F	Used as a water supply.
Orland R.	Very good	Excellent	1,403	3,915	W. F. O	
Pierce Pond St.	None		0	111	F	Steep gradient, could possibly be made accessible.
Winslow (Cove) St.	Poor		0	125	F	Wight Pond stocked in 1943.
Parker Pond St.	None		0	52	W. F	Small summer flow.
Walker Pond St.	Fair	Good	697	697	W. F. O	Fishway needs attention.
Carleton St. or Allen Mill St.	Poor	Good	0	411	F. O	Second Pond stocked in 1943
Mill St. 3/	None		0	0	F	
Peters Br.	None		0	30	F	Stream small and brushy.
McCards St.	None		0	16	F	Stream small and brushy.
Western (Mill) Br.	Poor	None	0	0	F	Alewives were introduced here.
Patten St.	Poor	Good	1,102	1,102	W, F, O	Fishways need attention.
Union R.	Poor	Good	0	31,751+	F. O	Very high dam near mouth
Kilkenny St.	None		0	0	F	

TABLE 4. (Continued)

Name of stream	Alewife run		Lake area in acres		Sources of information[1]	Remarks
	At present	Formerly	Area accessible	Total area		
Egypt St.	None		0	0	F	
Taunton (Mill) Br.	Good	Yes	345	345	W, F, O	
Card Mill St. or Hog Bay St.	Good	Yes	715	715	W. F. O	
Little Pond St.	None		0	28	F. O	High natural fall
Basin Pond St.	None		7	7	F	Very small stream
Flanders St.	None		555	555	F	Flanders Pond stocked in 1943.
Morancy St.	None		60	60	F, O	Morancy Pond stocked in 1943
Jones St.	Good		360	360	W, F, O	
Prospect Harbor St.	Poor	Good	196	196	W. F.	
West Bay St.	None		0	300	F.	West Bay Pond stocked in 1943
Chicken Mill St.	None		0	50	F.	
Seal Cove Br.	Poor		0	315	W.F	Seal Cove Pond stocked in 1943
Denning Br.	Poor		0	244	F	Echo Lake stocked in 1943.
Great Pond St.	Fair		1,053	1,053	F	
Richardson Br.	None		?	28	F	Stream small.
Hadlock Pond St.	None		?	69	F	Stream small.
Jordan St.	Poor		211	211	F	Obstructed in summer by gravel seawall
Northeast Cr.	None		0	0	F	
Washington County						
Whitten-Parrin St.	None	None	0	0	W, F	
Tunk St.	?	Yes	0	3,237	F, O	Tunk Lake stocked in 1943
Narraguagus R.	?	Good	?	1,430+	F, O	Dams destroyed by ice in 1942.
Harrington R.	None	None	0	0	F	
Pleasant R.	Poor	Good	0	860	W, F, O	Fishway needs observation.
Indian R.	None		0	0	O	
Chandler R.	Poor	Poor	0	0	W, F	
Machias R.	Fair	Good	9,576	9,576	W, F	Difficult natural fall at mouth.
East Machias R.	Very good	Good	9,824	15,408	W, F	
Holmes St.	?		?	60		
Orange (Whiting) R.	Poor	Good	0	1,868+	W.	
Little Falls St.	?		?	20		

TABLE 4. (Continued)

Name of stream	Alewife run		Lake area in acres		Sources of information[1]	Remarks
	At present	Formerly	Area accessible	Total area		
Dennys R.	Good	Good	9,007	10,740+	W	Fishway at Meddybemps Lake needs to be kept open.
Pembroke R. or Pennamaquan R.	None	Excellent	0	1,904	W, O	
Boyden St.	?		?	1,728		
St. Croix R.	Poor	Yes	0		W, O	

1/ W - Warden's report (Sea and Shore Fisheries)
F - Our inspection (Fish and Wildlife Service)
O - Other information

2/ In Bucksport

3/ In Bluehill

TABLE 5.--Relationship between the lake area accessible to alewives and the importance of the run in Maine streams. 1/

Lake area accessible	Importance of the alewife run 2/						Total number of streams
	?	None	Poor	Fair	Good	Very good	
Acres							
?	9	8	2	1			20
0-9	3	44	23				70
10-19			1				1
20-39				1			1
40-79			1	1			2
80-159	1						1
160-319							0
320-639					3		3
640-1,279				2	3		5
1,280-2,559						1	1
2,560-5,119						1	1
5,120 & over					1	1	2
	13	52	27	5	7	3	107

1/ Does not include Lily Pond Stream or Flanders Stream in which former runs were totally destroyed; West Harbor Creek which became accessible in 1943; and Mill Creek (So. Orington), Muscongus Brook, Patten's Stream, Jordan's Stream, and the Machias River, all of which are partially obstructed by natural barriers or poor fishways.

2/ "?" means no definite information. In no case marked "?" is there a commercial run. A "poor" run is too small to be used commercially. A "fair" run is used commercially but does not support a regular fishery. "Good" and "Very good" runs support regular alewife fisheries, the difference between the two being based on the size of the run.

TABLE 6.--Lake area of Maine streams by counties.[1/]

County	Lake area of streams in acres											Totals			Grand total
	0-9	10-19	20-39	40-79	80-159	160-319	320-639	640-1,279	1,280-2,559	2,560-5,119	5,120 and over	Under 40 acres	40-159 acres	Over 160 acres	
York	9	1		1	2	1			1	1		10	3	3	16
Cumberland	5	1	1			1					1	7	0	2	9
Sagadahoc	2	2		1			1					4	1	1	6
Kennebec						1					1			2	2
Lincoln				4	2	1	1	1		3			6	6	12
Knox	1	1			2	1	1		1		1	2	2	4	8
Waldo	1			2	2		1	1	1			1	4	3	8
Penobscot					1		1	1					1	2	3
Hancock	6	1	3	5	2	5	4	4		1	1	10	7	15	32
Washington	4		1	1				1	4	1	3	5	1	9	15
Totals	28	6	5	14	11	10	9	8	7	6	7	39	25	47	111

[1/] Exclusive of the Androscoggin, Kennebec, Penobscot, and St. Croix.

large pools in this fishway is undoubtedly an important factor in the maintenance of the good run in this stream.

Kennebec County:--The only streams in Kennebec County proper are Cobboseecontee Stream, Nehumkeag Brook, and the main Kennebec River. According to Atkins (1887) alewives formerly ascended the Kennebec 91 miles to Norridgewock Falls and went some 20 miles farther up the Sandy River. The lakes of the Cobboseecontee Stream once afforded one of the principal breeding places for alewives of the Kennebec. The Nehumkeag Brook run (Atkins 1887) was destroyed by impassable dams in earlier years. We have no present information on this stream. In 1880, long after the main Kennebec had been closed by dams at Augusta and the Cobboseecontee by those at Gardiner, the catch of the lower portions of the Kennebec (including Eastern River, Cathance Stream, Nequasset Brook and a few smaller streams) was 675,000 alewives. In 1867 the catch of this same area was estimated to have been 1,200,000 alewives for some years previously. No attempts at restoration of most of these tremendous alewife runs are feasible under present conditions.

Lincoln County:--Nine of the twelve streams of this county containing in their flowage lake areas of over 40 acres were inspected. Of the remaining rivers, it is reported that the Goose River has no alewife run, and there is some doubt as to the accessibility of the lake. Although we have no positive information, it is improbable that the Eastern River or Deer Meadow Brook contain more than a few stragglers.

The Sheepscot River once had a good run, destroyed in the last century by a dam at Head of Tide. The warden's report that a few alewives still spawn in a short stretch of river below this obstruction. Dams farther upstream at Whitefield and Cooper's Mills have been abandoned --the dam at Whitefield is passable and the dam at Cooper's Mills was commencing to wash out in 1941. By building a fishway over the 12-foot concrete dam at Head of Tide, this river, containing in its basin more than 2,800 acres of lake area, would be available for alewives and should be capable of supporting a large run. Atkins (1887) asserts that the Sheepscot River was once frequented by salmon and shad to a greater extent than any other river between the Kennebec and the Penobscot, so that any fishway over this dam should be designed to meet the minimum requirements of salmon also.

The Dyer River has apparently always had an alewife run, which at present is too small to be of commercial importance. The inspection, on May 12, 1943, showed the cause of the falling off of this run, namely, that the river is completely blocked at the mouth of Dyer Long Pond by an old abandoned dam, without a fishladder. The crumbling ruins of an old mill astride this dam would render it very difficult to do any work on the dam. The dam is built chiefly of large loose rocks and at the time of our inspection a few alewives were observed trying, in vain, to negotiate the swift water rushing between them. As 576 acres of lake area lie above, and a few alewives continue to come as far as the dam, it appears highly probable that a good run can be restored merely by clearing a passageway through this utterly worthless structure.

A small run in Lily Pond Stream was destroyed some years ago by a fish screen at the outlet of the lake. It may be possible to reestablish this run.

Back River Stream is reputed to have once had a small run of alewives, which we do not recommend reestablishing, as Adams Pond is used as the water supply for Boothbay Harbor.

West Harbor Creek (Campbell's Creek) once had a good commercial run of alewives. The stream itself is merely a fishladder connecting West Harbor Pond with the sea. As this run was observed by Bigelow and Welsh (1925) the disappearance of the fishway must have been at some time within the past 15 or 20 years. The failure to maintain the ladder resulted in the complete extinction of this run. The Sea and Shore Fisheries Department replaced this ladder in 1943, thus facilitating restoration.

The alewife fishery in the Damariscotta River was created about 1803 (Atkins 1887) when citizens of Nobleboro and Newcastle planted alewives in the lake and built a fishway over the falls. The run soon developed to commercial proportions and due to careful management has been the most consistent large commercial run in Maine. In the fifteen year period from 1866 to 1880 an average of 800,000 alewives were dipped from the river at Damariscotta Mills. In 1880, 1,700,000 were caught there and an additional 2,300,000 were captured by weirs, gill nets, and seines in Bristol and Edgecomb. The latest figures of catch available (1942) show 1,050,000 pounds or approximately 2,000,000 alewives.

The Pemaquid River had an alewife run of some local importance which Atkins (1887) said was destroyed by impassable dams and improvident management. This run was apparently restored in later years. Smith (1899) gives the catch in 1896 as 206,000 fish or 115,875 pounds. The fishway over the dam at Pemaquid Falls was renovated in the fall of 1940. It now provides an easy ascent but it is doubtful if the present small run can become of much commercial importance with no more than the present 50 acres (Boyd Pond) of spawning ground. However, a fishway over the 12-foot concrete dam at Bristol would provide an additional 2,750 acres. With this area available the Pemaquid should be able to support a run comparable in size with Damariscotta.

The alewife run in Muscongus Brook has dwindled to very small proportions owing to partial obstruction just below Webber Pond (253 acres) by large boulders that have fallen into the narrowed streambed at a former damsite. Efforts to clear a channel for the 1943 run were only partially successful. We recommend the complete removal of these boulders and the construction of one or two pools to aid the fish in surmounting the rapid at this point.

The Medomak River in 1896 produced 73,800 by count or 41,512 pounds of alewives. A small run still ascends to the first dam, just above tidewater, and at times fish have been dipped over the dam in an attempt to keep the run from becoming extinct. Altogether there are four dams all without fishladders between the mouth and Medomak Pond, and below the two upper dams the river is choked with banks of sawdust and wood waste. None of these dams is high enough to present any obstacle to the building of fishways, which we believe should be installed. Ladders on this stream should be large enough to accomodate salmon.

Knox County:--Out of six streams in Knox County, with more than 40 acres of lake surface in their flowages, only the St. George River has any lake area at present accessible to alewives. The Megunticook River, the only other stream in this county with a large lake area (1,332 acres), is blocked by several dams at Camden. It is reported that Chickawaukie Pond (343 acres) on Mill River is used as a water supply by the City of Rockland. Vinalhaven Stream is said to have a wooden dam four feet in height blocking a small alewife run from suitable spawning grounds. Sea and Shore wardens reported that the town is contemplating the building of a fishway over this dam. Inspection of Goose River disclosed that Hosmer Pond (80 acres) is rendered inaccessible to alewives by a long stretch of steep ledges.

The St. George River has had a very excellent alewife run, but about the middle of the last century, gradual curtailment of the area of their breeding grounds by the closing of tributary lakes and the difficulty of passing the dams at Warren caused a decline in the number of the alewives (Atkins 1887). In 1880 the catch had fallen to 515,000. In 1896 the take was 686,000 or 385,800 pounds and in 1942 it was 324,000 pounds or approximately 650,000 alewives.

Waldo County:--Out of seven streams in this county with more than 40 acres of lake surface only the Ducktrap River supports a commercial alewife run. The Goose River in Belfast has the largest lake area (1370 acres) but the stream is effectively dammed at the mouth for a power development that uses a very large and very long penstock making it doubtful if this stream could be made suitable for alewives.

The Passagassawaukeag River, which has 567 acres of lake surface, is obstructed at Holmes Mill about one mile from the mouth by a 10-foot concrete dam. A fishway over this dam would open Cross Pond with 162 acres. The main river is blocked one and one half miles farther upstream at Poor's Mill by a 7-foot masonry dam, which is so constructed, however, as to render installation of a fishladder comparatively easy. A fishway here would permit access to Sanborn and Dutton Ponds, with 122 acres. There are three other ponds totaling 248 acres on a tributary which enters the main river above Poor's Mill, but this tributary was not examined to determine whether or not it is passable to alewives.

Wescot Stream, entering Belfast Bay just east of the mouth of the Passagassawaukeag, is barred to alewives by a natural fall over bare rock ledges at its mouth. A fishway over this fall, which is only about five feet at the steepest part, would render 50 acres of lake available for alewife spawning grounds.

A few alewives ascend Searsport Stream a short distance above tidewater to a 12-foot wooden dam at U. S. Highway 1. The building of a fishway at this point would be difficult because the mill has been built completely over the stream and the leakiness and disrepair of the dam might cause difficulty in operation. A fishway here would open up 50 acres for the spawning of alewives.

Marsh Stream is obstructed close to the mouth by a stone dam about ten feet in height, thus blocking 156 acres of lake area.

Marsh River or Colson Stream, with 155 acres of lake surface is said to be unobstructed, but has no commercial run.

Penobscot County:--The main Penobscot River and the three streams that enter the estuary of the Penobscot below Bangor have poor alewife runs. Alewives were apparently never very abundant in the main Penobscot (Atkins 1887) and today only small numbers ascend above the Veazie dam.

Souadabscook Stream, entering the Penobscot at Hampden, has 456 acres of lake area. There is an impassable 12-foot concrete dam a short distance from the mouth provided with a large concrete fishladder which appears to have fallen into disuse. The construction and location of this fishway are such that it should not have been expected to attract fish.

Alewives ascend Sedgeunkedunk Stream in small numbers as far as the dam in South Brewer. Until an examination has been made of the stream and tributary lakes no decision should be made as to the advisability of a fishway.

Mill Creek, South Orrington, has a small run of alewives of which a few are used locally. Under proper management the 125 acres of lake area should support a much larger run. The smooth rock ledges and the abandoned concrete dam near the mouth, however, present obstacles to the passage of alewives.

Hancock County:--Of the 22 streams in Hancock County with more than 40 acres of lake area in their basis only 7 were found to be entirely devoid of alewives. There are several potential alewife streams awaiting restoration.

The Union River with nearly 32,000 acres of lake surface is reputed to have had an abundant run well over a century ago (Atkins 1887) but today the stream is blocked by a 60-foot concrete dam at Ellsworth.

The lake on Mill Stream in Bucksport is used as a water supply for the town and is not accessible to alewives.

The Orland River has an excellent alewife run which passes over two fishways into Alamoosook Lake. The fishway at the tidewater dam is at present so short that it can be ascended by the fishes only during the higher stages of the tide. The size of the run might be increased, if this ladder were lengthened and redesigned. The second ladder at Alamoosook Lake should have the exit altered to take care of different water levels in the lake above. At present the fish must struggle through under a head of water, which often greatly delays their passage.

Pierce Pond Stream, with 111 acres of lake, has no run. Although there are no permanent obstructions other than large boulders in the stream, the gradient is sufficiently steep to make it doubtful if alewives can accomplish the ascent.

Winslow Stream, with 125 acres of lake, has a poor run of alewives, which ascends about one and one-half miles to a 6-foot timber dam at the mouth of Wight Pond. The mill is built directly over the stream and mill waste chokes the stream bed below. A side stream from a wing dam enters

the main stream about one hundred yards below the mill. A fishway was reported, but our inspection disclosed no evidence of it. It is recommended that a fishway be installed on the side stream and that the main stream be barricaded where the side stream enters it to guide the alewives into the fishway.

The summer flow of Parker Pond Stream (with a 52 acre lake) was reported by the Inland Fisheries warden to be very small, and, therefore, this stream probably is unsuitable for development.

Walker Pond Stream, connecting Walker Pond (697 acres) with the Bagaduce River, an arm of the sea, is extremely short. This stream formerly supported a heavy run of alewives, that has declined to small proportions, apparently due in large measure to failure to maintain proper conditions in the fishway over the dam at the outlet of the pond. When inspected, the fishway, consisting of a side stream which joins the main stream below the mill, was choked with sawdust and mill waste. No barricade was provided in the main stream to guide alewives into the side stream and no provision was made at the exit of the fishway to adjust for different levels of water in the pond.

Carlton (Allen Mill) Stream with four ponds totaling 411 acres, is undoubtedly the stream in Bluehill mentioned by Atkins (1887) as once supporting an alewife fishery that by 1880 had long disappeared. A few alewives still enter the stream, which is blocked about one-quarter of a mile from tidewater by a stone dam about six feet in height. The mill at this point is built over the stream, so that the construction of a fish-ladder would be extremely difficult. The stream below the mill is almost entirely choked with banks of sawdust and mill waste.

Patten Stream is reputed to have once had a good run of alewives, but as long ago as 1880 the run had dwindled to less than commercial levels owing to obstructions by dams (Atkins 1887). Inspection reveals clearly that the decline in this run is caused by failure of the alewives to reach the excellent spawning grounds (1102 acres) afforded by Lower and Upper Patten Ponds despite supposedly effective fishladders. The first dam, two miles from tidewater, built of lumber and about six feet in height was inspected in March 1943. The fishladder at this dam is flimsily constructed, poorly designed, wholly inadequate for the proper passage of fish as large as alewives, and at the time of inspection was completely clogged with sawdust and mill waste. The second obstruction is composed of a main dam and a wing dam at the outlet of Lower Patten Pond. The upper end of the fishladder in the main dam is located in such shallow water that the ladder becomes dry when the water level in the lake falls slightly, as it is bound to do in dry weather, owing to bad leaks in the wing dam. The lower end of this ladder is poorly located to attract fish. Even at the time of inspection, in March 1943, the water level of the lake was so low that most of the water was escaping through leaks in the wing dam. The latter should be made water-tight and the fishladder in the main dam redesigned and relocated.

Taunton (Hill) Brook and Card Mill (Hog Bay) Stream in Franklin, unobstructed streams, with 345 and 715 acres of lake areas, respectively, both support commercial runs of alewives.

Flanders Stream was once obstructed by two dams and a fish screen below Flanders Pond (555 acres) but the obstructions have disappeared. As there is no run in this stream at present, it offers an opportunity for restoration.

Morancy Stream has only a 60-acre pond but the stream itself is of fair size. If there was a former alewife run it was undoubtedly destroyed by a fish screen, which has since rotted away. This stream offers an opportunity for development.

Jones Stream with a pond area of about 360 acres has had an alewife fishery since about 1880. This run, started by artificial stocking, is maintained by placing a portion of each year's run in the lake.

Prospect Harbor Stream has a poor run of alewives today, but once had a much better one. This run could undoubtedly be rebuilt under careful management.

West Bay Stream has a fair sized lake area (300 acres) in West Bay Pond, which has a wooden dam seven feet in height at the outlet. The presence of a ledge at one end of the dam would make it easy to install a fishladder and since the dam is used only to maintain the water level, operation of the fishway would be simplified.

Chicken Mill Stream has no run, but an artificial pond of about 50 acres impounded by an 8-foot stone dam could be used for alewives, if a ladder were constructed.

Seal Cove Brook on Mount Desert Island drains two ponds totaling 315 acres. A few alewives ascend the brook about 200 yards to a point where the remains of an old dam blocks the stream. The removal of this obstruction would permit reestablishment of the run.

Denning Brook in Somerville drains 244 acres. A few alewives ascend three-quarters of a mile to an 8-foot masonry dam with a drop of four feet at the spillway. As the dam is used only to create an artificial pond it can easily be made passable by the construction of two or more pools across the main stream.

Great Pond Stream drains the largest lake area (1053 acres) on Mount Desert Island, and it is reported to have a fair alewife run. The stream has a concrete dam at tidewater about four feet in height with a steep beach below it. A large concrete fishladder has been provided but at the time of inspection the edge of the lower pool was broken.

Hadlock Pond Stream has such a small flow that it is probably not suitable for alewives.

It is reported that a few alewives ascend Jordan Stream, which has 211 acres of lake area. We were informed, and our inspection confirmed, that during the summer low-water periods the stream becomes so diffused through the sea wall and gravel bars at the mouth that it is impassable.

Washington County:--In this county there are 10 rivers with more than 40 acres of lake area in each of their basins. These watersheds include 46,811 acres of lake surface, of which 28,407 acres on three streams are more or less accessible to alewives.

Tunk Stream is blocked about ten miles from the mouth by an 8-foot dam at Unionville. Construction of a fishladder at this point would open more than 3,200 acres of lake area for alewife restoration.

The alewife run in the Narraguagus River was destroyed a great many years ago by several dams at Cherryfield. The destruction of these dams by ice in 1942 rendered considerable lake area accessible but further inspection of natural obstacles will be necessary to determine which lakes are now usable.

Pleasant River (860 acres) is reported by Atkins (1887) to have had a large alewife run about 1820. Later the run was stopped by the dam at Columbia Falls and it declined until the catch was about 30 barrels per year by 1880. A small run continues to spawn below the dam.

The Machias River has a small run of alewives, but they are not sufficiently numerous to be taken commercially. According to early reports (Atkins 1887) they were never as abundant in this river as in the East Machias, owing perhaps to the very difficult natural falls at the head of the tide. With more than 9,500 acres of lake available for spawning, this river should support a very large run of alewives if these falls were made passable.

The East Machias River with the largest lake area accessible to alewives of any of the streams in Maine, has a good alewife run. In 1942 it produced 693,000 pounds, second only to Damariscotta.

The Orange (Whiting) River with nearly 1,900 acres of lake area is rendered inaccessible to alewives by high concrete dams at its mouth.

The Dennys River with 9,000 out of 10,700 acres of available lake area accessible to alewives has a fair run. This run has never been exceedingly large within the last century due to dams that existed in the river at various times, and amounted to only 126,000 pounds in 1942. This run could undoubtedly be greatly increased by proper management, especially by keeping open the fishway into Meddybemps Lake.

The Pembroke River once had an excellent run of alewives according to Atkins (1887) but today the 1,900 acres of potential spawning grounds are blocked off by impassable dams at the mouth.

RESTORATION BY MEANS OF STOCKING

The survey has shown that alewives have been eliminated from a considerable number of Maine streams. The first step in returning these streams to productivity is reestablishment of a run. The second step, discussed under management, is provision for self maintenance of the run by the diminution of detrimental pollution and assurance of free passage between the sea and the lake areas needed for spawning and nursery grounds.

In no known case in which the run to a stream has been completely destroyed, have the alewives become naturally reestablished. (Belding 1921, and Bigelow and Welsh 1925). Many instances, however, are recorded, in which the planting of adult alewives in such a stream has resulted in the reestablishment of a run (Belding 1921).

Several streams were selected for stocking with adult alewives during the 1943 run. Because of the shortage of manpower and gasoline these streams were selected partly on the basis of their accessibility from the fisheries stations at Boothbay Harbor and Craig Brook from which the stocking trucks were operated. The truck from the Craig Brook Station was supplied and operated by the U. S. Fish and Wildlife Service and the other by the Maine Sea and Shore Fisheries Department. A biologist from the Fish and Wildlife Service accompanied each truck to supervise and aid in distribution of the fishes.

These trucks held about 500 gallons of water when filled to the proper level and were fitted with compressors to aerate the water. The adult alewives were obtained from the Damariscotta and Orland Rivers, by dipping them from the stream into wash tubs or directly into the tanks. Care was taken to dip only a few fish at a time to prevent the weight of the top fish from injuring those underneath.

Where conditions permitted, the fish were released directly into the ponds instead of into the stream. The truck was driven close to the pond, the fish dipped directly into the pond or carried in buckets or wash tubs filled with the water, and counted with a hand tally as they were released. After release any that appeared injured or weak were removed and subtracted from the count.

The temperature of the stream was taken at the time each truck was loaded. No difficulty was encountered because of temperature for the first few loads handled, but as the weather became warmer it was found necessary, when hauling larger loads, to keep the water in the tank a few degrees cooler than that of the stream from which the alewives were taken, by the use of ice.

Table 7 lists the streams stocked, losses enroute, temperature of the streams, etc. A total of 9,244 fish were carried, 1,746 fish died enroute or while planting, making a total of 7,498 adult fish, ready for spawning, planted in 13 streams. West Harbor Creek received the heaviest stocking (1,969 fish) because of its proximity to Boothbay Harbor, where one of the trucks was garaged.

The alewife has a very high fecundity. Belding (1921) estimated the number of eggs to be from 60,000 to 100,000 per female. That the survival of the young must be high is evidenced by the artificial maintenance, for more than a century, of a commercial run in Jones Stream (West Gouldsboro) by planting about ten percent of each year's run in Jones Pond for spawning. Our observations of runs in other streams lead us to believe that the escapement in most streams with commercial runs does not average much higher. Therefore, although the number of adult fish hauled was not large, we have confidence that the results will be satisfactory.

Evidence that the alewives which were planted spawned successfully has already been demonstrated at West Harbor Creek. In July, dense schools of small alewives, appearing to number in the hundreds of thousands, resulting from the stocking of the adults planted in West Harbor Pond during May, were seen passing down the newly constructed fishladder into the harbor.

TABLE 7.--Alewife stocking in Maine streams during 1943.

Stream stocked	Date	Place planted	Temperature		Number of alewives			
			Where loaded	Where planted	Carried	Died	Stocked	Stream total
Sheepscot R.	May 20	Sheepscot Pd.	58°F.	60°F.	425	125	300	
Do.	21	Do.	58	58	546	164	382	682
Lily Pond St.	25	Lily Pond St.	58	63	425	37	388	388
West Harbor Cr.	17	West Harbor Pd.			475	6	469	
Do.	19	Do.	58	63	334	217	117	
Do.	20	Do.	58.5	60	511	8	503	
Do.	21	Do.	57.5	59	468	8	460	
Do.	24	Do.	58	64	704	284	420	1,969
Pemaquid R.	12	Pemaquid Pd.	52		429	1	428	
Do.	25	Do.	57	65	469	14	455	883
Medomak R.	19	Medomak Pd.	58	60	768	578	190	
Do.	24	Do.	58	63	498	127	371	561
Winslow St.	18	Wight Pd.	58	68	318	3	315	
Do.	19	Do.	58	65	260	0	260	575
Carleton St.	18	Second Pd.	58	59	235	8	227	
Do.	18	Do.	58	59	453	105	348	
Do.	20	Do.	60	65	256	15	241	816
Flanders St.	21	Flanders Pd.	59	55	260	0	260	260
Morancy St.	24	Morancy Pd.	60	54	280	5	275	275
West Bay St.	25	West Bay Pd.	62	64	312	1	311	311
Seal Cove St.	19	Seal Cove Pd.	58	60	250	12	238	238
Denning Brook	20	Echo Lake	60	58	256	16	240	240
Tunk St.	25	Tunk Lake	64	64	312	12	300	300
Totals					9,244	1,746	7,498	7,498

MANAGEMENT OF ALEWIFE RUNS

Introduction:--Given a stream with a sufficiently large area of quiet water for spawning and for the development of the young, and a sufficient flow to favor downstream passage for the young during late summer, an alewife run, once established, should not be difficult to maintain. Of course detrimental pollution must be abated, and all artificial or natural obstructions to the migration of the fish must be made easily passable.

Having assured the fish unobstructed passage to and from suitable spawning grounds, the most important remaining problem is to permit a large enough proportion of each year's run to escape the fishery to form a brood stock.

Except perhaps for a very few streams in highly industrialized localities, observations do not indicate that pollution has been an important factor in the decline of the alewife runs in Maine. This leaves two factors that account for most of the difficulties, namely, obstructions to migration and failure to permit an adequate number of adults to spawn.

Obstructions to migration:--Natural obstructions occur on very few of the streams inspected and most of those observed could be easily made passable.

Except for fish screens, all artificial obstructions observed were due directly or indirectly to dams. In many cases, streams are blocked by dams long since abandoned by the owners. There is no logical reason why these structures should be permitted to interfere with the proper utilization and maintenance of the fishery resources. Anyone holding title to such an abandoned structure should be required either to open a passageway through the dam or to permit similar action by others.

Dams that are still in active use present a more serious problem due to fluctuations in water levels, to temporary drying up of stream beds, to the danger of destroying fish migrating downstream by water wheels, turbines, and pumps, and to the use of the entire stream flow, leaving none for a fishway.

Many of the fishladders observed were poorly designed, constructed, and maintained; therefore, since several must be built to accommodate the runs returning from the stocking program now under way, they will be discussed in some detail.

The basic requirements of a successful fishway are that it shall provide a passageway over the dam for the various types of migratory fish in the particular stream at any water level or volume of stream flow. Furthermore, the fish must be able to make the ascent without injury or the exertion of extreme effort and must not be unduly delayed at the barrier while searching for the fishway entrance. To meet these requirements particular attention must be paid to certain features of location and design.

The entrance of a fishway, if located too far downstream from the barrier, will be passed unnoticed by the fish, which tend to follow the main channel until barred by the dam. If they find such an entrance at all it is often found only when drifting downstream, exhausted or injured, after fighting in vain to pass the obstruction. Therefore, the entrance should be located very close to the foot of the dam. If the dam is built obliquely across the stream, the entrance to the fishway is usually best located at the upstream end. One of the primary requirements for attracting fish into the ladder is that the entrance shall be located sufficiently close to the main current from the spillway or tail race so that fish following this current will almost automatically find themselves at the entrance. If it is so favorably located that the fish find it, then inducing them to enter is largely a matter of providing a sufficient flow of water. The volume necessary depends to a great extent on that of the main stream.

The most prevalent type of alewife ladder observed is merely an inclined sluiceway, in which the water is supposed to be somewhat retarded by a series of baffles extending alternately from each side of the flume. This type is entirely unsuitable for a dam of any height, for, unless the incline is very gradual, the water rushes through at high speed. Furthermore, unless the dam is very low, the entrance is too far downstream.

Fish have less difficulty ascending a series of pools connected by low falls or short rapids. The consistent success of the Damariscotta alewife fishery is probably due largely to a ladder of this type. Where it is impractical to construct pools of natural rock or masonry, a series of wooden or concrete boxes may be substituted -- such a ladder is depicted in figure 1. The drop between successive boxes should not exceed twelve to sixteen inches. The size of the pools can vary somewhat in accordance with that of the stream and of the run that must be accommodated. In streams with a good run, the boxes should be not less than six feet long, four feet wide, and four feet deep. If the ladder is also to accommodate salmon, it is desirable to increase the size somewhat, thus a box eight feet long, six feet wide, and six feet deep provides a ladder of ample proportions.

It will be noted in the sketch of the fishladder (figure 1) that provision has been made for differences in the level of the water in the forebay, by building two pools parallel with the face of the dam. If the dam is very high or subject to great fluctuations in water level, this number may have to be increased. The exits are provided with stop logs, so that the flow can be readily adjusted. Many dams, instead of stop logs have a gate setting on the bottom of the opening, that can be raised to allow water to pass into the fishway by flowing under the gate. This method of regulating the flow, however, has certain definite disadvantages. If the gate extends deep enough to provide water for the fishway when the level in the forebay is low, the opening is so deeply submerged at high water levels that the fish must force their way through the opening under the gate against a considerable head of water. Furthermore, with the increased pressure at high levels the opening must be made so small, to compensate for increased velocity of current that the space is usually too small. We have seen several otherwise good ladders that were difficult for fish to pass because of undesirable watergates. The pool type of ladder is especially desirable for streams with a very small summer flow, as it can be run efficiently with less water.

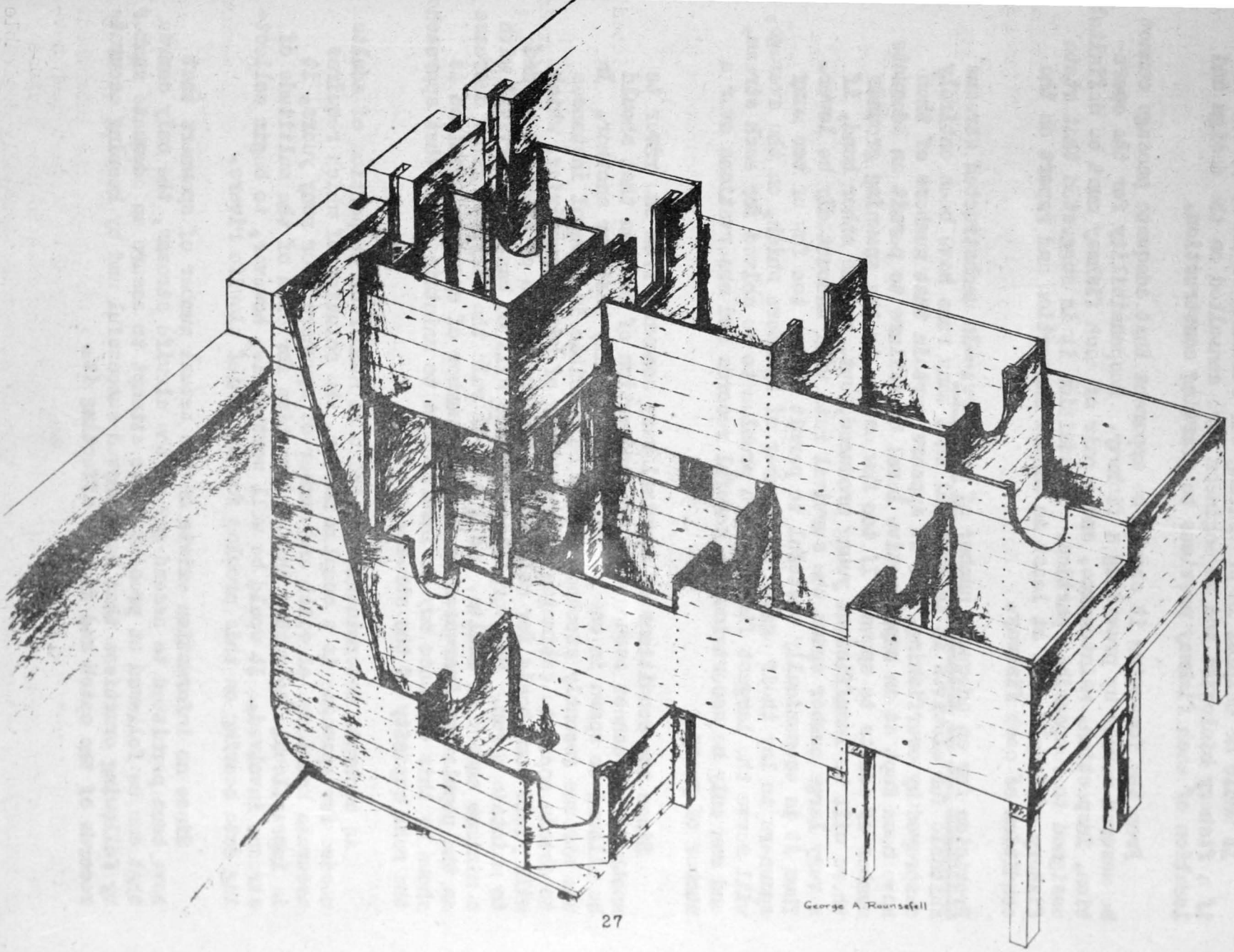

Figure 1. Sketch of a pool-type fishway designed to pass alewives over a 12-foot dam. J1980

It would be helpful in preventing the building of unsuccessful ladders if a fishery biologist and an engineer were consulted on the design and location of each fishway previous to starting construction.

From the foregoing it should be apparent that adequate passage cannot be assured merely by providing a fishway. Responsibility for the operation, inspection, maintenance, and repair of each fishway must be definitely assigned to responsible parties. In addition it is suggested that state fishery officials make at least an annual inspection and report on the condition of each fishway.

Provision for an adequate number of spawners:--In unobstructed streams suitable for alewives it is doubtful that many runs have been entirely destroyed by overfishing, but it appears certain that numbers of them have been kept at an unproductive level by failure to permit an adequate number of adults to spawn. If too few escape to the spawning grounds there will be insufficient young produced, but, on the other hand, if a very large number spawn the survival rate will undoubtedly be lower. Thus it is economically wasteful to permit either too few or too many spawners to lay their eggs. The number of spawners which, on the average, will serve the largest fishery is a problem to be solved for each stream, and can only be ascertained by careful records and observations over a number of years.

Since the conditions of survival vary somewhat from one river to another, one cannot assume that the proportion of the run that should be allowed to spawn in one stream is necessarily best for another. In the streams recently stocked, it may be possible in several instances to obtain accurate estimates of the number of adults surviving, which will yield some basis for calculating the proportion of spawners needed to maintain a run. However, these figures will be based on survival with a minimum number of adults. As a general rule the survival rates decrease as the population increases so that the number of spawners required as shown by this evidence may be insufficient to maintain a run that approaches the real capacity of the stream.

As accurate determination of the best number or proportion of adults needed for spawning is a complex matter, the solution of which requires accurate knowledge of catch and number of spawners over many years, it is impracticable to gather this information for each of the multitude of streams involved. It would be well worthwhile, however, to begin collecting data bearing on this problem for the chief alewife rivers.

Since no information exists on the actual number of spawners that have been permitted to ascend any of the alewife streams, the only course that can be followed at present is to attempt to assure an adequate number by following practices that have proved successful and by keeping accurate records of the catch and factors affecting it.

One practice that may be largely responsible for curtailing the number of spawners below the economic level is permitting weirs and seines to be fished in salt water in the narrow estuaries of some of the streams. These may take a heavy toll of the fish before they reach the stream, where they are then subjected to the regular town fishery. This practice is unfair to the town that tries to maintain a successful fishery, since it must maintain the fishways, operate them, and see that a fair proportion of the run escapes to spawn. So far as possible this double toll should be eliminated and the agency running the fishery should have full control of the catch.

The method used in taking the fish may have a considerable influence on the amount of escapement. In some of the smaller streams the fishways may be entirely closed on days when fishing is being done. If the fishways are then left open for the full 48 hours of Saturday and Sunday, as provided by state law, and no nets or other obstructions are used to hinder their ascent, fair escapements may result. However, this method has certain disadvantages. Alewives do not run steadily, but even during the height of the run may stop entering a stream for two or three days at a time if the weather turns cool. In order to be certain of sufficient escapement under the usual method of fishing in which the numbers permitted to pass are not accurately estimated, the fishways should be left open at all times. At Damariscotta the fishladder is a series of natural pools forming a stream that reenters the main stream below the dam. This side stream is always open and no fishing is permitted in it.

Probably the chief cause of overfishing is the leasing of a stream to a company or private individual. The best procedure is for the town to do the fishing, with proper regard for the brood stock, and then sell the fish taken.

The ideal situation would be to have all fish pass through the dipping pool. Then the town fish committee could let a certain proportion of the fish escape by releasing every third, fourth, or fifth poolful, throughout the run. By keeping careful records of the number of fish caught, it would be possible to estimate quite accurately the actual number of alewives permitted to spawn each year. After a number of years the committee would be able to estimate the best number of spawners for that stream. With this knowledge, the proportion allowed to spawn could be changed from year to year in accordance with the size of the run, so that a larger share could be caught from large runs and a smaller share from small runs.

RECOMMENDATIONS

The streams listed in table 8 should be made passable for alewives. Nine of the streams listed were stocked with alewives in 1943 and 3 of the remainder will require stocking to get runs reestablished. The streams are listed roughly in accordance with their apparent importance to the program, based on the spawning area to be made available, the volume of stream flow, and the probable relationship between the expense of the work and the size of the runs to be expected.

TABLE 8.--Recommendations for action on stream obstructions listed approximately in the order of their importance.[1]

Stream	Location of obstruction	Type	Approximate height (feet)	Lake area to be made accessible (acres)	Recommended action
Pemaquid R.	Bristol	Con. dam	12	[2] 2,753	Provide a fishway
Sheepscot R.	Head of Tide	Con. dam	12	[2] 2,311	Fishway
Tunk St.	Unionville	Log dam	8	[2] 3,047	Fishway
Patten St.	2 miles from mouth	Wood dam	6		Redesign and rebuild present fishway
	Outlet Lower Patten Pd.	Wood dam	5	1,102	Redesign and rebuild present fishway, repair leaks in wing dam.
Dyer R.	Outlet Dyer Long Pd.	Stone dam	4	576	Clear away remains of old dam
Saint George R.	Union Village	Log dam	4		Fishway
	Outlet Sennebec Pd.	Con. dam	12	602	Fishway
East Machias R.	Outlet Gardner Lake	Con. dam	10	5,584	Fishway
Pleasant R.	Columbia Falls	Wood dam	10	860	Modify ladder for alewives
Seal Cove Br.	Tremont	Old dam	3	[2] 315	Clear away remains
Denning Br.	Somesville	Stone dam	4	[2] 244	Fishway
Muscongus Br.	Outlet Webber Pd.	Boulders	Rapid	253	Clear streambed, construct pools
West Bay St.	Near Gouldsboro	Wood dam	7	[2] 300	Fishway
Carleton St.	Bluehill	Stone dam	6	[2] 411	Fishway
Winslow St.	Outlet Wight Pd.	Wood dam	6	[2] 125	Fishway
Medomak R.	Waldoboro	Log dam	6		Fishway
	Winslow Mills	Stone dam	10		Fishway
	Below Medomak Pd.	Stone dam	12		Fishway
	Below Medomak Pd.	Wood dam	5	[2] 320	Fishway
Passagassawaukeag R.	Holmes Mill	Con. dam	10	162	Fishway
	Poors Mill	Stone dam	7	122	Fishway
Royal R.	Yarmouth	Con. dam	7		Fishway
	Yarmouth	Stone dam	9	250	Fishway

[1] See text.
[2] Stocked with adult alewives in 1943.

The stocking program should be continued for four years in each stream selected for stocking in order to establish a run in every year of the alewive's four-year age cycle.

Someone should be given full responsibility for the operation and maintenance of each fishway. State fishery officials should make a detailed inspection and report on each fishway at least once a year. All fishways should be checked by a biologist during the up- and down-stream alewife migrations to determine their efficiency.

Accurate records of the catch should be obtained by the State for each stream at the close of the alewife fishing season.

To encourage adequate management by the towns controlling the alewife fisheries, the use of weirs and seines for the capture of alewives near the mouths of the rivers should be discouraged.

SUMMARY

The results of former alewife plantings, coupled with scale readings from three rivers, indicate that the age at maturity is probably four years in Maine and three years in southern Massachusetts. Thus the first returns from the 1943 Maine stocking are expected in 1947.

Analysis of the data from the survey of Maine streams shows that there is a high positive relationship between the size of the run to a stream and the acreage of lakes and ponds accessible for spawning and for the development of the young.

The chief factors limiting alewife production in Maine are impassable dams, poorly designed and maintained fishways, and overfishing.

Thirteen streams were stocked with 7,498 adult alewives during the 1943 run. Observations at West Harbor Creek indicate that the adults reproduced successfully.

Excluding the four larger rivers, the Androscoggin, Kennebec, Penobscot, and St. Croix, the survey showed 162,717 acres of lakes available on streams between Kittery and Calais. Of this total, 78,558 acres lie on seven streams with high power-dams and industrial developments that render it somewhat doubtful if the cost of making these streams suitable is justified for alewife fisheries alone. An additional 876 acres of lake area were found unsuitable and for 4,013 acres no information was obtained.

Of the remaining 79,270 acres of potential alewife lakes, only 28,932 acres, or 36.5 percent, on ten streams are supporting regular alewife fisheries. Runs that are not sufficiently abundant to be exploited commercially occur on 11 additional streams with 12,332 acres of lake area. The runs to seven of these streams, with 2,156 acres, can be improved by proper management, and, in some cases, by the modification of fishways and the removal of obstructions.

The 29,000 acres now producing good runs can be increased by 19,337 acres of suitable area, now wholly or largely inaccessible, by carrying out the recommendations for stream improvement listed in Table 8 in conjunction with a program of stocking for those streams that are now devoid of runs. An additional 837 acres of accessible area on four streams, from which alewives were eliminated by former obstructions, were restocked for the first year of the four year cycle in 1943. When the necessary stream improvements are made and the runs reestablished, the alewife spawning areas now supporting the regular commercial fisheries will be increased by 70 percent.

Production from alewife runs in Maine can be easily doubled by carrying out the suggestions embodied in this report in regard to fishways, natural obstructions, management methods to guarantee an adequate annual spawning stock, and by continuation of the stocking program.

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