THE SMELTS

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INTRODUCTION

From early youth the writer has been familiar with the smelt, and to him the little fish always has been of intense interest. Some years ago he became imbued with ambition to write a monograph on the smelts and smeltlike fishes of the world. Every opportunity was grasped for making collections and studying the habits of the fish and for compiling all available published information concerning them; but during the fleeting years there were so many more or less prolonged interruptions by other work in which smelts had no part that it became necessary to restrain the comprehensive ambition and restrict the proposition to a treatise concerning the smelts of the Atlantic only, and particularly to those of the eastern United States.

In the course of the studies it was somewhat surprising to find that almost nothing was known, or if known had not been published, concerning the habits and life history of the smelt. Extensive collections of smelts of the Atlantic coast and inland waters of the Eastern States were made, and hundreds of specimens were studied in detail in an effort to solve certain problems of relationship and the life history of the fish in the interest of the fisheries and fish culture. It is now believed that sufficient data are at hand to contribute substantially to the desired solution and knowledge. A report upon these phases of the subject is in preparation, but as that report will be somewhat technical in nature, and in view of the facts that so little is generally known concerning the smelt and such information as has been published is so scattered, often in brief notes, through many publications, it has been thought desirable to bring together in one publication available published and unpublished matter of more general interest. This the writer has attempted to do in the present paper.

As much as possible pertaining to the natural history of the smelt, based upon the scattered literature and occasional observations by the present writer, has been embodied in the discussions. A brief history of the smelt fishery has been included, but it may be regarded as almost "ancient history," for the reason that there are scarcely any data pertaining to the smelt fisheries in the last 10 years excepting in Canada. Fish-cultural propagation, depletion, and conservation also are subjects that receive some attention.

A list of publications consulted and quoted is appended In the text both direct and indirect quotations are credited to the author, when known, or to the publication in which the article quoted appears. Such credit references are indicated by the authority and the year of publication in parenthesis, which signifies that the full literary reference is to be found in the bibliography. If more than one publication by the same author appears in the same year, the second, third, or fourth are respectively indicated by *a*, *b*, *c*, etc., both in parenthesis and in the list of references.

While it is recognized that the discussions embodied in this document are incomplete and otherwise defective, it is hoped that those facts will stimulate effort directed toward the attainment of greatly needed further knowledge, and more intensive and intelligent measures and action toward the conservation of the fishery.

THE SMELT FAMILY

"Second cousin to the grayling and trout, and one of the neatest, most graceful, and delicate of all our food fishes, is that universal favorite, the smelt." Samuels (1904)

The smelts, with closely related forms, compose a group of fishes of wide geographical distribution in nothern latitudes. Their recorded distribution shows them inhabiting both coasts of the North Atlantic, both North Pacific and both Arctic coasts, or their coastal fresh waters, thus forming an irregular, interrupted, distributional belt that encircles the Northern Hemisphere.

Concerning most of these forms very little is known; and it was not until in comparatively recent years that any of them received any scientific attention beyond that of description of species and attempts at classification, which for the most part were based upon small numbers of museum specimens preserved in alcohol.

The full significance of these little fishes in the "scheme of nature" has not been recognized, although some of them for a long time have been locally of considerable commercial importance both directly and indirectly—directly as food for man and indirectly as natural food supply for fishes of greater commercial importance. In fact, in some localities the success of the cod fishery depends upon the seasonal presence of one of these forms—the capelin. While this is known to be true in connection with this particular species, it is not known how much the fishery for some other fishes of great commercial value may depend upon one or another of these little fishes.

For a time these fishes were regarded as members of the same family that included the salmon, trout, grayling, and whitefishes, but recently it has been shown that by virtue of certain distinctive structural characters they constitute a family group by themselves. While smelts are denominated as salmonoid (salmon like), structurally they are somewhat remote in relationship to the salmon or other members of the salmon family.

Wherever any species of these fishes occur they abound, or once abounded. E. A. Samuels once wrote (1904):

> Some idea of their abundance at this period [spawing time] may be had when I state that they are or were netted by the hundreds of barrels full and used by the farmers on the bay shore for manure; this was the case a number of years ago, but I believe the practice of using them in this manner has been abandoned for the more profitable one of packing them in cases and shipping them to the great markets of the country. This business has become a large, important and lucrative one; many packing stations having sprung up on the coast of Maine and the Maritime Provinces.

All or nearly all are essentially shore fishes, at least in their breeding seasons. None of them, so far as known, spawns in deep water. Some spawn in the surf along the shore, some among the seaweed in quiet water, others in brackish water, and still others, like all members of the salmon family, ascend fresh-water streams for breeding. It is during the breeding season only that some of them are caught; and in the instance previously mentioned of the dependence of the cod fishery upon one of the species, it is when the little fish are approaching the shore to spawn.

The genera comprised in the smelt family (Osmeridæ), according to Jordan's latest "Classification of Fishes" (1923), are principally the smelts (Osmerus), several species; capelin (Mallotus), 1 species; the eulachon (Thaleichthys), 1 species; and the surf smelts (Hypomesus), 2 or more species. The latter two genera are peculiar to the Pacific. The others are common (generically) to the Pacific, Arctic, and Atlantic. This paper is concerned only with the genus Osmerus, principally with the smelts of the Atlantic, and more particularly with those of the Atlantic coast of North America.

Opinions vary concerning the number of species of smelts comprised in the genus Osmerus. Whatever the number of species, they are all very closely related and not easily distinguished at a glance. Mary Fisk (1913) recognizes three species on the California coast—*Osmerus thaleichthys*, *O. attenuatus*, and *O. starksi*. The most northern of the Pacific smelts and the one most closely related to the Atlantic forms is technically known as *Osmerus dentex*. Besides these is the little known *O. albatrossis*, Jordan and Gilbert, for which Jordan (1919) made the new genus Eperlanoi. Smelts that have been identified as this species have been caught at Point Barrow, Alaska, at the mouth of the Mackenzie River, and on the northern coast of Siberia. A later classification (Hubbs, 1925) causes the genus Spirinchus (Jordan and Evermann, 1896, p. 522) to comprise *O. thaleichthys* and *O. starksi*, and he makes a new genus, Allosmerus, for *O. attenuatus*. This arrangement leaves *O. dentex* as the only species of Osmerus on the Pacific coast.

There are, or have been, ichthyologists who regard the smelt of both sides of the Atlantic as specifically identical and identical with the above-mentioned *O. dentex*. Futhermore, both in northern Europe and eastern North America there are smelts permanently resident in fresh-water lakes. As a rule, these also have been considered as specifically indistinguishable from the marine smelt. Thus Smitt (1895) does not distinguish between the smelts of certain lakes of Sweden and smelts of the Baltic, although he recognizes and shows that the Arctic-European smelt (Murman and White Seas) noticeably differs from the common smelt of Sweden.

In this country smelts from two lakes in Maine were long ago described and named as specifically different from the marine smelt and also from a fresh-water smelt from another Maine lake. Years ago Foster and Atkins (1868) suggested that there might be many distinct species in the fresh-water lakes of Maine. Aiming at a solution of this question, hundreds of smelts have been studied by the present writer, and a great many data remain to be analyzed. This is reserved for a future paper. Herein the marine and fresh-water smelts are discussed separately but in a very general way.

ATLANTIC MARINE SMELTS

RANGE

Smelt of one species or another occur on both Atlantic coasts. In Europe they range from England and France northward to the White Sea; in North America they are recorded from the Delaware River to the Gulf of St. Lawrence. Bloch (1796) wrote that the salt-water smelt lives in the depths of the North and the Baltic Seas, whence it leaves and appears upon the coasts in November, December, and January. Pennant (1776) said that it inhabits the seas of Europe, but he believed it never was found as far south as the Mediterranean. The Seine is mentioned as one of the French rivers inhabited by it, but he could not authoritatively say that it occurs south of that stream. He said that it inhabits the littoral waters of the British Isles throughout the year, never going very far from the shores except when it ascends the rivers. Reuter (1883) says that it is met with in the White Sea but not on the coast of the Arctic Ocean; at Hogland and around Kokar it is rarely met with, but it is to be found in Sweden, southern Norway, Denmark, and northern Germany, and along the coasts of the North Sea. He said it is found very seldom

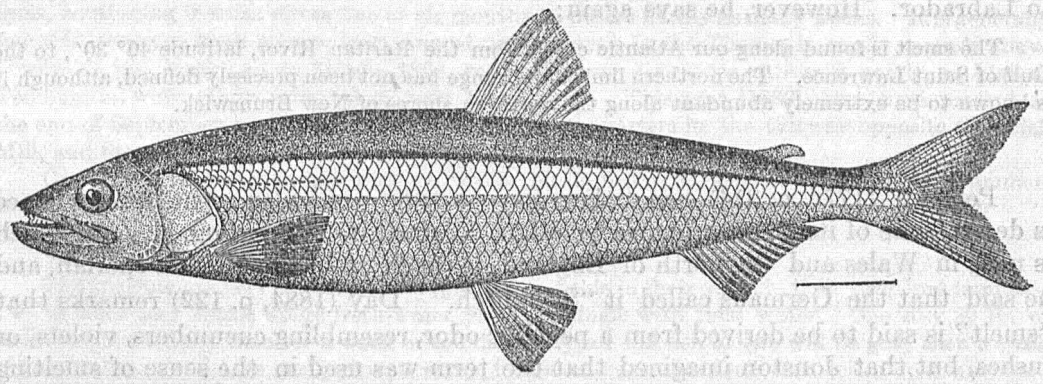

FIG. 1.—Eastern smelt, *Osmerus mordax* (Mitch.) Gill.

on the west coast of Sweden and not at all on that of Norway. Smitt (1895, p. 872) states that generally speaking the smelt is confined to a zone comprised between the fortieth and sixtieth degrees of latitude. He mentions, however, that in the Baltic it is found up to the head of the Gulf of Bothnia. He wrote:

> South of France it is unknown, and it is not common south of the northwest of that country; but from this region, including the British Isles and the Continent, up to the southeast of Norway, throughout the greater part of Sweden, in Finland, and in Russia, it occurs, and in suitable localities is common, within the basins of the North Sea and the Baltic.

Goode (1884) says that it is found in southern Sweden as far north as the Christiania Fjord district, latitude 62°, and south as far as the entrance to the Loire, latitude 47°, ascending the Seine as far as Rouen; also that it is found in the Baltic, and entering the Gulf of Finland becomes a member of the fauna of Russia.

Cunningham (1896) states that it is found in the Thames and Medway but not on the southern coast—for example Plymouth—where a fish belonging to a different family is called a smelt. He says that it is found in the Firth and the Tay, the rivers entering the Solway, the Dee, and the Mersey, but that it is not known to

occur in the rivers of Ireland. Regan (1911) gives its range as southward on the British coasts as far as Hampshire and North Wales, and says that it probably occurs also on the northern coasts of Ireland. Meek (1916) regards the Baltic as evidently a self-contained area, as no smelt are obtained in the sound, and says that like the grayling the smelt is absent from Ireland.

According to Gaimard (1851) the smelt occurs on the coasts of Iceland, but Faber (1829) does not mention it and Sæmundsson (1908) says that its occurrence in Iceland is very doubtful.

On the Atlantic coast of North America the range of the common smelt has been said to extend as far south as Virginia (Goode, 1884). Norris (1862) records it from below Fairmount Dam in the Schuylkill, and in 1868 from the Brandywine below the dam at the head of tidewater as well as at the foot of rapid water at Trenton in March, "appearing for a short time before spawning and apparently only for that purpose"; but it is not now known south of New Jersey. From there it becomes progressively more common as far north as the Gulf of St. Lawrence, but there appears to be no definite record of it from Labrador and northward, although Goode (1884, p. 543) gives the general distribution of the American form as from Virginia to Labrador. However, he says again:

> The smelt is found along our Atlantic coast from the Raritan River, latitude 40° 30′, to the Gulf of Saint Lawrence. The northern limit of its range has not been precisely defined, although it is known to be extremely abundant along the northern shores of New Brunswick.

VERNACULAR NAMES

Pennant (1776, p. 314) says "they have a very particular scent, from whence is derived one of its English names 'smelt,' i. e., smell it." Sparling, he says, which is used in Wales and the north of England, is taken from the French éperlan, and he said that the Germans called it "Stinkfisch." Day (1884, p. 122) remarks that "smelt" is said to be derived from a peculiar odor, resembling cucumbers, violets, or rushes, but that Jonston imagined that the term was used in the sense of smelting metals and was derived from the transparent appearance of the fish, as if it were going to melt away. However, according to Regan (1911), it has been wrongly said to take its name from its odor, which is commonly stated to resemble that of cucumbers and is sometimes quite strong, but there can be little doubt that the word "smelt" is from the Anglo-Saxon "smeolt," signifying smooth and shining. Regan also says that the name "sparling" is the equivalent of the German "Spierling" and the French "éperlan," the old French being "esperlan."

On our Atlantic coast the fish is known everywhere as smelt. There are other fishes, however, not at all closely related, that are known locally as smelts. Thus, a minnow in the Potomac is called smelt. Usually, however, there is some prefix or nominal attribute to distinguish such fishes from the true smelt. For instance, the common silverside (Menidia) is sometimes called "sand smelt." The name "frostfish" has been applied to it locally, and the smelt of Lake Champlain is referred to commonly as "icefish."

In Europe each country, naturally, has its peculiar names for the fish. In "Fauna Svecica," Linnæus (1746) stated that there were two varieties, the larger being known as "slom," which has no bad odor, and the smaller, of bad smell, being called

"Nors." Bloch (1796) wrote that it is called "Stint," "Seestint," and "grosser Stint" in Germany.

Goode (1884) says that the smelt is the Stint or Sparling of Germany, the smelt or sparling of England, and the spiering or spearling of Holland. Hoek (1904) lists the names used in Europe as follows: Smælt (Denmark), Norssi and knore (Finland), spiering (Holland), éperlan (France), Nors (Sweden and Norway), and korjuschka (Russia).

HABITAT

The marine smelt of the western Atlantic, and probably of Europe also, is of far greater commerical importance than the fresh-water smelt. It is essentially a shore fish that apparently varies its habitat to only a limited degree, and that variation is largely in accordance with the variation in habits of the various ages of the fish, which itself is detemined largely by the different requirements pertaining to food, food supply, and other conditions of self-preservation. Day (1884, p. 122) says of it:

> A gregarious and voracious species, remaining with us throughout the year, and passing a portion of each season in fresh, and the remainder, as a rule, in salt water, but irregular in its migrations, continuing in some rivers five or six months, in others hardly as many weeks. It is generally found in rivers or fresh waters, from August until May. In the Thames it rarely ascends above Woolwich, but Buckland in March, 1868, received three live ones captured nearly as high as Teddington, while others were taken near Kew Bridge. This year [1882] some were present at the end of September, and had selected their spawning quarters in the tideway opposite Chiswick Mill, and Strand-on-the-Green.
>
> One fully 9 inches long was captured while bleak fishing at Wooden-bridge-creek, Hammersmith. It drives the dace before it, these latter fish ascending to Richmond, Isleworth, etc.

In another place (p. 123) he wrote:

> The sparling are very uncertain and apparently fickle in their visits to their supposed haunts—i. e., in holes near rocks, where fresh-water streams mingle with tidal water. One day 20 lb. or 30 lb. may be taken; then for a week or ten days only an odd fish or two will be got; then a week of good takes. They are easily driven away, for on one occasion some men left a boat anchored in a hole to reserve the right of first draw. Whilst that boat remained there no sparling rested in the hole, but when it was removed they returned to their haunt.

Smitt (1895, p. 873) says:

> As the spawning-season approaches, it assembles in large and dense shoals; but at other times it leads a more solitary life, being frequently taken in the herring-nets used in the Baltic, but not in any great number.

This may be true of the European smelt, but it is well known that in this country smelts occur in large schools in the fall of the year during the fishing season. Young smelts appear always to be in schools. However, if opinion were based upon the number of smelts taken in the herring weirs in the sardine fishery of Maine perhaps the same conclusion would be reached as in the case of the Swedish smelt. Perhaps if they were fished for in the Baltic as in Maine, for instance, they would be taken in greater numbers.

Nordqvist (1910) states that in the Gulfs of Finland and Bothnia the smelt lives all winter in brackish water, chiefly at depths of 15 to 16 fathoms, but that near Helsingfors the large smelts occur at depths of 17 to 18 fathoms, and the smaller fish at depths of 8 to 9 fathoms.

While other factors are concerned, temperature of the water appears to influence the local distribution and movements of the smelt to some extent, as well as do the tides and character of the shores. The exact extent of these influences is not known. It is known that certain localities are frequented by smelts throughout the year, while other localities are devoid of them at all times. These facts appear to be determined by natural conditions.

In some localities the presence of smelt is a seasonal phenomenon—that is, adult smelts are apparently absent during the summer but appear in the fall and remain until spring. In this connection the following quotation from the Fishing Gazette for February 1, 1925 (p. 3) is of interest.

> The size of smelt that have been frequenting the waters of the Ipswich River for a number of days past has not only been unusally large, but the fish run quite uniform in size, and as is to be expected at this season of the year, many of the female species are filled with spawn. It is probably in this latter phase of the situation that the answer may be found as to the reason why the fish are now in the river, and such being the case, when the fish disappear they may make their exit over night. Some of the experienced fishermen at the "shore" part of the town, hold to the theory that the recent dredging of the river has provided deeper water way for the fish to follow on a journey to the upper waters of the Ipswich River.

SIZE

The American smelt is known sometimes to attain a length of 13 or 14 inches, although such sizes are not common, and smelts from 10 to 12 inches long are regarded as exceptionally large fish. The average length of smelts selected for their large size probably would not exceed 9 or 10 inches. The general average of the most common smelt may be inferred from the following: Fish obtained in the Washington market in December and said to have come from Portland, Me., averaged six to the pound, ranged from 7.5 to 8.75 inches in length, and averaged 8.1 inches. A lot from New Brunswick average eight to the pound and ranged in length from 6 to 8 inches, averaging about 7.14 inches.

Storer (1858) states that the largest individuals he had ever seen in Massachusetts were taken in Milton River in the latter part of December, 1837. Four specimens taken without regard to size weighed 1½ pounds. According to the Maine Sportsman for January, 1896 (p. 19), "Peaks Island fisherman caught a remarkably large smelt the other day in Casco Bay (Maine). The average weight of these little fish is less than two ounces, and this one weighed but half an ounce less than half a pound."

According to Atkins's notes (made in 1871), two spent smelts obtained at Verona Island, about 9 and 9.35 inches long, respectively, weighed 3.4 and 4.3 ounces.

At Eastport, Me., 18 smelts seined on a sand beach on July 31, 1893, ranged in total length from 7 to 10.5 inches. On August 23, 1893, at Harbour de Lute, Campobello Island, New Brunswick, 14 smelts seined on a gravel beach ranged from 7 to 9 inches in total length.

The following figures represent the sizes of smelts as obtained from commercial fishermen of Maine in various years. They are arranged in sequence of months, however, rather than of years. Those from Casco Bay were obtained from weir fishermen, probably after the larger or marketable sizes had been removed from the catch.

Those from Dennysville and Millbridge were just as they came from the weirs. The sexes are shown separately but many of those designated as males were immature and perhaps uncertain.

Locality	Date	Sex	Number of individuals	Range in size, inches	Approximate average
Casco Bay, Me.	Sept. 9, 1915	Male	26	4 - 5.2	4.7
		Female	6	4.5 - 5	4.8
Do	Oct. 2, 1908	Male	15	4.16- 5.5	4.8
		Female	12	5 - 6	5.37
Do	Oct. 31, 1907	Male	97	3.7 - 6.2	5
		do	59	4.75- 7.7	6
		Female	81	5 - 7.16	6.1
		do	4	5.3 - 5.8	5.4
Do	Nov., 1907	Male	50	4.5 - 6	5.12
		do	11	4.8 - 5.75	5.3
		Female	14	5 - 5.75	5.38
		do	4	5.3 - 6	5.75
Dennysville, Me.	Nov. 6, 1915	Male[1]		4.8 - 6.75	5.7
		Female	30	5.2 - 8	6
Millbridge, Me.	Dec., 1915	Male	128	3.8 - 7	5.6
		Female	38	4.6 - 6.5	5.6

[1] Immature specimens thought to be males.

Smelts bought in the market at Freeport, Me., on October 24, 1903, averaged 14 to the pound. Among them was one of 10 inches total length, not counted in the average.

For comparison with the foregoing sizes, the total lengths of breeding fish taken in a brook flowing into an arm of Casco Bay (at Freeport, Me.) are given as follows:

Date	Sex	Number of individuals	Range in size, inches	Approximate average	Date	Sex	Number of individuals	Range in size, inches	Approximate average
Apr. 20, 1903	Male	6	6 - 6.5	6.2	Apr. 9, 1925	Male	30	5.9 - 6.9	6.68
	Female	6	5.7 - 7.7	6.7		Female	10	6.2 - 9.2	8
Apr. 12, 1924	Male	101	6 - 8	7.12	Apr. 10, 1925	Male	43	5.7 - 7.1	6.5
	Female	4	7.2 - 7.8	7.5		Female	32	6.3 -10.4	8
Apr. 13, 1924	Male	249	5.75- 8.87	6.66	Apr. 16, 1925	Male	122	5.5 - 7.5	6.25
	Female	17	6.4 - 7.8	7.33		Female	55	5.9 -10.25	7.14
Apr. 28, 1924	Male	23	6.4 - 8	7	Apr. 21, 1925	Male	23	5.65- 8	6.4
	Female	14	7.38-10	7.7		Female	10	6.3 -10	7.4
Apr. 29, 1924	Male	8	6.3 - 7.33	6.9	Apr. 22, 1925	Male	74	5.85- 8.35	6.5
	Female	6	6.66- 8.75	7.25		Female	45	5.9 - 8.75	6.75
Apr. 30, 1924	Male	10	6 - 6.5	6.33	Apr. 23, 1925	Male	45	5.8 - 8.1	6.4
	Female	26	6.2 -10	8.5		Female	30	5.95- 9.2	6.9
May 5, 1924[1]	Male	80	6.3 - 7.8	6.8	Apr. 29, 1925	Male	15	6 - 8	6.7
Apr. 1, 1925	Do	13	6.2 - 8.7	7+		Female	10	6.25- 9	7.1
	Female	1	10.4		May 1, 1925	Male	16	5.9 - 6.9	6.3
Apr. 2, 1925	Male	45	6.2 - 8.15	7.18		Female	15	6 -10.15	7.4
	Female	21	5.15- 9.3	7	May 2, 1925	Male	25	5.5 - 7	6.3
						Female	35	5.5 -10	6.9

[1] Among 105 smelts taken only 1 female was found. Its total length was 7.2 inches.

FOOD

Writing of the Swedish smelt, Smitt (1895, p. 872) said:

It is a voracious fish of prey—which which may easily be seen by its teeth—and its form of body indicates no lack of agility. * * *. It feeds principally on fish, small or large—at least up to half its own size—and especially on herring fry and the young of its own species. Other kinds of food, however, such as crustaceans (shrimps and Gammaroids), worms, and larvæ, do not come amiss.

In the Gulf of Finland, according to Nordqvist (1910), adult smelts subsist largely upon mysids (*Mysis relicta*, *M. mixta*, and *Neomysis vulgaris*), but that they also eat little pelagic crustaceans, especially *Euytemora herundoides*, which form the principal food of young smelts. Although bottom crustaceans, such as *Pontoporeia affinis*, and other gammarids are stated to be only rarely found in the stomachs of smelts, *Idotea entemon* is mentioned as smelt food.

Day (1884) says that it appears to be particularly partial to small fish and shrimp, and cites an instance of a "sparling" having been opened as soon as it was taken out of the net which was found to contain herring fry. Cunningham (1896) says that the English smelt feeds on small fish and Crustacea. Regan (1911) regards it as a "greedy fish of prey, feeding on small fishes, shrimps, worms, etc."

At a meeting of the Academy of Natural Sciences of Philadelphia Norris (1868) presented a vial containing the stomach contents of a smelt, comprising three shrimp, one small fry of some fish, and a half dozen fish ova "not quite as large as those of our brook trout." He said that the ova had made no progress in the process of incubation, from which he inferred that they had been seized by the smelt as soon as or not long after they were deposited by the parent fish.

As indicated by our own observations, the larger individuals subsist largely upon crustaceans such as various shrimp and shrimplike forms, amphipods, etc., as well as small fishes such as young killifishes, sand eels, etc., much depending upon what the other conditions that affect their habits render available.

Numerous smelts seined at Saltworks Beach, Eastport, Me., on July 27, 1893, had their stomachs distended with crustaceans locally known as shrimp (Thysanopoda). Again, on July 31 and August 1, 91 specimens seined in the same place as the above, measuring in length from 6 to 10 inches, with one specimen 13 inches long, were found to contain mostly the previously mentioned shrimplike crustaceans (Thysanopoda) and scuds (amphipods—Gammarus). One individual had in its stomach one young stickleback (Gasterosteus) and some phosphorescent material.

In the same year (1893) smelts collected at Freeport, Me., gave the following data: On November 8 nine smelts 6 to 7.5 inches long had their stomachs distended with young killifishes (*Fundulus heteroclitus*) and a few shrimp (*Crangon vulgaris*). On November 9 seventeen specimens 5.5 to 7 inches long contained killifishes and shrimp. On November 10 seven smelts had their stomachs distended with killifishes and a few shrimp (Crangon) and scuds (Gammarus). On November 13 seven smelts contained killifishes, shrimp, and scuds. On October 24, 1903, nine female smelts taken in Casco Bay were mostly empty, but a few contained shrimp (Crangon).

Smelts taken at Dennysville, Me., on November 5, 1915, had their stomachs full of Thysanopoda. One was distended with scuds (Gammarus) and one contained a young alewife a little over 2 inches long.

The food of the very young smelt is composed of minute organisms technically called "plankton," consisting mainly of small crustaceans usually referred to as Entomostraca. In the first feeding stages the food necessarily is microscopic in size, but the fish rapidly attains a size that permits it to feed upon larger entomostracan forms.

The following notes were made by Prof. A. A. Doolittle, of the Central High School, Washington, D. C., in an unpublished report to the Bureau of Fisheries:

Four lots of smelts from 2.6 to about 4.7 inches in length were taken from the salt water of Harraseeket River, Freeport, Me., in the years 1900, 1907, and 1908. The fish taken in August, 1900, had no food in the alimentary tract. Those taken in October had two small shrimp, two fish, and large fish eggs. The collections of 1907 and 1908 were made in late October and early November, and the 12 specimens examined all had fed upon Entomostraca and 4 species of Copepoda, averaging 150 Entomostraca each. A few small shrimps (averaging two-thirds of a shrimp each) supplemented the diet.

A collection of smelts made in the "eel pond" at Woods Hole, Mass., in mid-July showed that three out of five smelts of from 4.9 to a little over 8 inches in length had food in their stomachs. They had eaten in all 46 Entomostraca, amphipods, annelids, and gastropods.

In salt water smelts feed upon Entomostraca to an extent sufficient to state that they are staple, but they are frequently supplemented by considerable miscellaneous food, such as small decapods, amphipods, gastropods, annelids, fish, and fish eggs. Only those taken after the 15th of October showed any considerable amount of food, which was then entomostracan.

Stomach contents of smelts taken from the salt water of the Harraseeket River, Freeport, Me., and the eel pond at Woods Hole, Mass.

Locality	Date	Length		Number of fish examined	Number of fish eating Entomostraca	Number of Entomostraca eaten	Miscellaneous food eaten
		Millimeters	Inches				
Harraseeket River, Freeport, Me.	Aug. 11, 1900	120	4.7	1	0	0	
	Oct. 6, 1900	122-250	4.8 -9.8	5	0	0	2 shrimp, 2 fish, fish eggs.
	Nov. 4, 1907	68-90	2.7 -3.5	6	6	1,030	
	Oct. 27, 1908	70-90	2.75-3.5	6	6	775	8 shrimp.
Woods Hole, Mass., eel pond.	July 19, 1912	133-160	5.2 -6.3	5	3	46	Crab larvæ, amphipods, gastropods, annelids.

Of 127 smelts caught in Harraseeket River, Freeport, Me., between October 2 and November 20, 1925, 34 had no food in their stomachs, but there was more or less dark-colored unidentifiable material in some of the intestines. All but the 35 specimens of November 12 were taken at night. This lot was seined in the afternoon at first of flood tide. The organisms eaten consisted of a species of isopod crustacean related to the common sow bug (*Idotea irrorata*); a species of mysis or a small shrimplike crustacean (*Mysis stenolepsis*); the common shrimp (*Crangon vulgaris*); small amphipods locally called "sea fleas" and sand hoppers (*Orchestia agilis* and Gammarus sp.); an annelid commonly called clam worm (*Nereis virens*); a mummichog commonly called minnow (*Fundulus heteroclitus*); and a silverside, in this region incorrectly called capelin (*Menidia notata*). One smelt about 7⅔ inches long contained a somewhat folded piece of eelgrass (Zostera), which when extended measured about $3\frac{3}{16}$ inches in length. Another smelt 8⅞ inches long contained 20 isopods of various sizes, besides two shrimp.

Of 127 smelts caught in the same place as shown in the preceding table, between October 6 and November 21, 1926, 21 had no food in their stomachs; but the intestines of most of them contained remains of crustaceans and unidentifiable refuse. The fish were seined at night. The species represented are the same as those of 1925,

excepting possibly some of the amphipods. The crustaceans of November 20 were mostly young.

The following table shows the foregoing in detail:

Stomach contents of smelts taken from salt water of Harraseeket River, Freeport, Me.

Date	Number of smelts examined	Length in inches	Stomach contents														
			Number of smelts containing—								Number of each organism contained—						
			Nothing	Isopods	Mysis	Shrimp	Amphipods	Worms	Minnow	Silversides	Isopods	Mysis	Shrimp	Amphipods	Worms	Minnow	Silversides
1925																	
Oct. 2-3	22	6.18- 9.0	11	6	1	4	2	1	0	0	10	1	4	3	1	0	0
Oct. 22-23	21	6.4 -10.4	2	11	5	7	0	0	2	3	32	11	11	0	0	2	3
Oct. 29-30	28	5.35- 8.5	6	3	16	12	0	0	0	1	23	16	16	0	0	0	3
Nov. 12	35	5.47- 8.7	15	9	6	4	0	0	0	2	55	4	4	0	0	0	0
Nov. 19-20	21	7.0 - 8.4	0	14	14	10	0	0	0	0	29	10	10	0	0	0	0
1926																	
Oct. 7	16	5.8 -10.0	9	7	0	4	0	0	0	0	7	0	4	0	0	0	0
Oct. 11	15	7.12- 8.5	2	16	3	10	1	0	0	0	17	3	10	1	0	0	0
Oct. 22	47	5.9 - 9.25	2	8	11	29	2	0	0	8	16	18	62	30	0	0	10
Nov. 2	21	5.9 - 8.66	8	6	1	9	0	0	0	1	33	(?)	12	0	0	0	1
Nov. 20	28	5.8 -10.4	0	9	23	20	25	0	0	0	16	120	72	234	0	0	0

BREEDING HABITS

Season.—Concerning the spawning season of the European smelt, Bloch (1796) states that it occurs in March, when they arrive in great numbers and deposit their eggs upon the bare rocks. Pennant (1776) says that they appear long before they spawn and are taken in great abundance in November, December, and January in the Thames and Dee, but in other rivers not until February, and in March and April they spawn; after which they all return to salt water and are not seen in the rivers until the next season. In a footnote he indicated that in the rivers Conway and Mersey the smelts never continue spawning more than 3 or 4 weeks. It was observed that they never entered the Mersey as long as there was any snow water in the river.

According to Yarrell (1836) the British smelt repairs to fresh or brackish water and remains there from August to May. Day (1884) stated that Lubbock observed migrations of roach and dace in the Thames, fleeing from smelts that regularly ascend the river in spring to spawn and only stop their upward course at some insurmountable barrier.

Cunningham (1896) says the smelt spawns in March, April, and May, ascending to near the limit of the rise of the tide, where the water is fresh or nearly so. In the Forth it spawns annually just below Stirling, where Cunningham said he had taken the eggs and fertilized them artificially.

Boulenger (1904) states that the smelt breeds in salt water, and although it often enters rivers it does not ascend beyond tidal influences.

Regan (1911) says that in the early spring the smelt assemble in shoals and ascend the rivers to spawn, in some localities not going farther than tidal waters for this purpose, but in others pushing up well beyond. He also states that spawning

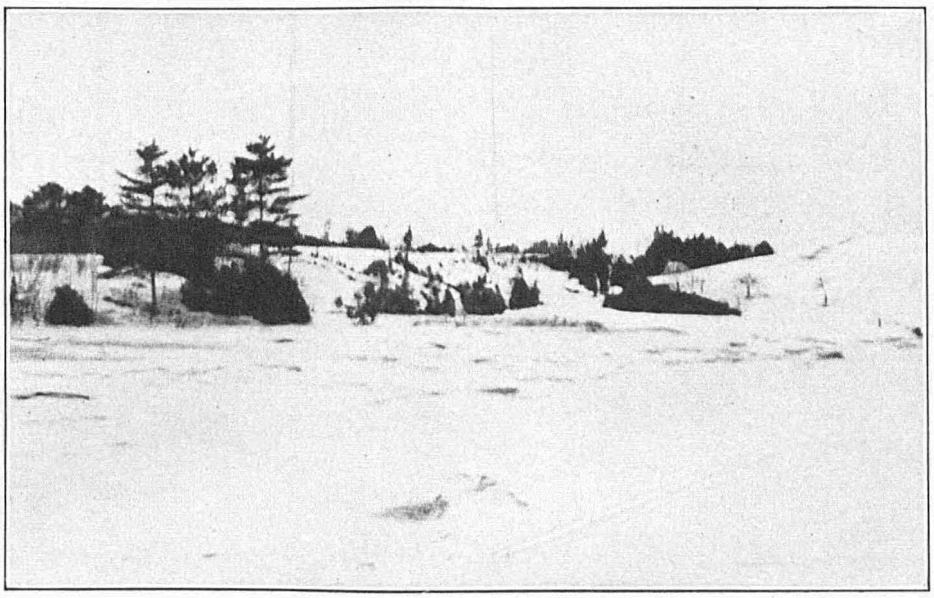

FIG. 2.—Upper portion of tidal creek (Porters Landing, Freeport, Me., smelt brook), looking upstream from near Porters Landing bridge, in early spring just before (about two weeks) breaking up of the ice

FIG. 3.—Porters Landing smelt brook (Freeport, Me.), a short distance below mean high tide limit, in spring just before (about two weeks) breaking up of the ice

FIG. 4.—Porters Landing smelt brook (Freeport, Me.) just below mean high tide limit. W. C. Kendall taking temperature on the "rips," where during the smelt run many smelts are picked up by hand

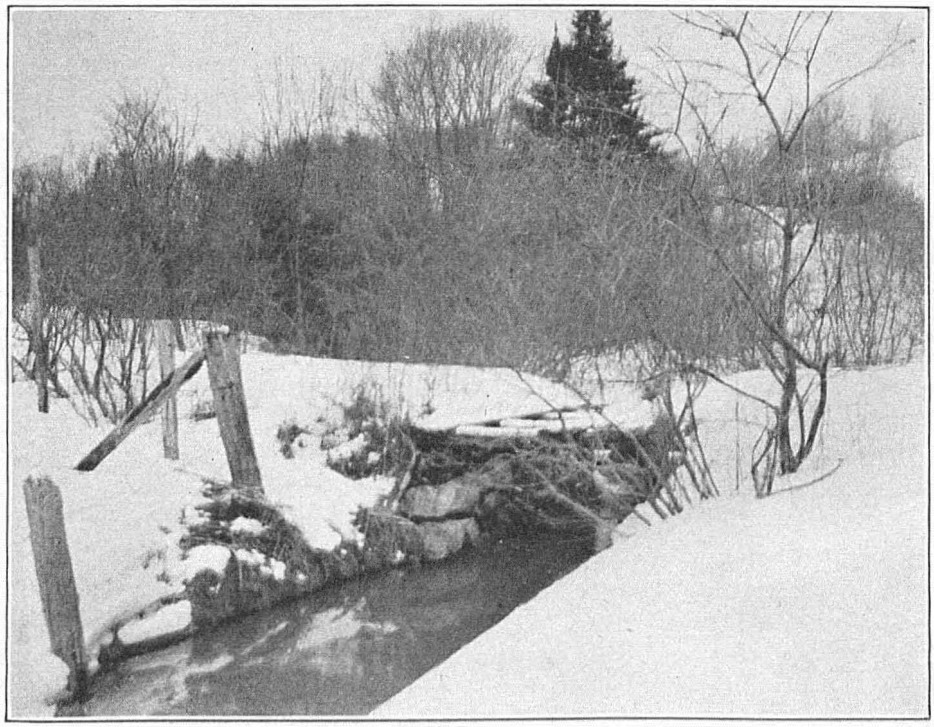

FIG. 5.—Porters Landing smelt brook just below the remains of the bridge shown in Figure 4. Extremely high tides reach this point. Taken in the early spring about 2½ weeks before breaking up of ice

usually takes place from March to May, "when the fish crowd together in dense array and the eggs are shed."

Meek (1916, p. 140) writes that the smelt migrates into estuaries in the early winter, the young shoals appearing first. The mature fish ascend the estuaries in the spring as far as fresh water to spawn. Meek cites Masterman's statement that the breeding season for the smelt in the Wash district in England is end of February to the beginning of April. The spawning time in the River Ouse (in England), according to Charles W. Harding (1882, p. 428) in a letter to Prof. Spencer F. Baird, extends from April to the beginning of June.

Smitt (1895, p. 873) says: "It is a migratory fish like the salmons, though not in so high a degree, roving at the spawning-season from salt water to fresh, or, in the lakes, from deep water to the shallows." He mentions that in the Norrstrom off Stockholm, Sweden, a female 196 millimeters long (7.7 inches) and a male 188 millimeters long (7.4 inches), both quite ready to spawn, were taken on the 4th of November, 1892; but as a rule "the smelt does not muster in Sweden for its breeding expeditions until the end of March or even later." He says that Ekström wrote: "In March or April, according to the earlier or later breaking up of the ice, the smelt ascends to rivers, straits, or shores where there is some current."

Johansen and Løfting (1919, p. 134) say that the smelt spawns in the main stream of the lower Gudenaa between Frisenvold and Langaa in March and April, and that in these months large shoals of ripe smelts coming from the Randers Fjord enter the Gudenaa, and they seem to return shortly after spawning, always choosing water of some depth with clear, sandy bottom. It generally rises toward evening and continues its journey the whole night, but at daybreak again retires for the most part to deep water. A remarkable circumstance is that whereas all other fishes prefer to spawn in fine weather the smelt is just the reverse. In squally and snowy weather it is most eager in its ascent, the violent gusts of wind and snow that occur then being known as *nors-il* (smelt squalls). Males and females swim in company during the spawning and are so densely massed that they seem merely to rub their bodies together in order to rid themselves of the roe, which is deposited on the bottom beneath. Smitt says that the young start first, but do not ascend so far up the rivers as the older fish, and often spawn in the lakes [1] on shallow shores. Ekström's account (1895) is the most complete of any known to us concerning the spawning migrations of the European smelt.

There is not much more published concerning the breeding habits of the American marine smelt. Norris (1868, p. 94), referring to the smelt that he had announced as a new species under the name of *Osmerus sergeanti* and the northern smelt, said:

> In observing the habits of both species above referred to I have found them to go to the head of tide, but no further, for the purpose of spawning. This occurs as soon as the rivers are free from ice in the Spring.

Goode (1884, p. 543) says:

> The smelt enters our rivers and brackish bays during the winter months for the purpose of spawning, and at this period is caught in immense quantities in nets and by hook and line.

[1] Both Smitt and Ekström appear not to distiguish between the marine and the fresh-water smelt.

Goode apparently had no definite information concerning the actual spawning season, for he further remarks:

> It is to be regretted that no one has made careful observations upon the beginning and close of the breeding season of this species at different points along the coast, but the spawn appears to be deposited, generally, late in the winter and early in the spring.

In general it may be said that for breeding purposes our smelt ascends freshwater streams variably from late in March until early in May, and farther north the season may extend into June. The streams ascended may be of any size, from the smallest rivulet to a great river, although in the latter it is probable that they divert themselves into smaller tributaries for spawning. This is known to be the case in a few instances at least.

Samuels (1904) says:

> Along the Massachusetts coast and thence north and east the fish enter the brooks and small streams in immense numbers. The spawning season varies with the degree of latitude, beginning almost with the breaking up of the ice in very early spring in Massachusetts, and becoming later in Maine and Nova Scotia, the fish entering the streams that empty into Margarets Bay, N. S., early in May, while in the rivers which flow into the Bay Chaleur quite late in that month, incredible numbers ascend the Jacquet and other rivers as late as May 20 or 25.

It is probable that all along the coast the first runs of smelts follow the clearing of the streams of ice and abatement of freshets—in other words, as soon as the streams become suitable—the successively late appearance of smelts being correlated with the successively later breaking up of the ice northward. The streams are not ascended until clear of ice and turbid or snow water, but the fish appear to congregate near the outlet of the streams in salt water or tidal creeks.

The local seasonal variations that affect the time of their ascent may differ in different years. Meek (1916, p. 140) said of the European smelt: "It has been observed that the migration takes place at night at the surface, the shoal retiring from the surface during the day."

In the case of the American smelt there appear to be no published observations on this fact. It is known that the smelt runs take place at night and always during ebb tide, according to the present writer's observations. Ehrenbaum (1894) says that the smelt of the Elbe presents itself in tne spring in very large numbers in the brackish and salt water to spawn in fresh water. If the British smelt spawns in salt or brackish water, it is contary to all known habits of the fish on this side of the ocean; and it would seem that the smelt of northern Europe spawns in fresh water.

Atkins stated in his notes that on May 25, 1877, he collected 53 eggs that he found attached to stones, sticks, and weeds, of which 22 were imuregnated and 12 were white. He said that most of these were attached to green seaweed, and none of them were found above high-water mark, where the water must have been pretty salt when the tide was in, yet the eggs developed. He also observed that those low down among the seaweed were twice as large as those taken near high-water mark. He stated that the eggs were in various stages of growth, from early appearance of trunk of the embryo to black eyes. Where the eggs were found were sundry marine organisms, such as amphipods, isopods, etc.

In Brunswick, Me., a brook flows into "Maquoit Bay," an estuary of Casco Bay. This brook flows over a ledge at high-water limit, making a waterfall that smelts can not surmount. Below the fall, at low water, is a long channel of virtually fresh water that the smelt ascend at the spawning time as far as the falls. It is probable that they spawn at the foot of the falls, notwithstanding the fact that on flood tide and during high water the water must be fairly salt. However, the smelts undoubtedly spawn in fresh water, and as there is a longer period of fresh and slightly brackish water than of the salt water it may be that the salt water has no deleterious effect upon the eggs. As a rule, however, as previously stated, the smelts ascend to fresh water to spawn, and it is more than probable that the eggs would not develop in salt water or even strongly brackish water if at first subjected to such conditions.

It is not impossible that smelts sometimes spawn in the tidal portions of creeks where conditions of bottom are suitable. As the smelt run up the brooks on ebb tide, the tide having left the creek with a stream of fresh water in the channel, the smelts coming in on the late ebb may deposit their spawn in that section, particularly if shoals or other obstructions, impassable by smelts, are left by the receding water. The upper tidal portions of such creeks are subjected to salt water for a brief period at high tide.

Thomas (1876) says that in the creeks of Long Island smelts were found "in perfect condition" from Febuary 20 to March 20.

In 1878 the Massachuetts law provided a closed season for smelts from the 15th of March to the 1st of June. In that year a correspondent of Forest and Stream ("Memoir" 1878), writing from Medford under date of March 23, said:

> Smelts have returned to their spawning beds at an earlier date and in larger numbers than heretofore. * * * During the unusually warm weather of the first of the month they made their appearance in large and goodly numbers.

The most definite records of smelt runs in Massachusetts appear in the later reports of the commissioners of fish and game of that State. The report for 1918 (p. 141), referring to Weir River near Hingham, says:

> By March 18 the ice was gone from the salt water, but still thick in the pond. From the 19th to 26th the air temperature rose steadily, and on March 29 (eight days later than the previous year), at 12:50 A. M., twenty minutes after high tide, the first smelt of the season came up Weir River and remained until 2:15 A. M., thus opening the season.

Concerning a run in the same river, the report for 1919 (p. 97) says:

> The salt-water smelt season of 1919 was an unusual one. With an open winter the fish came to tidewater in the rivers in January and lay there until March 1, when the run was on, earlier than is usually the case. * * *
>
> On March 6 there was a large run of fish at Weir River and Fresh River, and they were in perfect condition for spawn-taking. On March 10 the first spawn, about 35 quarts, was taken. Cold weather and low water temperature followed immediately and lasted until March 23, when eggs were again taken. Unfavorable conditions continued, and on April 14 part of the crew was sent home as the run was over, and what fish came were very few and small. * * * On April 22 there was a good run of fish * * * .
>
> The first few nights of the run, it has been noticed, are the best for taking eggs, as the fish are full, having shot none of the spawn. After ten days a great difference can be noticed in the fish. They soon begin to harden, and the quanity of spawn is less. On moonlight nights the run

is not so heavy and the fish are very wild, whereas on dark nights they lie very still and have no fear of a noise.

Temperature records of the water were kept from March 6 to April 13, both inclusive, both at noon and midnight, as follows:

Date	Noon, ° F.	Midnight, ° F.	Date	Noon, ° F.	Midnight, ° F.
Mar. 6	37	35	Mar. 25	43	42
Mar. 7	38	36	Mar. 26	46	44
Mar. 8	40	38	Mar. 27	47	44
Mar. 9	39	37	Mar. 28	43	37
Mar. 10	40	37	Mar. 29	30	(2)
Mar. 11	38	36	Mar. 30	31	(2)
Mar. 12	40	37	Apr. 4	----------	39
Mar. 13	37	31	Apr. 5	39	39
Mar. 14	38	30	Apr. 6	38	38
Mar. 15	30	29	Apr. 7	41	44
Mar. 16	30	30	Apr. 8	48	49
Mar. 17	29	(1)	Apr. 9	48	46
Mar. 21	40	40	Apr. 10	42	44
Mar. 22	40	39	Apr. 11	48	48
Mar. 23	37	----------	Apr. 12	50	50
Mar. 24	47	42	Apr. 13	51	50

[1] Ice on ponds and rivers. [2] Ice on falls.

The report for 1920 (p. 71) says:

Mild weather prevailed the third week of March, and on the 25th the fish made their first appearence at the falls in the Weir River, Hingham. * * * . Heavy rains began to fall and the water in the river rose to the freshet mark. The deep, swift-flowing current of water was more than the spawn-loaded fish could navigate, and they appeared content to remain far below the falls, where they deposited their spawn upon the river bottom. * * * .

As soon as the water receded to its normal flow, making it possible for the fish to reach the falls with ease, the weather broke, and cold and stormy weather prevailed. The mild weather of April was of brief duration and the water temperatures fluctuated greatly. The spawn in the fish develops only in warm water, and the sudden changes in water temperatures retarded this develop. ment to such an extent that the depositing of spawn was not completed until the middle of May, making the season one of the longest on record.

The report for 1921 (p. 75) says:

Following a generally open winter, spring came early, and the spawn-loaded fish made their first appearance at the Weir River, Hingham, on the night of March 8, nearly three weeks ahead of the normal year. Both water and weather offered the most favorable conditions possible, and by March 10 an abundance of smelt was to be found in all the streams. A very large run was observed in all the South Shore streams for two weeks, until about March 22, when the numbers began to fall off, notwithstanding favorable conditions, indicating the first run had completed spawning. The new run, from April 13 to the freshet of April 29 to May 1, was reasonably steady. To the best of our observations the 1921 run of smelt was the greatest in a number of years, being about 25 per cent greater than that of 1918, which was a record year. With the water at normal height throughout the season of 1921 there was no such destruction of spawn as occurs when, during a freshet, it is deposited on the high shoals, only to be left high and dry with the recession of the waters. The natural hatch was unusually heavy. * * * .

It appears that a temperature of at least 45° F. is necessary for the opening of the spawning season.

The report contains a chart showing the comparative run of smelt in the Weir River, Hingham, during 1918, 1920, and 1921, as well as the temperature of the water in 1921. Concerning this chart the report says that the intimate connection

between the temperature of the water and the run of smelt is shown, the fluctuations depending upon the sudden changes in the temperature and the heavy rainfall. The chart shows that in 1918 the first aspearance of smelt was on March 28, and the height of the first run from April 1 to 3, with a falling off to none at all on April 10. There were no more fish until April 15, when a small run reached its maximum on April 17 and declined again to April 20, there being no more fish until April 22. This intermission was followed by a comparatively large run on April 23, which gradually increased to the 27th, which height was maintained until May 1, and after that date declined to May 8. A few continued until May 13, followed by their disappearance May 15.

The first run of 1920 began March 24, increased in numbers until March 30, and again declined irregularly to April 6, followed by an intermission of 3 days. Then there was a large run on April 12, followed by a falling off to April 15, at which point it remained until April 17, when it again increased to a point equal to that of March 30. Then followed a decline to April 22 and an entire absence of fish until April 26. The intermission was followed by a small run, which attained its maximum on April 27 and declined again to April 29. It fluctuated to May 5, and then a large run equal to that of April 27 occurred. Finally a fluctuating decline terminated on May 15.

The comparison of runs and temperature in 1921 perhaps may be better shown by the following table:

Notes	Date	Temperature, °F.	Notes	Date	Temperature, °F.
Run began about	Mar. 8	40	Numbers maintained	Apr. 11–Apr. 12	45–50
Small increase	Mar. 10	40–50	Considerable increase to numbers equal to those of Mar. 20 and 21	Apr. 14–Apr. 15	60–50
Decline to	Mar. 12	50	Numbers maintained	Apr. 16	60
Rapid increase to	Mar. 16	53	Decline to	Apr. 18	52.5
Numbers maintained to	Mar. 18	46	Numbers maintained (heavy rainfall)	Apr. 19	52.5
Some decrease	Mar. 19	43	Increase to numbers of Apr. 15 to 17	Apr. 20	58
Small increase	Mar. 20	53	Numbers maintained	Apr. 21–Apr. 29	61–54
Increase maintained	Mar. 21	51	Decreases to no fish (heavy rainfall caused a freshet)	May 1	52
Decided decrease to	Mar. 24	50	Freshet carried the fish out of the river from May 1 to May 3	May 3	54.5
Constant low run	Mar. 25–Apr. 4	44–55	Later a small run to	May 5	57
Small increase	Apr. 5	55	Decrease	May 6	60
Decrease	Apr. 6	55	Small numbers to	May 10	(?)
Number maintained	Apr. 7	50	Decrease to no fish	May 12	(?)
Some increase	Apr. 8	50			
Numbers maintained	Apr. 9	58			
Decrease to same level as from Mar. 24 to Apr. 4	Apr. 10	47.5			

The director's report for 1922 states:

As a whole the spring run in 1922 was much greater than the previous one. The smelt appeared in the falls on March 14 and the first run began the 23d, but was broken by a heavy snowstorm on the 30th just as it began to be heavy. The second run from April 10 to May 1 surpassed all records, with the day run nearly equaling the night run, and smelt were found in practically all the streams.

About the only observations made upon the breeding habits of the smelts of Casco Bay, Me., were by the present writer from time to time in previous years.

In a gully a short distance back of the writer's boyhood home is a small brook that was then called the "Smelt Brook," as it was frequented by smelts in the spawning season. The fresh-water portion of the brook is not over a mile in total length. It is fed by springs and three small spring rivulets some half mile, more or less, in

length. Except in occasional pools the brook is nowhere over 3 feet wide in ordinary height of water, until within two or three hundred yards of extreme high-tide mark. At this distance above high-tide mark there is an old stone bridge, through which the water flows over large rocks, making a cascade beyond which smelts could not pass. The brook then becomes considerably wider, with a few pools and intervening shallow ripples over gravelly and rocky bottom. Below high-tide mark the stream becomes a tidal creek, with sandy bottom in the channel or continuation of the brook, and with mud flats and marsh on either side, which are covered by salt water at high tide. This condition extends for about a quarter of a mile, when it broadens out into the head of Harraseeket River, a tidal arm of Casco Bay, at "Porters Landing," Freeport, Me. At the lower end of this brook proper there is a short extent that salt water covers only during high runs of tide. At other times the water is unaffected by the tide. The immediate banks of this portion of the stream are without bushes or trees, but above, as far as the stone bridge, it is mostly thickly overhung by alders.

Just below the lower end of the creek another much smaller and shorter tidal creek comes in on the right. Its channel is very shallow and muddy below the fresh-water brooklet that supplies the fresh water. The brook is a mere spring-fed, woodland rivulet, which in narrow portions is not over a foot wide but in places is relatively deep, especially in the marsh near high-tide mark. To distinguish it from the previously mentioned brook, the boys used to designate it as the "Little Brook." Smelt ascended Little Brook also, but according to the present writer's recollections not as early as in the large brook. Why smelts should divert themselves into this little creek and brook when their course was practically straight away up the larger stream is hard to explain.

As soon as the ice was out of the creek and the water of the brook fairly clear the smelts would appear. The time of the first appearance varied more or less, according to the season, from the latter part of March to some time in the first week of April.

There are other brooks in the region in which usually smelts did not run quite as early, being considerably larger streams and requiring a longer time to become clear of ice and turbidity.

The first smelts to appear were comparatively small, dark-hued males, their bodies rough with tubercles, which, when a fish was taken in the hand, made it feel as though covered with sand. Later the smelts would run in gradually increasing numbers, comprising both sexes, until in the latter part of the season it would hardly be exaggeration to say that the brook was full of them. It is literally true that on some mornings after a big run the pools would be black with smelts, as, looked at from above, the fish appear black or very dark.

The runs are known to extend well into May, but gradually decrease in number near the last of the season. No intermittent runs, as mentioned of the smelts in Massachusetts, were noticed, although fish would appear more abundant at certain times than at others. Of course, there might be times of heavy rains and freshets that prevented runs of smelts, or at least they could not be seen if present.

Smelts never were known to run in these brooks in the daytime, or, so far as any authentic information goes, in any other brook in this vicinity, and at no time did

they appear until after the tide had begun to ebb. The numbers would increase with the lowering of the waters. Smelt fishing at these times too frequently interrupted or annihilated the runs.

Standing by the brook on a dark night, one could very accurately judge whether smelts were numerous or scarce by the sound made by the fish as they ascended the riffles. If numerous, there was an almost continuous sound caused by the flipping of the tails of hundreds of fish as they darted up the shallow water. Anyone with a lantern could stand in the brook and watch the fish as they passed, paying no attention to the person or the light, unless now and then a brief pause in the ascent of some individual was thus attributable; but it is more than likely that any such pause was to gather momentum against the current or to determine direction amongst the stones before attempting to go on, for if one waded in the brook above them and tried to drive them downstream the fish would endeavor to pass by. Many succeeded in doing so, too, even against violent agitation of the water by the feet and alder brushes that the fishermen used in making a " drive "—that is, driving the fish into the nets set below.

There appears to be no evidence that the smelts that ascend during the night return to salt water the same night; in fact, in the one particular brook above mentioned it would have been impossible for them to have done so, as at low water some distance down the tidal creek, just below the junction of Little Brook Creek with this creek of the "Smelt Brook," the passage was obstructed by the site of a one-time gate of a tide mill. Although sometimes the smelt fishers would follow the creek down to this point, in the daytime or even at night, no smelt was ever observed there. If smelt returned to salt water after spawning they would need to wait until the next tide. Furthermore, if by good fortune smelts were undisturbed the night before, there were always many in the pools of the brook the day following the run.

For a number of years no smelts were known to ascend these brooks except on occasion, when a few would put in appearance; but in the last few years the runs appear to have increased gradually, although by no means have they become as large as they used to be. In the last three years (1924, 1925, and 1926) it was the writer's good fortune to have an opportunity to make some observations upon the smelt runs in these same streams, but unfortunately certain unavoidable interruptions broke the continuity of the observations.

In 1924 smelts began to ascend the larger brook a few days (or nights, rather) prior to April 1, and they continued until about May 15. On that date only four smelts were found in the brook, and they were males. As usual, the runs occurred at night. If, as was observed, high tide occurred before dark, as soon as it was dark smelts were seen in the lower part of the brook. As the season progressed the smelts increased in quantity, but usually impatient smelters, who would not wait long enough to permit many fish to ascend, effectually checked the run by a violent and abusive method of fishing. This method is described hereafter.

In 1925 the first smelts were found in the brook on the morning of April 1, doubtless having ascended the previous night or early in the morning, when it was high tide at about 5 o'clock. The water in the brook was still somewhat turbid and

rather high. The temperature of the water was 42° F. and the air 50° F. at noon; at 8 p. m. the water was 40° F. and the air 32°. The smelts continued to run until May 6. The last seen were only two inividuals on the morning of May 7. On May 6, at midnight, the temperature of the water was 42° and that of the air 40°. Probably very few smelts escaped capture, for almost every night the brooks were frequented by boys and men who fished in the usual abusive way.

In 1926 the season was very backward. No smelts were seen until April 17, when three or four were observed below extreme high-tide mark. The fish must have come up during the preceding night, when high tide occurred at 3.05 a. m. At 10 a. m. the temperature of the air was 40° F. and that of the brook 36° F.

The first visit to the brook was on April 11, when the stream was high and muddy and the weather very cold. Cold weather continued, with the exception of April 14 (which was mild), until the 17th, when three or four smelts were seen. On that date it is possible that other smelts than those seen were present, but the water was turbid.

On the 18th the brook was still turbid but had subsided considerably. One male smelt, nearly 7 inches long, but not quite ripe, was caught. No other fish were seen. At 9 a. m. the temperature of the air was 34° F. and the water 36° F.

On the night of the 20th 10 smelts were caught and a few others were seen. At 10 p. m. the temperature of the air was 32° and that of the brook 34°. High tide occurred at 5 to 5.20 a. m. The smelts were all taken below high-tide mark.

From that date the smelts gradually increased in number, with some fluctuations, until April 30, when they began to fall off. The last (about a dozen) were taken on May 16. This season the fish were not nearly as numerous as they were the preceding year, and there were so many fishermen it is probable that the fish were nearly all caught.

The following notes represent some of the observations made in previous years in the aforementioned brook in Freeport, Me., and in another tributary of Casco Bay at Brunswick, Me.:

Freeport, Me., April 18, 1903.—The ice went out during a warm spell in the last of March. Smelts were caught for some time prior to this date. On the night of the 18th a few hundred were caught. It was high tide at Portland at 4 p. m. The smelts did not appear in the brook until after dark, but were running on ebb tide for some time after the tidal water had left the brook. About 9.30 p. m. one young man had taken about 200 smelts and ceased fishing. He estimated that about 400 in all had been taken.

Freeport, Me., April 18, 1903.—A good many smelts were caught by six boys and young men. Most of the fish were taken below high-tide mark, even several hundred yards below; probably between one-half and one bushel of smelts were caught. Notwithstanding the intensive fishing evidently some escaped, for a number were seen some distance up the brook. Fishing had been begun too early to permit of a good "run." The fish were easily caught by hand. So intent were they on ascending the brook that it was with difficulty that they could be driven down into the nets set in the brook. Milt did not run freely from the males, but eggs were easily expressed from the females.

Freeport, Me., April 23, 1903.—Considerably many smelts were taken in the previous two nights. One boy got 11 dozen on the night of the 22d. Only two boys were on the brook this night, and they got four dozen smelts each.

Freeport, Me., April 24, 1903.—Some smelts were taken this night.

Freeport, Me., April 27, 1903.—The previous night the boys got a few smelts by "dipping" above the high tide. There were a few along the brook in the morning. Small schools were observed here and there along the stream for about 300 yards, or nearly as far as it was possible for them to ascend. Two spent males were caught.

Freeport, Me., April 30, 1903.—No smelts were seen in either the fresh-water or tidal sections of the brook. However, for two days previous the water had been roily, although the bottom could be seen in most places. At 2 p. m. the temperature of the air was 59° F. and of the water 51° F. At 10 p. m. the temperature of the air, as indicated by the thermometer, was 44° F., but the stiffening of the nets when removed from the water suggested a lower temperature. The temperature of the water was 46° F.

Brunswick, Me., April 26, 1903.—During the day smelts were observed in a small brook flowing into Casco Bay. When disturbed the tendency of the fish was to conceal themselves. They rushed *en masse* to one or the other end of the pool, and if sufficently frightened would run farther upstream, but seldom downstream. If they did run down at any time it was only a short distance; then they would run up again. Occasionally one or more sought concealment under the bank. Most of these smelts were in pools below high-tide limit, but some were found here and there for a mile or more up in the fresh-water section of the stream. Two fish were caught, one a spent male 5¾ inches long and the other a spent female 10 inches long.

A man familiar with this brook and well informed concerning smelts said that some smelts remain in the brooks very late in the season, even to the last of May or first of June, and that they "waste away to water" and become sick and are attacked by "worms" especially under their gills or throat. He said that he had picked them up in dying condition and almost dead, not from injury but apparently from inanition, which suggested to him a general mortality among smelts after spawning. The temperature of the brook at 12.30 p. m. was 51° F.; that of the air was 59° F.

Some little plausibility is lent to the idea that there is considerable mortality amongst breeding smelts by the statement of Smitt (1895, p. 873), who says that after the spawning the shore and the bottom are strewn with numbers of dead smelts that have struggled in vain to disburden themselves of the roe. Furthermore, it is a well-known fact that many dead and dying fresh-water smelts often are observed during the spawning season. This phenomenon is discussed in connection with the part of this paper concerned with fresh-water smelts.

Brunswick, Me., May 7, 1903.—On this day no smelts were seen until about one-half mile up the brook, where eight were caught. In a pool not far from the salt-water limit four specimens were taken out of a school of about a dozen. A man met on the brook, who was trout fishing, said that farther up were quite a number of smelts. The smelts caught were all spent males, from which only a very little milt could be expressed. At 5 p. m. the temperature of the air in the shade was 50° F.; temperature of the water, 52° F.

Freeport, Me., April 6, 1904.—Smelts first appeared in this season in the particular brook previously discussed, but none had been found in other brooks, as they were not yet free of ice. On the night of April 8 some were caught in other brooks, and smelts were still running on April 17.

The breeding season in a given locality of average abundance may last from four to six weeks for the species (not individuals), yet individuals may remain in the stream for a long time after they have spawned. (As far as observed all individuals that seemed so reluctant to leave proved to be spent males.)

The statement has been made, and it is a prevalent belief, that smelts run up a stream, spawn, and return to salt water on the same night. Apparently this is the case when the run on ebb tide takes place early in the evening and the subsequent high tide occurs early in the morning before daylight. However, the aggregation composing one night's run, if undisturbed, may remain in the stream for several days. Especially is this so in case of the later season.

Concerning the Scandinavian smelt, Smitt (1895, p. 873) says:

> Each shoal completes its spawning operations in a few days; but one shoal follows in the wake of another, and thus the spawning continues as a rule from the latter part of March to the first weeks of May.

The only information concerning breeding smelts east of Casco Bay available to the present writer is contained in the previously mentioned notes of Charles G. Atkins. In his notes of 1878 he definitely mentions the following streams, flowing into Penobscot Bay, as frequented by smelts in the breeding season: A brook entering Surry Harbor from the west; Browns Brook, in the vicinity of Surry; Lawrence Brook and another above it, about 2 miles upriver from Bucksport; Sweetsers Brook near Bucksport; and three brooks on Verona Island.

In 1878 he says that on April 21 what were supposed to be smelt eggs were seen on the rocks below the dam at Orland. Some smelts were being taken there then, but on May 1 none was to be found. John Whitmore, of Verona Island, a weir fisherman, knew of two brooks on the island in which smelts abounded about "high tide" of May; and George Small thought that smelts abounded in a brook near his weir in June. On May 1 Atkins got two smelts from the island, but they were completely spent. On May 20, according to a Mr. Tower, smelts were running in Lawrence Brook. On May 23 only three smelts were caught in Sweetsers Brook. On May 25 Atkins received some freshly caught smelts from the same brook. On May 28 no smelts were found in this brook, and very little spawn, whereas on the 25th of May, 1877, one got a bushel. Up to May 27 hardly any smelts had been seen in the brook at the head of Surry Harbor or in Browns Brook.

Writing of the smelt of New Brunswick, A. Leith Adams (1873, p. 244) said:

> As soon as the ice breaks up and drifts seaward, sculls upon sculls of this savoury fish push their ways up the rivers, where they bite bait readily, and are captured by nets.

Farther north our available data are still meager. On May 26, 1895, the present writer observed smelts ascending creeks at Owls Head Bay, Nova Scotia.

Concerning smelts in the St. Lawrence region, Chambers (1903a) wrote that there had been very little observation of the habits of the smelt in the St. Lawrence.

FIG. 6.—Porters Landing brook at the old bridge shown in Figure 10. The ice is all gone and snow melted except in sheltered places. Taken in April, 1924. The brook is now muddy and no smelts have yet been seen

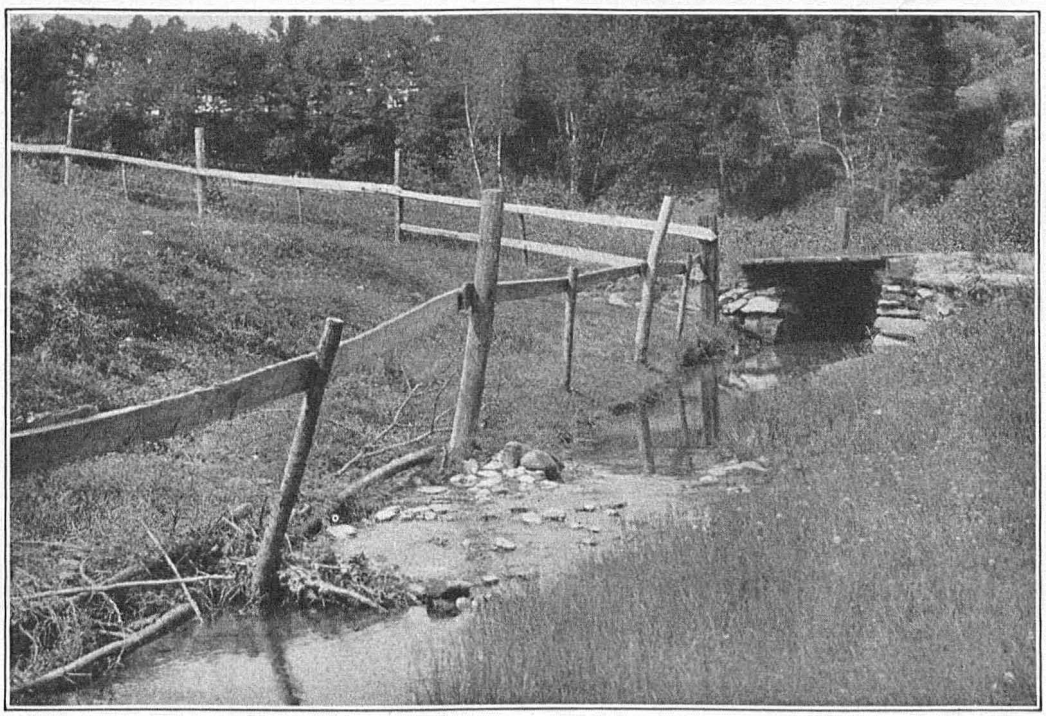

FIG. 7.—Porters Landing smelt brook (Freeport, Me.) just above mean high tide limit. Extremely high tides reach the bridge. Typical of the smaller smelt brooks

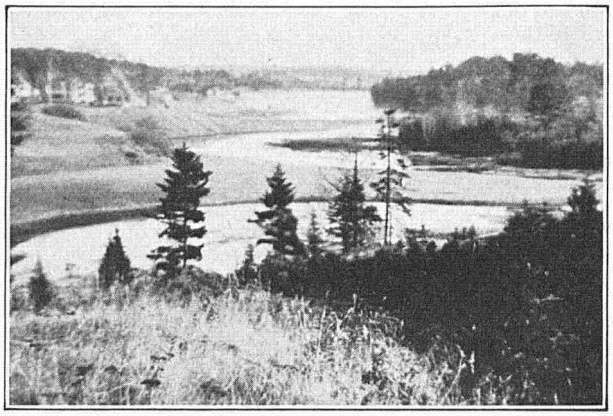

FIG. 8.—Section of tidal creek at Porters Landing, Freeport, Me., May, 1924

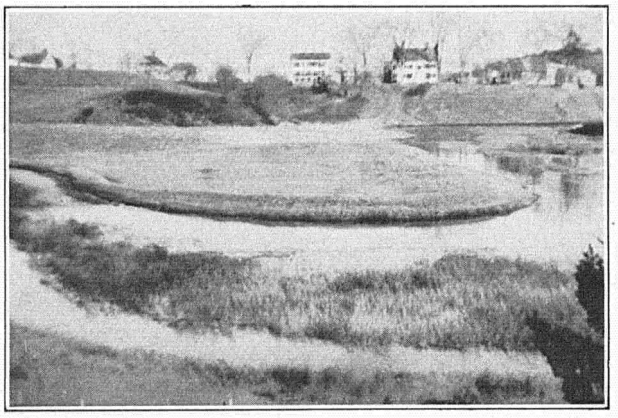

FIG. 9.—"Close up" of tidal creek at Porters Landing. Another view of the low point shown on the other side of the creek opposite the trees in Figure 12. May, 1924

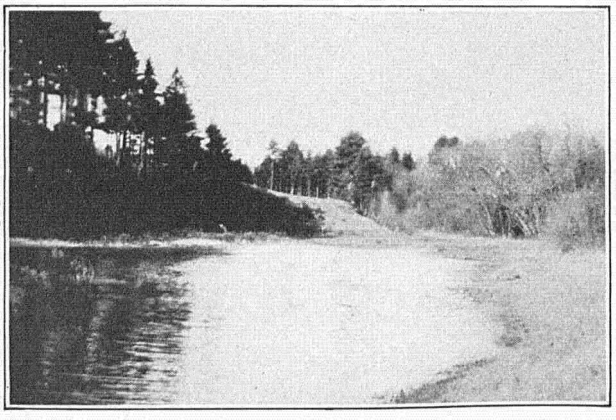

FIG. 10.—Upper section of Porters Landing smelt brook (Freeport, Me.) at extreme high tide. Section of the brook is the same as shown in Figures 10, 11, and 12. The tide at this time reached nearly to the old bridge. May, 1924

He said that it was presumed that they spawn there in the spring, as they do elsewhere, but he considered it as rather remarkable that they ran up the river both at the commencement and at the end of winter, and that many of them were found to contain spawn in the autumn as well as in the spring.

Concerning the same condition, Cheney (1894a, p. 162) wrote that he had a query from a correspondent in Canada who said:

> "We catch smelts here in the St. Lawrence twice a year, in April or May, and again in October or November. At both seasons they are full of spawn. How is this to be accounted for? Do they spawn twice a year, or are they not the same individuals that run up spring and fall?"

Concerning this point it may be said that in the fall the ovaries and eggs have begun to develop and the little eggs are plainly visible, being clear yellow in color, but they do not completely fill the fish then as they do in the spring near the breeding season. The bright yellow color of the eggs makes them so conspicuous, however, that those who have observed them often have been misled and regarded them as fully developed.

Smitt (1895) says of the Swedish smelt that the greater part of the breeding shoal is composed of females. This is contrary to the present writer's observations. It has long been observed that the initial runs consist almost wholly of males, and that as the season progresses the proportion of females increases until they are approximately in equal numbers. In 1924 such regularity in increase of females was not observed, although they did increase in number. Males greatly predominated at first, and of 113 fish caught on April 12 only 4 were females. Perhaps if observations could have been continuous and unhindered by fishing operations they would have shown a different tendency.

On April 13, of 266 smelts taken, 17 were females. Of 37 smelts taken on April 28, 23 were males and 14 females. On April 29 so many persons were fishing that the writer secured only 14 smelts; 8 of these were males and 6 were females. On April 30 again observations were hindered by fishermen and only 33 smelts were secured, of which 10 were males and 23 females. On May 6, 105 smelts included but 1 female; and finally on May 15 there were only 5 smelts to be seen in the brook, the 3 caught being males.

The interruption in the runs of smelts was not caused wholly by fishing, but also may be attributed to heavy rains and freshets. In fact, the latter may have been the principal cause. So far as the principal brook under observation is concerned, the smelts appear to have ceased to run by May 15, as subsequently none was seen there. The night of the 16th was beautiful and there was a high run of tide, high water occurring at 9.42 p. m. The brook was explored but no smelts were found.

In the spring of 1925, in the same brook, the proportion of females to the total number caught on consecutive dates from April 1 to May 2 was as follows: On April 1 only 14 fish were taken. Of these only one was a female. On April 2, 66 fish were caught, of which 22 were females. On the 8th only 11 fish were caught, 7 of which were females. On the 9th 45 fish comprised 11 females. The 10th yielded 75 fish, of which 32 were females. On the 16th 177 fish comprised 55 females, and

on the 21st 10 of 33 fish were females. On the 22nd 119 fish comprised 45 females; on the 23rd 75 fish, with 30 females, were caught, which proportion is very close to that of April 10. On the 29th, of 29 fish 13 were females. On May 1 of 31 fish 15 were females, and the last catch of the season, on May 2, consisting of 60 fish, contained 35 females. For the whole season 735 fish comprised 276 females and 459 males.

In 1926 the spawning run of smelts in this brook was considerably smaller than in the preceding year. The season was backward and the run did not begin as early as in 1925. The first catch, on April 20, consisted of only 10 fish, and these were apparently nearly all that there were in the brook. Of these 5 were females. The proportions for subsequent dates up to May 10 were as follows:

April 21, 18 fish, comprising only 4 females; April 23, 25 fish, comprising only 3 females. Thirty-seven fish taken on April 27 comprised 14 females, and 29 fish taken on April 29 comprised 16 females. This is a curious coincidence, in that the same number of smelts were taken on the same date in 1925. On May 6, of 103 fish 61 were females; on the 9th, of 14 fish 6 were females; and on the 10th, of 18 fish 7 were females.

Of the total catch of 259 smelts, 116 were females and 143 were males.

The choice places of spawning, when possible, are gravelly ripples, which may contain aquatic moss, water cress, or other plants, or sticks, leaves, and other adventitious material. The fish sometimes spawn in pools or along the stream margin, but always normally where there is some current. Bloch (1796), writing of the European smelt, said that they deposit their eggs upon the bare rocks.

Regan (1911) says that the fish crowd together in dense array and the eggs, when shed, attach themselves wherever they happen to fall. Regan repeats the much quoted reference to the spawning of the smelts in the Forth, saying that when "the smelts spawn in March, about two miles above Stirling Bridge, every stone, plank, and post has been described as covered with their yellow eggs." This reference is to the statement of Richard Parnell in 1839, who said the smelts ascend the Forth in numerous bands in the month of March for spawning. It occurs, then, in great quantities 2 miles below Stirling Bridge (not above, as stated by Regan) and soon each pier is covered with their eggs, which have a "yellowish color."

From the foregoing it would appear that the English smelt spawns in streams large enough to be called rivers. If this is so of the smelt in this country, it has not been discovered, although the general impression is that it sometimes does. Beyond doubt it does ascend rivers; but it seems probable, judging from analogy, that the smelt diverts itself from the rivers into tributary brooks; at least most references pertain to moderate streams, such as are called brooks. Samuels (1904) says they appear to have favorite localities for spawning and visit the same brooks and streams year after year.

A run may be observed in a small brook about high tide, or soon thereafter a few smelts may be seen straggling upstream and ere long they come faster and thicker. When a light is cast upon them they may pause or even settle back a little, but they soon shoot ahead. So intent are they in ascending the stream that

it is with difficulty that they can be driven downstream, even when violent beating and thrashing[2] of the brook with alder tops or wading in the stream are resorted to. If the fish are particularly numerous those near the net (set crosswise in the brook) may be driven in, but the net must be lifted quickly or many of the smelt will run out. The fish do not rush upstream but move with moderate speed until they come to a place where the water is swift, when they shoot ahead; and if the water of such places is shallow, the flipping of the tails of the fish indicates how numerous they may be.

Writing of the Swedish smelt, Smitt (1895, p. 872) says:

> "The smelt is of a stupid and sluggish temperament," wrote Ekström, and this opinion has afterwards been reiterated by other writers—"silly as a smelt" is a common Swedish saying. But why it is thus stigmatized more than other fishes, we cannot say. Gathered in shoals during the spawning, when it is ruled by sexual instincts alone, it is easy to catch like many other fishes; and this is probably the origin of its reputed stupidity.

On the day following a run of smelts the eggs may be seen attached to grass, stones, leaves, sticks, twigs, or anything in the water with which they come in contact. A great many of the eggs are observed to be white. In fact, it is the white eggs that usually attract attention, as the natural amber-hued eggs are difficult to see in the water. Sometimes the eggs are deposited in tidal water—that is to say, where the fresh water has been backed up—so that after ebb tide there are may eggs left high and dry. Usually, too, during the first of the season the brooks are much higher than later, so that after subsidence eggs are left dry. Thousands of eggs are destroyed in this way. Atkins was inclined to believe that the unfertilized eggs that he found on May 28 in Lawrence Brook were attributable to the pursuit of the fish with dip nets, which he felt sure must break up spawning operations. This quite probably was the cause of some of the white or unfertilized eggs observed by the present writer.

The report of the commissioners of fisheries and game of Massachusetts for 1917, referring to the great waste of naturally deposited smelt spawn, said (p. 76):

> At Weir River, Hingham, in 1917, the smelts were depositing spawn on the river bottom at the rate of a quarter of an inch each night when there was a good run. Eggs would be found in layers from 1 to 2 inches in depth, and in eddies, even from 4 to 6 inches. Under such circumstances the top layer only is exposed to the running water and properly fertilized, the remainder being wasted.

In his annual report for 1922, the director of the division of fisheries and game of Massachusetts (1922, p. 21), referring to the interrupted runs of smelts in Weir River, stated that the deposit of spawn by the first run was very good, and as it was not overabundant the eggs had a better chance to hatch. The water was not excessively high, so there was no great waste of spawn on the ground above normal water mark, and probably all had hatched before the second run began. The deposit from the second run was so heavy, in many places 3 or 4 inches deep, that doubtless nearly all went to waste.

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[2] There is no word that adequately describes the process of driving with these alders. A word in common local use among the smelt fishermen is "raunching." If one has witnessed the procedure one will appreciate the aptness of the word "raunch," which appears to have been adopted on account of the sound made by the quickly successive, violent thrusts of the alder into the water, rather than on account of the original meaning of the word.

ENEMIES

Very little has been published concerning the so-called enemies of the salt-water smelt, although doubtless it has many. Bloch (1796) mentioned at some length a parasite infesting almost all of the fish he had examined. He said that ordinarily they were on the upper part of the back; sometimes in the muscles, where they were occasionally completely buried. One was on the head near the eye. It was only necessary to hold the fish to the light to perceive the parasite, as the smelt was transparent and the parasite opaque; and he stated that the "worm" would live on dead fish for many days, as he had observed it on those sent from Hamburg.

Day (1884, p. 124) says that the picked dogfish (*Acanthias vulgaris*) destroy large numbers of them. Smitt (1895, p. 874) said "Man is not the only enemy which the smelt has to fear; it often falls victim to predatory fishes and waterfowl."

Under date of April 17, 1878, in his notes, Atkins indicated that on good authority a salmon brought from St. John in July had been opened and found to contain six smelts, and that Commissioner Stilwell said that at Bickford's (a fish dealer in Bangor), the preceding summer, a salmon was found to have smelt in it.

Venning (1902, p. 493) wrote that in his boyhood the trout from the rivers (New Brunswick) came down in the spring in large numbers to meet the smelts coming in to spawn.

Chambers (1902) stated that the arrival of the autumnal run of smelts in the St. Lawrence River, in the vicinity of Quebec early in December, 1902, was quickly followed by that of a number of porpoises that remained for some days disporting themselves in front of the city. He said that these unusual visitors apparently were in pursuit of the toothsome little smelt, and the latter apparently were aware of the fact, for during the time that their monster enemies remained in the neighborhood the smelt were conspicuous by their absence, and the smelt fisher fished in vain. After the porpoises left the smelt resumed biting.

On April 26, 1903, in a brook flowing into Casco Bay, Brunswick, Me., the present writer caught 11 brook trout from 5.75 to 7 inches long, averaging nearly 6.4 inches, all of which, among such things as caddis-fly larva cases and sand, contained many smelt eggs. The sand probably was ingested with the smelt eggs.

On May 13, 1903, 13 specimens of sticklebacks (*Gasterosteus aculeatus*), all females, ranging from 2.36 to 3 inches in length, were caught in the tidal portion of a creek flowing into Casco Bay at Freeport, Me. One individual 2.67 inches long had its stomach distended with recently hatched smelt fry.

Twelve specimens of another species (*Gasterosteus bispinosus*), ranging from 1.6 to 1.87 inches in length, were taken. All were distended with smelt fry with the exception of one, which contained only a few fry and a lot of some unidentified material.

One of six specimens of the four-spined stickleback (*Apeltes quadracus*), 1.8 to 2 inches long, was also found to be distended with smelt fry. The others contained other material or were empty. All but one of the eight specimens of the nine-spined stickleback (*Pungitius pungitius*), 2.16 to 2.63 inches long, contained more or less smelt fry.

SMELT FISHERY

EUROPE

According to Bloch (1796), at spawning time the smelts were taken in large quantities, especially in Prussia, where they were air-dried, placed in casks, and shipped to Pologna. Great quantities were found in the Elbe, also. He stated that as the fisheries of Hamburg could not sell all they caught, they salted and dried them and shipped them to neighboring Provinces. Quoting Pennant, he said that in London they were eaten at breakfast with a glass of wine.

Day (1884, p. 123) stated that in Norfolk, England, the fishery for smelts commences in March and continues until the middle of April, during which period the fish are full of roe. He credited Lubbock with the following description of one of the methods employed.

> Hour after hour does the smelter persevere, moored exactly in the same spot with a torch attached to the side of his broad flat-bottomed boat (for this is a nocturnal occupation) in flinging his immense casting net, dropping the near side of it at each throw, within three inches of the torch. One fortunate cast, if smelts sell well, may recompense him for hours of fatigue, wet, and cold: and he waits like the losing gambler for the lucky throw which is to brighten his fortune. The smelts captured are kept alive in a tank.

Day went on to say that they were also taken in the estuary of the Ouse and in Breydon by means of the stake nets. He wrote that smelts could be caught with a "paternoster" line and No. 8 or 9 hooks, with or without floats, using bait of shrimps (either fresh or boiled), gentles, redworm, or pieces of fish. Early mornings and late evenings were considered the best times for this fishing, and bread crumbs were recommended as ground bait. Day said that in the Solway Firth the best fishing season in September, but that the fish disappear the next month until March and April, when they ascend to spawn.

According to Nordqvist (1910), near Helsingfors smelts are caught as long as the sea is frozen—from December or January to April. In the northern sections of the Gulf of Bothnia, where many large rivers enter, many smelts are caught in winter with drag nets.

The well-know smelt fishery in the Norrstrom off Stockholm, according to Smitt (1895, p. 874) is carried on with large hoop nets, such as are in general use at many places among the island belt of Stockholm to secure all kind of small fishes for bait. These hoop nets, usually 3 to 3.5 meters in diameter, are let down and hoisted up from a boat with the aid of a long pole erected obliquely upwards in the stern, and a hand net is employed to scoop the fish out of the large net. The smelt is also caught on the hook with a bait of shrimps, sand hoppers (gammaroids), worms, or bits of fish, but this method is successful only when used for the large smelts—the *slom* or *norskung*, as they are called in some parts of Sweden when they occur as solitary specimens among the smaller smelts.

Quoting Ekström, Smitt says that it is during the spawning season that the smelt is taken in any quantity, the fishery being commonly conducted in the following manner: Across the straits or the rivers to which the smelt ascends in order to

spawn fences are built of green spruce branches arranged so as to leave gaps at the deepest parts of the channel. At these gaps the fisherman stations himself with a scoop net large enough to fill the opening and having meshes so fine that the smelts can not slip through. This net, which is distended on staves, he lets down into the opening and takes up after a longer or shorter interval, according to the numbers of fish that come up, the take being turned out of the net into a "catte" held in readiness.

When the smelt spawns on shores or off headlands, it is taken in dragnets, which differ from the ordinary seine only in the comparative fineness of the meshes. This fishery is pursued only at night, bonfires not infrequently being lighted on shore by the fishermen in the belief that the fish, enticed by the glare, come nearer land.

ATLANTIC COAST OF NORTH AMERICA

In former years of abundance the smelt generally was regarded as of minor importance as a food fish, and except in a few localities no use was made of it except as fertilizer, a limited amount only being used for home consumption. However, the aborigines evidently used them as food, for Capt. John Smith, in 1622, records that "of Smelts there is such abundance, that the Salvages doe take them up the rivers with baskets, like sives." In more recent times the fishery gradually assumed importance. Forty years ago Goode (1884, p. 543) wrote: "The smelt fishery is increasing yearly in importance, owing to the greater facilities for the transportation of fish in ice." Nine years before this Scott (1875, p. 340) wrote: "Trade in smelts is confined to six months, or to the inclement season of the year, for which time the sales in Fulton Market averaged 1,352,000 [pounds ?] at 16 cents—$216,320.00."

In former years it appears that the smelt fisheries of New Jersey and Long Island were of the greatest importance, few if any smelt being caught south of those localities. However, over 60 years ago Norris (1862, p. 59) called attention to smelts in the Delaware River. He said:

> I have been told that these fish can be taken occasionally in February along the wharves and in the docks of the Delaware with a cast net. They are taken with case and scoop nets at Fairmount dam. They are common and abundant at New Brunswick, New Jersey, on the Raritan, and it is said also in the Passaic, though during some winters they even there are comparatively scarce.

John A. Thomas, of Reading, Pa., under date of March 7, 1876, contributed a short article to Forest and Stream concerning New Jersey and Long Island smelts, from which the following is an extract:

> In the creeks of Long Island, they are found in perfect condition from February 20th to March 20th. In the Jersey river, for a long period in the early spring and fall, they are not taken with the hook, I believe, but [are dipped] up in quite large quantities by those who know their value. I remember once buying in Jersey nearly one half bushel for seventy-five cents, which was more than the boys asked for them, fresh, not an hour from the water. These fishes might be cultivated wherever they can reach the salt water. It is supposed that they love to keep near the shores on sandy bottoms. I have seen them at least twelve inches long, playing in the bays of New England and in the harbor of New York, about Communipaw.

As this fishery, like other fisheries, depends upon an adequate supply of fish, those more southern localities once noted for abundance of smelts, such as the Raritan

and Passaic Rivers in New Jersey, Long Island, and southern New England, are no longer any considerable factor in smelt production.

In statistics of the Bureau of Fisheries for 1888 no smelts were recorded for New Jersey or New York, and in the United States Census Report for 1908 a catch of 7,500 pounds, valued at $1,500 taken by seines, was credited to New Jersey. The record for Connecticut showed increases from 9,600 pounds, valued at $770, in 1888, to 10,000 pounds, valued at $7,200, in 1908. In Rhode Island, for the same period, there was a falling off from 61,500 pounds, valued at $3,135, to 1,200 pounds, valued at $100.

At the present time probably the largest proportion of Atlantic smelts appearing in the markets of this country come from New Brunswick, although at times some have been received from Nova Scotia, Prince Edward Island, and Newfoundland. Thus it is seen that the commercial smelt fishery has receded gradually northward. However, it is locally of considerable importance in Maine. Probably one of the most potent factors operative in the depletion of smelt waters has been net fishing during the spawning season of this fish. This sort of fishing had such marked effect upon the smelt supply of Massachusetts that long ago legislation tended toward the reduction of net fishing and the encouragement of the hook-and-line method.

Massachusetts.—As early as 1868 or 1869 taking smelts by any other method than by hook and line was prohibited excepting in a few specified instances, when they were permitted to be taken by seines when fishing for "perch," etc. With little modification the law still stands. Prior to the passage of the act referred to, smelts were caught chiefly by seines and dip nets near and in the streams to which the smelts resorted for spawning. The report of the commissioners of fisheries of Massachusetts for 1869 (p. 15) states that the seine used might be 360 feet long and 20 feet deep, with a 1½-inch mesh. The report cited one haul of such a seine in which 6,700 pounds of smelts were taken, and said "as twelve usually go to a pound in the 'school' fish, this would make 80,400." The report further stated that smelts were taken in great quantities with dip nets on the spawning beds. A table was given, which showed the number of dozens of smelts taken by two dip nets during 13 seasons at the backwater dam at Milton on the Neponset River, as follows:

1855	300	1862	417
1856	100	1863 (3 nets)	2,275
1857	21	1864	850
1858	1,113	1865	1,715
1859	507	1866	714
1860	927	1867	1,154
1861	725		

The foregoing figures represent approximately as many or perhaps twice as many pounds, according to size of fish. The report for 1870 (p. 23) notes an increased catch of smelts by hook and line in the autumn of 1869 in Back Bay, "quite out to Brookline. The mill-dam was lined with patient anglers; and distinguished merchants, of lower Beacon Street, might be seen, at early hours, eagerly catching their breakfast from their back doors."

The report for 1871 (p. 11) remarks:

The present season has proved even better than the last, and the hook-and-line men everywhere report a good catch, and often an increase of large specimens.

The report for 1874 (p. 18) indicates that a law was passed prohibiting the catching of smelts by any other method than by hook and line in all State waters except Taunton Great River, Dukes County, Yarmouth, Dennis, Bass River or its tributaries, North, and Westport Rivers. The statement continued:

Twenty-five years ago the lower waters of the Mystic River were, in winter, crowded with little tents for the protection of persons engaged in fishing. Many, out of employment at that season, made two to three dollars per day catching smelts, with hook and line, for the market, at six or seven cents per pound. The seining in the river and netting them on their spawning beds soon destroyed all fishing with hook and line, and, in a few years more, seines and nets were abandoned because they did not pay. So completely was the the river depleted that the fish committee of the town of Winchester spent several nights in catching fifty-two smelts for the purpose of stocking the river above Mystic dam. For the past five years these fish have been carefully protected in this river and its tributaries; so rapidly have they increased that in the spring the small streams are alive with them crowding up to spawn, and last winter the little tents began to appear on the river below, many persons catching from twelve to fourteen dozen, each, a day.

The report went on to say that seven-eighths of the constant and steady supply of smelts for the Boston market came from Green Bay, near Portsmouth, and were caught with hook and line, the fishermen making from three to five dollars per day.

The report for 1875 said that smelts had been very plentiful that fall, as high as 80 dozen having been taken with a single rod in one day. According to Forest and Stream, this year smelts were abundant and retailed at from 25 to 30 cents per pound.

Ordway (1875), writing from Boston on December 12, 1874, to the commissioners of inland fisheries of Massachusetts, said:

In reply to your inquiries as regards the practical working of the smelt-law, passed by our last legislature, and the effect of the close time, allow me to say that it has exceeded the most sanguine expectations of the friends of this beautiful fish. Smelt of enormous size have been caught, whilst thousands of small smelt have shown the beneficial result of allowing the females to throw their spawn last spring, instead of being stolen by a few seines. Besides this, hundreds and tens of hundreds of poor mechanics have had a chance to catch a good mess for their families after their day's work was over. In addition to this, the dealers have reaped a good harvest, from the fact that they have had a better class of smelts, and received better prices. But perhaps I cannot do better than to give you a few extracts from letters sent me by gentlemen who take an interest in smelts. These are but a few of the many which have been sent, all expressing similar views. A gentleman, writing from Salem, says, "You have done a great and good work in increasing the smelts in this vicinity. It seems like old times to see the boys with their baskets well filled." Dr. E. J. Thompson, writing from Lynn, says, "It would do your soul good to come to Lynn and visit the wharves at the present time [October 12], and see the smelt-fishers at it, —old and young, rich and poor, split-bamboo and beanpoles, all together, and such smelt-fishing as they have not seen for years. Every one thought that smelt-fishing was played out; but now some of the best fishermen have caught as high as twenty and thirty dozen in one day."

Benj. P. Ware, Esq., writing from Marblehead, after speaking of the wholesale and wasteful methods of slaughtering fish with seines and trawls, especially in the spawing season, says: "Smelts, which were becoming quite scarce, have this fall been very abundant. In Swampscott, where smelts in previous years have been almost unknown, they have been taken in great numbers, many of them weighing half a pound each. This change is doubtless due to the close time and legislative Acts passed in relation to the catching of smelts."

In this connection, I would say that many persons have, to my knowledge, made from ten to twenty dollars a day catching, legally, with hook and line, so plenty have smelt become; and I have no doubt that this winter, as the result of the law, hundreds of persons who perhaps could not get work, will be enabled to make excellent wages by catching through the ice. I have no hesitation in saying that the law has worked splendidly, and that another close time, next spring will produce excellent results; viz., still larger smelts and in greater numbers.

Forest and Stream (1874, p. 188) attributed the marked increase of smelts to a law passed by the Massachusetts Legislature in the preceding winter, making it unlawful to seine or net smelts at any season; and four years later the same journal contained an article by some one signing himself "Memoir," dated at Medford, March 23, 1878, which said:

Smelts have returned to their spawning beds at an earlier date and in larger numbers than heretofore. The law provides for their safety (or rather the watchman's pocket) from the 15th of March to the 1st of June, but during the unusually warm weather of the first of the month they made their appearance in large and goodly numbers, which necessitated the employment of a watchman to protect hasty *eperlanus* from the frying pan of the immediate neighborhood.

No further reference was made to smelts in any of the reports of the Massachusetts fish commissioners until 1880, when the following catch for 1879 was given in a statistical table of seines: Westport, 5,598 pounds; Tisbury, 44,250 pounds; and Edgartown, 3,000 pounds. The report for the year ending September 30, 1880, gave 28,184 pounds for Westport and 53,850 pounds for Edgartown, while that for the year ending September 30, 1881, showed that 2,414 pounds were taken at Westport and 32,800 at Tisbury.

The returns for the year ending December 31, 1882, were as follows: Tisbury, 28,050 pounds, and Edgartown, 6,500 pounds. In the fall of 1885, according to John Cutter, of Charleston, smelts were selling for 20 cents per pound and the following numbers were taken: At Tisbury Great Pond, 126,000; at Job and Great Neck Pond, Edgartown, 25,955; and at Oyster Pond, Edgartown, 65,728. No further reference was made to smelts, except in citing amendments or revisions of laws, until 1916.

In 1891 exceptions to prohibition of seines and nets were made in favor of Bristol, Barnestable, Nantucket, or Dukes Counties "during the time and in the manner in which fishing is allowed for perch, herring, or alewives."

In 1894 the following localities were restricted to hook and line: Boston Harbor, Hingham Harbor, Weir River, Weymouth Fore River, Weymouth Back River, Neponset River, Charles River, Mystic River, or any cove, bay, inlet, or tributary of same.

Statistics later than the foregoing are found in the reports of the United States Commissioner of Fish and Fisheries for 1900 and 1905, and the report of the United States Bureau of the Census for 1908. According to these statistics the total catch in 1900 was 7,079 pounds, valued at $515, taken as follows: Dukes County, by seines, 2,479 pounds; Bristol County, by seines, 4,200 pounds; and Barnstable County, by pounds and traps, 400 pounds. In 1905 the total catch was 7,375 pounds, valued at $866, taken as follows: Dukes County, by seines, 2,000 pounds; Bristol County, 3,150 pounds, 3,100 of which were taken with seines; Barnstable County, 325 pounds in pound nets and traps; and Essex County, by hook and line, 1,900 pounds.

"Grif" (1900) wrote:

The Massachusetts law allows the smelt to be caught with only hook and line, and no seining is permitted. It also makes a close season during the spawning time, and on account of this law, the fish have increased in number and in size.

The Fishing Gazette (New York) for March 16, 1907 (p. 259) contained the following:

It is safe to say that the ice smelt fishery in Essex River, which was closed down Thursday last until June 1st, will be an established pursuit at Essex next winter, says a Gloucester exchange. The strike of Warden Nixon, of the Massachusetts Fish and Game Commission, has fairly set the fishermen of the town into a state of excitement. Ever since the day when the warden located the fish, the river in the locality of the strike has been fairly alive with men and boys, all fishing Some of them fished all day and many fished well into the night, by lantern light. The smelt were an extra big run and fully half of them are by far the largest ever taken in this vicinity, easily running from 10 to 13 inches in length.

In 1908 the total catch was 16,200 pounds, valued at $2,500, principally in Essex and Suffolk Counties, of which 3,200 pounds were taken by seines and 13,000 by lines. The following is quoted from the report of the commissioners on fisheries and game of Massachusetts for 1916:

The smelt fishery in Massachusetts is in a depleted condition, and strenuous and radical measures will be required to save this species from extinction. The only available natural breeding grounds of importance are the Weymouth Back and Fore rivers, particularly the former. To this locality each year thousands of smelt resort for spawning. Unless steps are soon taken to prevent it, even this last breeding ground will soon be past history because of the depredations of man.

Plans are now under consideration toward protecting this locality as a reservation where a station can be established for obtaining the smelt eggs, the majority of which would otherwise perish, and from which the collected eggs could be distributed for restocking other coastal streams, possessing suitable spawning grounds. Only by this means can the smelt fisheries of our coast be maintained and replenished.

The report of these commissioners for 1917 (p. 76) says:

The smelt fishery of Massachusetts, while never achieving a commercial importance like that of the New Brunswick fishery (an important winter fishery, carried on through the ice, and the product shipped frozen to market), is now of value to the recreational fishermen, and does represent a substantial food supply. The commercial possibilities should be the primary reason for its development, for conditions can be made favorable to restoring the once abundant supply.

The reappearance of smelts in localities that they had not frequented for years was attributed to previous stocking. The annual report of the Massachusetts commissioners for 1918 (p. 148) said:

It was reported to one of our men on January 29 of this year that large quantities of smelt were being taken from Bournes Wharf River, in the Duxbury Marshes, in the part called Captain Simmons Turn. Fifty pounds were taken in one day by one man. This, our deputy reports, is an unusual circumstance, since in forty years of acquaintance with the river he never knew smelt to be so plentiful or present at that season. This is doubtless attributable to the informal stocking a few years ago by deputies of the department, who, in passing to their work, were in the habit of filling baskets with eyed spawn at the Weir or Weymouth Rivers, and depositing it in the rivers where smelts were formerly found, but which had since become depleted.

Results have also been apparent in the Jones River, Kingston, where the fishery was badly depleted. In 1916–17 the fishermen took large quantities of smelt through the ice, weighing frequently two to the pound. One of our deputies was eye-witness to a catch of 139 pounds by one man, all large-sized smelt. In the same river, in the winter of 1917–18, some good catches were

made, but the ice was very thick, and on extremely cold days the fish did not bite. There was an average of from 12 to 40 pounds. The prices received were from 21 to 35 cents. The average smelt this year ran four or five to the pound.

Some years ago eggs were planted in Poor Farm Brook in Saugus where smelt had been extinct for some years, and three years from the next fall there was good fishing.

An analysis of the foregoing indicates that many years ago smelts were abundant. The catches of the eighties also indicate that they were still plentiful. Records of anglers fishing in the vicinity of Boston and along the north shore in that period support the evidence, but in the nineties there is evidence of decline. This may be illustrated by taking Dukes County alone, where the seine fishing in the Great Ponds was practically monopolized by two or three individuals. In 1880 this county had a catch of approximately 3,687 pounds, which constitute about 97.9 per cent of the total catch of Massachusetts, as shown by available statistics. In 1882 the catch of the same county constituted 100 per cent of the total State catch, and in that year exceeded the total catch of Massachusetts by some 2,000 pounds; but in 1908 no smelts were reported from Dukes County, although the county may have been included in the category "all other counties," which showed some 500 pounds. In 1900 other counties were represented in the statistics—that is, Bristol and Barnstable—with something over 59 per cent of the total catch, Dukes County having a little over 35 per cent. In 1905 the total catch of the State somewhat exceeded that of 1900, the increase being attributable to the hook-and-line fishing of Essex County, which was first recorded in this year. Dukes, Bristol, and Barnstable Counties each fell off, Bristol, however, leading. In 1908 Essex County reported 62.5 per cent of the total State catch, of which 81.25 per cent was by hook and line.

It is quite evident that for some years the smelt fishery of Massachusetts has been declining, notwithstanding the prohibition of dip nets and seines, which was intended to protect them. But other things were not equal; while there is no definite information at hand, everything being taken into consideration, it seems evident that the depletion is not wholly attributable to excessive and untimely fishing, except possibly in the case of Dukes County, but to the fact that streams formerly resorted to for spawning had become unsuitable or inaccessible.

Maine.—In Maine, fishing for smelts through the ice seems to have been one of the most primitive methods, for in 1677 Josselyn thus described the Indian way:

> The *Frostfish* (*O. mordax*) is little bigger than a *Gudgeon*, and are taken in fresh brooks; when the waters are frozen they make a hole in the ice, about half a yard or yard wide, to which the fish repair in great numbers, where, with small nets bound to a hoop about the bigness of a firkin-hoop, with a staff fastened to it, they take them out of the hole.

It is not known whether present-day ice fishermen use dip nets, but hook-and-line fishing through the ice was the practice long before any sort of net was used, except dip nets in the brooks during the spawning runs.

Of smelt angling for sport alone their appear to be no records in this State, but there are accounts of winter fishing with hook and line for profit. Many hook-and-line fishermen combine business with pleasure, disposing of their catches by sale. The principal hook-and-line fishery was, and still is, largely a commercial proposition in certain localities along the coast. According to Hallock (1893) Portsmouth, N. H., near the Maine border, was a favorite winter resort for smelt fishermen, but now

most of the hook-and-line ice fishing is carried on farther east. A very good description of the winter hook-and-line smelt fishery in Maine, entitled "Taking smelts through the ice," was printed by the Belfast (Me.) Journal in 1884. An extract from this article follows:

On Monday afternoon a Journal representive took a tramp up the river among the smelt fishers. There are twenty-three cosy tents on the ice, fifteen of which are in a cluster, or rather in a row, close together off Kaler's Mill. Four tents are off Beaver's Tail and the others are scattered along the western shore. The fishermen all said " This is the best season for fish we ever knew, or at least for many years." As soon as the ice was of sufficient strength the fishermen placed their tents thereon. The smelts were there in plenty and took the hook readily. In fact, before the river was frozen Mr. Fred Cottrell caught large quantities from the shore with a line attached to a pole. Entering the tent of Mr. Joseph H. Trussell, one of the successful fishermen, he politely gave up his chair, and with a board across the head of a small keg he improvised a seat for himself. His tent is a frame about five feet square and six feet high at the ridge pole, covered with drilling. The covering is painted to better protect the fishermen from the wind. A small coal stove is at one side, the pipe leading out through the roof. The fire not only keeps the tent warm but heats the fisherman's dinner. The floor is boarded, with the exception of a square space with a corresponding hole in the ice. Through this opening, and made fast to a rack above, four lines are suspended, each having a single hook. The lines are kept down by a lead sinker, to the lower end of which the snell and hook are attached. The hooks are baited with clam worms dug from the flats. Seated on a chair the fisherman thumbs his line with as much comfort as though by the fireside in his own house.

Some of the tents are double and contain two fishermen with a double set of gear. The single ones are considered the best, as two persons will make more or less noise. The fish bite better on the ebb tide when they are moving down the river. This can not always be relied upon, however, for some days they take the hook readily, at other times sparingly. It has been observed that the smelts bite better on cold stormy days. Last Saturday as many as sixty pounds per man were caught. At such times the fisherman has brisk work with his four lines. Mr. Trussell thinks there are two different varieties of smelts—one he classes as the school smelt and the other as the permanent smelt—those that are always to be found in the river. The school smelt, he thinks, moves about from place to place and takes the hooks most readily. This smelt has a very light colored back. The fishermen all thought that smelts would be more plentiful in our waters if the mill dams were provided with fishways. Goose River, the Wilson stream and Gurney's are dammed so that the fish are unable to ascend to deposit their spawn, and are obliged to spawn along the rocks, where they are mostly destroyed. * * *.

The fish are mostly sold to Sleeper and Field of this city, who ship them frozen to the Boston, New York and Philadelphia markets. The fish are nicely packed in a box back down, and will keep for a long time.

A still more interesting account of ice fishing appeared in the American Angler (Vol. V, Feb. 2, 1884, pp. 72–73). As a matter of history and of early customs it seems worth reprinting in full. Its title was simply "Fishing for smelts."

"If any one likes fishing through the ice with the thermometer ten degrees below zero and the wind blowing sometimes at the rate of twenty-five miles an hour, he can find his ideal sport just now on any of the rivers and inlets along the coast of Maine," said "Mort" Scott, well known in angling circles in this city, who returned on Saturday from a week's fishing for smelt on the Maine coast. "Smelt fishing is now at its best up there, but the weather is about at its worst. At least in the estimation of the visiting sportsman it is; but those native and to the manner born think it couldn't be better. They don't seem to mind a little matter such as the mercury registering fifteen degrees below, and to see their tents lifted from the ice by the wind and carried upward like a balloon is regarded by them as only an episode that adds zest and humor to their enjoyment. When I left there last Thursday it was so cold that the holes in the ice froze over nearly as fast as they were cut, even with fires in the tents, and to keep them open required a little more labor than

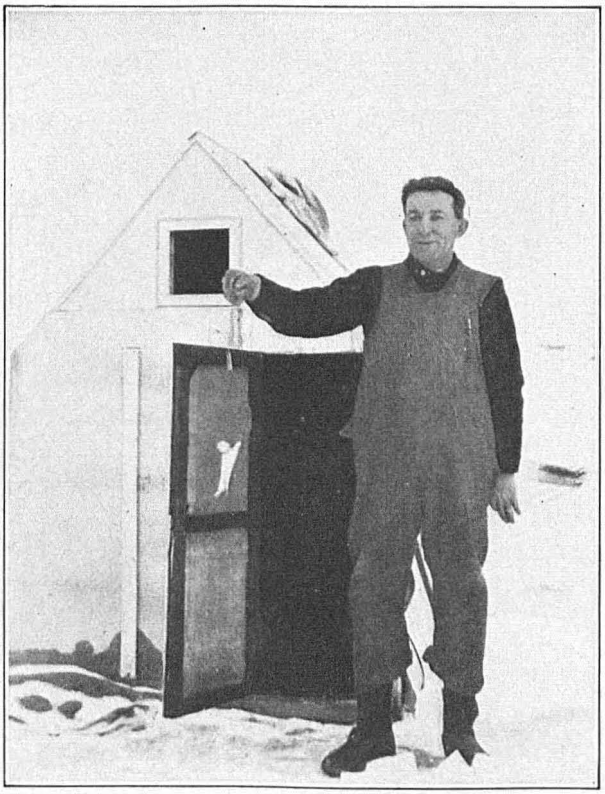

FIG. 11.—Smelt house and fisherman, Damariscotta River, Me., winter of 1925–26. Fisherman holding up two smelts caught at the same time

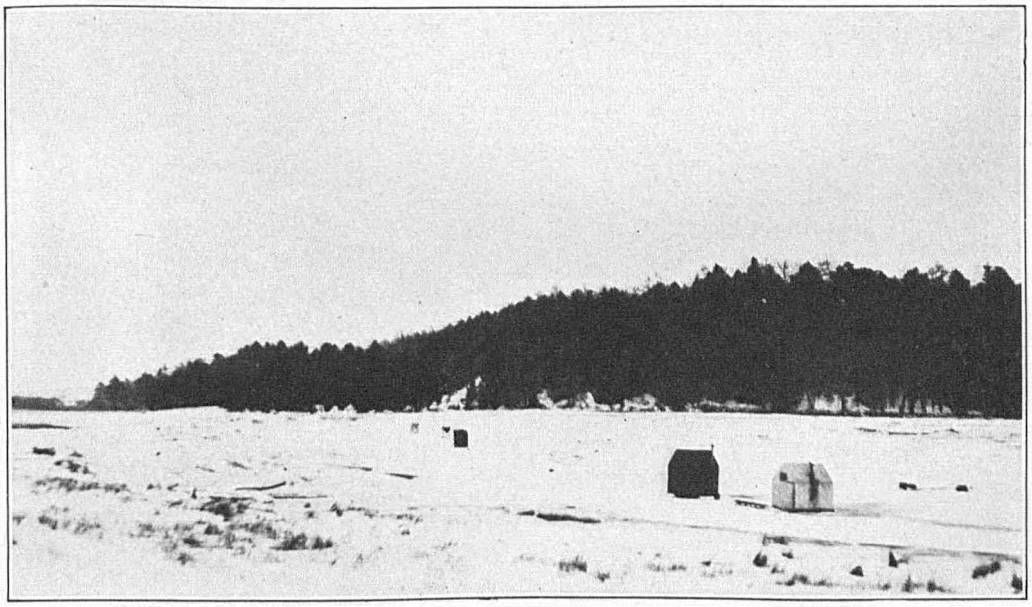

FIG. 12.—Smelt houses on Damariscotta River, Me., winter of 1925–26

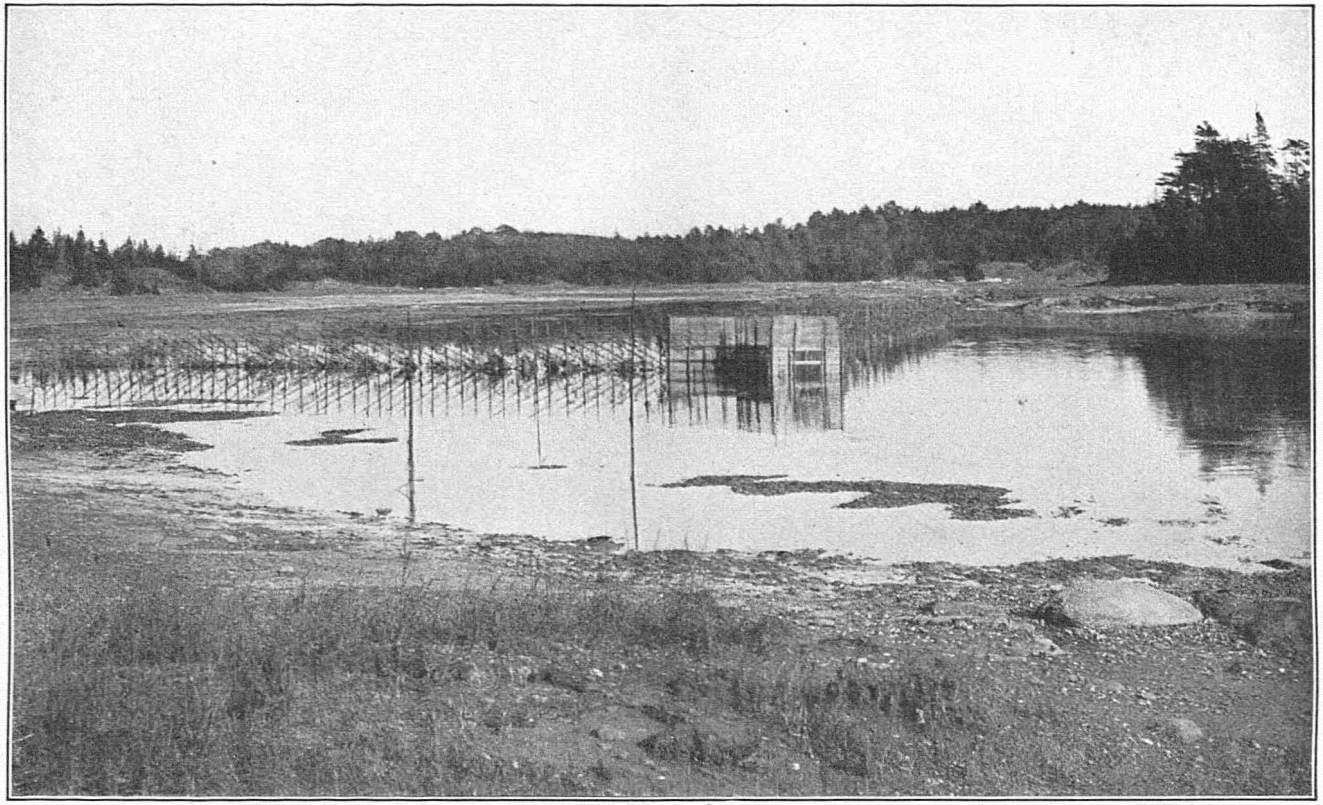

FIG. 13.—Brush weir for smelts in a tidal creek at Freeport, Me. There are now no weirs in this creek, nor in the neighborhood anywhere

even my enthusiasm in the sport could well overbalance. But there were scores of fishermen on the ice when I left, for the smelt seems to bite better the colder it is, and after this month the fishing gets poorer, and the fish move gradually to other quarters.

"Smelt fishing through the ice," continued the speaker, "does not differ much from the same mode of angling for pickerel, but the element of uncertainty is unknown in the former sport. You may fish all day sometimes for pickerel, then be obliged to buy enough to save yourself from going home 'skunked,' but when you cut your holes in the ice and put in your line for smelt, you are just as certain of being kept busy pulling out fish as you bait your hook. A smelt isn't as big as a pickeral, but he's a game fighter, and there is an excitement about 'tending' the lines that pickerel fishing does not create. The people up in Maine look upon smelt fishing as the sport of the year, and they come from miles about the country to enjoy it. Even the Indians from the far back country tramp in to the coast during the season to excerise their skill in luring smelt. The tackle for smelt fishing is very simple. The line is an ordinary stout linen cord, about four feet long. To one end of this is attached a piece of lead about three inches long and the size and shape of a three cornered file. This is called a file-sinker. To a swivel in the other end of the sinker is tied a pink-colored snell, made of common fish line, to which is attached a hook such as is used in fishing for catfish. The snell is two feet long. The water acting on the triangular sinker hung on swivels, keeps it constantly twirling about, and the bait, which is an ugly looking insect called the clay worm, always in motion. Each fisherman will have out an average of four lines, in as many different holes, if he seeks the enjoyment of the sport under the protection and shelter of a tent, or 'house,' as the natives call them. If he, like many of the local anglers, is braving the elements with the sole intention of extracting profit from the catch, and dances and trots about on the ice regardless of extraneous aids to combat the wind and storm, he is likely to have or a dozen lines to care for, spread over an area a hundred feet around; and if the fish are biting good he will have but little time to think of the cold, as he will be kept busy hauling up his lines and keeping the holes open.

"It has only been within a few years that such a thing as smelt fishing under shelter was known. The fishermen had either to stand out unprotected against the gales and storms that seem to be kept 'on tap' along the coast for use at any moment, or pull their lines and go home. To be sure, they would pile up walls of ice and patch them with pine boughs, but as it frequently is necessary for the fisherman to change his location and the ice barricade could not well be taken along, the building of them was generally time and labor thrown away. By the way, that is a peculiarity of smelt fishing. The fish may be biting so that you will be kept constantly hopping from one hole to another to stand your catch. Suddenly your 'tipups' will cease to tip. The smelt have taken it into their heads that the locality is not safe for them and have moved. Well, in a case of this kind, as I said, the angler would find his ice and pine boughs useless, and he would have to desert them to hunt up the spot where the fish had changed their base. But one season a man named Job Secor went up from Boston to try smelt-fishing. He tried it for a day and froze one foot and both ears, and then went away. But he didn't go home. He went to Belfast, and had a heavy wooden frame ten feet square made by a carpenter. He procured some sail canvas and covered the frame with it, leaving an opening for a door. The frame was on runners. When the house was finished he had it drawn upon the ice and placed over the holes he intended to fish through. Then it occurred to him that he might add still further to his comfort, and he bought a small box stove, ran a pipe from out of one side of the house, started a roaring pine wood fire in it, and, seated on a bench, fished as comfortably as if he were in his room at the hotel watching a stove pipe hole in the floor. The house was secured to the ice by grappling irons. If smelt ceased biting in one spot, he simply loosened his grapples, shoved his house along on the runners, and 'squatted' in more favorable quarters. No one who fishes for smelt simply for the sport there is in it has gone on the ice since then without one of the houses. Many who make a business of smelt fishing have adopted the plan, and now, in the height of the season a stranger going, for the first time to any of the rivers or inlets along the coast, would imagine that a small army was in camp there.

"On a good day for smelts the average catch per line will be at least 100, or say, 30 pounds. The fish net the business angler about five cents a pound, and have a ready sale in the local markets. On Wednesday of last week I was having a busy time in my house. I had only two holes in use, for the fish were biting so lively that I couldn't take care of any more. It was snowing

hard and blowing harder, but my fire was roaring inside, and I was tolerably comfortable. Suddenly, along came one of those zephyrs that love to play up and down the Maine coast. It seemed to think that I was cutting things a little too fast around there, and it stopped at my hut, got a leverage on my grapples, and the next instant hut, fisherman and stove were moving off at a lively speed. The front part of the stove—which was not much more than a toy stove, being only two and-a-half feet long—dropped into one of the holes in the ice, and the whole business went down among the smelt. We were scudded along for a hundred yards, when my house came in contact with another fisherman's house. This called a sudden halt, and I took advantage of it to crawl hastily out. The collision loosened the grapples on the other house, and in a moment both were flying along over the ice in all parts of the inlet. The gale lasted for not more than ten minutes, but the whole smelt-fishing village had been moved about a mile from its site when it ended. That little episode convinced me that it would be more pleasant for me to leave smelt-fishing until next May or June, and then resume it on a convenient stream; so I struck my tent and cut sticks for Belfast.

"I believe smelt-fishing is becoming more popular every year, and even the ladies are manifesting a willingness to brave its risks and, sometimes, its hardships. There was a party of three ladies and gentlemen from Boston camped on the ice when I came away."

Later that season George W. Singer (1884) wrote:

I read in your issue of Feb. 20 [Forest and Stream] an account of smelt fishing in Saco, and I think an account of the same in another town in Maine may be of interest. I left Waldorough [*sic.*, meaning Waldoborough], Me., seven weeks ago. There were then about sixty shanties on the river. They are neat little houses of ¾-inch stuff, and vary from 4 x 6 feet to 6 x 10. A cousin and myself fished in a shanty 6 x 10, and we used twelve lines. From Dec. 26 to Jan. 20 we took from fifteen to forty pounds every day, usually averaging in size about nine to the pound. We fished about four hours each day, just before and after low water. I left for home Jan. 22, but I have learned that there has been not more than a week since when the smelts did not bite. We use a great variety of bait, but nothing attracts them like marine worms or clam worms.

In his report on the sea and shore fisheries of Maine for 1886, Commissioner Counce stated that during the winter months the shipping of smelts had become quite an important business in Maine, many thousand pounds of this little fish being sent out of the State during the winter and spring. Two years later the American Angler, for February 25, 1888 (p. 126), contained the following notice:

Tons of smelts are being sent daily from Bath, Me., to the New York and Boston markets. The fishermen have erected a village of shanties on the ice in Back River, Arrowsic. The ice serves as flooring for the shanties, which are large enough to contain two men and a stove. A small hole is cut through the ice and fisherman plies his vocation indoors. Some of the smelters who fish in the open air are protected from the chilling blasts by screens of cotton cloth stretched between two posts. When the weather is cold they build bonfires on the ice to keep them warm. Most any afternoon from 75 to 200 men and boys make up the army of smelters and they are a jovial set. They get from four to five cents a pound for what they catch, and they earn from $1 to $4 a day each during the smelting season, which lasts during the winter months.

The report on the sea and shore fisheries of Maine for the same year (Counce, 1888) stated that "this little fish is caught in weirs and in large quantities in this State, and shipped to Boston, New York and Philadelphia, at a profit in the fall and winter." Two years later (April 10, 1890), Forest and Stream, quoting from an exchange (Gloucester Daily Times), said:

Old fishermen say that smelts have not been so abundant in the Kennebec River for twenty-five years as they have been this winter.

The account stated that "Winterport, on the Penobscot, is said to be the greatest smelt-fishing town in Maine. The fishing is done with bag nets, which are set at the beginning of the flood tide, and drawn at high water. The best catches are made at night. Eighty pounds is considered a fair catch, but this amount is generally exceeded."

According to the Maine Sportsman for April, 1894, the eastern smelt fisheries continued good as to quantity of fish caught, although it appears that in this instance the account pertained to smelts caught near the breeding season, if not in it. The account said:

> Smelt fishing in the river at West Pembroke came to a close early last week. The catch during the last day was a remarkable one, the quantities landed by the nets being so great that it required several teams to transport them to Eastport and Calais, it being necessary to send half a ton or more to the latter place to go by rail, as the smelt season in Massachusetts closed the 15th instant, and they had to be rushed into market before that date. The season has been very fair as to catch, but prices have been rather low. For the first time in the prosecution of the business in that river the purse net was used this season and to good advantage. The smelt industry has reached large proportions in Maine and is worthy of some special attention from the bureau of statistics.

In March, 1897, the same journal announced that 15 tons of smelts were caught on Damariscotta Bay by hook and line during the months of December, 1896, and January and February, 1897. "They netted 7 cents a pound." This would make the total value of the smelt fishery at this place for the three-month period $2,100.

Nickerson (1898) reported as follows:

> The catch of smelts for 1898 in which every county on the coast is represented, was 1,156,684 pounds, which returned to the fishermen eighty thousand, three hundred and fourteen dollars. As compared with the previous year there were 35,579 pounds more caught in 1898 than in 1897. Ten hundred and ninety-five persons were engaged in the taking of the above fish with weirs and seines, and by hook and line. There is usually a quick market for smelts, and recent prices, though fluctuating have ruled high. Large shipments are made to the Boston and New York markets, and December consignments have returned to the fishermen fifteen cents clear of expense to the pound.

Over 40 years ago, at Surry, on May 27, Atkins noted that according to N. Hinckley, Esq., House of Representatives, smelts were formerly of considerable importance. They were taken mostly through the ice with hook. In the spring they were said to run up the stream that enters the head of the harbor west, but this year (1878) hardly any had come up into the stream. It was suggested that the failure was attributable to too much dipping of them early in the season when the tide was out and the fish collected in bodies in tide pools. On May 28 of the same year Atkins indicated a scarcity of smelts in Lawrence Brook, whereas the year before an individual got a bushel at one catch.

It would seem, however, that at Surry, some 22 years later, the fishery had not declined greatly. The following excerpt from the Bangor Commercial of January 23, 1900, indicates that the Surry hook-and-line fishing was still yielding satisfactory returns:

> Nearly 100 men and boys together are engaged in the winter's fishing at Surry, and in 35 years more than $40,000 worth of smelts have been taken.
>
> The smelts are all caught with hook and line. Taking them otherwise, such as by seine, would be regarded by the fishermen here as a great wrong. The fishing is all done in tents, the

tents being about six feet long, five feet wide, and high enough for a man to stand up in them. These tents are covered with cloth, heated by a stove, and lighted usually by a lantern. I have known the temperature of my tent to vary, however, 60 degrees within 10 minutes during a cold day.

A hole about six feet long and eight inches wide is cut in the ice, and the tent set lengthwise of this. Six lines attached to a pole fastened to the plates of the tent hang into the water nearly eight inches apart. These lines, during fishing hours, are always kept in motion.

The way the fishermen handle these lines, how they can bait the hooks and slat smelts, when, as they say, they are "taking holt," is certainly wonderful. I have known one man to catch 100 pounds in less than one hour. This means at least 1,000 fish, or about 17 a minute. One smelter has been known to catch 500 pounds during one tide's fishing. Some have made $25 to $30 a day, and others $200 in a few weeks. But these big catches are only made by those expert in fishing. The chances are that a green hand would starve the first winter if dependent wholly on what fish he caught.

During the fishing season politics, religion, war and all other subjects generally discussed in the stores are dead issues. Nothing but smelts is talked about; nothing but fish discussed by the fishermen. The usual salutation when meeting another is: "How many?"

It is a beautiful sight some still, cold, morning to watch the streams of white smoke belching out of a hundred stove pipes and slowly ascend almost perpendicular 100 feet in the air. From a distance these little houses huddled together remind one of some miniature city. Sometimes when the Bay first freezes these villages come into existence with as little notice as that of a mining settlement.

The smelts are all shipped to Boston and New York markets.

For about the same period (1899–1900) the report of the commissioner of sea and shore fisheries of Maine (Nickerson, 1901) indicates a continued prosperous smelt fishery in that State. It says that from this business (considered small and practically of no account by those who do not know about it) in the year 1900 the State derived a revenue to its fishermen of $77,074, the yield being 1,017,434 pounds. The total investment in boats and gear, weirs and camps used in this business in 1900 was $25,398, or about $26 to each person engaged in the fishery, which numbered 977 persons, men and boys. All the counties on the coast excepting Knox, Cumberland, and York prosecuted the fishing largely through ice from camps, while the Waldo County catch was taken without the use of either weirs or camps, and that of York County entirely with hook and line. Most of the fishermen carry on the fishing but a few weeks and in some sections but a few days, still the men engaged average about $80 each. As compared with the previous year (1899) the catch and money return increased somewhat over the latter year, and the men fishing increased from 830 to 977. Large shipments continued to be made to Boston and New York markets.

The commissioner's report for 1903 and 1904 (Nickerson, 1905), states that the aggregate yield for the term of the report was greater than shown in any previous report; the catch of 1903 was very large compared with previous years, being an increase of 343,000 pounds over 1901. The average price in 1903 was 11 cents per pound, a higher average than in previous years, which showed a good demand in the markets of New York and Boston, where the fish are principally shipped by the fishermen direct. The report says:

While the winter fishing is much pursued as a sport these fishermen receive very good wages while thus engaged fishing through the ice.

The commissioner's report for 1905–6 (Nickerson, 1907) stated that it was obliged to report a largely reduced catch as compared with the last previous report.

The catch of 770,391 pounds for 1905 was a falling off as compared with the previous year of more than a quarter million pounds, and for the two years here reported the production is 319,128 pounds less than for 1903 and 1904.

This condition may be accounted for in measure by the fact that the number of men engaged in the fishery has been very materially decreased. In 1903 there were 824 men thus engaged, while in 1906 the number has fallen to 654.

The average price received by the fishermen was almost 12 cents a pound, a little better showing than two years ago.

The ice fishing has been classed in some localities as a "sport," but the catches have been so large, and returns so satisfactory, that it has become a business proposition, a hundred or more dollars being easily and quickly gathered in, while for a few days the local "sport" has engaged in this "pastime"—a pastime so profitable is likely to be popular.

As has appeared in the foregoing, other methods of fishing than by hook and line were sooner or later adopted. These methods were by some sort of nets, such as seines, weirs, traps and pounds, bag nets, dip nets, gill nets, and fykes. As this net fishery expanded the catch of smelts increased for some time, but the inevitable decline was shown later.

The statistics of the New England States for 1905[3] indicate that in that year in Maine, there were 5,986 shore fishermen, of which the Maine sea and shore fisheries commissioner's report shows 776 were smelt fishermen. The quantity of smelts taken in that year amounted to 587,985 pounds, valued at $64,000. The following table shows the take of smelts, by countries:

County	Pounds	Value	County	Pounds	Value
Cumberland	95,135	$9,008	Penobscot	8,000	$640
Hancock	220,100	18,875	Sagadahoc	34,500	3,325
Knox	52,500	6,150	Washington	121,900	18,516
Lincoln	54,700	7,283	York	1,150	207

The report says:

Since 1902 there has been a decrease of 47 per cent in the catch of smelts and 34 per cent in its value. There is always a demand during the fall and winter, however, and the fishermen seldom realize less than 10 cents a pound, the average being considerable more.

In 1905 the hand-line fishery was paramount and was restricted to Hancock, Lincoln, and Sagadahoc Counties, according to the statistical report. Hancock County led Sagadahoc and Lincoln Counties by 115,000 pounds, as follows:

County	Pounds	Value
Hancock	156,500	$12,520
Lincoln	25,600	4,293
Sagadahoc	15,500	1,550

Pound nets, trap nets, and weirs being so nearly alike in principle, the catches are combined. These were employed in Cumberland, Hancock, Sagadahoc, Washington, and York Counties. The catch of Washington County exceeded the combined catches of the other four counties by 29,450 pounds.

[3] Report, U. S. Commissioner of Fisheries, 1906, Bureau of Fisheries Document No. 620, 93 pp. Washington.

County	Pounds	Value	County	Pounds	Value
Cumberland	2,500	$300	Washington	51,900	$7,851
Hancock	14,300	1,585	York	1,150	207
Sagadahoc	4,500	325			

Seines were fished in Cumberland, Hancock, Knox, and Lincoln Counties, with the following results:

Counties	Pounds	Value	Counties	Pounds	Value
Cumberland	92,635	$8,708	Knox	52,500	$6,150
Hancock	16,000	1,600	Lincoln	25,100	2,590

Gill nets appear to have been used only in Washington County, where they took 17,500 pounds, valued at $2,035. Dip nets and bag nets were employed in Hancock, Penobscot, Sagadahoc, and Washington Counties. The largest catch was in Washington County, which fell behind the combined catches of the other counties by 1,800 pounds.

County	Pounds	Value	County	Pounds	Value
Hancock	33,300	$3,170	Sagadahoc	13,000	$1,300
Penobscot	8,000	640	Washington	52,500	8,630

Fyke nets were used only in Lincoln and Sagadahoc Counties. The combined catch of the two counties was only 5,500 pounds, valued at $550, of which Lincoln had 4,000 pounds, valued at $400. The following table shows the quantities of smelts taken by the various methods from 1887 to 1908, as revealed by the only available statistics:

Methods of capture	1887	1888	1898	1905	1908
Hand lines	589,105	601,812	577,133	197,600	89,000
Seines	142,300	179,600	590,703	186,235	222,000
Weirs, traps, and pounds	79,650	93,600	6,196	74,350	113,000
Bag nets and dip nets	388,145	397,538	266,272	106,800	29,000
Gill nets			12,000	17,500	34,000
Fykes	3,600	2,000	4,237	5,500	107,000
Total	1,205,150	1,279,550	1,608,045	587,985	654,000

On December 10, 1906, smelt fishing in Maine had begun, according to advice from Bangor Fishing Gazette, New York, 1906).

At the mouth of Union River the ice is safe and enough smelts are being taken to encourage the fishermen to continue, but there have been no big hauls. At Surry, the most important smelt-fishing town in Maine, 10 or 15 tents have been erected by fishermen. Within a week or two, if the weather continues cold, half of the population of the town will have moved out on the ice, and there will be fully 100 tents and shacks. The Penobscot River smelt fisherman have not been able to begin the season because the ice has not formed solidly below Hampden.

The following table shows the amount of smelts, in pounds, caught in each county for certain years from 1897 to 1924, derived from reports of the commissioner of sea and shore fisheries of Maine and reports of the United States Bureau of Fisheries:

Year	Counties								
	Washington	Hancock	Penobscot	Waldo	Knox	Lincoln	Sagadahoc	Cumberland	York
1897	41,360	240,114	----------	65,450	1,638	207,237	180,692	376,714	7,900
1898	117,875	150,852	----------	68,790	16,200	339,200	92,576	368,000	3,191
1899	115,110	193,134	----------	81,860	24,078	272,335	4,206	187,236	2,147
1900	199,960	219,658	----------	70,850	37,700	193,731	78,935	212,600	4,000
1901	149,267	102,523	----------	45,540	24,042	214,085	79,056	71,815	----------
1902	249,088	187,034	----------	28,425	52,900	297,320	67,940	119,055	----------
1903	255,065	315,364	----------	30,142	29,276	204,024	55,729	139,900	400
1904	276,872	280,393	----------	56,835	17,000	203,385	17,010	127,345	2,300
1905	176,800	151,166	----------	29,160	84,000	214,700	11,945	101,420	1,200
1906	245,818	235,508	----------	33,300	49,500	176,887	15,535	164,765	208
1907	238,635	180,249	----------	46,700	25,375	117,648	11,900	169,030	497
1908	263,780	149,228	2,000	----------	68,875	210,500	3,440	227,545	1,350
1909	306,601	217,738	7,500	----------	25,195	137,600	31,190	228,130	----------
1910	207,170	292,109	12,000	45,000	57,100	176,000	34,255	264,820	----------
1911	292,790	334,257	16,000	----------	96,750	125,200	60,310	242,785	----------
1912	317,675	131,700	15,700	----------	61,500	185,000	66,635	211,935	----------
1916	52,433	176,200	25,500	200	61,000	3,000	24,040	195,500	----------
1919	36,300	95,435	1,900	23,450	93,600	53,500	74,230	136,202	8,000
1924	92,315	105,115	24,140	52,000	58,289	106,760	99,005	86,583	3,500

The following table shows the available statistics of the total catch, in pounds, value of the catch to the fishermen, number of fishermen and average catch of each, average value received by each, and the average price per pound received by the fishermen in certain years from 1897 to 1924, inclusive, as derived from the reports of the commissioners of sea and shore fisheries of Maine and the United States Bureau of Fisheries:

Year	Pounds	Value	Number of men	Approximate quantity per man	Average value per man	Average price per pound
1897	1,121,105	$67,960	1,121	1,000+	$60.62+	$0.060
1898	1,156,684	80,314	1,095	1,058+	73.34+	.069
1899	880,106	66,682	830	1,060+	80.33+	.076
1900	1,017,434	77,074	977	1,040+	78.80+	.076
1901	686,328	56,930	859	798+	66.27+	.083
1902	1,001,762	95,833	753	1,330+	127.26+	.096
1903	1,029,900	101,720	824	1,249+	123.44+	.099
1904	981,140	97,769	765	1,282+	127.79+	.099
1905	770,391	86,588	776	993+	111.58+	.112
1906	921,521	107,206	654	1,409+	163.92+	.116
1907	790,034	86,437	----------	----------	----------	.109
1908	926,718	110,186	----------	----------	----------	.119
1909	953,954	110,004	----------	----------	----------	.115
1910	1,088,454	115,107	----------	----------	----------	.106
1911	1,168,092	125,011	----------	----------	----------	.107
1912	990,145	106,351	----------	----------	----------	.107
1916	537,633	63,679	----------	----------	----------	.118
1919	523,967	94,496	----------	----------	----------	.180
1924	627,707	137,430	----------	----------	----------	.219

Basing computations upon the figures shown in the foregoing tables, there apparently was a considerable decline in the smelt fishery up to 1916. In the decade from 1887 to 1897 a falling off of 84,045 pounds is found, which might, perhaps, represent only a fluctuation due to one cause or another; but in the 20-year period from 1888 to 1908 there is a greater loss of 625,550 pounds, and in the 30-year period from 1887 to 1916 a still greater falling off of 667,277 pounds is seen. Again, taking a 20-year period, from 1897 to 1916, as shown in the last table, while a drop

of 583,472 pounds is shown in the period from 1897 to 1911, an increase over 1897 of 46,987 pounds is indicated, and the quantity taken in 1911 was larger than that of any year represented in the tables since 1888, but there is a pronounced falling off in quantity in subsequent years.

From 1897 to 1906 there was a fluctuation in the number of fishermen, which would account for some fluctuation in the quantity caught, indicated also in the average quantity taken per man. The average value of the fishery per man shows a fluctuating but progressive increase, as does the average price per pound of fish. Whether the increase in value and average price per pound are attributable to increased demand or to a relative decrease of the smelt, and whether the apparent comparative steadiness of the supply may be attributed to more intensive fishery methods, can not be determined from present data. It is unfortunate that there are not more complete data extending up to the present time, whereby some light might be thrown upon these points. The figures for 1919 show a marked falling off in quantity from those of 1911 and a considerable decrease from 1912, but there is a marked increase in value per pound.

During the fall of 1924 there was a general complaint of scarcity of smelts, although now and then a fair catch would be made by one or another fisherman. Such complaints have arisen from time to time in the last few years. Statistics for that year indicate an increased catch over that for 1919, as well as increased value.

The gradual increase in price per pound up to 1916 without fluctuations corresponding to fluctuations in the quantity of fish taken, with an increase in the number of fishermen, would strongly suggest a relatively diminished fishery. In this connection an item that appeared in the Fishing Gazette (New York) for February 1, 1925, entitled "Maine smelt fishing pays well this season," may be regarded as highly significant. It said:

> Years ago the winter smelt fishermen in the vicinity of Bath used to get six or seven cents a pound for smelts. When they went to 10 or 12 cents they considered themselves fortunate. Today they are receiving as high as 40 and 45 cents a pound for the maximum quotation and 30 for the minimum. At Arrowisic, where most of the fishing is done from little smelt-houses placed on the ice, there are an unusually large number of fishermen this winter. In former years there have been as many as 200 of these little smelt shanties on the Arrowsic ice.

Comparison of the quantity, value, and average price per pound of smelts taken in the coastal fisheries of New England in 1888, 1908, 1919, and 1924

State	1888			1908		
	Pounds	Value	Average price per pound	Pounds	Value	Average price per pound
Maine	1,279,550	$94,927	$0.074	654,000	$65,000	$0.099
New Hampshire	36,000	3,600	.100	2,600	300	.115
Massachusetts	10,800	1,152	.106	16,000	2,500	.156
Rhode Island	61,500	3,135	.050	1,200	100	.083
Connecticut	9,600	770	.080	10,100	1,200	.120

State	1919			1924		
	Pounds	Value	Average price per pound	Pounds	Value	Average price per pound
Maine	523,967	$94,496	$0.180	627,707	$137,430	$0.219
New Hampshire				3,835	1,630	.425
Massachusetts	39,150	10,690	.273	37,698	9,823	.260
Rhode Island				7,860	1,592	.202
Connecticut	25,217	4,466	.177	11,300	2,410	.213

Apparatus employed in the smelt fishery of coastal waters of the New England States, except Maine, in 1888 and 1908

Year and apparatus	New Hampshire		Massachusetts		Rhode Island		Connecticut	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1888								
Hand lines			8,000	$897			2,200	$150
Seines					19,300	$982	7,400	620
Weirs, pound nets and trap nets	36,000	$3,600	2,800	255	42,200	2,153		
1908								
Hand lines			13,000	2,200				
Seines			3,200	300			8,000	1,100
Weirs, pound nets and trap nets	2,600	300			1,200	100	1,500	100

Canada.—The smelt fishery of Canada has attained considerable magnitude. During the period from 1912 to 1923, both inclusive, the largest catch for the Dominion was taken in 1914, when 9,038,900 pounds valued at $713,501, were recorded. The smallest catch was in 1923, when 5,811,800 pounds were taken, but the value was considerably greater, being $789,361, representing a gain of $75,860.

The Canadian Provinces that support any smelt fishery are New Brunswick, Nova Scotia, Prince Edward Island, and Quebec in the east, and British Columbia on the west coast. In the east, also, Newfoundland appears to have entered the list of northern smelt-producing localities. The smelt of British Columbia is a different species from that of the east. The largest quantities are taken during months when there is little or no smelt fishing in the east, and compared with eastern fisheries it is of far less commercial importance.

The smelt fishery of Canada first became of note in New Brunswick, and that Province is still paramount in the fishery. The profits realized by New Brunswick in this fishery could but impress other localities where smelts were obtainable, so later other Provinces became interested in the industry.

The history of the development of the smelt fishery of eastern Canada is very interesting, but whatever has been published pertains largely to New Brunswick. Very little has been written concerning the other Provinces, and most of the data pertaining to them consist of statistics.

In 1849 Perley (1850, p. 135) said:

> The smelt (*osmerus eperlanus* of Cuvier, and *osmerus viridescens* of Agassiz), is found in excessive abundance in all the Rivers and Streams flowing into the Gulf. In the latter part of winter, when in the best condition, they are taken through holes in the ice, and at that season are a very great delicacy; they are then frequently called "frost-fish." Immediately after the ice disappears,

they rush in almost solid columns up the brooks and rivulets to spawn, and are then taken by cart-loads. This Fishery, under proper management, might be made one of considerable profit as the smelt is really delicious, and always highly esteemed.

In the same report specific mention is made of the River Miramichi. Perley said that the smelt ascended this river and its tributaries very early every year, in almost miraculous quantities; and in Buctouche River he stated that there was a great abundance of smelt every spring, and that parties of French settlers went up the brooks in log canoes and each party frequently got 50 to 60 barrels of smelts, which were used to manure the land.

In 1871 W. H. Venning, then fisheries inspector of New Brunswick, stated that large quantities of smelt were sent in a frozen state from Northumberland County to the United States, where they brought good prices. In 1872 the same inspector stated that from Westmorland County smelts were taken in large quantities and shipped fresh to the Boston market. In Kent County, in the same year, smelts were said to have been abundant in the rivers and a valuable resource for the fishermen during the winter season.

In 1873 Venning reported that smelts were being taken in larger quantities than ever before in Kent County, and that preparations were being made for extensively shipping them to the United States, where they commanded a ready sale and good prices. In his report for 1876 Venning (1877) said:

> Hitherto smelts have been very numerous because the fishery has not been followed to any great extent, but the facilities now offered for transportation are so great that a large business in this fish is growing up all along the Nothern Shore of New Brunswick, including the counties of Kent, Northumberland, and Gloucester. They are sent to the United States, where they find a ready sale at profitable prices.

Adams (1873), writing of New Brunswick, said:

> Enormous numbers of smelt are caught on the seaboard in midwinter, mostly to feed pigs, the flesh of which becomes tainted by the cucumber flavour of this fish.

Whiteaves (1874), in a report for 1873, said that the smelt was or might be taken abundantly throughout the Gulf of St. Lawrence all the year round, and that in New Brunswick and Nova Scotia smelts were exported to New York and Boston.

A note in Forest and Stream for October 12, 1876, stated that a large number of men were employed daily near Barthurst, New Brunswick, in fishing for smelts for American markets, principally New York and Boston. "During the past two weeks [first half of October] about forty tons have been forwarded by rail."

Venning (1877) indicated that the closed time for smelts in New Brunswick from April 15 to May 15, did not cover the spawning season of the "summer smelt" nor sufficiently protect the breeding fish. He said that large numbers were taken after the 15th of May (before they were done spawning) and used as manure. He stated that to be effectual the close time should be extended to the 1st of July, not only to prevent destruction of the spawning fish but also to prevent their being used as manure, adding that if they were caught all winter to the extent that then prevailed, and then destroyed wholesale during the spawning time, a very few years would effect their exhaustion.

Available statistics for a period of some 50 years ago, more or less, when W. H. Venning was inspector of fisheries of New Brunswick, indicate that the smelt fishery

of Canada was restricted to New Brunswick and Nova Scotia, at least so far as export to the United States was concerned. The reports for the years 1871 to 1878, both inclusive, show a constantly rapid increase in quantity of smelts and a corresponding enhanced gross value. The increase appears to have been attributable to more intensive fishing operations. The price per pound remained almost constant from 1873 to 1877, but in 1878 a 50 per cent drop in the price received by the shippers occurred, and Venning states that only 1 cent a pound was paid to the fishermen. This situation was due to an oversupply.

Year	All Canada		New Brunswick		
	Pounds	Value	Pounds	Value	Price per pound
1871	520, 146		485, 100		
1872	584, 160		495, 500	$10, 527. 00	
1873	810, 499	$48, 623. 94	697, 520	41, 851. 20	$0. 06
1874	1, 156, 440	69, 391. 00	915, 600	54, 936. 00	. 06
1875	1, 451. 580	87, 094. 80	1, 086, 280	65, 176. 00	. 06
1876	1, 990. 825	98, 228. 40	1, 559, 200	93, 552. 00	. 06
1877	2, 264, 002	13, 584. 12	1, 950, 700	117, 042. 00	. 06
1878	2, 715, 107	90, 007. 86	2, 426, 952	72, 808. 56	. 03

Twenty-five years later the same inspector, then retired (Venning, 1902), after referring to former abundance and their use as fertilizer, said that since the I. C. R. had furnished a means of reaching Provincial and United States markets, frozen smelts had formed a large export from all the northern countries, and in 1901 the aggregated shipment from New Brunswick amounted to 7,863,000 pounds. Samuels (1904) wrote:

I have before me a clipping from a St. John paper, which contains a communication from Richibucto, N. B., that shows how important the smelt packing industry has become in that place, which is one of many that are scattered along the shores of the bay. It reads as follows:

"The smelt fishing season, which opened yesterday, is the biggest thing in this part of the country. Although it is carried on but a little over two months in every twelve, it does more real good in that time than all the other industries put together can do in a whole year. The secret of its beneficial effect is found in the system by which the business is conducted. Other kinds of fishing, lumbering and such things are nearly all done by due method, but the man who attempts to take a hand in buying smelts without cash on the spot, 'is not in it.' * * * .

"Following the catching of the fish comes the preparation of them for market. It is nothing unusual for small boys to earn from a dollar to a dollar and a half a day packing the smelts in boxes. No matter in what way you are connected with the work it is cash. Forty or fifty thousand dollars emptied out within a radius of ten miles in a few months, means something, and the man or woman who cannot talk about smelts from now to the middle of February, is of no use in the vicinity."

Samuels stated that the net used in seining smelts is pretty close-meshed, and large enough to inclose several thousand pounds at a haul. He said:

The struggles of the fishes as folds of the net encompass them more and more closely, together with the weight of the captives as they become compact, forces the spawn from them, and that to such an extent, that I have seen the beach where the seining was done covered with the eggs in winrows looking like so much saw dust.

An article in the Fishing Gazette (New York) for November 24, 1906, asks the question:

Did you happen to know that the smelt output of the Dominion is now upward of 5,000 tons annually; that the monetary value is a half million dollars, and that only a few years ago the fish were taken for fertilizing uses?

On January 5, 1907, the same publication, quoting the P. E. I. Agriculturist, said:

As many as thirty fine boxes [of smelts] were taken in one "draw" quite recently. At this rate there is a little fortune in the business and if there be no extended break in the winter communications many of our fishermen will make more during the winter months than any of us. A few of the fisherman have, we are told, discarded the purse net and take smelts, as they catch herring, in old-fashioned gill nets which lets the little ones through. This is the only method by which the smelt fishing will be preserved and which ought to be adopted by all fishermen.

Again, the Halifax correspondent of the same journal, on March 9, 1907, says:

Apropos of dainty food fish, Capt. Sol Jacobs, the noted mackerel king, recently sent the first shipment of Newfoundland smelts to Boston across to Sydney and then by rail. These smelts averaged four to the pound and proved excellent in flavor. Should the supply be sufficient a large demand will doubtless spring up.

In 1912, five years later, Henry S. Culver, the consul at St. John, New Brunswick, stated that smelt fishing in New Brunswick, which he said commenced the 1st of December, was an important industry, the catch of 1911 having amounted to 726,661 pounds.

In 1913, Theodosius Batkin, the consul at Campbellton, New Brunswick, wrote:

Smelt, which only a few years ago were caught solely for fertilizing purposes by the farmers, are now an ever increasing source of revenue. In 1911 over 691,000 pounds, valued at $46,553, were exported by carload lots to American markets. In 1912 more than 1,120,000 pounds, valued f. o. b. at $63,595, were sent to American centers. These figures do not include the numerous exports by express and otherwise where the value of the shipment fell below $100. Most of the smelts are taken at the mouths of the Restigouche and other streams near by.

On December 1, 1916, E. Verne Richardson, the consul at Moncton, New Brunswick, reported: "Opening of the smelt season in the Province of New Brunswick, begins to-day." He stated that consular invoices certified at the Moncton consulate during the calender year showed shipments of smelts to the United States totaling 880,176 pounds, valued at $56,395, or a little over 12 cents per pound average selling price.

Quantity, in hundredweights, and value of the smelt fishery of all Canada, eastern Canada, and New Brunswick from 1913 to 1924, and average price per pound in New Brunswick

Year	All Canada		Eastern Canada		New Brunswick		
	Hundredweight	Value	Hundredweight	Value	Hundredweight	Value	Price per pound
1913	73,937	$689,959	73,937	$689,959	60,117	$601,170	$0.100
1914	90,389	713,501	90,389	713,501	65,189	651,890	.100
1915	62,143	562,064	62,143	562,064	52,961	529,610	.100
1916	66,109	825,115	66,109	825,115	55,025	715,112	.129
1917	69,780	994,545	69,780	994,545	55,703	834,415	.149
1918	82,638	925,625	82,638	925,625	69,937	801,244	.114
1919	75,271	835,195	74,023	820,513	54,963	611,839	.111
1920	58,118	789,361	56,749	773,425	40,041	565,279	.141
1921	84,597	835,393	82,780	815,963	62,042	589,804	.095
1922	83,268	934,608	82,868	930,194	62,680	731,151	.116
1923	65,254	868,629	64,218	858,929	43,210	475,523	.110
1924	90,066	1,146,673	88,926	1,134,500	63,975	844,730	.132

In comparing this table with that on page 261 it is interesting to note that in the 45 years from 1878 to 1923 the quantity of smelts caught increased by about 1,894,000 pounds, and increased in price received per pound from 3 cents (or possibly it should be normally 6 cents) to 11 cents per pound.

As previously indicated, the smelt season in New Brunswick is chiefly in the winter and lasts for about three months—December, January, and February. The foregoing table shows the annual quantity of smelts and their value for the year, but it does not show the extent of the fishery in any one season. The following table gives the quantity and value for each month of the season, from September to March, a period of seven months, during the seasons of 1911–12 to 1916–17, and quantities and values in quarterly periods from 1917–18 to 1920–21, inclusive:

Month	1911-12		1912-13		1913-14	
	Hundredweight	Value	Hundredweight	Value	Hundredweight	Value
September	22	$132	78	$412		
October	1,177	3,743	894	3,292	260	$1,040
November	3,045	11,363	1,115	3,603	364	1,434
December	18,829	80,401	25,664	102,206	18,859	76,236
January	22,368	88,704	28,616	127,468	21,791	102,010
February	12,616	49,639	15,563	67,785	1,284	64,135
March	152	608	100	500		
Total	58,209	234,590	72,030	305,266	42,578	244,855

Month	1914-15		1915-16		1916-17	
	Hundredweight	Value	Hundredweight	Value	Hundredweight	Value
September	73	$365	50	$150		
October	297	1,037	324	1,114	566	$2,499
November	948	3,604	782	2,662	1,911	9,670
December	19,908	102,586	12,188	58,260	12,403	91,523
January	22,479	102,395	20,468	118,668	25,807	210,690
Feburary	20,025	77,037	18,690	98,231	18,906	173,562
March						
Total	63,730	287,624	52,502	279,085	59,593	487,944

Month	1917-19[1]		1919-20		1920-21	
	Hundredweight	Value	Hundredweight	Value	Hundredweight	Value
September						
October			22,898	$164,323	10,550	$94,751
November						
December						
January						
February	[2]61,598	[3]561,475	31,430	214,882	38,532	353,973
March						
Total	61,598	561,475	54,328	379,105	49,082	448,724

[1] Includes the seasons of 1917–18 and 1918–19.
[2] Of this amount 30,834 hundredweight are for 1917–18 and the balance is for 1918–19.
[3] Of this amount $353,177 are for 1917–18, and the balance is for 1918–19.

Secretary Dimick of the Boston Fish Bureau, under date of December 30, 1924, is the authority for the following statements concerning shipments of smelts from Canada, Newfoundland, and Maine:

Canada.—The Canadian smelts are exported largely to the Boston and New York markets. The catch for the nine months ended September 30, 1924, amounted to 60,783 hundredweights valued at $563,299, compared with 32,450 hundredweights, valued at $377,573, in the same period in 1923. The total catch in Canada for 1923 amounted to 62,254 hundredweights, value $868,629, compared with 83,268 hundredweights, value $934,608, in 1922.

Newfoundland.—During the winter of 1923–24 there were exported from Newfoundland 99,825 pounds of smelts, valued at $10,460, compared with 116,832 pounds in the previous winter, valued at $12,189.

Maine.—It is estimated that 10,000 boxes of smelts, or about 300,000 pounds, are received at Boston in a season from Maine, valued at $66,000. The total production in Maine probably would amount to 700,000 or 800,000 pounds, as a good many are sent from there to New York.

As about all of the Canadian and Newfoundland smelts are sent to the Boston and New York markets, the above figures will give you some idea of the receipts of smelts.

According to the Canadian Fisherman for June, 1924 (p. 169), the smelt-fishing season in the Miramichi fishery of New Brunswick extends from the 1st of December until the 15th of February, leaving an open season of only about two and one-half months. Most of the fishing is done at night at the "turn of the tide," and the catch per net in one night's fishing has ranged from 100 pounds to 2 tons, for which the fishermen got from 8 to 14 cents a pound, the average for the season being around 10 cents. The account went on to say:

The Miramichi smelt fisherman makes his home on the ice near his nets during the fishing season. Small tar papered shacks are hauled to the most convenient places and here the fishermen make their home. "Smelt Shanties" as they are called, have room for only two and despite the coldest weather are always warm and comfortable and once inside the shanty, though the wind may blow its hardest the hardy fisher folk live in peace and comfort.

Bag nets and box nets are both used but the bag net seems to hold the favor. It has a mouth about twenty feet square with a trailer of about forty feet, at the end of which is located a trap in which the smelts are taken. To empty the net one closes the mouth, fishes up the trap, unties the end and empties his catch on the ice. Here they are sorted, for in addition to smelts, the fisherman is always assured of a generous catch of tom cod and flounders—their value is very low, ranging from $1.25 to $2.00 per barrel—and these are generally marketed in Upper Canada.

The smelt, however, finds its favor with our neighbors to the south, and so highly is it prized, that it, almost alone, is exempt from the Fordney Tariff of 1 c. to 2 c. per lb. as is imposed on other fish. During the season just closed there were shipped to the United States from the Miramichi district alone a total of over 4,347,000 lbs. of smelts, with a total declared value of approximately $711,052 in United States currency.

Let us place the Canadian consumption at one-tenth of that shipped to the United States—a prominent fishermen places this as a very conservative estimate—and we can easily put the catch for the season of 1923–24 at 4,782,000 lbs. and the value at $782,157.00. To this add the exchange at the current rate for the United States shipments and we find that during the past winter the smelt fishing industry was worth upwards of $800,000 to the Miramichi, or over $10,000 for every day of the fishing season. Sunday included.

To sum up the matter—the smelt fishing industry is one of the biggest industries in the province to-day and one of the least heard of. Unlike the lumber industry, it is growing enormously, and with proper regulations is practically inexhaustible. It deserves more sympathy and support than it now receives from the residents of the Miramichi and the province of New Brunswick in general.

ANGLING FOR MARINE SMELT

Probably the oldest printed account of smelt fishing for sport is a short sketch entitled "Smelt Fishing—As practiced in Boston," which appeared in the American Turf Register and Sporting Magazine for October, 1832 (Vol. IV, No. 2, p. 85). The author, who signed himself "Walton, Jr.," after a preliminary reference to the novice's fly fishing and a highly laudatory description of the smelt as a pan fish, went on to say:

This amiable fish frequents our shores during the fall and winter months. In the latter season he runs up rivers to spawn, but he affords sport to the angler, from September to December. At this time, our wharves and docks are crowded with anglers of all sorts, sizes, and colors, and in no kind of fishing is the effect of skill and good tackle more evident * * *. I have known twelve dozen killed in one tide by one sportsman, but he was a right good one. I, myself, with one other killed seven dozen in two hours one cold morning in November.

A light fly rod is the best for this sport, your line of silk or grass. Running tackle is not essential, but every true angler will use it, on account of its superior neatness and convenience. The main thing is the disposition of the hooks, which should be from four to ten in number, each hook whipped on a strong bristle, and attached to the snood (which is of gimp) by a little swivel of bone or ivory, so that it may turn freely in any direction, observing that the hook stands at right angles with the snood—this is to prevent so many hooks from entangling. A large cork float, well painted, is to be used—the best bait is the minnow—though the angle worm is used, or better still, a smelt's throat. You will have a small tin kettle, with the cover pierced with holes, for your baits, and a creel strapped to your back for your fish.

Being thus appointed, you arrive on the ground at young flood, if a frosty morning so much the better; bait each of your hooks with a minnow, passing it carefully under the back fin, so as to allow him to play freely—graduate your float so as to fish at mid water, after drawing up your line and letting it sink again. When your float goes under water, give a moment's time, and then strike him with a gentle turn of the wrist, which is much more killing than the furious twitches which some delight in. In this way you may catch two or three smelts at once, and a lady might kill her dozen of fish without soiling her flounces. This, although not so exciting as killing dandies might do by way of variety.

Seventeen years later Frank Forester (Herbert, 1849, p. 175) expressed some doubt that the smelt was ever taken by hook and line. He listed the American smelt as "*Osmerus Viridescens;* Le Sueur, De Kay, Agassiz," with a recognizable cut He wrote:

This highly-prized and delicious little fish does not properly fall within the angler's catalogue of sporting fishes, inasmuch as it is questionable, at least, whether it is ever taken with the hooks I have heard it positively asserted that it has been captured, both with the fly and with its own roe, but I consider the fact doubtful, to say no more—the fish having probably been confounded with the Atherine or Sand-smelt, a small fish commonly known in this country as Sparling, and much used as a bait fish.

Later in his discussion of the smelt, however, he says:

It would by no means surprise me to find, that, during the time when Smelt run up our streams, they may be taken freely, either with a very small bright fly, or with morsels of shrimp or pellets of their own roe, upon a number-twelve Limerick Trout-hook, and thrown like a fly, on the surface. Should such prove to be the case, they would afford very pretty light fishing at a time when there is no other sport for the angler.

The author was evidently somewhat uninformed concerning smelt fishing, which was commonly practiced in the vicinity of Boston even in his time.

Twenty years later the commissioners of fisheries of Massachusetts, in their report for 1869, said that it had been both maintained and denied that smelts would not take the hook after they had been three or four weeks in tidal or fresh water. The commissioners suggested that the truth was very likely that "as the spawning season approaches, the gravid fish cease to feed (as among other Salmonidæ), but as there may be several successive runs, which spawn at different times, there are always fish that will bite, up to a certain season." However, nearly 50 years ago smelt angling had locally become a recognized sport, according to Genio C. Scott (1875). He wrote as follows:

As affording sport, the smelt is no mean game. Late in autumn, when ice begins to border the streams, the angler rigs a long perch-rod with a small multiplying reel, and a fine line rigged with half a dozen small trout or minnow hooks on short snells fastened to the main line, six inches apart, and baited with pieces of shrimp or bits of clam, and resorts in boat up small tidal streams, anchors and angles for them during the flood tide, when it is not uncommon to take from a fourth to half a dozen of these pearly beauties at a time, as fast as he can bait his hooks and cast them near the boat. There is nothing prettier than these gems dangling and shining at the end of the line, when they emit the odor of fresh cucumbers. On the approach of winter, anglers of all ages are seen on the bridges and along the saline streams of the coast, from Delaware Bay to the eastern boundary of Maine; and as an article of commerce, thousands are sold in New York markets, the average retail price being twenty cents a pound. The smelt is eminently the winter sport for the angler, succeeding the white perch in small tidal creeks. This fish will also take the fly when sunk to their feeding level near the bottom.

As has been seen, as early as 1868 or 1869, taking smelts by any other method than by hook and line was prohibited by law in Massachusetts, excepting in a few specified instances. Thus, either one or both of two conditions were recognized—growing scarcity of smelts or the paramount importance of the hook and line fishery, which, as has been stated, was largely that of sport-fishing, although some fished in that way for the market.

The report of the commissioners of fisheries of Massachusetts for 1875 said that smelts had been very plentiful that fall, as high as 80 dozen having been taken with a single rod in one day.

"As evidence of the popularity and attraction of smelt fishing to our eastern friends," said Forest and Stream in 1874, "it is on record that ninety-five smelters were counted on the wharf at Marblehead, Mass., at one time on Friday of last week, successfully engaged in this exciting sport."

No further reference was made to smelts in the Massachusetts commissioners' reports until that for 1880. However, in some of the intervening years notes on smelt fishing or angling appeared in Forest and Stream. In that journal, in an article entitled "Game fishes of Connecticut," the author says:

This little fish is certainly worthy of the angler's notice. It is very abundant in the eastern third of the coast and is taken around wharves and mouths of tide-water creeks.

The Massachusetts report for 1917 indicated that smelt angling about Boston was still of considerable attraction and importance. The following is extracted from the report:

This year, to ascertain the magnitude of the smelt fishery and just what value it has as an asset of the Commonwealth, an investigation was conducted which resulted in some surprising revelations. On one Sunday morning along the coast at and adjacent to Hough's Neck no less

than 2,326 persons fishing for smelt were actually counted, leaving out of consideration the number who were out during the very early morning. In notebooks which were placed at every pier and yacht club for the purpose of registration as a part of the general census, 144 persons reported their catch to be 1,095 dozens. Computed roughly, this averages more than 90 fish apiece, or 6½ pounds figured at the rate of 14 fish to the pound. Continuing on this same basis the 2,326 persons observed in the act of fishing on this morning might easily have taken about 15,119 pounds, or 7½ tons, of smelt, with an approximate value of no less than $3,023.80. But even this is not the full money value, for in addition to actual market value these fish surely must be considered as of some worth from the viewpoint of providing recreation. As a very conservative estimate let it be considered that the sporting value to the fishermen of catching these fish averaged 10 cents per hour, and each person stayed out for three hours. This gives a total of 6,978 hours with a value of $697.80 to be added to the actual market value of the fish of $3,023.80.

Writing from Quebec under date of November 21, 1903, Chambers (1903a) said:

> There is an unusual run of smelt at present in the St. Lawrence, and the small boys who can steal a few hours from school or books to fish with rod and line from the wharves on either side of the harbor of Quebec are enjoying the fun of making big scores.

Again he wrote (1893):

> The wharves are lined with fishermen of all sizes, ages and tackles. Forty rods on one barge, all catching, is not an unusual sight. Even the ladies enjoy the sport from the decks of the Quebec Yacht Squadron.

LOCALITIES

Massachusetts.—Black Rock, North Cohasset, Marblehead, Gloucester, Hull, Paddocks Island, Hingham, Weymouth, Quincy Point, Inner Brewster, Spectacle Island, Thompson Island and other places in Boston Harbor. (Forest and Stream, 1874.)

Black Rock. ("S. K. Jr.," 1876.)

Hull Bay, Neponset, Dorchester Bay, Hingham, Downer Landing, Ware River, Black Rock, Annisquam River, Ocean Spray, Apple Island Flats, Winthrop Flats, Merrimac River, Neponset River, Weymouth River. (Cutter, 1885.)

Nantasket, Weir River, Bumkins Island, Paddocks Island, Strawberry Hill, Hull, the little bight or "hook" that makes the land between Hull Yacht Club pier and the steamboat landing. (Hallock, 1893.)

Hull, Hingham, Nantasket, Downer Landing, Quincy, Dorchester Bay, South Boston Bay, Peddicks Island. (Smart, 1894.)

Dorchester Bay, around Boston. ("Hackle," 1895.)

Weir River in Hingham, Weymouth River, anchorage of the Nantasket steamers at Nantasket. ("Hackle," 1896.)

Bays and inlets along the Massachusetts coast; Cohasset. ("Special," 1899b.)

Cohasset. ("Special," 1900.)

Essex River. (Fishing Gazette, New York, March 16, 1907.)

Maine.—According to the personal recollections of the present writer, smelts were caught at the wharves in Portland, Me., in Back Bay, at the mouth of the Presumpscott, and in other places about Portland; also in Mill Creek at Falmouth Foreside, Yarmouth River, and Harraseeket or Freeport River, at South Freeport and Porters Landing. Ice fishing localities are mentioned in connection with the commercial fisheries.

Canada.—According to Chambers (1893), angling was carried on at all the watering places on the lower St. Lawrence, Muncy Bay, Caconne Riviere Ouelle, Kamoureska, Riviere du Loup, and at Quebec.

ANGLING SEASON

Massachusetts.—July 23: "Smelts are now being caught at Black Rock, North Cohasset, Mass., with hook and line and pole. The bait, shrimp, is now quite scarce. The catching of these fish, which are excellent eating, furnishes hours of sport to many eastern anglers from now [July] through the winter months." (Forest and Stream, 1874.)

October 29: "Large numbers are being caught." (Forest and Stream 1874.)

September 11: "Smelts are now plenty." ("S. K., Jr.," 1876.)

October 31: "Smelts begin to run up the harbor after food and continue to do so until the weather becomes freezing." Hull Bay is mentioned at about the best place in the vicinity of Boston during the last of October and there the fishing continues "until snow flies." Merrimac River affords good winter fishing, as also Neponset and Weymouth Rivers. (Cutter, 1895.)

"At this season they afford much sport to the Angler." (Hallock, 1893.)

October 20: "Smelt fishing has been on in the waters adjacent to this city (Boston) for some weeks." (Smart, 1894.)

November 2: "Smelt fishing around Boston is booming just now." ("Hackle," 1895.)

February 8: Weir and Weymouth Rivers are mentioned as being productive, and the principal points to which Boston fishermen go. ("Hackle," 1896.)

July 22: "The rod and line smelt fishermen are having some success in the bays and inlets along the Massachusetts Coast." ("Special," 1899b.)

July 29: Smelt fishing fair. Many dozens taken by summer boarders in the vicinity of Cohasset and Falmouth. ("Special," 1899c.)

August 15–September 1: "About July 1 you begin to get the smelt fever. About August 15 to September 1 you begin to get smelt." ("Grif," 1900.)

September 29: "Smelting along the Massachusetts bays and inlets is already good and promises soon to be better. Cool, frosty nights will increase the sport." ("Special," 1900.)

March 16: It is safe to say that the ice smelt fishery in Essex River, which was closed down Thursday last until June 1, will be an established pursuit at Essex next winter." (Fishing Gazette, New York, March 16, 1907.)

Maine.—In Portland smelts have been caught as early as September, but October and later afforded the best fishing. November was always the best month at Freeport, Me.

Canada.—In Quebec, by reference to certain specific dates, Chambers (1893) indicates a season from August at least through November. Under date of November 4, 1893, he wrote: "Here in Quebec it [smelt fishing] is now at its zenith," and again: "Good smelt fishing is to be had in August at all the watering places on the lower St. Lawrence, * * * and at Quebec from the beginning of October to late in November."

BAITS

Smelts are more or less capricious, sometimes taking one bait when they will not take some other kind, and at another time bait previously refused will be taken with avidity. Almost all fishing is done with natural baits. The following notes have been extracted from articles elsewhere quoted.

Shrimp.—"Shrimp and minnows." (Forest and Stream, 1874.) "Shrimp is in great demand; clam worms used in fishing through the ice." (Cutter, 1885.) Shrimp (Hallock, 1893). "* * * sea worm is the great bait for night fishing, while the shrimp, the best bait for day fishing, he finds almost useless for night use. Bloodworms are fair, but can not compare with the sea worm." ("Hackle," 1895.)

The bait principally used here is shrimp, which can be netted in the marshes or bought at fish stores. * * * . Sea worms are good, also; they can be found on any beach or under the rocks. Another favorite is the bloodworm, a long thick almost white worm found near the salt water. It has a large vein filled with blood running through it, and is tough and lasting. Small minnows are sometimes used, and I have found them a good bait at night for large fish. Common garden worms are also used by some. ("Grif," 1900.)

At Freeport, Me., the most commonly used bait was young killifishes (*Fundulus heteroclitus*), although occasionally shrimp (Crangon) was used. The killifishes, called "minnies," were preferred, as they lived longer in a minnow bucket and were not so easily stolen from the hooks by the smelt.

"The fish seem to take worms, beef, and pork equally well [at Quebec]." (Chambers, 1903a.)

METHODS

They "are taken in tidal currents along the coast with a light rod, hooks and line, baited with shrimp, two 6-inch snoods, with their hooks attached, being bent on to the ends of a wire spreader shaped like a letter A." (Hallock, 1893.)

Concerning the use of shrimp as bait, the same author (1893) says:

Every boat is provided with a bait car filled with sedge grass or seaweed which keeps the shrimp fresh and active. The shrimp costs $2 a quart at the market, but if one wishes, and knows how, he can net his own shrimp in the creeks with a long-handled scoop. A gill of shrimp will answer to start with, but it will take about $5 worth to stock up a bait car for an afternoon's fishing.

Then the author facetiously adds:

Hooks are put on lengthwise, the point into the tail, through the body and out at the head. Shrimp prefer it that way. By the time the novice has learned the trick most of the bait is gone. Just then the fish begin to bite sharp and he has to borrow. At the finish, after reckoning up all expenses of the outing, the boat hire, the bait, the rig, the car fares, the luncheon, and the Waukesha water, the amount of fun and fish required to balance the account is considerable.

This [shrimp] should be placed on the hook tail first, the point of the hook almost coming out through the head. Some insist on breaking off the sharp little spike on the head of the shrimp, but this I consider unnecessary. ("Grif," 1900.)

One thing I have never seen in print about this fish, yet known by every initiated brother, is the manner in which it sometimes takes the bait. This is called sucking, and many a good freshwater fisherman has been perplexed on raising his line to find the hooks skinned when he had not felt even a nibble. If you should ever get a chance to see the fish at low water (if you look close), you may see a smelt advance to the bait in a leisurely manner; about an inch from it he will stop, then opening his mouth very wide he will make no offer to touch the bait, but by suction will draw it toward and into his mouth; and all this time the mouth has never closed. And now is the time

to hook him, for if he is given a moment you will see your bare hook rejected from the still open mouth. Again, he may reject the bait after drawing it in, and the bait is often blown up on to the gut snell. ("Grif," 1900.)

In the Gulf of St. Lawrence they are often taken with small scarlet (ibis) flies while fishing for sea trout." (Hallock, 1893.)

According to Chambers (1893), in Quebec they use "a bamboo rod, piece of cord, and half a dozen small hooks, some folks put the whole half dozen on their line at once in the same manner as flies, but with a few shot for sinker, and three fish at a time is a common occurrence. Some connoisseurs use worms for bait, but the majority a bit of red meat and then a smelt cut up, which these small cannibals seem to prefer."

Some of the young fishermen string as many as a dozen hooks on their smelt lines, and it is by no means unusual to see them haul out three and four fish at a time when the conditions are favorable." (Chambers, 1903a.)

The rigs used at Freeport, Me., usually were cane poles, although sometimes a trout rod was employed; a linen line, with or without some sort of float or bob; and a wire (usually brass) spreader. The most common spreader was simply a bowed wire with a loop at the center for the attachment of the line, and a loop at each end for the attachment of snelled hooks. Occasionally a four-hook spreader was used, being formed by two bows of brass wire crossed at right angles and soldered. Even one of six hooks has been seen. These multiple spreaders were denominated "bird cages."

FISHING CONDITIONS

Smelts also like to gather around the lobster cars and under the floats at the boat houses.

When the waters commence to run out of the estuaries and inlets the smelts are on their feed. Voracity drives out caution then, and suspicious fish which have been wary until now lose all their shyness snatching the tempting bait with avidity, and without reserve. (Hallock, 1893.)

On the other hand, another writer ("Grif," 1900) wrote:

The flood tide is almost invariably the best for fishing, and in the ebb as a rule they seem to slack off, yet, like all rules, this is occasionally broken. * * *.

Forester's theory of that ferry having any effect on smelt can hardly be correct, as I have seen them caught under and over hawsers, and in places where tugs and steamers were constantly keeping the water in a turmoil. At a favorite spot for night fishing, a culvert runs under the road and the flow of water through is regulated by gates, and, until these close, and the water stops running through, you can't get a fish; yet 2 minutes after the gates close they may be biting all along the line. Whether it is because they are afraid of being drawn into the sluice or not I don't know, yet the fact is that they don't bite until then. At this place, while fish are frequently caught at night, it is, indeed, a rare thing to catch even one during the day.

At Freeport, although smelts were caught during the day, the best fishing was on cold frosty nights. Day or night, they could be caught from the first of flood tide to nearly high water, but after the beginning of ebb they did not bite as well. The best day fishing was while the water was more or less turbid, especially after a heavy rain. After the beginning of very cold weather, when the water cleared up so that the bottom could be seen at several feet of depth, no smelt could be caught, although shrimp and killifishes were still common, especially the shrimp. During

the winter, especially in the latter part of the season, fishing through ice was practiced by some.

The best time is when the tide begins to flow to about three-quarters full, and then at the finish of the ebb. (Chambers, 1893.)

CATCHES

1874.—July 23: "Large numbers are being caught." (Forest and Stream, 1874.)

1876.—September 11: "Smelts are now plenty, and as high as 40 dozen to a boat have been taken at Black Rock." ("S. K., jr.," 1876.)

1885.—"Mystic River in years past was a famous place, but in later years very few were caught there." (Cutter, 1885.)

October 31: "From 10 to 20 dozen, the average catch by an angler." (Cutter, 1885.)

1894.—October 20: "Good catches have been made in all directions." (Smart, 1894.)

1895.—November 2: "Smelt fishing around Boston is booming just now, and both the sportsmen and regular market fishermen are getting great numbers * * *. They are averaging larger this year than for seasons past, * * *. One of the best catches, as regards quantity, which I have heard about was made by two market fishermen on one day last week. In a little less than three hours' time they captured 533 fish, weighing 72¾ pounds." ("Hackle," 1895.)

1896.—February 8: A few days prior to February 8 a young man caught 40 pounds in a very short time, and "they were beauties as to size and quality. The anchorage of the Nantasket steamers at Nantasket has also provided good sport during the past week. An aquaintance took 80 pounds there on the turn of the tide a few mornings ago, and he estimates that fully 700 pounds were taken that day at this place by all the fishermen present." ("Hackle," 1896.)

1899.—July 22: One boy took several dozen each trip off Cohasset. ("Special," 1899b.)

July 29: "Smelt fishing is reported fair at several points along the south shore. In the vicinity of Cohasset and Falmouth many dozens are being taken by the summer boarders. * * *. Smelt fishing continues to improve. The boys are getting a good many dozen off the 'Punkins' and at other points near Falmouth." ("Special," 1899c.)

1900.—February 24: "Bucky Holmes and I have caught as high as 50 dozen in a day, using two rods each; another day three of us caught 70 dozen, and I have known market fishermen to go about a hundred dozen in a day." ("Grif," 1900.)

At Freeport, in the old days, several dozen smelts taken by one fishermen in a few hours were not an uncommon catch. In later years smelts appeared to be scarcer, and where the present writer used to fish as a boy, now no one fishes. In recent years he tried the fishing occasionally, but has caught none since 1893. On November 8, 1893, he caught 9 smelts, 6 to 7½ inches long. On November 9 he caught 17, and on the 10th 7 smelts, using "minnies" for bait.

FRESH-WATER SMELTS

Throughout the geographical range of the smelt there are localities where they are permanently fresh-water residents. They are so-called "landlocked" or fresh-water smelt. It has been assumed that in times long past some smelts remained in fresh-water lakes and formed fresh-water races and perhaps species.

Bloch (1796) recognized two kinds of smelts in Germany, one of which was marine and the other a fresh-water form. According to him, the fresh-water smelts occur in many lakes that have sandy bottoms, and they are rarely taken except when especially searched for in those places.

Reuter (1883), who does not distinguish between salt and fresh-water smelt, says that in Finland the smelt is distributed over the whole country, as far north as 68°.

Goode (1884) says that the smelt is found landlocked in cool lakes, especially those of Norway, and also in many of the lakes of northern Germany, and even as far south as Bavaria.

Fresh-water smelts are mentioned by Pallas (1811) in certain lakes of Germany and Russia; Lake Pskov. In Great Britain Regan (1911) cited Rostherne Mere in Cheshire as inhabited by the fresh-water form. Smitt (1893) does not distinguish the Swedish fresh-water form as specifically distinct from the salt-water form. Jordan (1878) wrote:

> In regard to the American smelt, there are several landlocked forms in the waters of Maine which have been described as species, but which are probably local races.

However, only two fresh-water forms of Maine smelts have been described and named as distinct species, and these by Cope in 1877, one from Wilton Pond and the other from "Cobossicontic" (Cobosseecontee) Lake, in Kennebec County, in southwest Maine. He stated that Wilton Pond is near the head of the southwest branch of the Kennebec River in southwest Maine.

Cope also remarked that landlocked Osmeri occur in the lakes of Norway, and according to Professor Esmark, of Christiania (Oslo), they are found in Lake Mjosen, which is 500 feet above the sea and discharges into a stream that has a very high fall; also in Nors Vandsjo, near the town of Moss, and in the Stinksild.

In Canada, Halkett (1913) records a fresh-water smelt, under the name of *Osmerus mordax* Mitchill, from Lac des Isles, Gatineau District, some 60 miles north of Ottawa. In a footnote (on p. 55) he says:

> It is known that this species of fish exists land-locked in fresh water lakes in New Brunswick, Nova Scotia, and in the State of Maine, but its occurrence in a lake so far away from the sea as Lac des Isles, is perhaps worthy of mention.

In a letter Dr. Philip Cox, of the University of New Brunswick, informed the present writer that a diminutive fresh-water smelt occurs in Lake Utopia.

That smelts occur in tributary waters of the St. Lawrence is indicated by Chambers (1903), who stated that they were landlocked in some Canadian lakes as well as in the United States, mentioning particularly Lakes St. John and Memphremagog.

For many years it was known to occur in Lake Champlain. Thompson (1842), who did not realize that it was a permanent inhabitant of Lake Champlain, said that it occasionally made its appearance there and was caught in considerable numbers.

In waters wholly in the North Atlantic States fresh-water smelts are found naturally only in New England, and there, so far as is positively known, only in New Hampshire and Maine, although according to the following report they occur in ponds on Cape Cod. Concerning these fish, however, there may be some doubt about their having been naturally landlocked. Forest and Stream for April 18, 1889 (p. 259), contained the following account:

Landlocked smelt.—From Cape Cod, Mass., we have received some specimens of a fish known there as a fresh-water smelt. The examples are about 5 in. long, and represent the average size of the adult fish. The species is found in two or three large, perfectly landlocked ponds, which have no visible outlet and are remote from salt water. We are informed that no stream ever has connected these ponds with the ocean. The fish are never seen except for a few nights during the first week in April, when they come to the shore to spawn. They can then readily be taken with dip nets or landing nets. Under proper conditions bushels of them can be taken in a single night. Few persons know of their existence; unless the ponds are visited at just the right time and with a light the fish cannot be seen. This smelt is a very delicate and toothsome little species having the flavor of a salt-water fish. The ponds contain perch and pickerel. What a paradise these waters would be for the black bass. Landlocked smelt are now pretty widely distributed, being recorded from numerous lakes and ponds in Maine and New Hampshire, and forming one of the best of the natural foods introduced by the fishculturists into waters stocked with the larger *Salmonidæ*. The only changes that we can observe as the result of landlocking are a reduction in size and in the strength of the teeth. The specimens obtained were caught on the night of April 3, and appeared to be spent females. Sea smelt spawn in March and April.

In New Hampshire it appears that the smelt occurs indigenously in Winnepesaukee and Squam Lakes. In Maine, however, it is widely distributed in coastwise lakes and ponds, some of which are a considerable distance inland. The principal river basins all comprise some smelt waters. Foster and Atkins (1868) say:

Smelts are scattered all over the State. It seems probable that we have more than one species. Whether either of them is identical with the salt water smelt we cannot say, but the resemblance is very close.

NAMES

The fresh-water smelt appears seldom to have any distinctive name given to it. In Sweden it seems that large smelts are known as "slom" and smaller fish as "nors." Bloch (1796) wrote:

The fish is known by different names. They call it Stint in Germany; kleiner Stint, löffestint, kurzer Stint, and Stintites, in Livonia; jern Lodder and send Lodder in Lappland; nors in Sweden; spiering, in Holland; smelt in England and Denmark; lodde, rogn-sild-lodde, röpe, kröckle, in Norway; sjiro iwo, in Japan; and eperlan d'eau d'ouce in France.

Wherever it occurs in Canada it appears to be known to the English-speaking inhabitants as smelt, whenever it is recognized at all. Locally in Lake Champlain it is the "ice fish." W. M. A. Cowen, of Ticonderoga, N. Y., said (1900):

Formerly a resident of Essex-on-Lake Champlain, I have caught several thousand smelts, but never one ice fish (according to local name). * * * . Ice fishing, I think, is father to the name of ice fish, although I have frequently caught yellow perch and bluefish from the same hole.

SIZE OF FRESH-WATER SMELTS IN VARIOUS WATERS

Bloch (1796) stated that the fresh-water smelt is only 3 or 4 inches long. Reuter (1883) indicates the mature fresh-water smelt of Finland vary in size from 1½ or 2

inches to 10 inches in length. Smitt (1893) says that in the largest Swedish lake, Wener, the fish frequently attains a length of a foot to the extreme tip of the caudal fin, but in a footnote he says that Jernow (Vermlands och Dals Ryggradsdjur, p. 108) ascribes a length of nearly 15¾ inches. In Lake Malar, Smitt remarks, it frequently attains a fair size, something over 10½ inches, but in the smaller lakes it seldom exceeds a length of from 4 to 7⅘ inches.

Nordqvist (1910) indicates that 3-year-old smelts obtained by him in one lake were 94 to 112 millimeters (about $3\frac{7}{10}$ to 4⅖ inches) long, but that occasionally larger fish were caught. In a neighboring lake the fish were somewhat larger.

Of the Lake St. John smelt (in Canada) Chambers (1903) wrote that they "present a beggarly, half-starved appearance as compared with the St. Lawrence fish. They more nearly approximate to the smelt found by Cope in Wilton Pond, Kennebec county, Maine, and described by him as *Osmerus spectrum* in 1870."

Halkett (1913) stated that the Lac des Isles smelts are dwarfed but otherwise the external characters appear to agree with the ordinary *Osmerus mordax*. Cox wrote the presesnt writer that the smelts of Lake Utopia, New Brunswick, are diminutive.

Smelts from Memphremagog Lake, as represented by specimens in the collection of the present writer, range from 6½ to $7\frac{5}{16}$ inches, and average about 6.9 inches. In a collection from Lake Champlain 79 specimens taken in 1911 ranged from 5.4 to 11.2 inches and averaged a little over 7.1 inches, but much larger ones have been reported.

At a meeting of the Boston Society of Natural History in 1857, Dr. H. R. Storer presented specimens of smelt from Squam Lake, N. H. He said that when full grown this smelt seldom exceeded 6 inches in length, and was extremely attenuated.

The report of the New Hampshire commissioners on fisheries for 1870 stated that smelt occurred in Lake "Winnipiseogee" and several ponds in the vicinity, those in the smaller ponds, "contrary to the usual course of things, being much larger than those in the lake." It was said that the largest measured only 6 or 7 inches in length, and those in the lake itself were seldom found to be over 4 inches long.

The present writer has specimens from lake Winnepesaukee, 32 of which range from 2.7 inches to a little over 4 inches, and averaged about 3⅓ inches in total length; also 71 specimens from Lake Massabesic, N. H., run from about 4 to nearly 5⅜ inches, and average about 4.6 inches.

The more extensive available data concerning Maine smelts makes it desirable to refer to the particular waters represented by river basins.

PRESUMPSCOT BASIN

Sebago Lake.—May 1, 1878, Atkins received from J. R. Dillingham, of Songo Lock, a box of 36 smelts, all spent. Seven were large and ran in size as follows: One of 9.6 inches weighed 4 ounces; one of 9.4 inches weighed 4.4 ounces and another of the same length weighed 3.2 ounces; one of 9.2 inches weighed 4 ounces and another of the same length weighed 3.6 ounces; one of 8.6 inches weighed 3.2 ounces. They averaged 9.2 inches and 3.7 ounces. Twenty-nine of the smaller form ranged from 3.9 to 4.3 inches and averaged 4.1 inches.

In 1898 the late Frank Meserve, resident near and well informed concerning the lake, stated that the large smelts attained a length of 1 foot, and three of them had been known to weigh a pound. In 1907 George Moses, a well known guide of the region, fishing through the ice, caught a dozen smelts ranging from 12 to 14 inches in total length, and reported one that weighed 1¼ pounds.

A collection of 566 smelts made by the present writer during the summer and fall with hook and line ranged in total length from 6$\frac{5}{16}$ to 15¾ inches. A collection of 102 specimens of the small form, in breeding condition, taken in the Songo River in the spring of 1901, measured in total length from 4⅛ to 5.9 inches and averaged 4¾ inches.

Panther Pond.—April 17, 1910, 64 smelts ranging from 3⅓ to 4¼ inches and averaging nearly 3.9 inches in total length were taken from a tributary brook where they were spawning.

Long Lake.—According to Foster and Atkins (1868) the smelt of this lake had been reported to exceed half a pound in weight.

Mead (1883) stated that they ranged from 8 to 13 inches in length and would average 6½ ounces in weight. He said that a lot of 19 specimens averaged 6⅓ ounces each. The largest of the lot measured 11½ inches in length and weighed 7 ounces.

ANDROSCOGGIN BASIN

Lake Auburn.—A young man from Auburn informed the present writer that the smelts of Lake Auburn ran about 2½ to 3 inches, never exceeding the latter size.

Taylor Pond.—According to the same informant the smelt of this pond are only about 2½ inches long when in breeding condition. To clean them for cooking the preparator merely pinches off the heads or snips them off with a pair of scissors.

Sebattus Pond.—The smelt of Sebattus Pond were stated by Atkins, in a note dated May 8, 1868, to be abundant but of small size. Two specimens measured by the present writer in May, 1898, were 3$\frac{3}{16}$ inches and 3⅜ inches long, respectively.

KENNEBEC BASIN

Wilton Pond.—Atkins received 60 specimens from Wilton Pond on May 1, 1868, which he said were mature but so small that he at first thought they were young fish.

One of the specimens from this pond, which in 1870 Cope made the type of his new species *Osmerus spectrum*, was said to be a medium-sized example, measuring 3½ inches in length, in breeding condition.

A collection of smelts from this pond, sent to the present writer by the late H. O. Stanley a number of years ago when he was one of the commissioners of inland fisheries and game of Maine, ranged in total length from 2½ to 3$\frac{9}{16}$ inches and averaged 3 inches in total length. With them, however, was one specimen 5⅞ inches long. These were all in breeding condition, and the small fish were translucent, but the larger fish was darker and more like the ordinary fresh-water smelt of moderate size.

Great Pond.—In 1875 the largest smelts taken by Atkins in Tilson or Palmer Brook, North Belgrade, were two females, each of which was 12 inches long. On

the night of April 21, 1875, in the same brook, about 250 were caught, 36 of which weighed 13½ pounds, an average of 6 ounces each. The largest female was 12 inches long and weighed one-half pound. The majority of the females were from 11 to 12 inches long and the males from 10 to 11 inches, but some of the females were less than 11 inches. The present writer has seen but two smelts from Great Pond, one of each sex, each measuring about 10⅔ inches in total length.

In a letter to the present writer dated January 22, 1908, Atkins stated that the smelts found at North Belgrade were the largest that he had ever seen—some 15 inches long and weighing two-thirds of a pound each.

Mount Vernon Pond.—Eight smelts from a pound in Mount Vernon, examined by the present writer, ranged in total length from $3\frac{3}{10}$ to a little over 5 inches, and averaged 4⅖ inches.

Snow Pond.—On March 20, 1906, Prof. Wm. L. Powers, in a letter to the present writer, said:

> I have found that very large smelts are taken from a brook that flows into Snow Pond on the day that the ice leaves the pond. * * *. A man in Augusta telephoned me that he saw some weighed that came from there, and the combined weight was 6 pounds. * * *. The four fish were sent to Boston and exhibited in the market.

Messalonskee Lake.—A female smelt taken by Atkins from a stream flowing into this lake measured 12 inches in length, and one taken from Morrisons Brook on April 20, 1869, was 14⅞ inches long.

Cold Stream Pond.—Under date of April 3, 1878 (in his notes), Atkins mentioned that a Mr. Stillwell brought some smelts from this pond, the largest of which were 7 and nearly 7⅖ inches long and weighed over 1½ ounces each.

Cochnewagn Pond.—Smelts caught here by Atkins, April 30, 1878, he divided into four classes—(*a*) 12 males and 1 female 6.7 to 6.8 inches long; (*b*) 6 males and 2 females 5.1 to 5.7 inches long; (*c*) 8 males and 5 females 4.75 to 5.1 inches long; and (*d*) 12 males and 5 females nearly 3 to nearly 4 inches long.

Cobbosseecontee Lake.—Sixty-one smelts obtained by the present writer ranged in total length from 3.6 to 5.2 inches and averaged about 4.4 inches. Cope had five specimens upon which he based his new species *Osmerus abbottii*, which he said measured about 4 inches in breeding condition.

China Lake.—Smelts of China Lake are said to be remarkably large; some of them are said to weigh over 1 pound. The present writer has seen no examples from this lake.

GOOSE RIVER BASIN

Swan Lake.—Two specimens from this lake were received from E. D. Merrill in 1899, taken with a hook and line. They measured, respectively, 10½ and 6½ inches in total length. According to Merrill, smelts in this pond attain a weight of a pound.

PENOBSCOT BASIN

Sebec Lake.—According to B. M. Packard, proprietor of camps on Sebec Lake in 1900, the smelts of this lake were very abundant and of two adult sizes—the larger 8 to 14 inches and the smaller 4 to 5 inches in length.

Toddy Pond.—April 17, 1878, Atkins said that he was informed that the smelts that ascend Sucker Brook from Toddy Pond were about 4 inches long. A collection of 48 specimens examined by the present writer ranged in total length from 2⅞ to 4⅞ inches and averaged 4.1 inches.

Heart Pond.—In the present writer's collection are 11 specimens from this pond, which range in total length from 3⅜ to 4 inches and average nearly 3⅞ inches.

UNION RIVER BASIN

Green Lake.—One hundred and fifty smelts were received by Atkins on April 19, 1878, from Reeds Pond, as the lake was then called, of which eight averaged nearly 4.7 inches in total length. He said that the general average would be very little above this, for examples of about 4.9 inches occurred.

A collection made on April 20, 1906, examined by the present writer, consisted of 36 specimens, and another made on May 7, contained the same number, making 72 in all, which ranged in total length from 3⅜ to 4 1/16 inches and averaged about 3.5 inches and 3⅔ inches in each lot, respectively. This collection comprised the small form only. A collection of eight individuals taken on March 28 of the same year ranged from 5¼ to 6⅛ inches and averaged 5.7 inches.

ST. CROIX BASIN

Grand Lake.—Atkins (in 1879) wrote: "The smelts are among the most diminutive of this genus, averaging in length but little more than two inches." The present writer made a large collection of these little smelts in the salmon traps of the United States hatchery at Grand Lake Stream; they ranged from 2.1 to 2⅔ inches and averaged about 2⅓ inches in length. They were translucent but mature fish, as indicated by the presence of well-developed eggs. Among these fish were two specimens of a larger form about 3⅕ and nearly 4 inches long.

Location and size of smelt and authorities for same

Locality	Size	Authority
Germany	4 inches	Bloch, 1796.
Finland	1½ or 2 to 10 inches	Reuter, 1883.
Finland	3 1/10 to 4¼ inches	Nordqvist, 1910.
Lake Wener, Sweden	12 inches	Smitt, 1895.
Do	15¾ inches	Jernow.
Lake Maler, Sweden	10½ inches	Smitt, 1895.
Smaller lakes in Sweden	4 to 7 or 8 inches	Do.
Lake St. John, Canada	Similar to Wilton Pond, Me	Chambers, 1903.
Lac des Isles, Canada	Dwarfed	Halkett, 1913.
Lake Utopia, New Brunswick	Diminutive	Cox.
Lake Memphremagog	About 6 to 7½ inches	Kendall (notes, 1913).
Lake Champlain	6 to 12 or 13 inches	"Heathcote" 1895.
Do	15 inches; 3 to a pound	Cheney, 1895.
Do	14 to 16 ounces	Cowen, 1900.
Lake Champlain (Port Henry)	1¼ pounds	S. F. Lane.
Do	6 1/16 to 10¾ inches	Kendall (notes, 1911).
Lake Champlain (Presberry Point)	13 inches	Do.
Lake Champlain, N. Y	15 and 18 inches	Cobb.
Lake Champlain, Vt	Average, 7 inches	Do.
Sqam Lake, N. H	4 inches	Storer, 1857.
Lake Winnepesaukee, N. H	6 inches	Do.
Do	2 7/16 to 4 inches, average 4 1/16 inches	Kendall (notes).
Lake Massabessic, N. H	Small form, 4 to 5 5/16 inches; average 4 3/16 inches	Do.
Sebago Lake, Me	9⅛ to 9 3/16 inches	Atkins, 1868.
Do	Small form, 3 1/16 to 4 1/16 inches	Do.
Do	12 inches; average ½ pound	Meserve (in 1898).
Do	Large form, 6 1/16 to 15¾ inches	Kendall (notes).

Location and size of smelt and authorities for same—Continued

Locality	Size	Authority
Sebago Lake, Me	Small form, 4⅛ to 5⅝ inches	Kendall (notes).
Panther Pond, Me	Small form, 3⅛ to 4¼ inches	Do.
Long Lake, Me	Over ½ pound	Foster and Atkins, 1868.
Do	13 inches to 6½ ounces	Mead, 1883.
Lake Auburn, Me	2½ to 3 inches	
Taylor Pond, Me	2½ inches	Merrill.
Sebattus Pond, Me	Small	Atkins, 1868.
Do	3⅝ and 3⅞ inches	Kendall (notes, 1898).
Wilton Pond, Me	Very small	Atkins, 1868.
Do	3½ inches	Cope, 1877.
Do	2½ to 3½ inches	Kendall (notes).
Snow Pond, Me	4 fish averaged 1½ pounds each	Powers (letter, 1906).
Great Pond, North Belgrade, Me	10 to 12 inches	Atkins (notes, 1875).
Do	10¾ inches	Kendall (notes).
Mount Vernon Pond, Me	3⅜ to 5 inches	Do.
Messalonskee Lake, Me	12 and 14⅞ inches	Atkins, 1869.
Cold Stream Pond, Me	7 to 7⅞ inches	Atkins (notes, 1878).
Cochnewagn Pond, Me	3 to 6½ inches	Do.
Cobbosseecontee Lake, Me	4 inches	Cope, 1877.
Do	3⅞ to 5¼ inches	Kendall (notes).
Swan Lake, Me	6½ and 10½ inches	Kendall (notes, 1899).
China Lake, Me	Very large	Pope (in 1923).
Sebec Lake, Me	8 to 14 and 4 to 5 inches	Packard (in 1900).
Toddy Pond, Me	4 inches	Atkins (notes, 1878).
Do	2⅞ to 4⅛ inches	Kendall (notes).
Heart Pond, Me	3⅜ to 4 inches	Do.
Green Lake, Me	4⅝ inches	Atkins (notes, 1878).
Do	3⅜ to 4⅞ inches, small form	Kendall (notes, 1906).
Do	5¼ to 6⅛ inches, large form	Do.
Grand Lake, Me	2 inches	Atkins (notes, 1879).
Do	Small; 3½ to 4 inches	Kendall (notes).

Creaser (1925) ascertained that at 7¾ inches the smelt of Crystal Lake, Mich., weighs 1.5 ounces, and states that this is about the average 2-year-old size. Three-year-old fish weighed from 2 ounces, when 8¼ inches long, to 3 ounces, when 9½ inches long. Those of larger size, about 11 inches, weigh about 5 ounces.

SIZE CLASSES

Whether there be one or more species of fresh-water smelts in some New England lakes and in Lake Champlain or not, there are two distinct sizes of smelts in each, which in the spring ascend affluents to spawn, the time varying considerably in the different lakes. There is also a difference in the spawning time of the two sizes, perhaps a month between the height of the season of one to the height of the season of the other, of which fact Sebago and Green Lakes in Maine are examples. The two sizes are usually denominated, respectively, "large smelt" and "small smelt."

The two categories of smelts of some lakes are greatly different in size from those of other lakes. Sebago Lake, for example, has large smelt ranging from about 10 to 15 inches or more in length and up to a pound or so in weight, and small smelt not exceeding about 6 inches, with an average length of not over 4 or 5 inches. In Grand Lake, of the western St. Croix system, the large smelt does not exceed 4 or 5 inches in length and the small ones not much over 2 inches. The latter, even so small and transparent, are adult fish bearing eggs and milt.

The above two examples represent the extremes of variation, but there are other waters where the large and small smelts are relatively not as large and small. Some other lakes apparently contain only one class of smelt, either the large or the small race, as the case may be. Wherever the two categories occur they have long been recognized and are usually regarded as distinct.

Mead (1883) wrote:

About all the streams emptying into Long Pond and Sebago Lake are visited every spring by large numbers of smelts. Of these we have two kinds or varieties, known locally as the "large" or "big smelt" and the "little smelt." The point of difference, so far as common observation goes, is in the size and a slight variation in the time of coming to the brooks to spawn.

Concerning these two sizes J. G. Rich (1883) asks: "Are they both alike? Will the small fellow grow to be like the first run, and come up first next year?"

Mead again wrote (North Bridgton, 1885):

It would be a work for the scientists to fully explain the different varieties of smelts and their habits. That they belong to the salmon family all agree, but in this particular locality [Maine] there are three different varieties, commonly called the big, salt-water, and little smelts. The salt-water smelts, *Osmerus viridescens*, are common in all the rivers, creeks and streams along our coast. They are said to bear transferring well, even into waters entirely land-locked and fresh, but always with a diminution in size. The big smelts are like the salt-water variety in some respects, but are larger and darker colored. They are over ten inches in length, and average nearly a quarter of a pound in weight. Many occur much larger than this, and one was weighed here a few years ago that was caught through the ice with hook and line, and turned the scales at eleven ounces. A few are mentioned even larger, but they are rare, to say the least. The little smelts are but miniature representatives of their larger relations, weighing less than half an ounce each. Some have thought that these little fellows are only the young of the larger variety, but this can hardly be true, as they seem to be fully developed and are ready to spawn as they ascend the streams to their breeding grounds. They do not run up the streams until about a week later than the larger ones, and are much more abundant. They are also found in many localities where the big smelts do not occur. They vary somewhat in size, in different places, and are said to be larger in Norway Lake, only twelve miles away, than they are here. In the last mentioned lake no big smelts are found.

On April 28, 1911, Wilfred Rivers, a fisherman of Phillipsburg, Quebec, on Missisquoi Bay, Lake Champlain, told the present writer that they sometimes got a few small smelts, not over 3 or 4 inches long, and that they had spawn in them. These small smelts, he said, were sometimes entangled in the nets or mixed with larger fish when fishing through the ice with seines. No hook-and-line fishing for smelts or "ice fish" was done for the market in this region.

It has been suggested that if one or the other of the two sizes were to be transplanted the result might indicate the relationship of the two forms; for if the small smelt developed into large smelt or large and small smelts, or if large smelts when transplanted should develop into small smelts only, or into both categories, it would show that the two were merely different groups, probably age or year classes of the same species.

An instance of what are apparently two races or distinct sizes of transplanted smelts is that of the Rangeley Lakes in Maine. Small smelts of 4 or 5 inches are very numerous, but large ones, up to 10 inches at least, have been caught. According to the late Arthur Oakes, of Rangeley, the large smelts are restricted to Mooselucmaguntic Lake, while only small smelts occur in Oquossoc. This fact at first seemed to indicate that small smelts would grow large when placed in favorable waters, for the first smelts planted in those waters were from Weld Pond, where the fish, as has been shown, are very small. However, it subsequently developed that

smelts were later introduced from Swan Lake, where a large "race" or "size" exists. The latter were planted in Mooselucmaguntic.

Again, there is Square Lake, in Aroostoko County, where no small "race" or "size" has manifested itself as adult breeding fish, but smelts up to 10 inches or more are common. These smelts were derived from Swan Lake stock, according to L. T. Carleton, formerly commissioner of inland fisheries and game.

Still again, Sunapee Lake, in New Hampshire, affords an example of waters stocked with smelts that seldom, if ever, attain a large size. At least there are no breeding runs of large smelts. The source of the smelt eggs planted in Sunapee Lake is not definitely known, but probably they were either from Squam or Winnepesaukee Lake. The majority of the smelts now taken in Sunapee Lake are small, running about the size given for smelts of Winnepesaukee Lake; but even these little smelts are caught on baited hook in deep water and have been known, as elsewhere stated, to do likewise after spawning while still remaining in the brook. Nothing of this sort is known of the small smelt of Sebago Lake, which appear to subsist exclusively upon plankton; so if these fish originated in Squam Lake they have degenerated in size. That such is the case is indicated by a note in Forest and Stream of October 23, 1890, under the title of "Sunapee Lake Fishing," which says:

> The smelt which was introduced more than 20 years ago occasionally reaches 10 inches in length. It is extremely abundant, and is often washed up on the eastern shore of Sunapee by strong winds.

On the other hand, Cheney (1896c, p. 429) wrote that in November, 1896, while walking on the beach of Sunapee Lake, N. H., with Commissoner Wentworth, they picked up a number of smelts thrown up on the sands by the high winds and water. These were of two sizes, one from 1¾ to 2 inches long and the other 3 to 3½ inches long. They regarded the smaller size to be of the previous spring's hatching, while the larger ones were supposed to be adults that, had they lived, would have spawned the following year.

Still further evidence in this direction is that only the "large" form of Green Lake smelt was introduced into Crystal Lake, Mich., for the reason it was the large form only that was propagated at that station at that time. Creaser (1925) indicates that there was a spawning run of large fish only at Crystal Lake. The smallest smelts secured, which were 2-year-old fish, were 6½ inches in total length. Older fish had attained a length of 12 inches.

The forgoing are rather insufficient data upon which to generalize, but they suggest that in some waters there are "races" that do not attain a large size under any circumstances, and that the large race sometimes decreases in size so as to appear like the small race; but in such instances the habits are like those of the large race.

HABITS OF FRESH-WATER SMELTS

FOOD AND FEEDING

It has been stated that the food of the fresh-water smelt varies according to the size of the fish, and it may be added, according to its age. The character and arrangement of its teeth indicate its carnivorous propensities, while its comparatively

close-set gill rakers suggest rather minute planktonic food, at least at certain stages of its growth.

Concerning the fresh-water smelt of Germany, Bloch (1796) said that they live on worms and small mollusks. Reuter (1883) says that in Finland the food of the smelt consists of fish fry, worms, larvæ, fish roe, and young water cockles, and it does not even spare its own kindred, but gormandizes unmercifully on the smaller specimens, especially when it has returned to the lakes after spawning. Mead (1883) said:

> As to the food of the smelt I am not informed. That the larger kind sometimes feeds on the smaller, I have recently learned from a neighbor who found one in the stomach of a smelt that he was preparing for the table.

Nordqvist (1910) states that according to A. Luther, in Lake Lojo, in South Finland, the smelt subsist chiefly upon Corethra larvæ, and that I. Kutschin found smelts in Lake Ilmen and Wolko River (in Russia) 10.2 and 11.9 centimeters (about 4 and 4⅗ inches) long had been feeding exclusively upon little smelts; and that the stomachs of little smelts 3 to 6 centimeters (about 1⅕ to 2⅜ inches) long contained principally Cyclops, Diaptomus, Hyalodaphnja, *Bosmina lacustris*, *B. coregoni*, and some other Cladocera.

B. Heynermann is also mentioned as having smelts 9.5 to 14 centimeters (about 3¾ to 5½ inches), caught in Lake Wigry in Russia, which had eaten Entomostraca (*Bosmina gibbera*, *B. longirostris*, *B. cornuta*), Cyclops, Diaptomus, Hyalodaphnia Diaphasoma, and Bythotrychus. One smelt had swallowed Leptodora. Larval and young smelts up to about 7 centimeters (about 2¾ inches) were said to live principally upon Entomostraca.

The fact is that no one has made a special study of the stomach contents of the smelt. Anglers know what it will take as bait, at least on occasion, and perhaps some of those who have dressed smelt for the table or cut them up for bait occasionally have had their attention attracted to the stomach contents, but there are no published records. Examination of the stomach contents of the small smelt of Sebago Lake indicates that it subsists almost or quite exclusively upon Entomostraca, and, as shown later, the large smelt varies its diet but little from that of both "small" and young smelts.

It has been impossible to learn much concerning the food of smelts from other waters in New England by examination of specimens in hand, because the majority of them were taken in the breeding season in the brooks, when they virtually cease to feed.

The small smelts of Sebago Lake apparently never take a baited hook; but smelts of similar sizes, even the smallest of adults, in Sunapee Lake, N. H., are caught in that way. This fact suggested that adult smelts there, although small, did not feed exclusively upon such minute objects as did those of Sebago Lake, but fish ranging from a little over 1 inch to a little over 5 inches in length, taken in Sunapee Lake, were found to subsist largely upon Entomostraca, although some insects, a few crustaceans, and a few smelt eggs were found in the stomachs of some of those examined. Young smelts, like many other young fishes, subsist upon the minute floating animal life known to the scientific man as plankton, which in fresh water consists mostly

of minute crustaceans. Prof. A. A. Doolittle, of the Central High School in Washington, D. C., examined some smelts for the writer, and the following notes are taken from his report:

Concerning the food of the smelts of Sebago Lake he wrote that all were collected in the summer and fall, from July 15 to September 20, over a period of 6 years (1906 to 1911). Specimens of all sizes from about 7/8 inch to over 14 inches in length were examined. After passing above the 6-inch mark the food seems to change from an entomostracan diet to one of fish, usually small smelts. The number of Entomostraca found in fish under 6 inches in length varies greatly, but will average for the various lengths about 20⅓ to each one-tenth of an inch of length. Many smelts far exceed this limit, a specimen about 5⅛ inches long having in its alimentary tract 2,100 Entomostraca, or about 400 to each one-tenth of an inch of length.

For the small smelts Cyclops and Daphnia are the prevailing genera of Entomostraca entering into the food. For the larger forms there are added many more robust genera, viz, Epeschura and Lida.

Detailed table showing stomach contents of smelt from Sebago Lake

Date	Length in inches	Stomach contents and remarks
May 30, 1916	4⅓	Insect remains.
June 25, 1907	----------	Smelt about 1⅞ inches long. This 1 only, of 5 smelts, contained food.
June 25, 1910	13⅛	Smelt, 4¾ inches long.
Do	12⅛	Backbone of small fish, probably smelt.
Do	12	Smelt, 4½ inches long.
June 27, 1910	11½	Partly digested smelt.
Do	11⅜	Backbone of small fish.
Do	11	Smelt, 4 1/16 inches long.
Do	10⅝	Bait.
Do	9¾	Portion of insect.
July 6, 1909	11¼	Backbone of small fish.
Do	9¾	Piece of smelt 2¾ inches long.
Do	9½	Almost digested young smelt.
Do	9½	Backbone of smelt, 3 1/16 inches long.
Do	9	Partly digested small smelt.
Do	9	Smelt, 4 1/16 inches long.
July 21, 1910	9	Piece of fish.
Do	8½	Small fishbones.
Do	9⅛	Nearly digested smelt.
Do	12⅛	Partly digested smelt.
Do	12½	Nearly digested fish.
Do	11⅝	Partly digested smelt.
Do	10¾	Nearly digested fish.
Do	10⅞	Do.
Do	10	2 small smelts, partly digested, largest 3¾ inches long.
July 22, 1910	8¾	Partly digested young smelt, 1¼ inches long.
July 23, 1908	----------	Caught on 2. 0 salmon hook; bait, chub, 4 inches long. Insect and crustaceans.
July 24, 1910	8½	Backbone of small fish.
July 25, 1906	9⅛	Partly digested smelt; may have been about 3½ inches long.
Do	9 1/16	Pieces of backbone of small fish, probably smelt.
July 27, 1910	10 9/16	Partly digested smelt.
Do	11 1/16	Do.
Do	10⅜	Do.
Do	12¾	Do.
July 28, 1909	9⅛	Partly digested young smelt.
Do	9	Fragments of nearly digested smelt, 2 1/16 inches long.
Do	13	Bone of small smelt.
July 29, 1907	7⅝	Bait, young suckers.
Do	12⅝	Mass of mucus and vegetable matter.
Do	11¾	1 Mysis (?).
Do	11¾	Small amount of unrecognizable material.
Do	13¼	2 gravel stones and vertebræ of small fish (smelt ?).
Do	10 9/16	2 may-fly larvæ and some Entomostraca.
July 30, 1903	----------	1 young smelt; only 1 out of 24 smelts from to 8¼11 5/16 inches long contained any food.
July 30, 1909	9¼	Bones of small smelt.
Do	10½	Partly digested smelt, 4 1/16 inches long.
Do	13¼	Partly digested smelt, 4½ inches long.
Do	12½	Partly digested smelt, 4 1/16 inches long.
Do	10¾	Partly digested smelt, 4⅛ inches long.
Do	10¼	Partly digested smelt, 3⅞ inches long.

Detailed table showing stomach contents of smelt from Sebago Lake—Continued

Date	Length in inches	Stomach contents and remarks
July 31, 1909	13	Smelt, 4 1/16 inches long.
Do	10	Nearly digested smelt, between 4 and 5 inches long.
Aug. 1, 1906	13 1/4	2 gravel stones and bones of smelt.
Do	11 3/8	2 May-fly nymphs and some Entomostraca.
Do	8 3/4	Some Entomostraca (Cyclops and Daphnia).
Aug. 1, 1910	11 1/8	Nearly digested smelt.
Do	12 1/2	Partly digested smelt.
Do	11 5/8	Nearly digested smelt.
Do	10 5/16	Backbone, 3 inches long, of partly digested fish.
Aug. 3, 1908	10	Partly digested smelt, 3 5/16 inches long.
Do	9 3/4	Partly digested smelt.
Do	13 1/8	Partly digested smelt at least 4 1/2 inches long. Intestine full of vertebræ of smelt and some Entomostraca, which may have been from ingested smelt.
Do	13	Smelt, 4 1/16 inches long.
Aug. 5, 1909	8 3/4	Nearly digested smelt.
Do	9 1/2	Smelt, 4 1/8 inches long.
Aug. 6, 1909	9 3/8	Young smelts.
Aug. 7, 1908	10 1/4	Apparently fragments of amphipod.
Do	12 3/8	Partly digested smelt about 4 1/8 inches long.
Aug. 7, 1909	7 3/4	Young smelts.
Do	6 7/8	?
Do	6 7/8	?
Aug. 8, 1909	8 5/16	Small aquatic larvæ of insects and nearly digested small fish.
Aug. 8, 1908	12	Nearly digested young smelt.
Do	13 3/4	1 smelt, 4 1/8 inches long.
Aug. 9, 1907	10 1/2	Backbone of young smelt.
Do	9 1/8	Nearly digested small fish.
Aug. 9, 1910	11 3/4	Small insect.
Do	12 5/8	Partly digested smelt, 4 5/8 inches long.
Do	10 3/4	Partly digested smelt, 2 inches long.
Do	9	Nearly digested smelt, 3 3/4 inches long.
Aug. 12, 1909	12	Backbone of smelt, 2 3/4 inches long.
Do	10 3/4	Backbone of smelt and some brown stuff.
Aug. 13, 1910	12 1/4	Partly digested smelt, 2 1/2 inches long.
Do	11 1/4	Nearly digested smelt, 2 1/8 inches long.
Aug. 14, 1909	13 1/8	Backbone of small fish, probably smelt.
Do	11 5/16	Do.
Do	11 1/4	Backbone of small smelt.
Do	8 1/2	Young smelts.
Aug. 16, 1908	10	Few bones of small smelt.
Do	8 3/8	Partly digested smelt at least 1 1/8 inches long.
Do	9 3/4	Bait.
Do	11 1/8	Partly digested smelt at least 4 1/8 inches long.
Aug. 16, 1909	11 3/4	Smelt, 4 inches long.
Do	12 5/8	Smelt, 5 inches long.
Do	10 3/4	Larval insect.
Do	10 11/16	Young smelt, 1 1/8 inches long.
Do	10 1/16	3 young smelts, 1 1/4 to 1 1/8 inches long.
Aug. 16, 1908	10	Few bones of small smelt.
Do	8 5/8	Partly digested smelt at least 1 1/16 inches long.
Do	9 3/4	Bait.
Do	11 1/8	Partly digested smelt at least 4 1/8 inches long.
Aug. 18, 1909	14	Smelt, 4 5/8 inches long.
Do	13	Smelt, 4 inches long.
Do	9 7/8	Smelt, 4 1/8 inches long.
Do	7 3/8	Young smelt, 2 1/4 inches long; one stickleback (Pungitius) 1 1/16 inches long.
Aug. 20, 1909	12 5/8	Backbone of young smelt.
Do	10 1/4	Young smelts.
Aug. 21, 1907	12 3/4	Partly digested small smelt.
Do	----------	Bones of smelt, perhaps 3 or 4 inches long.
Do	----------	Small flylike insect.
Do	----------	Carapace, head, and wings of similar insect.
Aug. 22, 1916	11	Small smelt, 3 inches long.
Do	10	Small smelt about 3 1/4 inches long.
Do	9	Small smelt about 3 1/8 inches long.
Do	8 3/4	Small smelt about 3 inches long.
Aug. 23, 1908	13 1/16	Bait.
Do	12 1/2	1 smelt about 4 1/16 inches long.
Do	10 1/4	Bait.
Do	9 7/8	Do.
Do	12 1/2	1 smelt, 4 1/4 inches long.
Aug. 24, 1908	13 1/2	1 partly digested small fish and some bait.
Do	11 1/4	Bait.
Do	9 3/16	Fragment of party digested smelt nearly 3 inches long.
Do	9 1/8	Fragment of partly digested smelt about 2 1/2 inches long.
Do	9 5/8	Piece of smelt.
Aug. 25, 1907	14 1/4	Piece of smelt belly—bait; caught on 2.0 hook line, bait smelt 6 3/4 inches long.
Do	13 3/4	Backbone of 3 1/2-inch smelt; caught on same hook and bait dead.
Do	12 3/4	Insect nymphs.
Do	12 1/2	Bait, redfin shiner, 4 5/8 inches long, on 2.0 salmon hook.
Do	13 1/8	Empty.
Do	11 3/4	Do.

Detailed table showing stomach contents of smelt from Sebago Lake—Continued

Date	Length in inches	Stomach contents and remarks
Aug. 25, 1907	12	Redfin shiner bait, 3 inches long, and smelt belly.
Do	11¾	Redfin shiner bait, 3¼ inches long.
Do	11½	Empty.
Do	11	Backbone of smelt, 2½ inches long.
Do	11⅜	Empty.
Do	9⅜	Piece of smelt bait.
Do	10½	Bait, 3½ inches long.
Do	10⅛	2 smelts baits and partly digested smelt, 3 inches long.
Do	9⅝	Fragments of fish and larval insects.
Do	9⅛	Flylike insect.
Aug. 28, 1907	10	Insect.
Do	10⅛	Smelt, 3½ inches long.
Do	9⅛	Bones of 2 little smelts.
Do	9⅛	Insect like above.
Do	8½	Portion of insect.
Do	11⅞	Smelt, 4⅝ inches long.
Aug. 28, 1908	9¾	Partly digested young smelt.
Do	10⅝	Translucent young smelt, 1⅞ inches long.
Do	14	Backbone of smelt.
Do	10⅛	1 smelt about 4½ inches long, head forward; also bones of small fishes, mostly smelt.
Do	10½	Small yellow glutinous bodies apparently attached to slender white aggregated spicules.
Do	10	Bones of a small fish.
Do	9¾	Partly digested small fish.
Do	8¾	Partly digested small smelt.
Do	9⅛	Smelt, 5 inches long, head forward, occupying whole length of the alimentary tract.
Aug. 30, 1907	10⅛	Insect.
Do	9⅝	Fragments of fish and larval insects; bones of young smelt.
Do	9⅛	Insect.
Aug 30, 1910	9¼	Several little smelt bones.
Do	8⅞	Larval insects.
Sept. 8, 1910	13½	Smelt, 4½ inches long.
Do	12½	Do.
Do	11½	Partly digested smelt.
Do	12½	Do.
Do	10⅜	Nearly digested smelt.
Sept. 10, 1908		Nearly digested smelt and 1 fresh-water sculpin (Cottus) that had just begun to be affected by gastric juice.
Sept. 10, 1910	12⅞	Partly digested small smelt, 3½ inches long.
Do	14	3 smelts, 2 partly digested, largest, 4½ inches long.
Do	11¼	Bones of small smelt.
Sept. 11, 1908	11⅛	Partly digested smelt, 4⅛ inches long.
Do	10	Fragments of smelt, a portion of it 3 inches long.
Sept. 16, 1908	9⅛	Young smelt nearly 2⅝ inches long.
Do	10¼	Smelt nearly 4 inches long.
Sept. 17, 1906	10¼	1 young smelt.
Do	10⅜	2 larval Diptera.
Sept. 18, 1910	8¾	Small smelts.
Do	8¾	Young smelts.
Sept. 22, 1908	8	Smelt, 2¼ inches long.
Do	9¾	Do.
Do	10⅛	Bones of young smelt.
Sept. 23, 1908	9½	Insect larvæ and partly digested small fish.
Do	8½	Do.
Sept. 26, 1910	12¾	Bones of smelt.
Do	9½	Larval insects.
Do	9	Do.
Sept. 28, 1906	12¾	Bones of smelt, 3 or 4 inches long.
Do	11½	Bones of small fish.
Do	10⅝	Do.
Do	9	Young chub bait.
Do	8½	Insect larvæ.
Do	8⅞	Partly digested small smelt about 3 inches long.
Oct. 1, 1906	7¼	Partly digested small fish. 8 others empty.
Do	8⅞	Small fish, possible bait.
Oct. 20, 1909	13¼	Backone of small smelt, 1¾ inches long.
Oct. 23, 1911	13¼	Nearly digested smelt.
Do	10½	Bait.
Do	9¾	2 partly digested smelt.
Do	10¾	Empty.
Do	9	Do.
Do	9½	2 partly digested small smelts.
Do	12¼	Empty.
Do	7½	Bait.
Do	7½	Do.
Do	8½	Empty.
Do	9½	Do.
Oct. 27, 1909	11⅛	Partly digested small smelt; piece 1½ inches long.

Detailed table showing stomach contents of smelt from Panther Pond, Me., April, 1912

Approximate size, in inches	Stomach contents	Approximate size, in inches	Stomach contents
8 1/16	1 small smelt and 1 May-fly nymph.	9 1/16	1 small smelt with spawn.
9 1/16	Smelt eggs and parts of fish.	8 5/16	Parts of fish and 2 May-fly nymphs.
8 1/16	1 May-fly nymph and parts of fish.	8 3/16	1 Mayfly nymph.
8 2/16	1 May-fly nymph.	8 3/16	Do.
8 3/16	1 nearly digested small fish.	9	Parts of smelt and May-fly nymph.
9	1 small female smelt with spawn.	9	Nearly digested small fish.
9	Parts of small fish.	8 7/16	Parts of fish, May-fly nymphs, and parts of 2 or 3 others.
8 2/16	Do.	9 1/16	Parts of smelt with spawn.
8 7/16	1 May-fly nymph.	9 3/16	Do.
9	1 small smelt with spawn.	8 11/16	Piece of smelt.
8 3/16	1 small smelt with milt.	11 1/16	Parts of smelt with spawn.
8 3/16	Parts of nearly digested fish.		

The above listed 23 smelts were all of 94 specimens that contained food.

One of six smelts received from George Moses in January, 1907, contained one small salamander and a piece of fish, the latter probably bait.

Detailed table of stomach contents of two smelts from Pennamaquan Lake, Me.

Date	Length, in inches	Stomach contents and remarks
Aug. 30, 1893	3 5/8	Entomostraca. Seined amongst sedge and rushes in shallow water with sandy bottom.
Do	3 1/2	Entomostraca. The smelt were as silvery as salt-water smelt.

Detailed table of stomach contents of eight smelts that contained food out of 23 specimens killed by dynamite in Wilton Pond in the spring of 1904

Length, in inches	Stomach contents	Length, in inches	Stomach contents
3 1/16	Gnat larvæ.	3 1/8	Minute unidentified material.
3 1/16	Do.	3 1/4	Do.
3 1/16	Do.	3 5/8	Small diptera.
3 1/8	Caddis-fly larvæ.	3 9/16	Caddis-fly larvæ.

Detailed table of stomach contents of 22 smelts, all out of 78 specimens examined from Lake Champlain on February 16 and 17, 1911, that contained food

Length, in inches	Stomach contents and remarks	Length, in inches	Stomach contents and remarks
8 3/8	2 partly digested small fish, probably smelt.	7 7/8	1 partly digested small fish.
7 1/16	1 partly digested small smelt.	7 1/16	1 small smelt in good condition.
8 3/16	Do.	8	Nearly digested parts of fish
8 1/2	Do.	7 3/8	1 small smelt.
7 7/8	Partly digested small fish, probably smelt.	7 1/16	Nearly digested parts of fish.
8	Small piece of backbone of fish.	6 5/8	Small smelt in good condition.
7 3/8	Nearly digested small fish.	6 1/2	Parts of small smelt.
7 1/16	2 small smelt.	6 7/8	Parts of nearly digested fish.
7 1/16	1 partly digested small smelt.	6 1/8	Backbone of a small fish.
5 3/16	Do.	6 1/2	Nearly digested small fish.
7 3/16	1 partly digested fish.	6 3/16	1 small fish.

Detailed table of stomach contents of 5 smelts that contained food, out of 12 taken from Memphremagog Lake, April 23, 1894

Length, in inches	Stomach contents	Length, in inches	Stomach contents
6 11/16	Larval stone fly.	6 7/16	Crustaceans.
7	Nymphs of May fly.	7	Young smelt, 2 7/16 inches long.
6½	Larval insects.		

The following notes and tables were drawn from the report of Prof. A. A. Doolittle, of Central High School, Washington, D. C., to some smelts from Sunapee Lake, N. H., and Aroostook County, Me., were submitted for identification of stomach contents.

Concerning the smelts of Sunapee Lake, Professor Doolitte said in effect that the fish taken in April were spawning fish; they had eaten very sparingly of Entomostraca, only 2 of the 12 examined having taken Entomostraca, an average of 23 for each of the feeding fish and of less than 4 for each of the 12 smelts. Insect larvæ and pupæ were taken, an average of 4½ for all the smelts examined.

The specimens collected on August 12, 1910, were removed from the stomach of a brook trout caught in about 80 feet of water, or at least where the water was that deep. Only 2 of the 6 examined had eaten recently, the food consisting of 13 Entomostraca. After October 13 the Entomostraca food became very much more abundant, although of the 30 smelts examined only 60 per cent had in the alimentary tract when examined. For those feeding, the average was 203 Entomostraca, or an average of 120 for all.

Size or age of the smelts did not seem to effect the activity of the fish in feeding. There was a scattering of insect larvæ among the Entomostraca, an average of one-half an insect for each of 30 specimens. Parasites were abundant in the alimentary tract, consisting of tapeworms, diatoms, and threadworms. Most of the specimens taken in the fall were found dead upon the beach; they can hardly be regarded as fully normal individuals, but no relation between parasites and the amount of food taken can be determined from the data in hand. The main food, as determined, was Entomostraca, mostly of the genera Cyclops and Bosmina.

Detailed table of results of an examination of the stomach contents of smelts from Sunapee Lake, made by Prof. A. A. Doolittle in 1910

Date	Length, in inches	Number of smelts examined	Number of smelts eating Entomostraca	Number of Entomostraca eaten	Miscellaneous food
Apr. 22	3–4⅛	6	1	16	30 insects.
Apr. 23	3⅛–4½	6	1	30	22 insects; smelt eggs.
Aug. 13	1 5/16–1 3/8	6	2	13	
Oct. 13	2 9/16–5 3/16	6	4	482	1 insect.
Oct. 15	2⅛–2 11/16	3	2	474	
Oct. 17	2¼–4½	6	3	1,491	8 insects; 3 amphipods.
Oct. 26	1 9/16–2⅛	3	1	142	
Oct. 30	2 9/16–4⅛	6	3	152	6 insects.
Nov. 8	2 9/16–4 7/16	6	5	910	

Later, 13 other specimens were examined by Professor Doolittle. Seven of these were removed from the stomach of the brook trout previously mentioned, and six were picked up on the beach at Soonipi Park. The following tables give the results of the examination.

Young smelts taken from the stomach of a brook trout, August 13, 1910

Length, in inches	Entomostraca (Cyclops)	Length in inches	Entomostraca (Cyclops)
1	0	3⅛	0
1⅜	4	3⅛	0
1⅛	0	4⅛	0
2⅛	9		

Smelts washed up on the beach at Soonipi Park, October 15 and 26, 1910

Length and stomach contents	Oct. 15			Oct. 26			Remarks
Length, in inches	55	55	58	50	56	56	The Entomostraca were all species of the open lake.
Cyclops	0	131	4	0	0	125	
Halopedium gibberum	0	3	4	0	0	0	
Daphnia hyalina	0	38	8	0	0	0	
Daphnia obtusirostris	0	117	172	0	0	0	
Bosmina obtusirostris	0	0	0	0	0	17	

Specimens from Square and Cross Lakes (5 from each), from a little over 3⅛ inches to about 8$\frac{1}{10}$ inches in length, were examined. They were collected on July 2, 8, and 12, 1903, washed up on the beach. Only two Entomostraca (Cyclops and Bosmina) and eight insects were found in the alimentary tracts. Those from Cross Lake were very fat but heavily parasitized. The following table shows the details:

Locality	Date	Length, in inches	Number examined	Number eating Entomostraca	Number of Entomostraca eaten	Miscellaneous food
Square Lake	July 2, 1903	3⅛–6$\frac{3}{10}$	5	0	0	6 insects.
Cross Lake	July 8 and 12, 1903	4$\frac{8}{10}$–8$\frac{1}{10}$	5	1	2	2 insects.

Creaser (1925) observes that smelt on the spawning ground eat very little, stating that Dr. Jan Metzelaar examined 110 individuals from Cold Creek, Beulah, Mich., and found most of them empty, but a few contained an insignificant quantity of smelt eggs and the débris to which the eggs were attached.

Creaser's observations concerning the stomach contents of smelt caught in the lake are similar to those made at Sebago Lake. Doctor Metzelaar examined the stomachs of 147 smelt taken at Crystal Lake about September 1. Of these, 20 were totally empty. Three contained young rock bass (*Ambloplites rupestris*), 78 contained the remains of lake shiner (*Notropis atherinoides*), 35 more contained remains probably of the same species, 25 had insect larvæ or purpæ, either midges (Chironomidæ) or May flies (Hexagenia). In volume, 98.3 per cent was fish and 1.7 insect food.

HABITAT

According to Reuter (1883) the smelt of the inland waters of Finland always live in "shoals" (schools) and prefer, except during spawn time, deep water on sandy bottom.

Nordqvist (1910) states that in the lakes of Finland the smelt is found chiefly at a depth of 12 meters (about 39.37 feet), but that it occurs in shallow lakes as a result of introduction. He says that it appears to do better in lakes that have dark or turbid water than in those of clear, colorless water, and that it occurs at the same depths summer and winter, just as they do in the Gulf of Finland.

During the summer and fall the smelts affect rather deep water, or cool water. The depths at which the smelt is found in the larger lakes vary from 60 to 100 feet, more or less. They do not thrive in shallow ponds unless the water is cool enough for them, but are known to occur in ponds not over 30 or 40 feet deep. According to George Moses, who has for many years fished for smelts in Sebago Lake, the smelt is caught in just as deep water in the winter as in the summer. Mead (1883), quoting Jesse Plummer of Raymond, Me., says:

> When fishing for cusk at the "Images" in the month of June I have, while sitting on the rock, run my line to the depth of seventy-five or one hundred feet, and in a cusk caught I have found fresh smelts, which goes to prove that they resort to the very deep water during the summer.

Cheney (1894b) stated that the smelt of Sunapee Lake, N. H., were caught in deep water in June and July, with hook and line. The water was from 58 to 63 feet deep. He took the bottom temperature at this place in August, 1890, and found it 52° F., while at the surface it was 68° F. He said that in many places the bottom temperature was 42° F., and in one place it had been found to be as low as 38° F.

In 1910 the present writer caught smelts in Sunapee Lake with hook and line in about 90 feet of water, where the temperature on August 16 was 52° F. at the bottom. The surface temperature was 69.5° and that of the air was 65° F. The smelts ranged from 4½ to 7½ inches in length. The character of the bottom was not ascertained.

On February 16 and 17, 1911, the present writer found smelt fishermen at Port Henry, on Lake Champlain, fishing at various depths. One man was fishing in 38 feet of water and said that the largest smelts were found in deeper water, down to about 70 feet. Another man was fishing in about 25 feet of water and was doing very well in number of fish caught, but they were not very large, running about 8 or 9 inches. It was said that smaller fish could be caught near shore where the water was only 8 or 10 feet deep.

At a place called "The Reef" they were fishing in about 40 feet of water. This is in accord with the statement of Cowen (1900) to the effect that larger smelts were to be found in water 40 to 60 feet in depth.

While the present writer has caught smelts with hook and line during the summer and fall in water as shallow as 60 feet and as deep as 100 feet in Sebago Lake, it was found that the best fishing was at a depth of about 70 feet over a bottom of gray clay. Seldom were very large smelts taken at the lesser depths, but not infrequently small smelts were caught at a depth of 70 feet or more. On one smelt ground on July 8, 1911, where the water was 90 feet deep, the temperature at the bottom

was 46.5° F., at 60 feet 48° F., at 50 feet 53.75° F., and at the surface 70° F. At another place, at the bottom in a depth of 70 feet, an excellent smelt ground, the temperature was 44° F. on July 11, 45° F. at 60 feet, 49° F. at 50 feet, and 80° F. at the surface. The bottom was composed of gray clay. The fish caught were the large form of smelt, but as many of these had eaten both the adult small form and young translucent smelts, this suggests that they occur together at the same depths, although it is possible that the large smelts may sometimes ascend to lesser depths in pursuit of food. An occasional insect, such as an adult dipterous fly found in their stomachs, adds weight to this possibility, which is further supported by the fact that in the dusk of the evening the large smelts sometimes take the bait at a few feet below the surface. However, this occurs only over the greater depth and has been observed only when hauling in a line from the lower depth, so the smelts may have followed it up to the top.

The schooling of the small form and of young smelts at and near the surface is described later in this paper. While it has not been observed, it is possible that the large smelts pursue the smaller fish toward or even to the surface. They may even school at the surface, but there is no evidence to that effect.

BREEDING SEASON

The fresh-water smelt differs very little from the salt-water form in its breeding habits. It ascends tributary streams in the spring of the year and the runs take place at night, but, of course, they are not influenced by tides, as appears to be the case with the salt-water species. According to Bloch (1796), the German fresh-water smelt spawns in March, when it leaves the lakes and ascends the rivers in great numbers and deposits its spawn upon the sands of the bottom.

Reuter (1883) states of the fresh-water smelt of Finland that, like most of the Salmonidæ, it is a wandering fish. The largest variety as a rule chooses the most rapid and deepest waters for spawning, while the smallest, on the contrary, spawns on banks in the lakes or on long shallow shores and at the mouths of rivers.

According to Reuter's account, the spawning times of the large and small Finnish smelts are the reverse of those forms in Maine. He said that the smaller and younger fish spawn earlier, at the end of March and beginning of April, the larger and older individuals in April and sometimes in May. The spawning period lasts one or two weeks, spawning taking place at night, especially during stormy weather, and commonly during a snowstorm. Reuter recognized no specific significance in the variability of size and habits, saying that the smaller varieties chiefly belong to lakes where there is but a scanty supply of food, but added that in the larger lakes and in the sea both varieties were found.

According to Nordqvist (1910), in the northern regions of Finland the spawning season occurs later than in the southern districts, and that the spawning time is not determined by a definite water temperature.

Of the salt-water smelt in New Brunswick, A. Leith Adams (1873) says:

> As soon as the ice breaks up and drifts seaward, sculls upon sculls of this savoury fish push their way up the rivers, where they bite bait readily, and are captured by nets.

Of the fresh-water form he says:

Again, at the same season the individuals of the landlocked lakes, impelled by the same instinct as the others, issue from the deeper waters, and crowd many brooks and streams so densely that the struggling mass is often lifted out of water by sheer pressure from below and behind; indeed, so plentiful are they then in the brooks running into Lake Utopia, before noticed, that I have been told by by persons who captured them by thousands, that there is no difficulty in filling a landing net at every haul.

According to the report of the Massachusetts commissioners of fisheries and game for 1917 (1918, p. 75), the introduced smelt of one of the lakes in the Berkshire Hills has become very plentiful, and in the spawning runs exhibit a similar phenomenon to that mentioned by A. Leith Adams. He says:

In fresh-water lakes, as Onota Lake, Pittsfield, the season, lasting seven days, varies with the time the ice leaves the lake, since the fish start running up the brooks about ten days after the ice has gone. The fish lie around the mouth of the spawning brook two or three days before starting their run, which occurs at night, the fish returning to the lake at daybreak. During the first three nights the large ones pass up, then for a few nights the medium sized, and finally the small ones, evidently yearlings. So many fish run up Parker Brook from Onota Lake that they actually force each other out of the water on the grass and gravel sides of the stream. The spawn is deposited, one layer of eggs upon another, to a depth of about 2 inches, which inevitably results in millions of eggs being annually lost under natural conditions. When so covered the bed of the brook has the appearance of one large yellow sheet.

The report of the commissioners of fisheries of New Hampshire for 1870 says of the smelts of "Lake Winnipiseogee" that they ascend the brooks for spawning just at the time the ice leaves the lake, which usually occurs about the last of April. The report stated that the fish ran in the streams about a week, depositing their ova upon moss, sticks, and stones, to which the eggs adhered by a "glutinous substance." After the spawning season the smelts were said to disappear, not to be seen again until the following spring.

Concerning Sunapee Lake, N. H., Cheney (1896) wrote:

In New England lakes the fresh-water form of the smelt begins to run up the streams to spawn as soon as the ice breaks up in the spring, and at no other time are they observed in the streams or shallow water. Commissioner Wentworth, of New Hamshire, writes me that last fall, or perhaps I should say this winter, the ice formed on Sunapee Lake and Pleasant Pond, in New London, to the thickness of 8 in., and then broke up in a thaw, and at once the smelts began to run, something never before known. He does not say the smelt had ripe spawn, but they acted as they do at spawning time. Smelt run up a stream in the night, spawn and return to the lake or sea before morning, and as they run in great schools the spawn probably develops rapidly, and it would be curious to know that atmospheric changes could influence the development of fish spawn to change the spawning season several months. Anyway, we have yet quite a bit to learn about fish and their habits before we know it all, much as we think we know.

In 1910 the present writer made observations upon the smelts of Sunapee Lake during their entire breeding season. In Pike Brook, one of the principal tributaries of the lake, the first run of smelts occurred on the night of April 13. The runs continued to increase in numbers of fish until the 19th, on which night the smelts fairly swarmed in the brook. The run continued constantly large until the 25th, when they rapidly decreased in numbers until the night of April 30, when only a few stragglers were observed in the brook. After April 21 those remaining in the pools decreased in numbers. For some time, however, the brook was so high and roily

that had there been smelts there they could not have been seen. Subsequently the only smelts observed during the daytime were not over a dozen in each of the two pools under special observation on the 22d and 23d, only one smelt on the 24th, and a small school in the hatchery pool on the 25th.

The information concerning the breeding season of the fresh-water smelt in most of the lakes of Maine is derived from observations of several persons, but largely from unpublished notes made by Atkins many years ago.

Long Lake.—Mead (1883) referring particularly to Sebago waters, wrote:

"When the first frog peeps" smelt may be looked for with an almost sure chance of success. The time of their running up brooks but a mile or two apart varies. I have known the "big smelts" plenty the tenth of April; this year they were in the height of their run in the brooks emptying into Long Pond about the twentieth of April; they vary with the seasons. The smelts almost invariably ascend the brooks in the early part of the night and return to the ponds towards morning; a few times only have I ever seen them in the brooks by day-light. Both kinds (for I shall treat them as distinct kinds) come to the same brooks; the males of the "big smelts" are the first to appear probably to prepare the spawning beds. After making their appearance in "old bachelor" style for a few nights, females will begin to straggle along, and for the last few nights both males and females are taken in about equal numbers. The "run" lasts from one to two weeks. About the last of the run of the larger kind, the "little smelts" come to the same brooks and to all appearance on the same errand, straggling at first, but in multitudes finally; their run lasts about the same length of time as that of their big brothers, extending about as many days after the large ones have disappeared as they were behind them in making their first appearance. After the spring run, very little is seen of either kind for the remainder of the year.

Two years later, under date of April 25, the same observer (Mead, 1885) said that the run of smelts exceeded anything for many years. He stated that one party caught 480 large smelts the night before in Rogers Brook, and that he heard good reports from all the brooks on Long Lake. He said:

I am led to believe that the main army of smelts do not come to the brooks every year, and it may be that they pass over several years. For a number of years the run was so small that it appeared that they were diminishing rapidly. Fifty smelts to a net per night has been considered a good catch for a number of seasons past. It may be that on some particular year they were not disturbed and a large amount of spawn was left, but as all the brooks responded at the same time, I incline to the first view. The run this year is something like old times.

Again, two years later than this, signing his initials only, the same correspondent ("J. M.," 1887), under date of May 28, wrote that the run of smelts was equal to that of any recent season; that the water was unusually high and probably a larger number than usual escaped the dip net. He said that a few days after the water fell he visited Rogers Brook and was attracted by what appeared to be frost on a space a foot or more in width upon the brook margin, but upon closer inspection he found that it was smelt eggs left by the receding water, which had turned white by exposure to the air.

Sebago Lake.—The late Frank Meserve, in 1898, told the present writer that the smelts begin to run at about full moon in April, the large smelts preceding the small ones, and the runs of each size last about a week. It is said that they run in almost every stream, large or small, but usually are found later in the smaller streams than in the larger ones. He stated that the smelts ascended Crooked River as far as Edes Falls.

On April 23, 1901, the present writer obtained from the late "Nate" Paul, at Songo Lock, about a dozen and a half large smelts and a peck and a half of small ones. Some were ripe and some were spent. According to Paul the large smelts ran earlier than the small ones, the latter appearing about the 13th of April.

Ben Jones stated that smelts are found at one given place in Crooked River for about a week or 10 days, and that they leave suddenly. On April 28, 1903, one smelt found dying in the lake off Broad Cove emitted eggs upon gentle pressure.

In 1906 "Nate" Paul told the present writer that the large smelts begin to run as soon as the ice is out, and sometimes before. He said that he had known them to run up and back again before the ice was out of the lake, but that straggling fish sometimes remain in the stream after the main body had left.

In 1908 Ben Jones said that smelts sometimes ascend Crooked River as far as Edes Falls, much depending upon the height of the water.

On April 11, 1910, George Moses said that a few large smelts had been caught at Songo Lock, but that small smelts had not yet entered the river, although they had been seen at the "bar" at the mouth of the river. A few small smelts were taken at Songo Lock on the night of April 11, according to report.

Panther Pond.—Small smelts were running up a tributary brook about April 28 or 29, 1901. It was said that they run about a week earlier in the brooks of this lake than they do in the tributaries of Sebago Lake.

Rangeley Lakes.—According to the Maine Woods of 1904, on April 30 of that year smelts were running up Dodge Pond Stream "in bushels" from Oquossoc or upper Rangeley Lake. The same paper in 1905 indicated that the spawning period extended over a week or 10 days from time the ice went out. Again, in 1907, smelts were reported to be very much in evidence in Rangeley Stream about the middle of May. Rangeley Stream connects Oquossoc with Mooselucmaguntic Lake, therefore the smelts come up from the latter lake. The same paper (of April 28, 1910) reported that smelts had begun to run early in 1910, large quantities having been taken from Kennebago Stream during that week and the week before. The smelts were said to be of good size and fine quality, and the quantity unlimited.

It may be noted here that Kennebago Stream flows into Mooselucmaguntic Lake. The smelts of that lake were large smelts from Swan Lake stock, while the smaller smelts of Oquossoc Lake originated from Weld Pond stock, a very small smelt. (See Square Lake.)

Sebattus Pond.—On May 8, 1868, Atkins wrote in his notes that the smelts ascended the brooks in great quantities about 10 days earlier than in Cochnewagn Pond brooks in Monmouth. This year they were very plentiful on the night of April 30.

Cobbosseecontee Lake.—Smelts were found very abundantly at Fullers Meadow, East Winthrop, on April 30, 1868. On the night of May 4, 1868, Atkins found some smelts in a little brook that runs across a sandy beech from Brainards Meadow, East Winthrop; and on May 5, at the entrance of the meadow, he found the bushes and all the rubbish on the bottom covered with smelt spawn, most of it apparently in good condition; but there were enough white ones plainly to be seen scattered over the weeds. He was informed that on April 30 smelts were very plentiful at this place. The water was about 4 feet deep. In the sand shore brook very few eggs were

found, and a few dead and dying smelts were observed. The eggs were all fertile. Atkins stated that although the brook was muddy that day he believed it was naturally very clear.

Belgrade Lakes.—According to Atkins, information received on April 19, 1868, was to the effect that in Messalonskee Lake the smelts usually run about the 10th to the 15th of April, sometimes earlier and sometimes later; they contine to run about a week. The first appearance in the brooks this year was on the night of April 12, and on the 19th they were about done.

On April 15, 1869, only 10 males and no females were caught in one brook; they were the first to appear in that paticular brook but they had run in another brook on the 12th. This season was said to be about 10 days behind the previous season. In one stream on the 16th a few, mostly males, were caught. It was thought that the lateness of the season was due to high water in the streams, which overflowed their banks. On April 15 it was stated that there was more than a foot of water all over the fields. In another brook scarcely any smelts were taken until the night of the 18th, when one man got about half a bushel, and about a bushel in all were taken. In another brook the fish were said to be scarce and a catch of four dozen comprised more males than females. On the night of April 20 the brooks were still very high and only a few fish were caught. On April 21 it had rained nearly all day and the brooks very high. It cleared in the evening but only two fish were caught in one brook, but in another many were taken. One informant told Atkins that smelt did not run after 9 o'clock.

On April 15, 1875, Atkins fished in Tilsons or Palmers Brook at North Belgrade during a heavy rain beginning at 9 p. m. and stopping at 3 a. m. the following morning. Six "drives" at intervals of one hour and one-half hour yielded 94 smelts, of which 68 were males and 26 females. On the night of the 17th, in the same brook, four men got only one smelt up to 10 p. m. and then left. Later Atkins heard that on Saturday about 40 smelts were caught, and on the night of the 18th 247 were taken, which were said to comprise many more females than males

On April 19, in the same brook, three "drives" one and one-half and two hours apart yielded 83 smelts, 46 of which were males and 37 females. On the night of April 21, in the same stream, 250 smelts were said to have been taken, and of 36 fish bought by Atkins 7 were males and 29 females.

On the night of April 22, in the same brook, two drives were made between 8.30 p. m. and midnight and 34 smelts were caught, 17 of which were males and 17 females. Some were ripe and a few spent. In another brook (Eldreds) on the same night 300 smelts were caught, while in another only 45 fish were taken.

Great Pond.—On May 6, 1875, Atkins found the pond about three-fourths covered with ice. About 10.30 a. m. he found the temperature in Eldreds Brook to be 45° F. Smelt eggs were thick at the mouth of the brook and for about 7 or 8 rods and some at possibly 10 rods or more from the pond. No eggs were observed in the pond, and a little to one side of the mouth of the brook in the pond and in the brook they stuck to stones, sticks, leaves, and moss; to the latter better than to anything else. He said that it was a moss that grew abundantly on the shores of the brook, especially some distance up. Atkins judged that in the 7 rods of the lower part of the brook,

where it was about 5 feet wide, the good and bad eggs would count 30 to the square inch, which would give 2,592,000 eggs to the brook.

Cochnewagn Pond.—Atkins found that on May 7, 1868, the smelts of this lake had not begun to run, but that night he remained on the brook until midnight and managed to get about 20 small smelts and 3 "full-sized" ones. All were ripe. He said that the brooks were very small and that in none of them did the smelts run up more than 4 or 5 rods. The temperature of the brook at midnight was 43° F, and that of the lake on shore was 45° F. On the night of May 12 Atkins tried again for smelts at Monmouth. He succeeded in getting one "full-sized" fish. They had not begun to run in any quantity. On May 2, 1878, Atkins received a box of smelts that were caught in the brooks of this lake on April 30. The ice had left the lake on the 9th of April. All of the smelts appeared to be in breeding condition, the very smallest being a female with ripe eggs.

Toddy Pond.—In his notes Atkins said that the lower several rods of Sucker Brook, which flows from Heart Pond into Toddy Pond, was the spawning ground of a variety of smelt. He visited the brook on April 17, 1878, and found that the stones, roots, and moss were well covered with smelt eggs and many were hanging in bunches. In the afternoon the temperature of the brook was 46° F. A boy about 17 year of age, whom Atkins met, said that the smelts enter the brook before the suckers do. The boy had visited the brook on April 16 and found that there were very few smelts remaining in it.

Unpublished observations of Charles G. Atkins at Sidney, Me.—Messalonskee Lake

Date	Hour	Locality	Temperature, ° F		Remarks
			Water	Air	
1869					
Apr. 15	2 p. m.	Woodcocks Brook	37		First smelt; 10, all males.
Do	5.40 p. m.	do	33		Snow averaged more than 1 foot deep all over the fields; brooks very high; season 10 days behind last season. Smelts began to run on night of Apr. 12.
Do	8 p. m.	Morrisons Brook	38		Got 4 or 5 males and 2 females.
Do	10 p. m.	Woodcocks Brook	32		
Apr. 16	10.30 a. m.	do	33		A few smelts, mostly males; only 1 female.
Do	2 p. m.	do	35		
Apr. 17	7.20 a. m.	do	33		
Do	12 noon	do	34		
Do	2 p. m.	do	32		
Do	5.15 p. m.	do	32		Rise of 12 inches of water.
Do	10.15 p. m.	do	32		
Apr. 18	7.10 a. m.	do	32		
Do	9.28 a. m.	do	32		
Do	11.10 a. m.	do	32		
Do	1 p. m.	do	33		
Do	11.15 p. m.	do	33		A good many caught to-night, about 2 bushels; 2 men caught half a bushel.
Apr. 19	7 p. m.	do	33		Scarcely any smelts taken; succeeded in getting spawn to cover 8 dishes. Males yielded but little milt.
Do	9.25 p. m.	do	33		Brook very high.
Apr. 20	10 a. m.	do	35		Water falling.
Apr. 21	do	do	36		Much lower.
Do	4 p. m.	do	39		Muddy; only 2 fish caught.
Apr. 22	9 a. m.	do	36		Much lower.
Do	6 p. m.	do	41		
Do	7 p. m.	Morrisons Brook	45		
Do	9 p. m.	do	43		
Do	2.30 a. m.	Woodcocks Brook	33		
1875					
Apr. 14	7 p. m.	Mouth Tilson Brook	40		Clear and cold.
Do	9 p. m.	do	38.5	29	

Unpublished observations of Charles G. Atkins at Sidney, Me.—Messalonskee Lake—Continued

Date	Hour	Locality	Temperature, ° F		Remarks
			Water	Air	
1875					
Apr. 15	7 a. m	Taylors Veranda		33	Hazy; partly cloudy; southeast light breeze.
Do	9 a. m	Spring near Cooper's shop	40.5		
Do	do	Open brook, same place	33		
Do	do	Spring in swamp	44		
Do	10.30 a. m	Brook in woods	37		Hazy and mostly cloudy.
Do	do	Spring at head of brook	41		
Do	9 p. m	Tilson Stream	39		Cloudy; wind southeast.
Apr. 16	do	do	38	40	Rain in morning; wind northeast.
Apr. 17	do	do	38	30	Wind northeast and north; cloudy; snowed a little in afternoon; cleared 10 p. m., colder with northwest wind.
Apr. 18	9 a. m	Brook in woods	34.5		
Do	6 p. m	do	36.5	31	
Apr. 19	8 a. m	do	33.5	35	Snow squall.
Do	1 p. m	Mouth Tilson Brook	40.5	40	
Do	3 p. m	do		40	Cold northeast wind.
Do	5 p. m	do		32	
Do	10 p. m	do	34.5	25	
Apr. 20	4 a. m	do	34	18.5	Violent northwest wind, clear; snow in the afternoon.
Do	10 a. m	Brook in woods	34	28	
Do	11 a. m	do	34		
Do	do	Mouth Tilson Brook	36		
Do	6 p. m	Brook in woods	33		
Do	9 p. m	do		17	
Apr. 21	6 a. m	do		13	
Do	7 a. m	do		14.5	
Do	8 a. m	do	33		
Do	do	Spring	41		
Do	1 p. m	do		30	
Do	3.30 p. m	Brook in woods	36	33	
Do	4.30 p. m	Spring in woods, low, covered with snow water.	43		
Do	6 p. m	do		25	
Apr. 22	7 a. m	do		29	Wind northwest; clear.
Do	11 p. m	Tilson Brook	40	35	
Apr. 23	7 a. m	do		35	
Apr. 26	1 p. m	Eldreds Brook	40	40	Cold, blustering wind.
Apr. 27	2 a. m	Brook near Cooper's shop	33.5		Cold night; froze, light northwest wind.
Do	do	Brook in woods	38.5		
Do	8 a. m	do		38	
Do	1 p. m	do		51	
Do	2 p. m	do	46		
Do	do	Judkins spring	41		
Do	3 p. m	Brook at Cooper's shop	43		
Apr. 28	6 a. m	do	33	32	Ice on pond still firm.
Do	1 p. m	do		54	
Do	3 p. m	do	45.5		
Do	do	Spring in swamp	44		
Do	do	Brook in woods	48		
Apr. 29	7 a. m	Brook at Cooper's shop		35	
Do	1 p. m	do		59	
Do	5.30 p. m	do	33.5	30	
May 6	10.30 a. m	Eldreds Brook	45		

Notes on breeding season of fresh-water smelt

Locality	Season	Authority and remarks
New Brunswick	As soon as the ice breaks up	A. Leith Adams, 1873.
Onota Lake, Mass	About 10 days after ice is gone	W. C. Adams, 1917.
Do	Mar. 23 to Apr. 2	W. C. Adams, 1921.
Lake Winnepesaukee, N. H	As soon as the ice leaves, about the last of April	Commissioner of New Hampshire, 1870.
Sunapee Lake, N. H	As soon as the ice breaks up	Cheney, 1896.
Do	Apr. 13 to 30	Kendall (notes, 1910).
Long Pond	"When the first frog peeps"	Mead, 1883.
Sebago region, Me	Apr. 10 or later	
Do	Apr. 25	Mead, 1885.
Do	May 27, small form	Mead, 1887.

Notes on breeding season of fresh-water smelt—Continued

Locality	Season	Authority and Remarks
Sebago Lake, Me	Full moon of April	Meserve (in 1898).
Do	Apr. 13 and later, small form	Paul (in 1901).
Do	As soon as the ice is out, large form	Paul (in 1906).
Do	Apr. 11	Moses (in 1910).
Panther Pond	Apr. 28 or 29	Moses (in 1901).
Rangeley Lakes, Me	Apr. 30	Maine Woods, 1904.
Do	From time ice is out	Maine Woods, 1905.
Do	Middle of May	Maine Woods, 1907.
Do	Apr. 21 and later	Maine Woods, 1910.
Lake Auburn	Just after the ice is out	A. D. Merrill (in 1900).
Sebattus Pond	Apr. 30	Atkins, 1868.
Wilton Pond	May 1	Do.
Cobbosseecontee Lake	Apr. 30	Do.
Do	May 5	Do.
Jamies Pond	May 4 and 5	Do.
Do	May 13	Atkins (notes 1875).
Great Pond	Apr. 14 to 23	Atkins (notes, 1878).
Do	Apr. 22 to 26	Do.
Messalonskee Lake	Apr. 10 to 15	Atkins, 1868.
Do	Apr. 12 to 19	Do.
Do	Apr. 16 to 18	Do.
Do	Apr. 15 to 21	Atkins. 1869.
Cochnewagn Pond	May 7, last of run	Atkins (notes, 1875).
Do	Apr. 30	Atkins (notes, 1878).
Sebec Lake	As early as April or even in March	Packard (in 1901).
Toddy Pond	Apr. 16, very few left	Atkins (notes, 1878).
Do	Apr. 18, first spent male	Atkins (notes, 1903).
Green Lake, Me	Mar. 28 and 29, large form	Race (in 1906).
Do	May 7, small form	Do.
Do	Mar. 25 to Apr 15, large form	Story (in 1921).
Do	May 5 to May 20, small form	Do.
Do	Mar. 25 to Apr. 15, large form	De Rocher (in 1922).
Do	May 5 to May 20, small form	Do.
Do	Apr. 1 to Apr. 20, large form	De Rocher (in 1923).
Do	May 10 to May 13, small form	Do.
Sisladobsis Lake	February	Atkins (notes, 1879).

Creaser (1925) writes that spawning takes place at Crystal Lake before the ice breaks up in the lake as a whole. In 1923 the spawning started on April 10, which was somewhat later than in 1922, when it was all over by April 8. The run of 1925 was very heavy and was concentrated over the period of April 2 to April 8. At Beulah the smelt ran up a small permanent stream known to the residents as Cold Creek. This stream is not over a mile long and has its headwaters in a cedar bog; in the portion used by the smelt it flows through the village and enters the south end of the Lake.

SPAWNING HABITS

At Sunapee Lake efforts were made, night and day, by the present writer to ascertain if there were any peculiar habits or movements connected with the spawning. The following is a detailed account of the observations made:

The first observations were made on the night of April 15, 1910, when smelts were found making their way some distance above the mouth of the brook at the outer edge of the beach. After reaching the head of the channel they seemed to have some hesitation about entering the dead water above, swimming back for a short distance several times before going in. But this action may have been due wholly or in part to the lantern or the writer standing near the place. Whenever startled by anyone approaching the brook they would run down a short distance, but when "dipped" at with nets they strove to get upstream notwithstanding efforts made to drive them back by splashing the water in the brook.

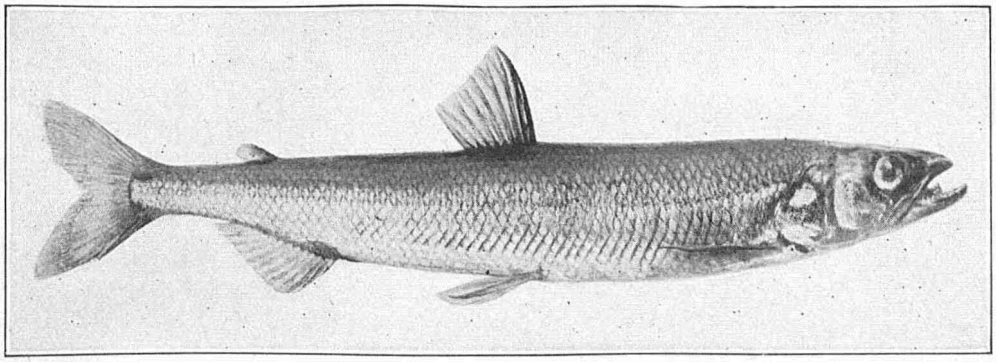

FIG. 14.—Fresh-water smelt. Large form from Sebago Lake, Me.

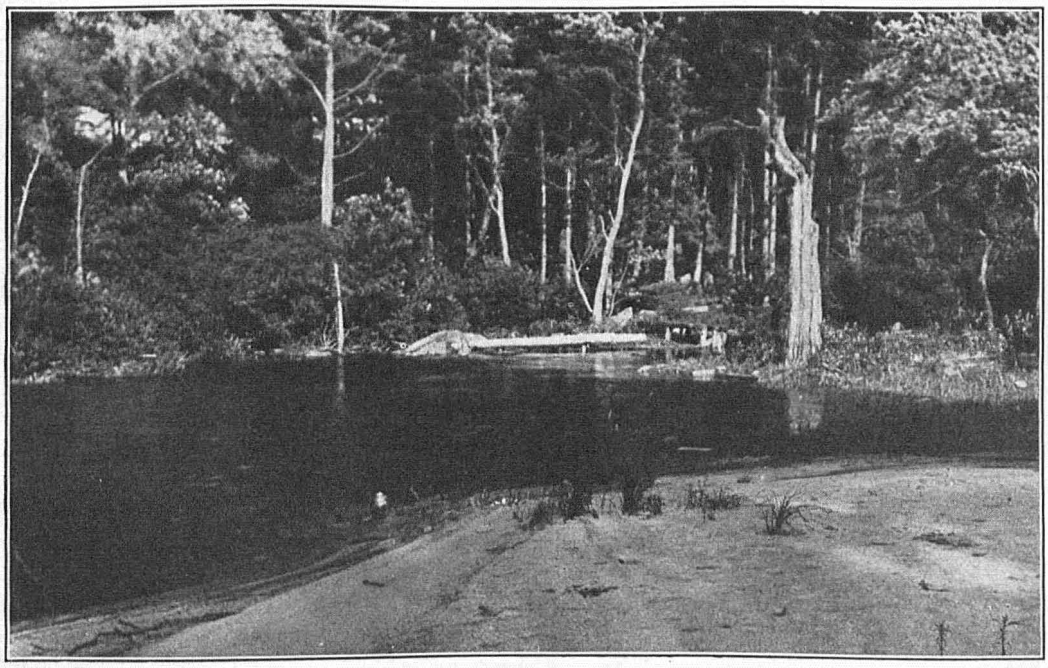

FIG. 15.—Mouth of Blodgett Brook in August. Deadwater just below bridge

During the day of April 16 in one pool the smelts occupied an eddy between two currents, circling about in the eddy, but not heading in definite order, sometimes downstream, sometimes up, and sometimes crosswise, and often some heading in one direction and some in another. In another pool above this a school occupied an eddy, swimming about irregularly and slowly to some extent, and generally rather stationary or drifting irregularly, but with their heads generally toward the slow return current at almost right angles to the bank.

In another pool a school, startled by the writer's step on the bank, darted downstream as far as a shoal ripple, then slowly returned with heads all directed upstream, some smelts above others, but all in the same direction. The smelts when undisturbed did not all occupy the same level in the water; some were near bottom and some farther up in the water, even near the surface at times, but they were all the time rising and settling again, swimming back and forth individually and to some extent collectively, but irregularly in the latter case. There was no evidence that they were at this time spawning. In the first pool mentioned a few eggs were seen attached to dead leaves, moss, and sticks, but they were white and may have been extruded when the fish were disturbed the previous night by dipping. Further observations show that the smelts very slowly moved about in the eddy in a comparatively large "circle" or rather ellipse, but in a very irregular manner.

Two smelts, one large and the other small, were seen to come rather quickly to the surface together, breaking water with their backs. Probably this was not significant, as no more were seen to do it, or anything like it, during a long watch. No evidence of pairing was observed.

Later, in another place, a small school of smelts was seen lying at the foot of a pool in which was considerable current. They were comparatively motionless, just above a shallow ripple, heads all upstream, merely drifting from side to side, when with one or two quick flirts of the tail they kept themselves from going backward. They scarcely moved upstream at all at any time, and when there was such a movement it was only on the part of one or two of them, not the whole school.

At 9 p. m. the smelts had mostly gone out of the deep holes and were scattered along the brook, generally on the ripples, but on the morning of April 17 the schools were all in the deep holes where they were seen the day before.

On the night of April 18 the writer observed some smelts in the brook by the hatchery that were evidently spawning, making no attempt to go farther up the brook. There were, however, others above and some running up by them. Those watched were in shallow water on sand, fine gravel, and pebbles, and headed upstream where the current ran quickest, but nearer the shore they would lie on the bottom with their heads in no particular direction. Sometimes they were so near shore that their backs were nearly out of water. There were some rather quick movements made by those in quick water, but evidently for the purpose of maintaining their position where they were swinging from side to side but not going forward, sometimes, however, turning and running down or to one side a short distance. But those in the still water lay comparatively quiet, some of them actually resting on the bottom, but they all moved about to a slight degree.

On the night of April 19 further observations were made on the smelts that fairly swarmed in Pike Brook. They did not seem to be disturbed by lantern light but, of course, it is possible that their movements may have been more or less modified by it. No very peculiar movements were observed. There appeared to be no pairing, each fish lying by itself, quietly on the bottom, slightly on its side in a sort of a curve. Sometimes one would lie near another and occasionally one would dart forward under the edge of a partly submerged sod.

During the day of the 20th the smelts were all in pools, usually stationary with heads pointed upstream, occasionally swimming a little and now and then turning to one side or downstream.

During the day of the 22d a fair-sized school was seen in the pool by the hatchery, but there was none in the deep pool where they were caught with hook. There were three or four "scattering" smelts in other places. In the night the fish were scattered mostly in shallow and quick water. Some that were probably spawning were observed. There was one group of 8 or 10 or more individuals side by side and before and behind, in rather quick water, neither going forward nor backward, but swinging back and forth with the current like a bunch of moss, those ahead with a slighter motion than those farther behind. A few others in pairs, or single, were in stiller, shallow water apparently spawning, moving about slightly but usually with the head upstream. There was some current here. They seemed to some extent to lie on their sides, and they moved up into shallow water until their noses were out of water on the gravel. One fish got on top of a stone with half of its body out of water and stayed there some time without seeming to mind it. There seemed to be no contact of bodies except apparently accidentally or incident to the swinging or waving in the current. On the other side of the brook on a rather steep slope of sand and clay bank in shallow water, quite a number were seen likewise stationary. Their movements were similar to the others just previously mentioned. No lantern was used in watching the first two lots mentioned. While the smelts mentioned remained stationary, many others were shooting up, over, and among them on their way up the brook.

There was a good run on April 23. At 8 p. m. some up under the over-hanging bank on a steep shelving bottom were watched. Their heads were upstream and they were swinging or waving from side to side, their bodies occasionally, perhaps, brushing against a neighbor, but no other contact was noticed and apparently no pairing or any approach to it took place.

The spawning period varies from three to six weeks at Sunapee, lasting on an average not over a month. The runs gradually increase in numbers of smelts to the height or middle of the season, then rapidly decrease in number of individuals. No smelts were actually seen leaving the brooks until April 18, when some were reported to be drifting tail first out of the mouth of King Hill Brook at 8.30 p. m. It is possible that they were really an inrun that settled back toward the lake upon the approach of the observer. On April 24, well up Pike Brook, at 9.30 p. m., a good many smelts were evidently running downstream head first, but at the mouth smelts were streaming in in large numbers. At no other times, however, were any seen actually descending the brook, although a decreasing number was observed in

the brook each successive day until May 1. But there was plenty of time in which they could have migrated unobserved.

It frequently has been stated and generally supposed that after spawing smelts invariably return to the lake on the night of their ascent. The writer's observations on the marine smelt in small coastwise brooks revealed that, when undisturbed during the night, large numbers, if not all, remained in the brook the next day, and often some smelts lingered in the brooks long after the spawning season was over, becoming emaciated and weak. Those remaining after the spawning season, so far as examined, always proved to be males.

These facts led to the suspicion that possibly fresh-water smelts might have a similar habit; and at Sunapee Lake it was found to be a fact that if the smelts were undisturbed during the night before the next day large numbers were found along Pike Brook as far up as they could ascend, but mostly congregated in the deeper pools. On April 16, 1910, notwithstanding the fact that there was some "dipping" during the first of the night before at the mouth of the brook, schools of smelts were found all along the brook, from just below the hatchery up 200 or 300 yards, in every little pool, and the same conditions obtained on the 17th. On the 20th smelts were observed in the pools, but there were not as many as could have been expected from the run of the night before. After the 20th no large numbers were observed during the day, but groups of a few or individuals here and there were sometimes seen (Kendall, 1914).

At Sunapee Lake it was observed that smelts, sometimes at least, begin to feed before descending to the lake. On April 20, 1910, in a large deep pool, some smelts appeared to be feeding, moving leisurely here and there as though picking up or looking for something floating in the water. In the afternoon the writer, using a tiny hook with a small piece of earthworm for bait, caught six of the smelts, which proved to be spent or partly spent males, still having rather large milts. Two were 4, one 4¼, two 4½, and one 4⅝ inches in length. There were many more bites, but the fish could not be hooked. Some of the fish would come up to the bait slowly, open their mouths, and take it in; some would dart at it quite smartly; some would not notice it unless it were moving rapidly; and some would pay no attention to it whatever. The latter were the larger smelts. The stomachs of three of the larger fish caught contained smelt eggs and several insect larvæ, apparently mosquito or possibly midge.

SEX PREDOMINANCE

The preceding notes suggest the predominance of male fish, at least during the early part of the season. According to Atkins, of 185 smelts taken April 26, 1875, 131 were males and 54 females; but on the other hand, on April 21, 1869, of two dozen smelts caught the majority were females.

Sixty-four smelts taken in a brook entering Panther Pond on April 17, 1910, comprised 48 males and 16 females. Of 526 smelts caught with hook and line in Sebago Lake, 218 were males and 308 females, but these were not breeding fish.

The best available data on sex predominance are afforded by observations made at Sunapee Lake in 1910. The following table shows that in this instance males predominated during nearly the entire breeding season.

Proportions of male and female smelts, and range in size of each sex

Date	Number examined	Number of males	Number of females	Size of males	Size of females
				Inches	*Inches*
Apr. 18, 1910	493	465	28	4–7	4–7
Do	871	771	100	4–7	4–8½
Apr. 19, 1910	1,336	1,000	336	3¼–7¼	4–8
Apr. 24, 1910	213	186	27	3⅜–5⅝	3½–4⅜

SCHOOLING AT THE SURFACE

The present writer knows of but two published references to the surface schooling habits of fresh-water smelts. One of these is that of Mead (1883), who wrote under the heading "October Frolics":

I have made mention of seeing smelts come to the surface of the lake for a frolic, or "sun bath," food or in migrations, I cannot say which, if either. One calm October day I was out on Long Pond in a boat with a party of young gentlemen. Some one noticed ripples on the water and remarked that a breeze was coming. Soon another said "it must be a queer breeze, for it only stirs the water in patches." After watching the phenomenon a few minutes one of the party suggested that it must be caused by smelts, as he had heard of them making their appearance in this way. Soon they came nearer, and by keeping perfectly still we had an opportunity to witness what was a novelty to many of us. The disturbance of the surface of the lake was caused by the smelts throwing themselves quite or nearly out of the water as though enjoying a lively game of gymnastics. Where fifty to a hundred would come to the surface, thousands were moving below in a direct line, in close order and with as much precision as a regiment of soldiers would march in review. The number of such schools in sight, as far as we could see in either direction, gave us some idea of the immense numbers of little smelts the pond contained. The dropping of an oar or the splash of a paddle would send them down out of sight as quick as thought.

The other reference is to smelt of Lake Champlain (see p. 326).

The present writer often has observed the schooling movements of smelts in Sebago Lake. Such schools, however, were always made up of the small form and young smelts. The schooling was not restricted to "October frolics," but on almost any calm day, particularly toward evening, the fish might be observed, sometimes moving in a definite direction, sometimes apparently simply loitering in one or another locality or moving about in no definite direction. The school manifested itself by a rippling of the surface of the water, and when near enough and moving quickly caused a sound much like that of a fine rain upon the water. The larger fish, which were judged to be adults of the small form, often would leap from the water, sometimes almost vertically but more often in a forward movement, much in the manner of a porpoise. When near enough to be seen, always there were fish below the surface that appeared not to jump at all, and often these fish were in tiers, about as described by Mead.

The following are chronological notes of some of the observations made by the present writer, which indicate that schooling takes place at no particular season of the year. It should be mentioned that the supposed adult fish never were seen near shore, but young smelts in the translucent stage often were.

June 15, 1899.—During the forenoon the sky was overcast and there was an easterly breeze; later it became calm. From Whites Point nearly to Squaw Island,

a distance of fully 2 miles, schools of smelts covering an area of many acres were seen moving eastward, rippling the water much in the manner of a school of mackerel, frequently leaping from the water. Again, in the "Notch," between Raymond Cape and Fryes Island, numerous schools were observed, also moving eastward. Again, at about 5 p. m., other schools were seen behaving like those just mentioned.

June 11, 1901.—The lake was calm and the water covered with insects, such as beetles, ants, moths, spiders, etc. Copepods and other entomostracans were observed in the water. Early in the morning smelts were observed schooling in the "Notch" and a few larger fish were breaking water.

September 17, 1906.—In the "Notch" three schools of young smelts were seen rippling the surface, sounding like light rain.

September 28, 1906.—While fishing in the "Notch" the writer observed smelts, perhaps 5 or 6 inches long, swimming by the boat near the surface during a calm. Other fish apparently were feeding upon them.

June 29, 1907.—Young smelts, from a little over 1 inch to nearly 2 inches in length, averaging a little over $1\frac{7}{16}$ inches in total length, were seen schooling near the entrance to Camp Cove. Specimens were secured.

July 28, 1907.—Three schools of small smelts were seen on the Jordan Bay side of Raymond Cape during a calm. Some other fish appeared to be feeding upon them.

July 29, 1907.—On the abruptly shelving west shore of the basin, just below Whites Bridge, large schools of small fish of several species were hovering close to shore. In a 25-foot seine, amongst other species, a number of young smelts, mostly about $1\frac{1}{2}$ inches long, were caught.

September 7, 1907.—In the outer half of Camp Cove, both in the forenoon and afternoon, many large and small schools of young smelts were seen at the surface rippling the water like the patter of fine rain. They were pursued by yellow perch. Specimens were obtained by first catching the perch and opening them. The smelts were nearly 2 inches in length.

September 13, 1907.—Many schools of young smelts were seen in the vicinity of Squaw Island at the surface over about 8 feet of water. These smelts appeared to be in tiers 2 or 3 feet deep.

September 20, 1907.—Near the shore of Whites Bridge, just below the causeway, several large schools of young smelts were seen and some were collected. These fish appeared to be moving about in an irregular manner, but 2 schools of larger size were seen just below the bridge heading against the swift current. Some were seen under the bridge. These fish would work their way up a short distance and, apparently unable to stem the current, would settle back again. They continued these movements until late in the afternoon. On September 21 no smelts were to be seen there.

July 31, 1908.—A school of young smelts, rippling the surface like rain, was observed on the west side of Fryes Island.

May 27, 1910—A school of smelts was observed in Broad Cove, pursued by other larger fish. One dead smelt, $3\frac{1}{4}$ inches long, was found on the bottom below the spot where the fish where schooling.

May 29, 1910.—A school of young smelts was seen offshore in Broad Cove. Several good-sized yellow perch were seen lying quietly on the bottom below the place where the smelts were.

June 7, 1910.—George Moses reported a large school of smelts not far from shore, "gilling" and jumping from the water. Temperature of air was 50° and of surface water 51° F.

June 12, 1910.—In the notch off Loon Island and Harpers Point numerous schools of smelts, individuals of which were "popping" from the water, were seen. The fish apparently were about 4 or 5 inches long. They were over deep water some distance from shore. Another observer reported smelts schooling off the "Straight Shore."

May 29, 1916.—The water was dead calm all the morning until 1.30 p. m.

July 5, 1916.—A large school of young smelts was observed behind the wharf and boathouse. They were still there on July 6, and a collection was made.

The only other waters in which the present writer has seen smelts schooling at the surface was in Little Sebago Lake on August 6 and 7, 1900. There they were observed in large numbers and numerous schools of the very small smelts that occur there. They were pursued by white perch. On October 30 of the same year several schools of tiny smelts were observed at the head of Lake Auburn. In Sebago Lake it was possible usually to get near enough to the schools of fish to ascertain their identity, but not always.

On September 11, 1908, off the northeast end of Fryes Island, many schools of small fish were observed near the point of the island, acting like the perch seen at Whites Bridge, mentioned later. These schools extended from among the bowlders, in comparatively shallow water, off into the lake toward Broad Cove. There were many fish but they could not be seen distinctly enough for positive identification; yet very probably in this case they were smelts, as some other larger fish were rising amongst them causing them to "rush." While the writer has seen smelts thus attacked, he never saw yellow perch or white perch harassed in this manner by other fish.

As smelts so frequently are seen schooling and are positively identified, one is prone to regard as smelts all schools of small fish when seen out in the open lake; but it has been found that such schools are not always composed of smelts.

Off the lower end of Raymond Cape, Sebago Lake, on September 8, 1908, the present writer observed a small school of fish that acted like small smelts; and in the bight above Whites Bridge and below Whites Point there were many schools, some large and some small, that behaved in a similar manner. Just below Whites Point one of these schools was approached near enough to ascertain that the fish were young yellow perch, apparently about 1½ to 2 inches long. All of these schools were heading out into Jordan Bay. In the Connecticut Lakes, N. H., in 1904, similarly acting schools of small fish were found to be composed (in part, at least) of redfin shiners (*Notropis cornutus*).

On July 27, 1909, between the head of Fryes Island and the west shore of Raymond Cape, Sebago Lake, many small fish, perhaps 4 to 6 inches long, were seen breaking water. They did not appear to be smelts, although their behavior was

similar; they looked like small chubs, or some such fish, and may have been redfins or chub minnows (*Couesius plumbeus*). The next day, off the head of Fryes Island, more of the same were seen but could not be positively identified.

MORTALITY

It has been stated that a very pronounced mortality occurs among fresh-water smelts at or shortly after the breeding season. This phenomenon does not appear to have been noticed in connection with breeding marine smelt. While this mortality has been noticeable at the breeding season, or shortly thereafter, it appears not to be restricted to that season; nor has the present writer ever seen it so extensive and intensive as has been reported. Forest and Stream of May 10, 1883 (p. 290), gives the following account of great mortality of smelts in Lake Champlain:

Smelt washed ashore.—The Burlington (Vt.) Free Press of May 5 reports a hard night for the smelt: Last Wednesday night was a disastrous one for the smelt in our lake. Thousands were washed in with driftwood and cast upon the beach of Burlington Bay. Two men who were on hand at the time gathered up fifty dozen, taking them in their hands as the waves rolled them in. A south wind blowing fresh all day had raised a heavy sea, and the next morning the beach presented the appearance of a general shipwreck. The driftwood lined the sands, piled up in high, long windrows. In the midst of this lay the mangled bodies of the unfortunate smelt, several hundred occasionally in the run of a few feet, and as many more buried beneath the sands. What a ghastly parody on the act of swimming, these creatures of the deep wrecked in their own element and cast up by the waters. Last winter fishermen thought themselves fortunate to capture a few dozen of these wily smelt in a day's fishing, and some had concluded the species were dying out. The sudden appearance of several thousand thrown up in one night would not certainly be an argument in favor of this theory. The greater part of the fish were stranded on what is called Job Reed's Bay on Rock Point, and what the destruction was in other parts of the lake we are unable to say. Before these fish were much sought after for food this general destruction in windstorms was of frequent occurrence, and the farmers who owned the land adjoining the lake were accustomed to gather them up and feed them to their hogs. This might appear to be a reversion of those days of plenty. It is likely that a large school of smelt allowed themselves to drift in from the lake and being caught before they were aware on the shallows, and entangled and bruised amid the churning driftwood thus met their untimely fate.

The following year the American Angler for March 1, 1884 (p. 138), quoted the following from the Plattsburgh Republican:

The Smelt fisheries of Lake Champlain have greatly declined within a few years. During the summer of 1882, for about a week, the lake was covered with these delicate fish which had evidently died nearly simultaneously, as they suddenly appeared floating, flecking many square miles of surface, and as suddenly disappeared, after uniformly going through the process of decay. This strange thing happened immediately after an extraordinary display of the aurora borealis, and an accompanying "electric storm" which greatly interfered with the telegraph system of the whole country for several hours, and the question has naturally occurred whether the sudden death of these fish may not have been in some way connected with a shock from Nature's electric battery. The mortality of the smelt furnishes a field for investigation by the scientists who are holding a "Crowner's 'quest" on the tilefish.

A correspondent of Forest and Stream, under date of May 20, 1899, wrote that smelts had been remarkably numerous in all the trout and salmon waters of Maine and New Hampshire, with more than the usual number of dead and dying at the surface. Maine Woods of May 12, 1905, referring to the Rangley Lakes, reported "lots of dead smelts floating on the surface." In 1890 Forest and Stream stated

that smelts often were washed up on the eastern shores of Sunapee Lake by strong winds. Halkett (1913), in a footnote (p. 55), says:

> Whilst engaged in some fisheries matters in the month of May, 1903, I found some specimens of the American Smelt floating dead on the surface of the water of Lac des Isles, in the Gatineau district, P. Q.

The following are chronologically arranged notes made by the present writer upon dead and dying smelts seen in Sebago Lake:

July 20, 1898.—A dead smelt, 11½ inches long, and a dead sucker were found at the surface in Witch Cove.

June 16, 1899.—Found one wounded smelt at the head of the "Notch," not quite dead. It bore tooth marks of some larger fish.

April 28, 1903.—Two wounded but still living smelts, 3⅓ and 5½ inches long, were found at the surface. One had a fungused wound, the other a fresh cut at the base of the tail.

April 29, 1903.—Off Broad Cove, 3 living smelts, 5¼, 5½, and 5¾ inches long, respectively, were picked up at the surface. Two of them apparently had been wounded. One was a male with fungus about the wound; the other a female, 5½ inches long, with swollen and inflamed vent. Eggs were discharged freely upon light pressure.

Down through the Notch several other smelts of about the same size were found. Some were nearly over to the south shore or mouth of Whitney Brook. They were fungused. Some had a slight redness under a small portion of the growth; others, perhaps, had lost some scales; otherwise there was no evident cause of the fungus. The fish were somewhat emaciated but not more so than any spent fish. There seemed to be more or less localized areas of redness, as though the capillaries were engorged or there was an extravasation of blood. The most conspicuous pathological condition was that of the gills, which were infested with small, white, parasitic copepods (*Ergasilus centrarchidarum*, according to C. B. Wilson). There were many copepods on all of the dead and dying fish. It is hard to say whether these copepods were the cause of the death of the fish or were present because the fish were weak, dying, or dead. Judging from the number of smelts found and the number of crows that were collecting, there must have been a good many fish in this condition.

April 30, 1903.—In the Notch three fungused smelts, 5¼, 5½, and 5¾ inches long, were picked up. They were infested with parasitic copepods on the gills, as were those of the day before.

September 25, 1906.—In Jordan Bay a dead smelt, 12¼ inches long, was found at the surface. Nate Paul, of Songo Lock, said that he had never noticed any dead smelts after spawning, excepting some that had been injured by dipping.

August 18, 1907.—In a fresh northwest wind one smelt was washed ashore at Whites Bridge.

August 26, 1907.—On a sand beach at Crib Point two dead smelts, each about 5 inches long, were found.

September 5, 1907.—One dead smelt was found at the surface in Jordan Bay. In a letter from George Moses, dated November 17, 1907, it was stated that just after a big storm he found a lot of little smelts and white perch washed up on the beaches at Fryes Island and on Raymond Cape.

May 7, 1910.—Pleasant and calm; 30 dead and dying smelts, from 4½ to 5½ inches long, were found by the "straight shore" in "slicks," where there were many insects. The smelts were more or less fungused, especially about the tail, but occasionally on some other part of the body. When the tail was affected the fungus extended at least a third of the length of the fish. There were copepods on the gills of all.

May 16, 1910.—Off the straight shoe one fungused dying smelt was found.

June 8, 1910.—A dead smelt, 5 inches long, was washed up on the shore of Raymond Cape, but no lesion or visible mark of injury was to be seen.

Observations made in other waters, in 1903, were as follows:

June 29.—Two dead smelts, each about 5½ inches long, were found on the beach of Square Lake at Cummings camps.

June 30.—In the morning dead smelts 6 inches more or less long were found floating at the surface in coves near the camps.

July 2.—Many smelts, 5 or 6 inches long, and other dead fish were found on the beach. The associated fish were large and small common suckers, few large and small common chub (*Semotilus bullaris*), chub minnows (*Couesius plumbeus*), some large redfins (*Notropis cornutus*), fair-sized "cusk" (*Lota maculosa*), and two little whitefish (*Coregonus stanleyi*).

July 3.—During a fresh blow many fishes were washed up on the beach, but no smelts.

July 4.—A few dead fish, but no smelts, were found.

July 6.—Smelts in dying condition, with fungus on front of the head, were found near the beach.

July 8.—On the east shore of Cross Lake numerous dead smelts from 5 to 10 inches long were found; some were old and others fairly fresh. Some redfins and suckers also were found.

July 10.—At the surface on Cross Lake some large dead smelts with fungused heads and one large chub minnow were found.

July 12.—On the shore of Cross Lake several fresh dead smelts, some chubs, and suckers, and one dead whitefish were found.

The present writer once wrote (Kendall, 1914, p. 75) that after the spawning period for some days, even weeks, many dead and dying smelts are found at the surface and washed up on the beach, bearing no lesions or marks of injury. It was formerly thought that perhaps it was due to the exhaustion and starvation of the spawning period, which causes them to succumb to slight changes of temperature, or inability to obtain sufficient food soon enough to enable them to recuperate. But throughout the season more or less dead of various sizes and ages are found washed up on the beaches. At Sunapee Lake some dead and dying adult fish, ranging in length from 3¼ to 7 inches, were observed near the mouths of brooks during the spawning season. Such fish, however, did not occur there in such large numbers as have been observed in other waters during and following the spawning, and young and adults were found throughout the seasons of 1910 and 1911.

Seldom were any lesions observable, and those at any time present were usually a congestion about the vent, which was ocassionally accompanied by a growth

of fungus in the same place. This condition was rendered insignificant as a result of the spawning function alone, as a number were found in October in a like condition. That the death at spawning time was only coincident, was indicated by the finding of several of them that were not quite ripe, and some ripe fish that had not been in the brooks; and young or yearling fish 2¼ to 3 inches long also were found at the beginning of the of the spawning season.

A few instances of dead fish that evidently had been in the brook were noted. They were spent, and their stomachs contained smelt eggs besides insects. This fact indicates that the death, even at spawning time, perhaps, could not be ascribed to weakness from starvation, especially when the dead and dying fish that had not entered the brook were found to contain some food.

The dead and dying fish picked up on the beaches were more numerous during the spring and fall than in the summer. This may be due to the fact that smelts reside mostly in deep water during the warmer months, and though they die in those months they would be snapped up quickly by trout and salmon. It may indicate that in the fall, as the water becomes cooler, the fish approach the surface and perhaps the shore, as indicated by the presence of insects in the stomachs of those examined.

The presence of dead smelts along the beaches could not be connected with any sudden change of temperature, although they usually and most abundantly appeared during or shortly after strong winds. The latter probably accounts only for their being washed up, although possibly smelts swimming in shallow water might be washed up and thus killed by the heavy seas raised by the strong winds. But this would not account for those found when there had been no strong winds. Intestinal parasites were found in many but not all of the October smelts examined, but this partial freedom from parasites seems to eliminate them as a factor in the mortality.

Therefore, the cause of death of so many smelts throughout the season is as yet unsolved. After all, those found dead on the shores or floating at the surface are few compared with the multitudes that live in the lake, and it is perhaps quite natural that there should be deaths due to obscure causes, as among higher animals.

ENEMIES OF THE FRESH-WATER SMELT

When an organism preys to any extent upon another it is usually accounted an enemy of the latter; so those animals that subsist upon the smelt are enemies of the smelt, and in turn the smelt is an enemy to the organisms upon which it feeds.

Probably at no time during its term of life, from the time it is deposited as an egg in the stream to the end of its existance, is the smelt free from enemies. Some of the habits of the smelt, at some stage of its existance, render it particularly subject to the aggressions of various predatory fishes. While there are no direct observations to support the assumption, it is quite likely that some mammals, such as the mink and raccoon, and some birds, such as the loon, sheldrake, heron, and kingfisher, prey to some extent upon smelts. There is circumstantial evidence to that effect.

The comparatively deep-water summer resort of the smelt probably is its safest retreat; but even there, in some localities, there are fish that feed upon them. Even

some shore fishes have been caught in the deep-water smelt habitat and occasionally been found to contain smelts.

The surface schooling of young and small smelts exposes them to greater dangers; and the schooling of young smelts in shallow water near shore, while perhaps to some extent an advantage, may expose them to dangers not encountered in the open lake or in deep water.

In streams to which smelts resort to breed, even in those inaccessible to large predacious fishes, they are by no means immune. In such places the mink, racoon, and perhaps other mammals, and birds such as the herons and kingfishers have their opportunity.

Spring spawning, while in some ways advantageous, has its disadvantages. Various spieces of cyprinids and suckers, not present in the breeding places of smelts at other seasons, are often numerous in the spring. In some localities there are permanent or year-round inhabitants of the gravel shoals where smelts spawn, which, judging from their known habits in other localities, may consume many smelt eggs and possibly recently hatched smelts. These fishes are not known to be present in the majority of natural smelt waters, but one or another species is common in some of the waters where the smelt has been introduced, and they occur in tributaries of Lake Champlain. These fishes are the little fresh-water sculpins or "miller's thumbs," locally known in Maine as "rock cusk."

Study of the food and feeding habits of the coresidents with the smelt sufficiently extensive so that all of the possible enemies may be positively designated has not been made. However, doubtless any predacious fish that comes in contact with smelts will eat them, but positive statements should not be made until the facts are known. There are available more or less definite records concerning the following species: Landlocked salmon, brook trout, lake trout, whitefish, eel, black bass, pike perch, yellow perch, white perch and burbot.

LANDLOCKED SALMON (SALMO SEBAGO)

The most conspicuous of these is the landlocked salmon. In fact, only one of the lakes naturally inhabited by landlocked salmon and apparently not by the smelt is known, and it is a question whether or not the salmon of that lake (Ontario) were landlocks. In some ways it would appear that smelts had been a factor in "landlocking" the salmon. There are no instances of the successful stocking of any lake with landlocked salmon when smelts also were not introduced.

Mead (1883) said:

> The smelt seems to be the favorite food of the land-locked salmon, and to their abundance is attributed the fair proportions of the *Salmo sebago*. When the smelts come up the brooks the salmon come to the bars and take up their quarters. In case of large streams like Songo River they move, with their base of supplies, several miles up stream, and when the smelts return to deep water, *Salmo* is not long in following suit. 'Tis then the angler sets up his rod and trolls for the land-locked. The little smelt is the most "taking" bait for the salmon or "red spot" yet discovered, either for trolling [or] still fishing. What the blue-backed trout is to the Rangeley Lakes the smelt is to Sebago—food for the larger fish.

Concerning this dependence of landlocked salmon upon smelts for food at Green Lake, Me., Bean (1892) asks: "What brings the landlocked salmon into shallow water

and the mouths of streams early in the season, say in May and June?" Then he answers the question himself, saying: "Smelt. These toothsome little fish form the favorite food of the salmon. They run up into the mouths of streams to spawn and are followed thither by the landlocks as well as big brook trout." Farther on, speaking of the smelt fry, which, he said, on July 1 were one-half to five-eighths inch long, he said they were just right to feed young salmon and trout in the hatching troughs and that the wild trout also helped themselves to the same delicate food. Writing of the smelt of Lake St. Johns, Canada, Chambers (1903) said:

> They are a favorite article of diet with the ouananiche, which, it has been suggested, might attain a larger size if a superior variety of smelts was planted in the lake for their benefit.

The following table shows a few of the many detailed notes made by the present writer upon the stomach contents of some of the landlocked salmon caught by him in Sebago Lake, Me.

Salmon			Smelts found in stomach		
Date	Weight, pounds	Length, inches	Number	Length, inches	Remarks
Apr. 23, 1903	----------	19.3	6	2, 3, 3½, 5	The other two were nearly digested.
June 25, 1907	5⅛	----------	14	3¼–4⅞	
July 24, 1907	2	----------	Many.	----------	Young and 1 adult.
July 25, 1907	2	----------	Many.	----------	Young.
July 26, 1907	8	----------	12	4–4½	
Aug. 1, 1907	16	----------	Numerous.	----------	Adult small smelts.
Aug. 23, 1907	7	27	26	3⅛–4⅝	
July 15, 1909	2	----------	Many.	----------	Young smelts among other things.
July 16, 1909	----------	----------	Some.	4⅜–5	Two comparatively fresh and others partly digested.
July 20, 1909	4	----------	2	4½–5	Partly digested.
May 15, 1910	2¼	----------	5	5½	Each.
May 16, 1910	----------	----------	1	5½	Disgorged.
July 15, 1910	2½	16	4	----------	Partly digested.
July 16, 1910	----------	17	4	4	Do.
Sept. 18, 1910	1	----------	Few.	----------	Do.
Sept. 20, 1910	----------	12	Few.	----------	Do.
Sept. 26, 1910	----------	12¼	Few.	----------	Do.
May 13, 1916	----------	15	Several.	4¾	Do.
May 29, 1916	Small.	Small.	Several.	2–2½	Do.
May 31, 1916	----------	14	Several.	----------	Young.

BROOK TROUT (SALVELINUS FONTINALIS)

In connection with landlocked salmon, two mentions were made of brook trout as smelt caters. Mead (1883) said it was a "taking" bait for "red spot," and Bean stated that wild trout fed upon young smelts.

A correspondent of Maine Woods, writing from Mooselucmaguntic Lake, Me., on May 24, 1907, cited an instance of a 3-pound trout that contained 37 whole smelts, and he did not know how many more. He affirmed that it was a true smelt story, for he put them on the wharf and the boys counted them.

At Sunapee Lake, N. H., on August 12, 1910, the present writer caught a trout, a pound or so in weight, which was gorged with young smelts.

LAKE TROUT (CRISTIVOMER NAMAYCUSH)

A Leith Adams (1873) wrote:

> The smelt is a favorite prey of the great spotted lake trout, which, with the brook trout, pursues them during winter, the former chasing the sculls to the influent waters, whilst the latter follows them up stream.

WHITEFISH (COREGONUS CLUPEAFORMIS)

While this species is known to subsist to considerable extent upon small fishes the following note made by the present writer at Sebago Lake on June 12, 1910, appears to constitute the only record of whitefish eating smelts. One specimen that the writer caught while fishing for smelts contained three partly-digested smelts, the most intact of which (nearly complete) measured 3 inches in length. It also contained one stickleback (Pungitius) 1¾ inches long.

EEL (ANGUILLA ROSTRATA)

The following notes were made by the present writer at Sebago Lake: August 14, 1908, one eel 29½ inches long contained one young smelt; September 11, 1908, one eel over 24½ inches long contained a smelt 5½ inches long; September 16, an eel 28 inches long contained one smelt $2\frac{5}{16}$ inches long; July 30, 1909, a 3-pound eel contained two smelts; August 8, 1909, an eel 23½ inches long had its stomach distended with grasshoppers, one black beetle, one smelt 3¼ inches long, and a partly-digested young perch or black bass.

BLACK BASS (MICROPTERUS DOLOMIEU)

Cheney (1894b) wrote that black bass do not feed to any extent on smelts, as they inhabit different portions of the water or a lake in which both fish are found. He said:

> Comparatively the smelt is a deep-water fish and the black bass a shallow-water fish. In the spring when the smelts run up the tributary streams to spawn, the bass have not come on to the shores and shoals to spawn, so they do not meet as a rule, yet occasionally a bass has been found with smelt inside of him.

On July 29, 1907, one young black bass $1\frac{9}{16}$ inches long was found by the present writer near shore at Sebago Lake. It had swallowed a young smelt 1¼ inches long, a portion of which protruded from the mouth of the bass. Young smelts were present near shore in great numbers.

On August 4, 1907, the present writer, while trolling for salmon in Sebago Lake, caught a 1-pound bass that contained a smelt 5½ inches long. This smelt may have been found dead or dying near the surface. On August 12, 1909, a black bass of about 1½ pounds contained a few partly digested young smelts. On August 7, 1910, off a point in Little Sebago Lake, Me., where the bottom shelves off gradually for about 50 yards and then within a few feet suddenly drops to a depth of 50 or 60 feet, large black bass gorged with smelts were caught in the deeper portion.

PIKE PERCH (STIZOSTEDION VITREUM)

The only references to pike perch feeding upon smelts are those of Bainbridge Bishop (1896), quoted in connection with the Lake Champlain fishery, where he states that while fishing for wall-eyed pike in about 100 feet of water he observed that very often the pike would chase and drive schools of smelts to the surface. He stated that some of the pike that he caught would throw smelts from their mouths after they were in the boat. In another place he wrote:

I have taken fair-size smelt from the mouths and throats of wall-eyed pike all through summer and fall months.

Again he says: "Smelt are the natural food of wall-eyes in Champlain and make the best of bait." Also, previously quoted in the same connection is the statement of "Ferris" (1896), who wrote that he had many times observed that after getting them in the boat they would disgorge one or more smelts.

YELLOW PERCH (PERCA FLAVESCENS)

The present writer made the following observations in Sebago Lake and vicinity on June 29, 1907. A yellow perch of the estimated weight of 1 pound, caught in Thomas Pond, contained four smelts, each about 4 inches long. September 10, 1907, in a cove perch were seen pursuing schools of young smelts at or near the surface. Five 10-inch perch were caught and were found to be gorged with these little smelts. From five perch 99 smelts were taken and from one 10 smelts were taken, making a total of 109 young smelts from 6 perch. These young smelts averaged nearly 1¾ inches in length. The perch were swimming with their backs out of water amongst the smelt, making a smacking sound as they took the smelt.

On September 2, 1908, Ben Jones, superintendent of the State fish-cultural weirs in Crooked River, stated that he had seen yellow perch devouring young smelts just above the weir in the spring of the year, when, as he judged, the smelts were about 1 inch long.

On August 5, 1909, an 11¼-inch perch was found to contain many partly digested young smelts. On August 18 of the same year a large school of yellow perch was seen breaking the surface and making the smacking sound mentioned above. Three were caught. They were found to have been feeding upon young smelts and were gorged with them. On June 4, 1910, a 12-inch perch caught in 65 to 80 feet of water contained a partly digested smelt about 3 inches long. A 13-inch perch taken in the same place contained two smelts 2 and 2½ inches long, respectively, tails excluded.

WHITE PERCH (MORONE AMERICANA)

On August 7, 1900, at Little Sebago Lake, Me., white perch were observed by the present writer to be pursuing and feeding upon small smelts schooling at the surface.

BURBOT (LOTA MACULOSA)

On July 30, 1903, George Moses told the present writer that he had often caught "cusk" that contained smelts; and, again, in October, 1906, he said that he had found them "full of smelts."

On August 9, 1907, a "cusk" 16¼ inches long, caught by the present writer in Sebago Lake, after being taken into the boat disgorged one smelt slightly over 1 inch long. Another, on August 21, disgorged a partly digested smelt that before ingestion probably had been between 4 and 5 inches long.

On August 14, 1908, while fishing for smelts, the present writer caught a "cusk" on smelt bait, which weighed 2 pounds 1 ounce. It disgorged many young smelts from 2 to 2½ inches long. A "cusk" weighing 3 pounds, caught on July 30, 1909,

contained one smelt. On June 27, 1911, a "cusk" 22¾ inches long contained two heads of large smelt, portion of the body of a large smelt, two partly digested small smelts, and two small fresh-water sculpins (Cottus); also a nymph of a stone fly. This fish was taken in about 70 feet of water.

PARASITES

Besides the previously mentioned vertebrate enemies, there are invertebrate animals that are regarded as more or less inimical to smelts. Concerning invertebrates that are actually harmful to smelts very little is known. Parasites of fishes have received some study by various specialists, but very little attention has been given those of the fresh-water smelt. Of those known to infest the smelt none has yet been shown to be actually injurious under ordinary conditions. The most conspicuous of fresh-water smelt parasites is a small degenerate crustacean known as a copepod. However, this animal is not peculiar to the smelt but has been observed attached to the gills, fins, or skin of other fishes.

To the gills, of some smelts taken by hook and line from Swan Lake, Me., and sent in by A. D. Merrill in May, 1898, many parasitic copepods were found to be attached; and on various occasions the present writer collected many dead and dying smelts on the surface of Sebago Lake. Thirty of these fish were from 4½ to 5½ inches long and were more or less fungused. Parasitic copepods were numerous on all of them, principally upon the gills but occasionally elsewhere. Some of these copepods were submitted to Prof. Charles Branch Wilson for identification, and from him the following letter was received:

> I find the parasites on the gills of the smelt taken from Sebago Lake to be *Ergasilus centrarchidarum* Wright. They do not usually occur in sufficient numbers to injure their hosts, but under favorable conditions may breed rapidly enough to destroy the fish. The physical condition of the fish has much to do with the effect produced upon it by the parasites, hence the latter produce pernicious effects during the fish's breeding season, when it becomes thoroughly exhausted and weakened. The minnows and darters usually catch enough of the larvæ of the parasites during their free-swimming period to keep them within due bounds, the small top minnow being especially serviceable in this respect. This is the same form that was found at Culver [Indiana] last summer [1906], and it probably infests the fish in all fresh-water ponds and lakes to some extent.

The other parasites of the smelt that have received scientific notice are "worms." The first to attract attention is a small leech, which in connection with the smelts up to the present time has been found in Lake Champlain. Cheney (1895, p. 229), writing concerning the icefish of Lake Champlain, said:

> I found that the smelts caught at Port Henry had an attachment which was entirely new to me, in the form of a sucker. The sucker was very like a worm, a little thicker than an ordinary knitting needle, dark gray, somewhat mottled in color, and they seemed to be jointed in the body. They were from one to two inches in length, and the sucker which occupied one end of the body looked like the end of a tin horn reduced in size. These suckers could be seen about the holes in the ice after the fishermen had removed them from the smelts, wriggling about on the ice or in the icy water. They made no mark on the smelt, nor did they do them any apparent harm, and they were entirely new to me.

Both at Port Henry and at Presberry Point on February 16, 1911, the present writer found some smelts infested more or less by these leeches. Sometimes a bunch

of them, about the size of a hickory nut, was said by the fishermen to be found on one smelt. Some of these were saved and identified by Prof. J. Percy Moore, of the University of Pennsylvania, as *Piscicola milneri*. It is not evident that they are harmful to the smelt.

Henry B. Ward, who studied the internal parasites of Sebago salmon in 1906, mentions but one internal parasite of the smelt. In the salmon he found a new trematode, which he named *Azygia sebago*, and it was the only trematode found in the salmon. In order to ascertain if the smelt played any part in the life history of this distome, he examined 52 smelts, and in 46 of them he found specimens of *Azygia sebago*. He said:

> The parasite occurred in the stomach only and the infestation was small, from 1 to 14 distomes being found in each host, with an average of only four to a fish. In most cases the parasites which were taken from the stomach of the smelt were immature, not having yet reached that size at which the production of ova begins; they were on the average 3 to 4 mm. long, or in some cases even smaller, running from 1.5 to 2.5 mm. [less than $\frac{1}{10}$ inch] in length. Single specimens reached a length of 6, 7, and even 10 mm. [nearly $\frac{4}{10}$ inch]. In one case, indeed, there was none shorter than 6 mm., and the specimens varied from that to 10 mm., so that one can not fairly maintain that they never reach the size attained in the salmon. Nevertheless, after the account is cast up the average shows distinctly that the distomes do not reach their full size in the smelt and, so far as collections made during July and August can indicate, those taken from this host are usually small in size and sexually immature. I did not obtain any information as to the source from which the smelt acquires infection, but in view of the universality with which smelt form the food of the salmon in Sebago Lake the latter undoubtedly owe to them the major portion of their infestation with this parasite.

In a footnote Ward states that these distomes occurred equally in both sorts of smelt and those from the smaller smelt were larger than those from the larger fish. "This," he said, "is, of course, a mere accident, but it serves to show that the two types of smelt conduct themselves alike toward the parasite."

Professor Doolittle found some smelts from Sunapee Lake with the alimentary tract containing parasitic worms, such as tapeworms, distomes, and threadworms. Subsequent examination by D. R. Crawford, of the Bureau of Fisheries, of 94 specimens from nearly 1⅞ to about 4⅜ inches long revealed that 27 were more or less infested by cysts of some parasitic worm in the walls of the stomach, and one was heavily parasitized, having cysts in the liver as well as in the stomach. Each of two specimens contained a small worm. The 29 parasitized smelts ranged from about 2½ to a little over 4⅙ inches, averaging nearly 3 inches. Ninety-four specimens were found dead and dying along the beach at Soo-Nipi Park on April 22 and 23 and November 8, 1910. Parasitized fish were found in both April and November. Of 71 smelts from about 4 inches to nearly 5.3 inches long, from Massabessic Lake, N. H., on April 14, 1904, 34 were infested with cysts in the stomach, the majority heavily so. These were all spawning fish and had no food in their stomachs.

As previously remarked, it is not known how harmful or harmless the parasites mentioned (or any other parasite) are to the smelt. As Doctor Wilson said, the copepod parasite is a menace only when conditions for its undue increase or other conditions are very favorable. He mentions that certain small fishes, by eating the parasite while in its free-swimming stage, ordinarily keep it within due bounds; but such fishes as darters and top minnows, which he mentions, do not occur in Sebago

Lake, for instance, although there are various species of minnows that may consume some of the young parasites along with other "plankton", and the small and young smelts, being almost exclusively plankton feeders, may be largely instrumental in keeping this parasite reduced.

OTHER ANIMALS

Various animals other than those mentioned have been accounted enemies of the smelt because they subsist upon it more or less, which may assist in this direction. Loons and crows are known to feed extensively upon the dead and dying copepod-infested fish, and thus destroy many egg-bearing copepods. If everything that eats smelts is to be convicted on that account, then the smelt is one of its own worst enemies. By referring to the detailed table of stomach contents of smelt in Sebago Lake, it is seen that a large proportion of the food of the large smelt consists of the young and the small form of smelt.

One of the most pronounced "natural enemies" of the smelt has been stated to be the landlocked salmon. With one or two exceptions, there is no one who would regard the smelt as an enemy of the salmon. On the contrary, its presence in salmon waters appears to be essential to the existence of the salmon.

If the distome parasite described by Ward as present in salmon is harmful to the salmon, then logically, in accordance with custom, this little worm is to be regarded as an enemy of the salmon. If Ward is correct in suspecting that the smelt acts as an immediate source of supply of the parasite to the salmon, then the smelt is to be regarded also as an enemy of the salmon. Ward found the parasite as common in the small smelt as in the large one. The possibilities, then, are that the small smelts transmit the parasite to both salmon and large smelts, as both subsist largely upon the small smelt. Therefore, if the parasite is harmful to the large smelt, to be consistent the small smelt should be reckoned among the enemies of both the salmon and the large smelt.

The foregoing affords possible examples of certain "enemies" that are both harmful and beneficial, but it has not yet been determined which exceeds the other. If such conditions obtain, probably under ordinary natural conditions there is a balance, and it is only when the balance is disturbed that the parasites become a detriment.

The paramount enemy of fish is man, for he is the great disturber of balances. He not only has been and still is to a great extent the most wanton and selfish destroyer of fish themselves, but if he suspects any other animal of eating any particular fish that is the object of his own pursuit, he immediately denounces it as an enemy to the fish and himself. He does not realize to what extent the existence of his favorite fish may depend upon one or another of the so-called enemies. If he sees a loon or a flock of sheldrake feeding in a salmon lake his imagination runs riot, and the birds are forthwith indicted for alleged destruction of salmon, when the fact is they are doing good work in cleaning the lake of dead and dying copepod-infested fish. Once the present writer heard his guide damn the crows and loons because the birds beat him to the dead smelts floating at the surface, which he desired for salmon bait. The sportsman observes a few heron along the still water of some trout stream; the heron is then, without benefit of clergy or jury, convicted of

destroying trout, when the birds were actually feeding upon suckers; and the sucker is condemned by the same judge for alleged destruction of trout eggs.

The same sort of situations extend through the whole field of so-called "enemies." The term "enemy," then, is an unfortunate misnomer when the balance has not been upset in favor of an alleged enemy. Under such circumstance the animal may actually become not only a menace but a destructive agent. However, the extermination of this, in the majority of cases, is not so likely to remedy the situation as it is to render some other factor more detrimental. Efforts directed toward control should be constructive rather than destructive. The aim should be to restore the balance as nearly as possible by renewal of the lost parts of the mechanism rather than by the removal of any more parts. While, as has been stated, some of the most highly esteemed game fishes are pronounced smelt eaters, they are not regarded as enemies by the sportsman. In fact, many anglers regard the smelt as undesirable and obstructive to angling. This question is discussed on subsequent pages.

HARMFULNESS OF SMELT

There is an occasional individual who rather inconsistently pronounces the smelt to be an enemy of certain game fishes. More than a quarter of a century ago Bainbridge Bishop (1897) entered a protest against the introduction of smelts into trout and salmon waters. By means of a long argument entitled "Are smelts a menace?" he evidently believed that he had proved his case. But while his objections to the indiscriminate distribution of fishes into waters not previously containing them is sound, his argument against the smelt is based upon false premises and is fallacious and misleading. The fault in his article was apparently attributable to his lack of knowledge concerning the habits of some of the fish discussed and concerning the smelt in particular. The article contains so much of interest and value that it is quoted here at length and is followed by comments on certain inconsistent and incorrect statements.

I see that the Fish Comissioners congratulate themselves that it took them only six years to fully stock two of the most beautiful trout and landlocked salmon lakes in New England, and that the lake trout there caught are larger and fatter than common. Just so; the adult trout fatten on the smelt and the smelt can fatten on the young trout and landlocked salmon; so the wheel goes round. The smelt being 1,000 to one in the majority, any novice can figure out what the result will be.

Let the Fish Commissioners be assured of one thing—they have effectually stopped the breeding and increase of trout and landlocked salmon in these lakes for all time to come. As an object lesson, look at Lake Champlain from Westport to Cumberland Head. It is an ideal lake trout water in every respect. For the last fifty years there has been once in a while a fine lake trout caught, but like angels' visits they are few and far between. Why do they not increase and become plenty? For answer I would say it was this: smelt have free access to this lake from the sea, and have partially or practically become landlocked, that is, they can be found at all times of the year in all the deeper parts of the lake and in the identical depth of water that would naturally be inhabited by the young and adult trout.

The planting of lake trout and landlocked salmon in Champlain, with the idea that they would breed and increase, is fallacious in the extreme. It will only result in a waste of time and money.

Although if landlocked salmon could be made to breed in the streams running into Champlain, that is above where the smelt go, and would stay there till they grew of a size that the smelt could not destroy, we might be hopeful of a favorable result.

Young lake trout and landlocked salmon have no more chance among smelt than young lambs have in a pack of wolves. Anyone who has fished through the ice for smelt, and has seen them dart a yard or more and strike a heavy sinker or large bait, can judge whether they are predatory fish or not. The boys catch them without a hook, by simply tying a white rag to a line for bait; the smelt strike this and hold on and are drawn out of the water. I have seen quite a number caught in this way. The smelt's mouth is large and well armed with sharp, hooked teeth. They are well equipped for business, and they breed like the plague of flies in Egypt. A pretty style of fish this to introduce into lake trout and landlocked salmon waters. Remember, when hungry they will attack a fish of nearly their own size and weight. This I know to be absolutely true. The most unfortunate part of the whole business is this, that the smelt live nearly the whole year round in the identical depth of water that trout, both young and old, frequent.

The introduction of smelt into the great lakes would be almost a national calamity. The day it is done foretokens the extinction of the trout fishing, both commerical and sporting.

Being myself an old fisherman and something of a student naturalist, I call upon the Fish Commissioners to rise and explain.

Mr. Bishop's diatribe, just quoted, elicited a reply in defense of the smelt from H. O. Stanley (1897), then one of the fish and game commissioners of Maine. He wrote:

I notice in your paper June 5 an article by Mr. Bainbridge Bishop entitled, "Are Smelts a Menace?". The writer, I should judge, is not familar with the habits and characteristics of the fresh-water smelt of Maine, which is the variety we are introducing into the lakes in Maine. This fish does not feed on the young of other fishes. In that respect they are as harmless as the sucker. Even if they did, they do not come into waters where you would find the young trout and salmon, *i. e.*, near the shore. This smelt is only found in deep water away from the shore, feeding mostly from the surface.

If the gentleman has ever been in Maine, the home of the landlocked salmon, and is familar with their origin, he must know that every lake where they are placed by nature abounds in smelts. He should also know that we cannot successfully raise fine salmon without smelts for food. In every lake in Maine where you find the smelt, there you find the finest trout, salmon and pickerel, and in greater abundance. In every instance where we have introduced the smelt, the salmon and trout have at once increased in size and quality in a very marked degree.

I think the gentleman need borrow no trouble about any harm coming to the trout and salmon by the introduction of the fresh-water smelt. We think so much of them in Maine that we are introducing them into every pond adapted to them in the State.

Mr. Bishop's accusations against the smelt, above quoted, were preceded by a reference to alleged damages to trout following the introduction of pickerel into certain waters, which he supplemented by the following warning:

It is a serious matter to disturb the balance of nature. Men should consider carefully before venturing to do so.

This is sound advice that should be applied to every proposition to introduce any nonindigenous species, not excepting the smelt, into any body of water. If in the past the commissioners of inland fisheries in Maine had considered the possible results of indiscriminate fish-cultural distribution in that State, present problems of inland fisheries conservation might have been avoided. However, as Stanley said, every lake naturally inhabited by landlocked salmon contained smelts; and, as stated elsewhere, the smelt may have been an important factor in the "landlocking" of salmon. Furthermore, as indicated by Stanley, there is no known instance of the successful establishment of introduced landlocked salmon where smelts also have not been introduced.

If Bishop referred to the large form of smelt he was quite correct in regarding it as something of a fish eater, in which respect it may be considered as relatively voracious, as already indicated by some instances mentioned in this paper in connection with the food of smelts; but under no natural conditions are they a menace to young trout and salmon, for the young of the latter two species do not occur in the deep-water resort of the smelt, and the smelt is not seeking food when it ascends streams to spawn, where young trout and salmon occur.

Nordqvist (1910) states that the fishermen at Lake Oppmanna, in southern Sweden, assert that the smelt destroy pike-perch fry in great quantities.

From what is known of the food and feeding habits of the smelt, under any circumstances only the large form could be regarded as to any extent dangerous to trout or salmon. A 14 or 15 inch smelt is quite a formidable fish of prey so far as dental equipment and capacity are concerned, but such smelts are not of common occurrence. With a few exceptions the smelts of natural, landlocked, salmon waters in Maine are comparatively small. One of these exceptions is Sebago Lake. There is no evidence that any scarcity of salmon in that lake can to any extent be attributed to the smelt.

There is no evidence that salmon ever eat the adults of the large form, although it probably does not discriminate between the young of the large and small forms. Therefore, in the introduction of smelts solely for salmon or trout food it would be advisable to select the small form; for, unless the small form, under favorable conditions, attains the size of the other, two services thereby would be rendered — (1) provision of food of suitable size at all times for the trout and salmon, and (2) avoidance of any possible danger from a potentially predatory large smelt.

It is known that in Lake Champlain salmon once existed in considerable numbers, and there can be no doubt but that the smelt (large smelt at that) was a contemporary inhabitant of the same lake; but there is no evidence that the smelt was in any way concerned in the extinction of Lake Champlain salmon or that it was a contributory cause of the scarcity of lake trout.

For the reason that there are still those who regard the smelt in inland waters with disfavor on account of some imaginary harmful trait or other, as depicted by bishop, this article has been given the prominence it has received here, although it is something over a quarter of a century old. An example of another common objection to the smelt is found in some extracts from a letter received by John W. Titcomb then fish commissioner of Vermont, and published in Forest and Stream of June 27, 1896, as follows:

> May 8th I reached Sunapee Lake and thought I would try the fish for a few days before writing to you, as I intended doing. * * * . The poor fishing was laid to the smelt, as they had come in shore and run up the stream and then gone back to deeper water, and are followed wherever they go by the salmon and trout. Now it is a question in my mind whether smelt are or are not an advantage, and from what I learn at Sunapee, and I have been there now a number of times, I am about convinced that they are a disadvantage in more ways than one.
>
> They no doubt spoil fly-fishing, as the trout and salmon are forever after the smelt, and after the first week or so after the ice leaves it is almost impossible to catch the smelt for bait, and even if they are caught they cannot be kept alive more than a few minutes, and consequently it is about impossible to obtain bait, and even if it could be got it is of very little use when dead. Of course

minnows, shiners, and small suckers, can be caught and kept alive; but where there are smelt in the water a piece of maple sugar for bait would be almost as effective as any other fish but smelt. No doubt of the smelt being great food; but if it spoils fishing with rod and tackle where is its advantage? It certainly may ruin the fly-fishing, as it no doubt does the bait fishing, to a very great extent.

There is no fly-fishing at Sunapee at all, and the only way it is accounted for there is the smelt.

In 1899, a correspondent of Forest and Stream ("Special" 1899a) after discussing the abundance of breeding smelts and the number of dead and dying at the surface, wrote: "Later these little fish disappear—no one knows whither—and the trout and salmon that have been feasting on them are forced to seek other food.

In another place, speaking of the fishing for salmon and trout in New England, he said: "The last reports say that the smelts are fast disappearing, and there is no doubt but what fishing will be better very soon."

In the May 20, 1899, issue of Forest and Stream a correspondent, writing of New England spring fishing, said that in Richardson and Mooselucmaguntic Lakes there were millions of smelts, many of them dead from spawning, and that the trout were gorging on them and would not take artificial flies or other bait till the smelts were gone. Yet, he added, "Still a few trout were taken."

Maine Woods of May 12, 1905 (p. 2), having reported "lots of dead and dying smelts on the surface of Rangely Lakes," said:

> It is a mystery yet unsolved why smelts die in this manner nearly every spring, but one thing seems pretty certain about it; the fish [trout and salmon] can not be caught at the time the smelts are dying. Trout and salmon both feed on smelts, and if one is caught it is found to be full of them. The period, however, is short, beginning as soon as the ice is out and lasting a week or ten days, when the supply runs out and the fish are ready for something else.

In the report of the division of fisheries and game of Massachusetts for 1921, concerning artifical propagation of the smelt, it was reported that no collections of fresh-water smelt were made for distribution. It said:

> The run at Laurel Lake, Lee, was scattering, and apparently the smelt are dying out—a source of gratification to local fishermen who believe them to be a detriment to the fishing.

Commenting on the statements contained in the letter above quoted, Mr. Titcomb (1896) wrote:

> It certainly would be unreasonable to think of depriving a body of water of desirable fish food for the purpose of forcing a fish to rise to the surface to take flies or artifical food.

This is a very pertinent remark, for where there is not sufficient food the fish can hardly attain a size to make them worth catching. Where insects afford the only food supply trout do not attain a very large size, and it has been proven that if there are no smelts the salmon as a rule do not thrive.

It seems to be a peculiar trait of some men to account for phenomena by the most prominent or conspicuous condition that may be a possible cause. In other words they are prone to jump at conclusions without sufficient verification. This is particularly characteristic of some anglers. If in any lake the water is high or low and the fishing good or poor, it is good or poor because the water is high or low, as the case may be. Good fishing or poor fishing in a lake abounding in or free from smelts is ascribed to the abundance or lack of food supply, and those persons have

in mind the one body of water and the immediate conditions obtaining there upon which to base their conclusions.

Smelts abound in Sebago Lake, Me., and they are apparently just as abundant one year as another, but the fishing varies; one year or at one portion of the season the fishing is good, at another bad. Which is the smelt accountable for? In Sunapee Lake also there have been seasons of good fishing, notwithstanding the smelts, and there were times of poor fishing before Sunapee knew the smelt, if the reports of the State commissioners can be trusted.

As for fly fishing being ruined by the abundance of smelts or other food supply, other waters where the smelt abound and where fly fishing is unexcelled need only be cited to controvert the contention. One of these is Grand Lake, in the western St. Croix waters. In any body of water one principal reason that fish are not taken on the fly is that they are not fished for with the fly. Notwithstanding the prevalent opinion that salmon never take the fly in Sebago Lake owing to the smelt, whenever anyone has persistently fished with a fly salmon have been caught by that means, and one usually has to persistently fish by any method to land many fish. Furthermore, the writer has examined hundreds of Sebago salmon, and while the majority, when they contained any food at all, had smelt in their stomach, many have been found having insects only, and some containing both insects and smelts or some other fish.

These remarks apply mainly to the landlocked salmon and it may be added that the writer has still fished for smelts and salmon on the same "grounds" and used live smelts, live shiners, and pieces of smelt for bait for salmon, and has caught just as many on shiners as on smelt and nearly as many on the "cut bait" as on live bait.

In trolling for salmon, while a fresh dead smelt is regarded as the best bait they are often taken on shiners and artificial lures, even while smelts are running and dead and dying strew the lake.

In the two weeks prior to mid-September in 1924 fly fishing for salmon and trout at upper Rangeley Lake was reported as very good on certain days. Some 6 and 7 pound salmon were thus taken. As previously stated, smelts abound in Rangeley Lake, and the fact is that salmon and smelts occur together in the deeper water during the summer months. It can not be for lack of smelt food that salmon take the fly or other baits at other season than in the spring, and it hardly can be attributed to the abundance of smelts that trout and salmon fail to take the fly or other lure in the spring. The writer was told by an angler who has fished Rangeley Lakes for 50 years or more that he seldom had found more than one or two smelts in a salmon at one time, but often caught trout on a fly and found them to be gorged with smelt.

It is quite possible that abundance of some food, as the smelt for instance, may modify the fishing. Perhaps fewer fish are caught than would be the case if there were no smelts. There is one more thing, however, and that is that landlocked salmon would not attain a very large size in any considerable numbers if deprived of smelt food or its equivalent in some other species.

FRESH-WATER SMELT FISHERIES

It appears that in northern Europe, particularly in Germany and Sweden, far greater attention has been given to the commercial possibilities of the fresh-water smelt than they have received in this country. Bloch (1796) stated that at the first freezing they were brought in quantities to the markets from the neighborhood of Müggel and other neighboring lakes. Every year tons upon tons from the lakes were said to be seen in the markets. Quoting Linnæus, Bloch said that at Upsal, Sweden, they formed heaps, which sent forth a bad odor in the streets. He said that they were taken in small-mesh nets, and that the smelt did not live long, dying soon after being taken from the water. He added that the fish was so common and cheap that it was hardly worth transporting.

According to Reuter (1883), in Finland, during the spawning time the smelt is caught in great quantities in seines and hand nets, and enormous quantities of quite young smelt fry, the so-called "Siniäisiä," are collected in certain districts. The smelt is caught all winter by nets as well as by bottom fishing. By "bottom fishing" probably is meant hook-and-line fishing.

In the lakes of Finland, according to Nordqvist (1910), the best fishing time is from the time the lakes are frozen over until the ice is covered with snow.

In two neighboring lakes that lie not far from the west shore of Lake Ladoga, the smelt is fished only in the winter, under the ice, mostly with very fine-meshed drag nets about 180 meters (a little over 180 yards) long and up to 25 meters (a little over 25 yards) deep. He mentioned one net which, when the size of the thread was considered, had a mesh opening scarcely more than 2 millimeters square (about .08-inch bar), but other nets had larger meshes.

In this country the fresh-water smelt fishery was restricted for the most part to Maine, New Hampshire, and Lake Champlain. In the New England States the fishery, if it may be called such, was largely carried on in the spring during the breeding runs of the smelts in the streams, although for a good many years there has been some hook-and-line fishing through the ice. In Lake Champlain hook-and-line fishing is the only method employed.

There never has been much more than a local marketing of fresh-water smelts caught in the spring, except in one locality to be mentioned later. Most of the spring fishing was in the way of sport, most often by dip nets, and always at night. A graphic description of this sort of fishing long ago on a stream flowing into Long Lake, near Bridgeton, Me., was written by J. C. Mead (1885) under the pen name "North Bridgeton." It is worth quoting at length:

> On the 21st of April the word went round that the "big smelts" had put in an appearance in the streams the evening before. This was enough to bring over a dozen men and boys to the banks of a certain well-known brook near the head of Long Pond. A part of these carried dip nets, and the most of the others bundles of pitch-wood or jacks, although two or three, one of whom was the writer, carried no equipments of any kind, but went "merely to see the fun."
>
> The evening was warm and very still, and a moon nearly at first quarter helped to prolong the lingering twilight. A fire had been kindled at some little distance from the stream, and as it had been agreed upon to keep away from the water until it was fully dark, all hands were grouped around the fire and were indulging in the usual gossip and jokes of such occasions. All at once

some one asked, "Where's Amasa?" A glance through the intervening alder thicket brought the answer, for in that direction a figure could be dimly seen standing in the brook and busily plying a long-handled dip net. This was sufficient to send everybody to the water, and jacks were soon flaring at intervals along the banks and showing fish by thousands. And now began the excitement. Those who had nets worked them, and those who came "just to see the fun" forgot that this was their object, and waded into the ice cold water, catching the fish in their hands and throwing them ashore. Boys screamed and men shouted. The air as well as water was full of fish, and the sedate man, regardless of shoes and stockings, was knee-deep in the current, his hands grasping here and there, while the pockets of his overcoat and the crown of his hat were full of wriggling fishes. Two dozen fish averaging nearly eleven inches in length, were captured with a single sweep of a dip net. The piles upon the bank were fast increasing to proportions far beyond a market stall, when a rational thought seened to strike some of the cooler heads. "Let's stop this, boys; it's nothing short of murder, for we have all we can make any use of." For once men were reasonable, and boys, as usual, followed in their lead. The fish upon the bank were gathered up, and Rodger's Brook with its swarming waters was left to itself. But in a very short time over three hundred weight of a species of fish than can hardly be surpassed in table qualities were on their way to the village. The express the next morning showed plainly that distant friends had not been forgotten, while a large box placed in front of a store with a "help yourself" attached was speedily relieved of its contents.

But this was only the work of one evening, and the next night the fish would be even more abundant. The word had spread, and long before dark everything for miles around that could be called a dip net was on its way. In place of a net one fellow carried a large corn popper with an extension lashed to its handle, and another had a tin pan with its bottom punched full of holes and nailed to a pole. Quaint as these implements were, both, it is said, did good service. Through the evening and well into the night dozens of jacks and torches sent their brilliant glare along the stream and into the surrounding forest. No doubt the excessive light frightened the fish and kept many back in the lake, but still hardly an individual went away without fish enough for any reasonable demands. On either this or the preceeding night two men, one to carry a light and the other to handle the net, could have filled an ox cart. This last statement, of course, is on the supposition that the two men could have had the stream all to themselves. As it was, the large number of fishermen, especially on the second evening, rapidly scattered the fish and drove the most of them back into the deep water of the lake.

The above is only a partial account of what happened on a single stream, and we hear similiar reports from nearly every tributary of the Sebago waters. At Bear Brook, in Harrison, but little more than a mile away, the run has been longer and probably even more fish have been taken. * * *.

* * * They are caught some through the ice in winter and in very deep water almost always. Those caught through the ice, or with hook and line at any time, are generally larger than those taken in the streams in breeding time. On the whole, smelts in these parts are something of a puzzle, and the people who see the most of them simply expect them to put in an appearance at about such a time, kill them by the thousands when they do come, and think no more about them until their next appearance.

The same author previously wrote in the American Angler (Mead, 1883):

Commonly, smelts are caught with dip-nets having long handles, sometimes with the hands, and I have heard of the spear being used the present season at Stevens' Brook. For a few years they have been taken in considerable numbers with the line through the ice; but as usual, where nets and spears get into use on any fish, line fishings ranks last in order.

In fishing with dip-net it is customary to pair off—one man takes the net and his comrade in battle takes a torch of pitch-wood or something of the kind. The torch-bearer "shines his light" so as to give the best view of the brook possible—the "net man" gets his eye on his game, and with a long sweep of his net with the current, dexterously bags his fish, "head on." It is fun for the boys when a novice comes to the front and dips against the current and the startled fish scoots cleverly off ahead of the net and safely takes a new position.

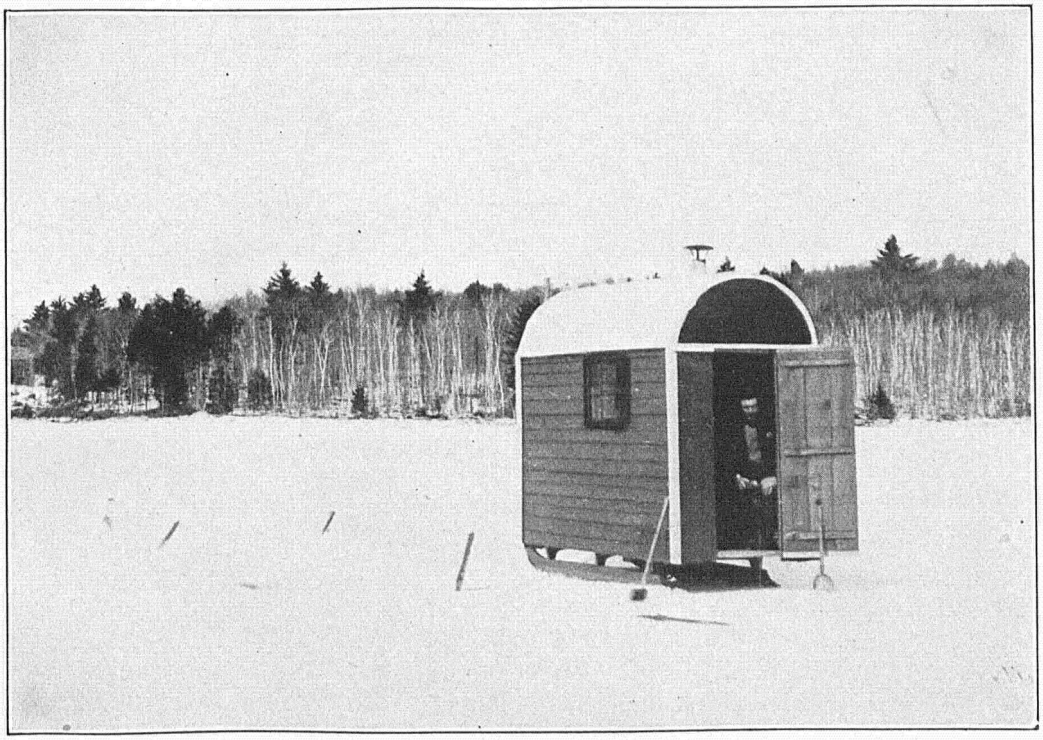

FIG. 16.—Smelt-fishing house on the ice at Sebago Lake, Me.

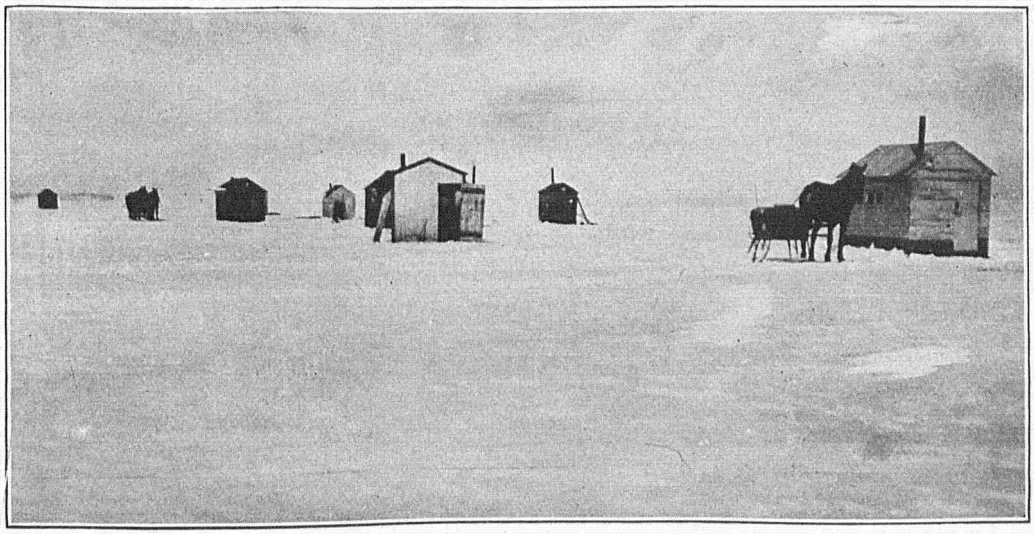

FIG. 17.—Group of smelt (icefish) fishing shacks on the ice at Port Henry, Lake Champlain, February, 1910

Catching with the hands is easily done; it is as simple as picking up "wet corn cobs." The roughness of the smelt in the water, or when fresh from it, makes it an easy matter to retain a hold on them.

Spearing is done after the manner of "jabbing suckers," I suppose, and is not a sportsman-like manner of killing anything but sharks and sword-fish. The same may be said of netting.

I do not dwell upon these methods for their merits as true sport, but simply to show the pratice of the times. Both nets and spears are prohibited by the laws of the State, but no penalty. Smelts are protected "above tide water," but nothing in the law is understood to apply to the fresh-water smelt. Some attempt has been made to call attention to the necessity of some act to regulate the taking of these smelts, but so far without success.

Fishing through the ice is practiced on Sebago Lake in February and March—usually in about sixty-five feet of water. Small hooks are baited with bits of pork or something of the kind, and are lowered toward the bottom.

Cheney (1894b) thus describes the method of fishing for smelts in Sunapee Lake, N. H.:

The tackle used in catching smelts is a hand line of small size, although the size is not material, and a fine leader 9 feet long. Have the leader tied with loops, three in number, exclusive of the two end loops for attaching snelled hooks. To one of the end loops of the leader fasten a sinker of sufficient weight to take the line quickly to the bottom. A pear-shaped sinker, with wire swivel and 1¼-oz. in weight, is what I have used. Fasten three snelled hooks, number 9 or 10, to the three loops in the leader and your smelt line is complete. Fish very near to the bottom and be constantly on the alert, for smelt bite very delicately and it requires some experience to hook them. For bait use earth worms untill you get a smelt, and thereafter bait the hook with pieces of cut-up smelt, which they seem to prefer to any bait which can be offered to them on a hook.

The present writer observed the method of smelt fishing in Sunapee Lake and even caught some smelts himself in 1910 and 1911. The hook-and-line fishing was done principally to secure bait for salmon and trout. The sinker was fastened at the end of the line and two or more hooks were put on a little distance above. No leader was used. As toll bait a paper bag of oatmeal was lowered to the bottom and then broken, letting out the meal, which was supposed to attract the smelts. Usually earthworms were used first, then a small piece of the belly of the smelt. The smelts, as elsewhere shown, were small—smaller than any that the writer ever caught on a hook elsewhere. They were just right for trout and salmon bait. As stated elsewhere, the depth of water was 80 or 90 feet.

A line with one or two hooks below the sinker was employed by summer fishermen in Sebago Lake, Me. In fact, one man used the same rig that he used in winter. As an innovation, which proved satisfactory, the writer used a brass wire spreader fastened to the line just below the swiveled sinker, with a snelled hook at each end. His preference for the large smelts was a No. 1 sprout hook. The fishing was usually in about 70 feet of water—sometimes more and occasionally less.

The bait varied according to what was available; sometimes only earthworms could be had, and with that possibly a smelt would be caught; then a short strip from the belly of the fish was used. Earthworms, while occasionally readily taken, as a rule were not very satisfactory. Usually the most successful baits were the young of suckers, chubs, or other minnows, from an inch upward in length; but occasionally the smelt would not bite readily on this bait but would take the piece of smelt with avidity. When a large smelt bites, one has no doubt of the fact, at least he is sure that he has a bite, but the bite by a larger fish, such as "cusk," salmon, or

whitefish, is often similar. It has previously been mentioned that large smelts often take a comparatively large bait, such as smelt or shiner intended for salmon, even a bait 5 or 6 inches long. (See page 383.)

Formerly there was limited winter fishing for smelt in Sebago Lake. To what extent it is now carried on is unknown to the writer, but he is inclined to believe that there is no market fishery as there used to be. For several years large smelts commanded a uniform price, year after year, of 25 cents a pound to the fishermen. Formerly one man and his family had virtually a monoply of the smelt fishery in the spring at Songo Lock, so it is claimed. The "monopoly" was due to an advantageous position on his own shore near the lock where the smelts congregated in a vain attempt to ascend. It is reported that he used to dip tons of these smelts every spring and ship them to market in Boston and New York, where for the large smelts he received 25 cents a pound. There is now a law prohibiting the capture of large smelts in this locality during the spring breeding run. Under certain regulations small smelts may be dipped.

A letter from Dr. Edward Paine, of Waterville, Me., in reply to a letter of inquiry concerning smelts in China Lake, stated that the large smelt were taken in 60 to 85 feet of water. He said that when he first began fishing for them they were caught only in the winter. One fall, before the lake froze, he tried for them and caught a few. The next year some one "stumbled upon the idea of fishing for them early in the morning." Now the summer fishing for smelts is in the early morning. They commence biting about daybreak and continue for two or three hours. Often a peck of smelts is caught with live bait to start with, and after a smelt is caught a piece of cut bait is used. Doctor Paine wrote:

> The smelt does not rank as a game fish, but considering the sport it affords and the fine food qualities it should rank above some so-called game fish.

In Sebago Lake the present writer has fished for smelts at all times of the day excepting very early in the morning. In view of Doctor Paine's statement, perhaps early morning fishing at Sebago might yield larger catches; but very satisfactory catches have been made at other times of day, and the largest numbers and largest fish usually were taken in the late evening from just before sunset until dark. The followining computation of catches of smelts was made from an equal number of trials at four different periods of the day—morning, forenoon, afternoon, and late afternoon or evening.

	Per cent
Morning	21.2
Forenoon	17.9
Afternoon	22.3
Evening	38.6
	100.0

The foregoing figures represent the times when fish were caught, with the exception of one forenoon when none was caught. So, of course, they do not show the many failures to catch smelts at any time of day. While the time of day, in many

instances, doubtless affected the fishing, other factors, such as weather and kind of bait used, undoubtedly were concerned.

As a rule better results were obtained on a cloudy day than on a bright, clear day. A ripple on the water during a hot day favored the fishing. Often fish were caught in very rough water. The season also probably has its influence. One of the largest catches was made on a calm, clear day (September 11), but a fairly large catch also was made on July 17, while it was clear and calm.

In the matter of baits, on some occasions at no time of day would they take any sort of bait. Sometimes they would take one kind and not another, or at one time of day one sort of bait and at another time in the same day shift to another. By using a spreader with two hooks it was easily ascertained what the choice of two baits seemed to be.

In a period from August 15 to October 1, both inclusive, the baits used consisted of "live bait," comprising mostly young chubs (*Semotilus bullaris*), young redfins (*Notropis cornutus*), and young suckers (*Catostomus commersonii*); "smelt bait," consisting of a small strip from the belly or side of the smelt; and earthworms to a limited extent, especially when live bait was not available. Sometimes the smelt would take dead "live bait" as readily as live minnows, especially if perfectly fresh; but stale minnows or bait of any kind, or even iced smelt, usually were refused, though the smelt pick up dead minnows when they are thrown overboard, even though soft, as shown by stomach contents later.

For the purpose of computation, the baits used are divided into the following seven categories: (1) Live bait, (2) smelt bait, (3) worms, (4) live bait and smelt bait, (5) worms, live bait, and smelt bait, (6) worms and live bait, and (7) cut bait other than smelt. Each category represents the baits taken at any one or more fishings, but does not signify that other baits were not tried. For instance, in the "live bait" category there were four instances when smelt bait also was used, but no smelt would bite it. In the category of "worms, smelt bait, and live bait" there was one instance when early in the day the smelt would notice earthworms only, but later readily took "live bait" and "smelt bait," the latter being the most attractive. Still later the smelts would not bite at all. In another instance, in the same category, in one of the largest catches the smelts took with avidity anything that was offered them, but the smaller smelts seemed to prefer live bait while the larger smelts took smelt bait readily.

The usual size of "live bait" was from 1 to 2 or 3 inches in length, but often they would take very large shiners and smelts used for salmon bait. Instances of this kind have already been mentioned, one of which was when a smelt took another smelt nearly half as long as it was itself.

As a rule young chubs appeared to be better bait than young redfins or suckers, but often it made no difference which was used. Occasionally young white perch and yellow perch were tried when nothing else was available, but they were not of much use. A small piece of fish of any kind frequently would secure a smelt, which was then used for bait. In the instance of "cut bait other than smelt," the initial bait was a piece of young pickerel.

	Per cent
Live bait only	11.7
Smelt bait	8.5
Worms only	1.5
Live bait and worms	11.5
Live bait, smelt bait, and worms	12.9
Live bait and smelt bait	53.0
Cut bait (not smelt)	.9
	100.0

The inference to be drawn from the foregoing figures is that live bait and smelt bait together are the best baits, and that live bait is somewhat better than smelt bait. It is quite possible, however, that in some instances where the two baits (live and smelt) were used, if only one or the other had been employed alone about as many smelts would have been caught. Besides, it has been mentioned already that at times they bite almost anything; yet the figures show that with a supply of live bait, which may be supplemented by smelt bait after one smelt is caught, the chances of making a good catch are better than with any other baits.

ICEFISH OR SMELT OF LAKE CHAMPLAIN

For many years the smelt of Lake Champlain has been caught through the ice, principally in February and March, which fact probably gives the fish its local name—"icefish." For a long time, however, it appears that the icefish was not generally recognized as a smelt. Nearly 50 years ago the question concerning the icefish of Lake Champlain arose, and from time to time for nearly 30 years discussions pertaining to its identity and origin appeared in sportsmen's papers and magazines. Notwithstanding the fact that each time the icefish was authoritatively identified as a smelt, the question would not down. Under date of February 22, 1876, Cheney wrote to Forest and Stream (vol. 6, No. 4, March 2, 1876):

> In your last issue you mention the range of smelt, and I do not think it is generally known that they are caught in Lake Champlain. About a year ago, while at Port Henry, I was told by the landlord of the hotel where I was staying that it was about time for "icefish" to make their appearance. As the name was new to me, I asked for a description of the fish, judging that icefish was a local name. Being informed that they were only taken through the ice during February and March, and that they were unknown until within a few years previous, I sent the description, as given to me to Seth Green, but from my meagre statement he was unable to give the fish its proper name. I published my inquiries, and found that they were veritable smelts. And here again comes in the question of range. They are caught little, if any, south of Port Henry; are more numerous about West Port; are taken at or near Burlington, Vt., and are unknown in Plattsburg, or thereabouts, at least by fisherman I questioned while there this winter, and I could not learn that they were caught at other than the places I have named. Of course, these come in from the St. Lawrence, but are they caught to any extent in that river?

In a later issue of Forest and Stream, under date of March 21, 1876, C. H. Morse, of Boston, stated that he had taken many dozens of that "delicious fish" near Burlington, Vt., when he was a youngster, and could say that they were taken in several localities in that part of the lake, one of the favorite places being near either end of the Burlington Breakwater.

A communication in the American Angler for March 7, 1884, stated that the fish were called icefish or frostfish and were caught through the ice in great quantities for about a month, in the latter part of February and the first part of March.

The question regarding the identity of the icefish again arose in 1886. Someone who signed "Peter" to his inquiry sent some specimens to Forest and Stream for identification, and they were identified as smelt, *Osmerus mordax*.

Again Cheney (1895) stated that about 20 years before he first heard of the "icefish" of Lake Champlain, and "found upon an introduction that they were the smelt * * * ." The following year (1896a) Cheney again wrote:

> More than twenty years ago I first heard of the "ice fish" of Lake Champlain, and when I saw them I found them to be the common smelt; but from that time to this the identity of the fish has been questioned at recurring intervals. Last year, when I saw smelts being taken at Port Henry, over 1 ft. in length and weighing ½ lb. each, and was told that even larger ones were caught through the ice at Port Henry and Westport, I was obliged to admit that I had never seen smelts of such great size; nevertheless that is what they were. Last week I was at Port Henry and the identity of the "ice fish" was once again discussed, with the added information that the fish were now sent quite regularly to New York city, where they were pronounced to be different from the smelt. I had some packed to bring home with me, and asked to have several of the very large ones put in the box to have the matter of species set at rest. The man who furnished the fish told me that after Mr. Cobb's visit to the lake the United States Fish Commission had sent for specimens to determine just what "ice fish" really were, and that specimens had been forwarded to Dr. Hugh M. Smith. I asked Dr. Smith about them and he writes me: "The specimens of 'ice fish' recently sent us from Lake Champlain were the salt-water smelt (*Osmerus mordax*). There were five examples, the largest being more than 1 ft. in length and weighing ½ lb. The females were filled with ripe spawn. I have never seen such fine smelts on the New England coast, although they are sometimes taken in Maine and Massachusetts fully as large as those under consideration. As you know, this species is landlocked in some of the Maine lakes, and Prof. Evermann took specimens in Lake Memphremagog; the fish in the latter lake, however, are quite small. In your opinion, do the Lake Champlain smelts come up the St. Lawrence River each year for the purpose of spawning, or are they permanent residents of the lake?"

Concerning the origin and habits of the fish in Lake Champlain, many of those who finally recognized it as a smelt thought that it annually ascended the St. Lawrence River and thence up into the lake, but as early as 1882 at least one view was that the fish was a perennial resident. A reference to the smelt in the American Angler, however, attributed their presence to transplanting, saying: "A few smelts put into Lake Champlain several years ago have led to their permanent establishment."

Two years later the same paper (American Angler, 1884) again said: "The Lake Champlain smelt is of comparatively recent date, as it is little more than a dozen years ago that they made their first appearance." Then, again, in 1890, the American Angler repeated the foregoing statement.

Cheney (1895) presumed that they must have worked their way up into the lake from the St. Lawrence. Again, in 1896, Cheney wrote:

> I believe that smelts are not permanent residents of Lake Champlain, as they are caught only through the ice in February and March, and a search for them by anglers in the summer and fall months has proven fruitless. In New Hampshire, where the smelt is landlocked, I have caught them in June, July, and August, and if they remained in Lake Champlain permanently they would be found by those who have peristently sought them. Another reason for thinking that they come from the St. Lawrence only to spawn, for it will be noticed that they are caught in the lake

just before the spawning season, is that they have two runs of smelt in that river, one of small fish and one of large fish, such as are mentioned by Dr. Smith; the large fish of the lake answering to those known to run up the river. The landlocked smelt that I have caught in New Hampshire are much more slender, length for length, than the Champlain fish, showing that the latter are accustomed to rich pasturage probably not found in the lake. In Lake Champlain the large and small smelts are caught together, showing that the schools must mingle after they reach the lake, and they mingle in more than one way, for large smelts have been caught with small smelts inside of them, showing that the big fellows feed on their small brethren. One big smelt has been convicted of eating seven small ones at a single meal.

It appears, however, that although general ignorance concerning the smelt prevailed, there were some who were better informed. Cheney's discussion, just quoted, elicited from Bainbridge Bishop (1896) a reply that is so replete with interesting information concerning the smelt of Lake Champlain that it is quoted in full here.

NEW RUSSIA, N. Y.—*Editor Forest and Stream:* I am surprised at the article on Lake Champlain ice fish in your paper of March 28. I am afraid the anglers our friend Cheney interviewed were a stupid and a queer lot. While having the greatest respect for friend Cheney and his writings (from what I have seen for the last twenty years), I beg to differ with him, and would say, be it known to all it may concern, that as a rule Lake Champlain smelt and herring do not migrate to salt water, but at the approach of summer retire to the deepest part of the lake, where they find 200 to 400 ft. of water. Here they stay at the bottom most of the time. When the broad lake freezes over they work up in shoaler water, where the fishermen take them through the ice. They are caught later in the winter at Port Henry, it being further away from the deeper part of the lake.

I have seen smelt in the lake every month in the year, and have caught them in most of the summer and fall months. While trolling off Cedar Beach in very deep water with a lake trout rig I caught a smelt 14 in. in length. This was in July. I was running a good-sized dace 150 ft. below the surface, using 1½ lb. lead. Also in August while trolling I caught a ½ lb. smelt in the middle of the lake opposite Westport, where I was running a minnow 200 ft. below the surface. When camping in August at Apple Tree Point, a little north of Diamond Island, I used to go out before sunrise to fish for wall-eyed pike in about 100 ft. of water. Very often the pike would chase and drive schools of smelt to the surface. They would leap out of the water by hundreds; they were fair-sized smelt.

In September I was fishing on a reef far out in the lake opposite Westport. This reef has 18 ft. of water on it, breaking off suddenly to 200 feet. A strong current was running from the deep water over the reef. Pike were biting finely. Once in a while the water would fairly boil close around the boat, caused by the smelt coming to the surface, driven up by large fish. Some of the pike threw smelt from their mouths after they were in the boat. Game protector Goper Liberty was with me at the time. Once while anchored on this reef in a still time with the current running as before, suddenly I noticed great quantities of air bubbles rising to the surface all over the reef. This was a mystery, but it was soon solved by the appearance of thousands of smelt leaping from the water apparently disabled and in trouble. It seems that the current brought them up from deep water and the diminishing pressure expanded their air bladders to such a degree that it brought them to the surface in distress, notwithstanding that they expelled part of the air before they broke water.

I have taken fair-sized smelts from the mouths and throats of wall-eyed pike all through summer and fall months; this was when fishing in and near very deep water; and have frequently used smelt so taken for bait with good success. My friend, Samuel P. Avery, Jr., tells me that he picked up a dead smelt on the shore of his island at Button Bay. He went out on his favorite reef and with this single smelt caught five fine wall-eyes. Smelt are the natural food of wall-eyes in Champlain and make the best bait. I have never found smelt in black bass taken in Champlain

Sometimes smelt come to the surface toward night, and in cloudy weather when the lake is still observing persons can see them swimming about in large schools, making a wide and curious

ripple on the water. This is generally seen at the middle of the lake, where the water is the deepest. Smelt can be caught in Lake Champlain in any of the summer months by going to the right place and using the right means, but I do not think to much advantage, as they lie in deep water and are more scattered than in winter; still, by a little effort enough can be caught to use for bait.

Here I want to raise a note of warning to those that think of introducing smelt to feed lake trout; they are ferocious little brutes and persistent destroyers of small fish living in all depths of water; they would destroy the young trout. This I think is one reason lake trout are not more plenty in Champlain.

But meanwhile Cheney had been enlightened by another distinguished observer. In the April 18, 1896, issue of Forest and Stream he stated that his friend, Rowland E. Robinson, had written him a letter concerning the question of residence and migration of the smelt, from which he quoted as follows:

Hon. M. F. Allen, of that place [Ferrisburg, Vermont], told me a few years ago of catching pike-perch off Split Rock, in Lake Champlain, that were gorged with smelt. I do not recall the date, but it could not have been earlier than the middle of June, and may have been in July or August. Mr. Allen is an old angler, well acquainted with the varieties of fish common in our waters, and could not have been mistaken in the identity of the smelt.

I well remember seeing an occasional specimen among the great hauls of other fish taken in the old days of unrestricted seining on the then famous fishing ground at the mouth of the Lewis Creek, the Sungahneetook, or Fishing Weir River of the Waubanakees. These facts go to show that the smelt remain in the lake during at least part of the summer.

Cheney then went on to say that the author of "Uncle Lisha" was the first person to his knowledge residing on or near Lake Champlain to call the smelt of the lake by its proper name, or, in fact, to admit that it was a smelt. Cheney then continued:

That Mr. Robinson has himself observed the smelt among the fish caught in the lake, and that Senator Allen bears like testimony, should settle the question of their presence in the lake in summer. There is a whitefish found in Lake Champlain the young of which might be mistaken for the smelt when found inside of other fish, unless the observer was familiar with both species, but this would not apply to either of the gentlemen quoted. A strange thing about the smelt is that they have not been caught by those who have searched for them in the summer months. My information on this subject comes from fishermen at Port Henry only. A year ago, when smelt fishing through the ice was at its height, I visited the fishermen on the ice, and questioned them as to their knowledge of the smelt in the summer months. All agreed that although search had been made for them they had not been taken. Another strange thing is that no one seems to know anything about where they spawn.

Another very interesting response to Cheney's communication was contributed to Forest and Stream by a correspondent signing himself "Ferris" (1896). He wrote:

I think your correspondent in Forest and Stream of March 28 wrong in his opinion that Lake Champlain ice fish or smelt are not permanent residents of the lake. Perhaps for those who are interested in this matter a few of the incidents coming under my personal observation may prove of interest.

At Thompson's Point, situated on the shore just across from Split Rock lighthouse, is no doubt one of the best fishing grounds for the American pike perch to be found along the lake. On the point are nearly two score of cottages, among them being that of Justice J. D. Brewers, of Washington, D. C. Here each season are to be found many of the disciples of Izaak Walton enjoying their summer outing.

On the reefs just off the point I have caught many a fine string of pike, and very many times have observed that after getting them in the boat they would disgorge one or more smelt. This

will more often happen if the fish is caught in deep water, say 35 to 60 ft. If the smelt is in a fair state of preservation, he makes a far more attractive lure than any live bait we are able to get.

Again, I have seen in the gray of the morning and at twilight thousands of smelt jumping on the surface in much the same manner as yellow perch do.

Mr. Harrington, a friend of mine here, caught last July three smelt in less than 20 ft. of water which appeared to be as firm and hard as any caught through the ice.

These facts, I think, are sufficient to prove that smelt can be found in Lake Champlain twelve months in a year if one only knew where to look.

Cheney (1900) called attention to an interesting point in relation to the restriction of the fishery to ice fishing. He said:

A few weeks ago when I was in Port Henry, no smelts had been taken, as the ice had not formed on that portion of the lake where the smelts are generally caught, for they are caught only in certain localities. This week, on my way to New York, I met a gentleman from Port Henry, who told me that "icefish" had not yet been caught at that place, but as he had promised some to friends, he thought they could be caught from a boat as well as from a shanty on the ice, and he had sent two men to the smelt grounds to fish for them, and they had caught but one fish, about six inches long, and he could not explain why it was so, for he was sure that within twenty-four hours after the ice had formed at that place where the men fished from boats, the ice fishermen would catch half a ton of "ice fish". This is very strange that on the same ground with same bait and same tackle and method of using it, the smelts will not bite just before the ice forms, and will bite directly after it does, and there is no reasonable explanation why it should be so that I can advance.

Cowen (1900) wrote that he had caught smelts in summer, stating that his impression was that great numbers remain in the lake, but do not take bait on account of the abundance of other food. He said that he had observed that as soon as surface water runs into the lake in the spring smelts will not bite so readily.

During the long discussion concerning the identity of the icefish, even ichthyologists were divided in opinion concerning whether it ascended the St. Lawrence or not. That the smelt occurred in Lake Champlain over 80 years ago, and over 30 years before Cheney announced that the icefish was a smelt, Zadock Thompson (1842) wrote:

The smelt is one of those migratory species of fishes, which pass a part of the time in salt water and a part in fresh. Though not a constant visitant in our waters, he occasionally makes his appearance, and is sometimes taken in Lake Champlain in very considerable numbers.

If the fact had been generally known that smelts equaling in size any Lake Champlain "icefish" had been caught in certain lakes of Maine, where they were permanently resident, it would have suggested to some of those interested that a like situation existed in Lake Champlain. However, it is now positively settled that the fish is a so-called "landlocked" smelt.

Nothing appears to be known concerning the breeding habits of the smelt of Lake Champlain, but as the smelts of New England lakes ascend streams to spawn it is quite possible, as predicted a number of years ago by the late A. N. Cheney (1895), whose writings have been quoted extensively in this paper, that if looked for at the proper time the Champlain smelt might be found breeding in some tributary streams. It has been stated that it appears possible to catch smelts, or icefish, only at certain localities in Lake Champlain, and it has been a source of wonder why they could not be caught elsewhere.

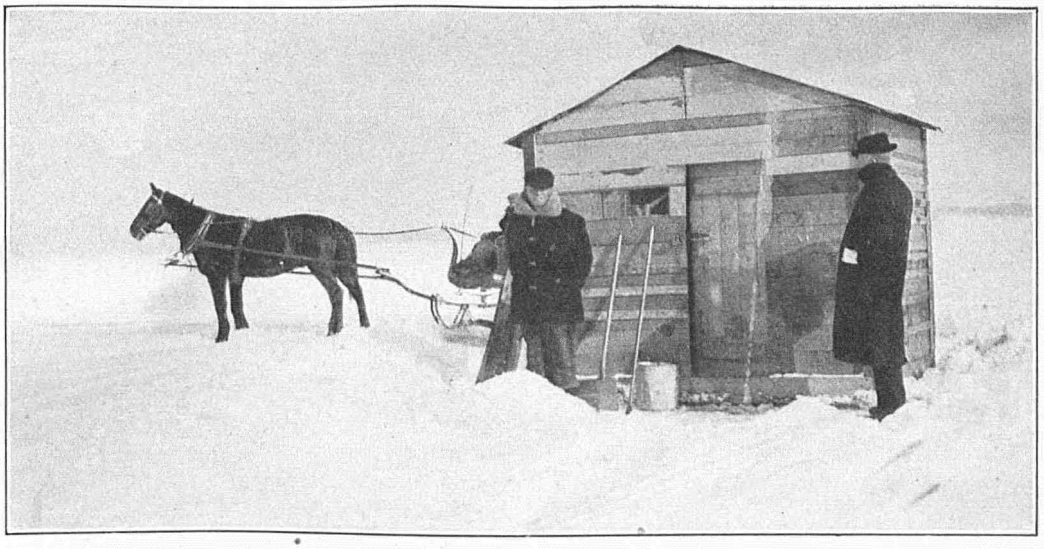

FIG. 18.—"Close up" of a smelt-fishing shack on the ice at Port Henry, Lake Champlain

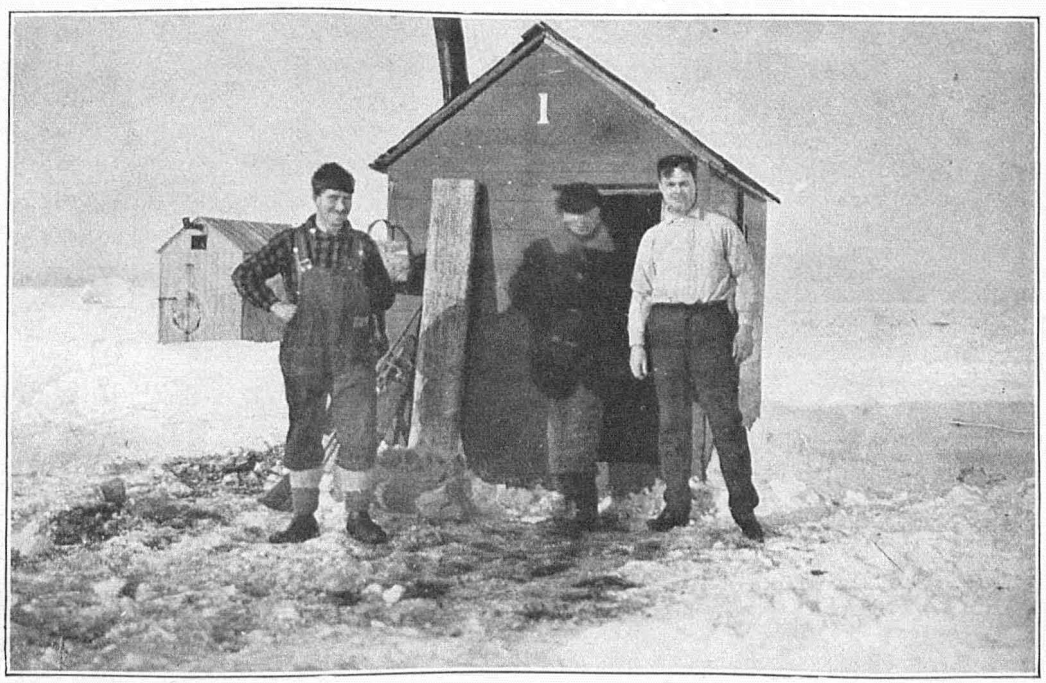

FIG. 19.—Smelt-fishing shacks on the ice, Port Henry, Lake Champlain

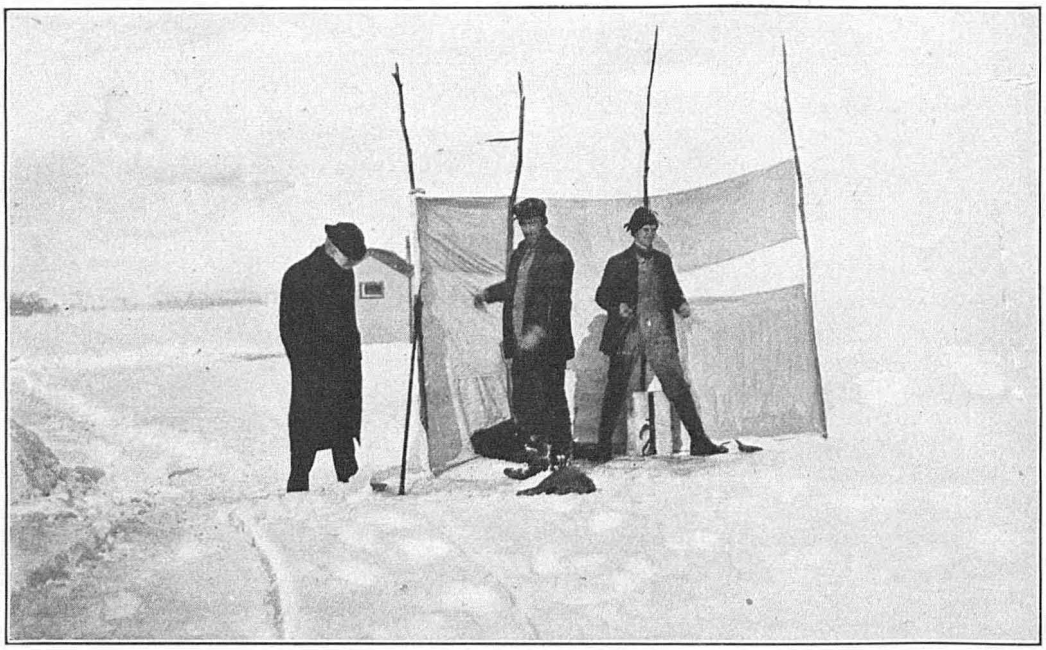

FIG. 20.—Another type of shelter for smelt (icefish) fishing on Lake Champlain. It is made of canvas

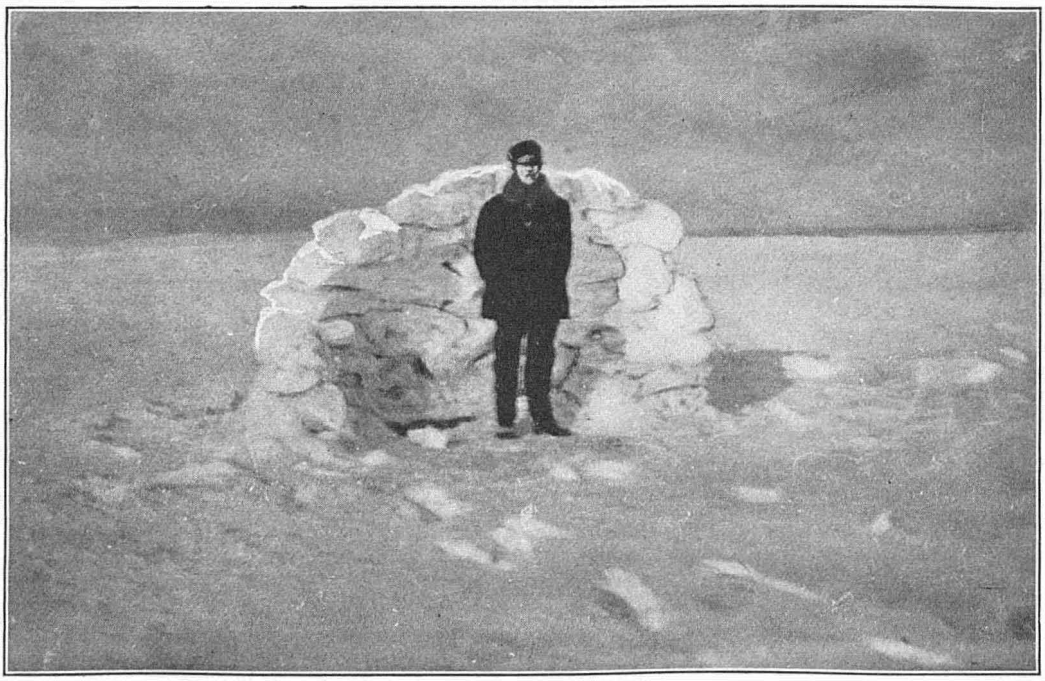

FIG. 21.—Still another sort of shelter for smelt (icefish) fishing on Lake Champlain. This is made of snow

As observed in Sebago Lake, Me., and other localities, the fresh-water smelt seems to prefer certain depths of water and kinds of bottom, the kind of bottom seemingly depending to a great extent upon the character of the surrounding country. In one locality the proper bottom seemed to be an outcropping of a stratum of gray clay on each side of a ridge. Either way, between or beyond these outcroppings, no fish could be caught. In Lake Champlain, near Port Henry, a similar condition seems to exist. A fisherman stated to the present writer that on each side of the place where he was fishing there was a channel, and the fish were caught between the top of the interchannel area and one or the other of the two channels. Fishing was carried on in water from 30 to 70 feet deep, and usually the larger fish were taken in the deeper water.

SMELT FISHERY OF LAKE CHAMPLAIN

As previously indicated, the smelt fishery of Lake Champlain is carried on with hook and line through the ice in winter. Cheney (1895) thus describes the method:

> The smelts, to call the fish by their proper name, are caught with hook and line through holes cut in the ice. The bait is the eye of a smelt or a piece of flesh cut from the fish near the tail, a strip as long and as wide as the little finger of a man's hand. The fish are caught close to the bottom in water from 50 to 60 feet deep, some of the men fishing with a single hook, and some with two hooks, one above the other, all placed below the sinker. A peculiarity of the fishing is the manner in which the fish are brought to the top of the ice after they are hooked. The line is tied to the end of a stick about eighteen inches long. This is moved around and around over the hole as if one were stirring the water with the line; suddenly the fisherman gets a bite, and his right arm shoots up and out to its full extent, and the left hand, also extended, catches the line, the stick then catches the line below the left hand, and this is repeated until the line is reeled in on the end of the stick and the left hand, and the smelt is brought to the top of the ice and the hook pulled from its mouth. * * *.
>
> * * * If the smelts were baited to hold them in one spot it is fair to presume that they would be found in other parts of the lake than those where they are now known. In Sunapee Lake, N. H., the smelts are baited by anchoring a bag of meat or bread, or chopped fish, and thus they are held in one place and landlocked salmon are also attracted by the presence of smelts.
>
> I think the Lake Champlain fishermen make a mistake in placing their hooks below the sinker, at least my personal experience in smelt fishing has taught me that more fish will be hooked by using a leader with the sinker at the extreme end and the hook placed above it. The sinker keeps the line taut, and the smelt biting so gently that it is difficult to distinguish the bite, more readily communicates the sensation of a bite than when the hooks are flying loose below a heavy sinker. There is no effort made to conceal the hook under the bait in ice fishing, the strip of smelt hangs like a wet rag from the bend of the hook, and too, the hooks are so large that it seems strange that the smaller smelts are hooked at all.

Two weeks later another correspondent of the same paper ("Heathcote," 1895) described the fishing method in a little more detail. He wrote:

> The fish pole is about two feet in length, having an eye at the end for the line to run through, and near the base a boat-cleat screwed on to keep the the line on when not in use, and to hold the excess of line Drawing the fish-pole to an easy distance with the right hand, a stick of about two feet long catches the line (with the left hand) about four feet down; then the fish pole again, and so on. The line in this way can be drawn up rapidly, about thirty feet in five seconds. Of course, all that is necessary is to keep a steady pull on the line, and as the fish nears the ice, slow up a little so as not to rub it off against the sharp edges. Some use the thumb of the left hand and the fish-pole in the right, but this is not so fast, and the cold, wet line makes one's hand ache. Then, too, the stick keeps the loops open and free to run out again, whereas when the thumb is used the struggling fish is apt to close up some of the loops while you are taking him off. Then comes the fun to "pick up your dropped stitches."

I knew an old one-handed fisherman who had a way of his own to draw up his fish. When he hooked a fish he would run the length of his line on the ice, the hole being cut so as not to catch the fish as he passed out.

About here they use for bait the flesh of the smelt. The cut is made beginning at the vent on the belly and cutting away from the belly-fin for about three quarters of an inch. Smelt's eyes are also often put on the end of the barb, and I think it pays to cover this up, but not many do it.

This method the correspondent termed "fishing à la Canuck," to the description of which he added the following:

If in a sitting or stooping posture, the fisherman assumes an erect position, on hooking a fish, at the same time raising the short fish-pole to the height of the shoulder with the right hand. Now the two-foot blank pole held in the left hand engages the line near the ice from the opposite or right side, and is immediately raised to the height of the shoulder, in a semi-circle described to the left from below, while the right hand with the fish-pole, decends, describing a complementary semi-circle to the right, from above to the ice, passes in front of the body to the left, and engages the line near the ice from the further side or left. When one hand is up, the other is always down. The arms are held far apart and rigid in order to keep the line taut. The same motion is gone through, only backwards, in holding a skein of yarn on the thumbs of both hands, while (say your sister) winds it into ball. Reverse this motion, that is reel it from the ball of yarn to your two thumbs, and you have the same motion nearly.

In a report upon an inquiry concerned with the fisheries of inland waters, in reference to the smelt fishery of Lake Champlain, an agent of the Bureau of Fisheries[4] wrote:

This fishery is carried on between Crown Point and Essex, the most important points being Westport and Port Henry. As soon as sufficient ice forms the fishermen carry small huts out to favorable positions on the lake, each hut provided with a small stove and a bench or chair, and having about a third of the bottom floored. The fish are caught with hook and line through a hole cut in the ice. For a time the "ice fish" caught in this part of the lake, which are exceptionally large (examples 15 and 18 inches long having been captured), were thought by the fisherman to be a different species from the smelt, as the fish taken in other parts of the lake and known as smelts average about 7 inches in length. At times the catch of "ice fish" is quite heavy, but in 1902 it was small, there being but few fishermen engaged. Nearly all who participate do so because they have no regular occupation, and as last year was a busy and prosperous one in nearly every town and the lake shore there were but few persons out of employment, consequently but few fishermen. In the fishing season at certain hours in the day the buyers visit the huts, gather up the fish caught and bring them to the towns, where they are boxed or barrelled for shipment.

The earliest statistics of the ice fishery of Lake Champlain are those of 1894 and 1895. These were collected by the agent of the Bureau of Fisheries who made the above report. These later statistics are after an interval, then, of some seven and eight years.

In 1894 the catch of smelts on the New York side of the lake was 33,170 pounds, valued at $3,957; in 1895, for the same locality, 39,076 pounds, valued at $4,506. In 1902 the catch was 17,600 pounds, valued at $12,160. From 1894 to 1895 there was an increase of 5,906 pounds and a gain in value of $549, with a slight decrease in the price per pound. In the seven years from 1895 to 1902 there was a falling off in the catch amounting to 21,476 pounds and $2,346 in value, but there was some increase in price per pound.

[4] The commercial fisheries of the interior lakes and rivers of New York and Vermont. By John N. Cobb. Report, U. S. Commissioner of Fish and Fisheries, 1903 (1905), p. 230. Washington.

The fishery on the Vermont side of the lake was comparatively small at all times. From 1894 to 1895 the catch fell off from 2,163 to 1,441 pounds, and in value from $119 to $89, representing losses of 722 pounds and $30; but the average price per pound increased from about 5½ cents to about 6⅙ cents. From 1895 to 1902 the catch increased from 1,441 to 6,000 pounds, and the value increased from $89 to $600, representing increases, respectively, of 4,559 pounds and $511. The price per pound increased 6⅙ cents.

QUALITY AND UTILIZATION

Of the German smelt, Bloch (1796) said that as the flesh of this fish is not easy to digest one would not advise its use by feeble persons and invalids. Fedderson, of Denmark (1870), wrote;

> It is a fish which, according to my opinion, will be more profitable to introduce into lakes where they are absent, on the ground that it is an excellent food for other fish and also has much value as bait on eel-hooks and as hog food, whereas no one can reconcile himself with its penetrating odor and eat it.

Concerning the smelt of Finland, Reuter (1883) also wrote:

> Its unpleasant smell, which is, however, in larger and older individuals less strong, makes it with us in general but little liked, and it is eaten therefore for the most part only by the poorer population and Russians staying here, who, like the English, find a peculiar enjoyment in the singular, strong, cucumber-like smell of this fish.

Reuter also called attention to the great value of the smelt as food for more important fishes such as pike perch and Salmonidæ.

Day (1884) said that in England the smelt is justly held in great estimation for the table, but after spawning becomes insipid. He repeated the statement that it used to be split and dried and was thus considered to add a particular relish to the morning dram of spirits. But referring to the experience of one investigator, he said:

> The gastric juice or fluid of the sparling was so acrid, that when he wiped his hands on his pocket handkerchief, and then used the handkerchief to blow his nose, both his nostrils and lips were inflamed and irritated, and more than once his tongue swelled in an extraordinary manner.

Concerning the Swedish smelt, Smitt (1895) wrote that the rank odor emitted by it offends the taste of many but that the flesh is good, and the belly, between the spawning seasons, is full of fat. Among epicures it is esteemed as a delicacy after the disagreeable smell has been removed by very simple culinary methods. He said that the fish must be carefully gutted, also, especially if it is in breeding condition, to rid it of the numerous intestinal worms that penetrate even into the air bladder. It is best fried and served with lemon juice or vinegar, but often is boiled or stewed in sauces. It is split also and dried for further consumption, and in this state may be eaten, he said, without further preparation. Another method is to soak the fish in lye and afterwards dress it for the table like other "stock fish."

Smitt further remarked that in addition to its utility as human food, the smelt also possess importance as one of the best baits for predatory fishes of greater size; and in several localities where it is taken in too great a quantity for immediate use it is even made into "guano".

Reuter said that the "Siniäisiä," or very young fry, in Finland were salted and prepared and eaten as caviar, and Day remarked that it was said by the French to be a good bait for eels.

John A. Thomas, of Reading, Pa., writing concerning smelts (Thomas, 1876), said that the best he had ever eaten, and he had eaten them from the extreme east to Jersey, were on the south side of Long Island and from the Passaic River. He said these smelts were always small, with the tenderest bones, and having the most perfect cucumber flavor. He said that the best smelts were the "young yearlings" that sought the spawning places for the first time. "There is no other fish," he said, "that would give the same untiring luxury as young smelts"; but when large he said that "they are tough, swift fish, and only fit to boil in a coarse cloth and be eaten with drawn butter."

Hallock (1893) must have had in mind the small fish to which Thomas referred, when he wrote:

> They are much prized for the table, and when cooked and served the backbone cleaves to the flesh unbroken, and all the little bones are chewed up and swallowed incontinently, while a fresh cucumber flavor lingers in the mouth in a grateful sort of way which epicures appreciate.

Also, "Grif's" experience seems to be in accord with that of Thomas, for he wrote (1900) concerning large fish, 15 inches long, weighing 14¾ ounces, "This large fish proved very rank and oily on being cooked, and bore out the practice of fishermen here, who prefer the smaller to the larger fish for home use, claiming they are much sweeter."

The American smelt, large or small, when perfectly fresh is one of the most delicious of pan fishes. It possesses a pronounced odor that in this country does not appear to be objectionable, judging by the esteem in which the fish is held. The usual method of cooking is by frying, after rolling the smelt in corn meal or cracker crumbs. However, if smelts become stale, or if they have been frozen and thawed and have not been cooked immediately, they possess a rank oily taste. Large smelts, if fresh, are no more likely to be "strong" than small ones, but many persons do prefer small fish to very large ones, claiming that they are "sweeter."

It has been claimed that the salt-water smelt is superior in flavor to the smelt of fresh water, but according to the present writer's experience this is not true. In fact, he has thought at times that the fresh-water form was the better, but not having compared the two at the same eating the apparent superiority may have been due to appetite.

In preparation for cooking the smelts usually are eviscerated but often the heads are left on. Some eat them, heads, bones, and all, but unless very small the writer prefers to remove heads, viscera, and tails. By cutting nearly through from just behind the head, ventralward, then pulling forward with the flat of the knife, the viscera are easily drawn out. Any remaining portion may be removed by squeezing along the belly when washing the fish. When served, they may be laid open along the back and the entire backbone removed.

Locally in Maine smelts are sometimes dried, or used to be. They were usually salted over night, entire, then strung on a slender stick, which was thrust through the eyes from side to side, and hung in the sun. Having been sufficiently

dried, they were eaten without cooking, or sometimes roasted on coals or in the oven. The fish dried were those taken in the spawning time. The writer once dried some taken in July, but they proved to be too oily and the flavor was unpleasant.

In Maine the fresh-water smelt, besides being eaten, is often used as bait for landlocked salmon and other fish; and, as previously indicated, it is regarded as necessary to stock with smelt any body of water in which landlocked salmon are to be introduced, as the smelt forms its principal subsistence under natural conditions.

FISH-CULTURAL PROPAGATION

The earliest attempts to hatch smelts "artificially" in this country seems to be that of Charles G. Atkins in 1868, an incomplete account of which was given in his notebook, which the present writer had the privilege of consulting. Under date of May 5, 1868, he wrote:

> At the hatchery house I was greatly surprised to find that a part of the fresh-water smelt eggs that I had brought from Sidney [Lake Messalonskee, Maine] are in a fair way to hatch. The eggs are well developed and the fish lively, writhing, and lashing their tails. I should think about one in ten is alive. They were taken the evening of April 18th.

In another place he stated that on May 5 the eggs were "infested with the white vegetable parasite," but that it was not making much progress.

It is not known how long the eggs obtained at Sidney on April 18 had been deposited, but from the time they were taken until the embryonic stage noted the time was about 17 days. However, another note, dated May 14, 1875, says: "Eggs from Brook-in-the-Woods, North Belgrade, hatched." Computing from his notes, it would appear that it took either 30 or 45 days for them to hatch.

In 1885 Fred Mather attempted to hatch salt-water smelts at Cold Spring Harbor, Long Island, and subsequently published accounts of his experience. Before a meeting of the American Fisheries Society he read a paper on the subject, which was published in the "Transactions" of the society. It appears that his first effort was on March 4, 1885, when from a female fish that had been dead 15 minutes 30,000 eggs were taken on a bunch of coarse meadow grass and suspended in a glass tank with a flow of water from a ⅛-inch cock, and in three days many were dead, and all died when one week old.

On the 5th he repeated the experiment with eggs from a dying female. In 5 days three dead eggs showed, the sixth day 100 dead, seventh day one-fourth of the lot were dead. Up to the 17th, the thirteenth day after taking, there was little change, and on the 20th the eggs were put in a box outside the hatchery in swift water, as they began to show fungus. March 26 about one-half were alive, and these were in bunches covered by dead eggs and fungus. All the outside eggs were dead, and there was little hope of saving any. On April 3 the fish could be plainly seen in the lower eggs by removing the coating of dead eggs and fungus that had covered them for 2 weeks. The eggs were again placed in the aquarium and 2,000 hatched on April 11, and on the 16th 9,000 more hatched and the rest were bad. About one-third of the eggs hatched under conditions that seemed hopeless and under which it would be impossible to hatch the eggs of salmon or trout. When the last eggs hatched the

mass of dead eggs was rotten and foul. The temperature ranged from 40 to 42° F. In taking the eggs the grass was laid in a milk pan and covered with water. The female was manipulated first, and as the eggs do not stick fast until some minutes after being taken, perhaps after impregnation takes place, they were distributed evenly over the grass with the tail of a fish.

Again Mather (1885) said that, knowing nothing of smelt hatching, the literature of which was meager, he determined to try several plans. So, on March 5, 50,000 eggs were taken from a weak female, on stones the size of a man's fist, in water, and placed outside the building in a covered waste trough, which took the water from the house to the ponds. The current was slow but the eggs washed off, refusing to stick in bunches as they did on the grass. The consequence was that the stones were covered with eggs only one layer deep. Three days after this they looked well, but in a week were all dead, though no fungus had formed.

He tried again on March 8, by taking about 70,000 eggs by the dry method on tiles, letting them stand five minutes before adding water, and then placing them in one of the hatching troughs. On the 16th one-half were dead, and on the 24th they were covered with fungus. On April 7 there had been no change, the eggs underneath the fungus were bright and good, but they were left unattended until the 12th, when the trough was found empty. The other attendants pronounced them dead and threw them away. Mather did not feel certain that they were all dead, for his experience that year told him that it required an expert to judge of this. He said that a mass of smelt eggs all rotten on the outside and covered with fungus half an inch thick should be given the benefit of all doubt and be carefully examined before condemnation.

Another trial was made on March 9, when 100 more fish that had been taken in seines were obtained. The first lot were so badly injured by gill nets that they were covered with fungus in a few days. On the 12th 70,000 eggs were taken on tiles and stones in water and placed in a trough that received the flow from nine hatching troughs, and consequently carried a swift current. These eggs were evenly distributed over the tiles and stones several deep, and did not flow off as in previous cases. Not until March 22, 11 days after, were any dead eggs or fungus seen. At 5 days old the formation of the embryo could be seen by means of a microscope, and at 15 days the fish could be seen with the unassisted eye. At this time fungus had spread all over the outside eggs, but underneath there were but few dead ones. On April 6, when the eggs were 26 days old, they were placed in the glass tanks with a flow from above and a siphon outlet, and 4 days later began hatching fast; 2 days later there were 11,000 fry, all that were obtained. The temperature varied from 37 to 58 degrees, and the time of hatching was 30 days. The water used in all these experiments was pure spring water.

The last trial was in the McDonald hatching jars and was the best of all, producing 60,000 fish from 200,000 eggs. They were taken on March 21 by the dry method, let stand five minutes, half a pint of water added, and kept in motion 20 minutes by tipping the pan from side to side and occasionally using the tail of a fish. The object of this was to keep the eggs from sticking together, so that they might be treated as free eggs. After this more water was added and the eggs allowed to rest for 20 minutes. They were then washed twice and placed in a McDonald jar.

They were taken at 5.10 p. m., were all loose at 6.30 p. m., and at 7 p. m. next day many were stuck fast to the jar and the tubes. On March 30 those still loose were placed in another jar, and on April 2 a few dead ones were observed, while four days later the eggs grouped together in bunches that increased in size until on April 15 the bunches were of the size of walnuts and covered with fungus. On the 20th a few hatched, and on the 21st all that were good came out. From this lot they got 60,000 fish in 30 days with a temperature varying from 40 to 65° F.

Concerning the fry, Mather said that they were the most minute of any that he had ever hatched and they were kept with difficulty. A strainer tube inclosing a a siphon such as was used for whitefish was entirely too large, for the fish passed through it with ease. After trying several things and having the aquarium overflow and the fish go out into the trout ponds he devised a spiral wire rolled on a stick of 4 inches diameter and covered with thin muslin, which kept the fish and allowed a small stream to flow out of the siphon that was inserted. The lower end of this siphon was placed in a jar of water to prevent its going dry. It was said that the difficulty with siphon outlets was the tendency to empty faster than the inflow, consequently emptying themselves and then failing to start again, as they will suck no lower than the top of the jar holding the lower end. Of the eggs remaining attached to the first jar and its tubes in a single layer, not one hatched. Most of the fish came from eggs that were in masses surrounded by fungus. Mather said:

> This year's experience upsets that of my eighteen previous years which taught me that the egg of a fish should be clean and free from fungus. I now except the smelt from the rule and think it [not] impossible that the embryo smelt must be protected from too much oxygen and good water by a coating of decayed eggs and fungus.

In the discussion that followed the reading of Mather's paper at the society meeting, H. J. Rice, among other things, said that according to his own experiments since 1876 and 1877 the result served to show greater success in hatching smelt in comparatively stagnant water than in any other manner. He said that the smelt appeared to be a peculiar form among fishes, and was no longer considered as one of the Salmonidæ. According to Rice, young smelts will live in the same water for nine days, and fish-culturists would at once recognize the vast difference in this respect between these minute embryos and those of some of the Salmonidæ, for which a constant change of water is absolutely necessary. The warmer the water the better the smelt appeared to thrive. He said that in the previous season and in the season in question experiments had been in progress to ascertain the feasibility of hatching young smelt in comparatively stagnant water and so far the attemps had been successful. Large numbers were hatched out with comparatively little trouble.

In the same discussion Mr. Lyman said that he recollected that in 1867 and 1868 attempts were made to hatch out some of the large variety called Belgrade (Me.) smelt. The eggs were put in somewhat swift running water in which trout eggs were kept, but none of them hatched.

Mather (1894) read a paper at the twenty-third meeting of the American Fisheries Society, entitled "Improved method of hatching smelts," in which he reviewed previous work in smelt propogation. Mather said that outside of his own articles on smelt hatching in the fourteenth, fifteenth, and sixteenth reports of the society he could find nothing on the subject except an item in the paper of the late Prof.

H. J. Rice on "Salt as an agent for the destruction of the fish fungus" in the thirteenth report. Mather went on to say that Professor Rice records that in 1877 he was studying the embryology of the smelt and found the eggs in masses in the hatching jars and covered with fungus, but not until 1884 did he have a chance to try the effect of salt on killing this Saprolegnia. The eggs were upon blades of sedge, or water grass, after the manner employed by Charles G. Atkins some years before, which "prevents to a great extent, if not entirely, the massing together of the eggs, since the rough surface of the blades allows only a single layer, at most, to adhere to the surface." Still there was much fungus present. The salt killed the fungus and "only about 5 per cent of the whole number failed to hatch." Mather said:

> This is a much better percentage than I can show to-day, and I do not know of any other fishculturist who has hatched this fish within the past five years. Professor Rice did not do the hatching but merely studied the development of the embryos and took the statements of others regarding the percentage; and the latter need salt, also.

Mather then referred to his paper of 1885, entitled "Protecting and hatching the smelt," which has been drawn upon in considerable detail in the paper. Another of Mather's papers was mentioned by him. It was published in the fifteenth annual report of the American Fisheries Society under the title of "Smelt hatching." The paper merely recorded efforts to induce the spawn to adhere to different substances and to vary the flow of water and the amount of light.

The paper was discussed by Frank N. Clark, Mr. Bissel, Dr. R. O. Sweeny, and Mather himself. Mather said that some eggs had been sent to Clark with the caution that they should not be thrown away "no matter how bad they looked on the outside, how much fungus there might be there, nor how foul an odor might arise from them." Clark said that he found the eggs in just the condition that Mather predicted, and that about 15 to 20 per cent of them were good. Mather said that he (Mather) could hatch 40 to 50 per cent in their jars. Continuing his review, Mather said:

> Mr. Bissel raised the question of light, and said "If the light affects the eggs of the smelt, would not the light affect them in their natural condition in a small stream?" Today I can only answer this very sensible question by saying that sunlight will kill our eggs in the jars, and in this year of our Lord, 1894, I have seen smelt eggs hatch on stones in a rapid stream with not over two inches of water over them, and in the brightest of sunshine. This is one of the problems that we have not solved.

Mather went on to say that in his paper before the society in 1887, on "Work at Cold Spring Harbor," he stated that he had planted fry of smelt representing about 50 per cent of the eggs taken. He stated that until 1893 the fish had been stripped and the eggs impregnated by hand, but it was found that by holding the smelt in the hatching troughs until ripe many females spawned in the troughs and also that the percentage of impregnation was very high and that they hatched well. So in 1894 all the eggs were gathered from the troughs, passed through wire screens to separate them, and then put in the jars. At intervals of two or three days, or whenever the eggs seemed inclined to gather in bunches, the operation was repeated, gently forcing the eggs through the screens with the fingers, and after a few such screenings the "foot" seemed to be destroyed.

He explained that the "foot" is a projection on the eggs, which is shaped like the stem and bottom of a wine glass and is the only point of adhesion that the egg of the smelt has, there being no glutinous coating around the egg of the smelt that will enable it to adhere at any point. So the breaking of the hold of the foot made it powerless to adhere to other eggs or to any object, and left the eggs as free and clean as those of whitefish or shad, and enabled the attendant to remove all bad eggs from the top, as was done with other eggs hatched in jars. The figures of results given by Mather for 1894 were as follows:

Eggs taken	31,708,000
Loss of eggs	9,105,000
Fry planted	22,603,000

"The figures show," he said, "that over 71 per cent of the eggs taken produced fry, and the reports of a few years ago show that when we produced 50 per cent, and thought it good, Mr. Clark remarked that it was as good as might be done with adhesive eggs."

In the report of the commissioner of fisheries of Pennsylvania for 1907 (p. 136) Jerry R. Berkhous, superintendent of the Torresdale hatchery, made a report on smelt hatching, having successfully taken 5,000,000 eyed eggs from Cold Spring Harbor to his hatchery, where they hatched in about a week. He said that he found the hatching of smelt eggs very easy by following instructions given him by Mr. Walters of the Cold Spring Harbor hatchery, and Mr. Safford and Mr. Meehan, although he found it quite different from other fish work. He said that the eggs were the smallest he had ever seen. It required 500,000 to fill a liquid quart and they were as small as mustard seed, if not smaller. His experience was the same as that of others in that the eggs would not hatch when exposed to light. There was too much light even when he closed the window shutters, and to give them sufficient darkness he had to hang a dark cloth curtain in front of them. He remarked that the prevailing opinion that small fish give fry of pretty good size did not hold good with his fish, for the fry were so small that he had to use a screen of linen, and double at that, to keep them from escaping after they were in the fry tank. Even then a few managed to struggle through.

They started to hatch about 10 o'clock at night, and in less than half an hour the entire 5,000,000 were hatched. He thought that a single sheet of linen would be sufficient to hold them. They began to hatch when he was in the dwelling house and the watchman called him. When he got to the hatching house he found the little fish passing through the single linen nearly as easily as he could "go through a door."

In 1912 J. F. McClendon submitted to the Bureau of Fisheries an article on "An improved method of hatching the eggs of the smelt," based upon experiments conducted by him in the Embryological Laboratory of Cornell University Medical College, New York City. As the article contains much of interest and has not been published so far as the present writer is aware, it is included here:

As is the case with all migratory marine bony fishes, the smelt migrates during the breeding season from the sea into fresh water. The eggs are laid in clusters, preferably in small streams. Each egg membrane is provided with a pedicle which attaches the egg to some support or to another egg.

At the New York State Fish Hatchery at Cold Spring Harbor, Long Island, the females are not stripped but are allowed to deposit the eggs. The egg clusters are gathered and passed through a sieve to separate them from one another. They are then hatched in regular lobster hatching jars supplied with fresh water. In this place the eggs are laid in about 10 days during the last half of March or the first half of April. The water supplied to the jars is quite cold and the mortality of the eggs is not as great as in the natural streams of the locality.

"However, I found in eggs taken from the hatching jars or from local streams during two consecutive seasons, about one embryo in a thousand with abnormal eyes. The cause of this abnormality has not yet been found; however, it may be remarked that the water contained an unusually large amount of carbon dioxide. The fresh water of Cold Spring Harbor comes from deep springs or artesian wells and is charged with this gas. Also I found various poisonous substances to produce this abnormality in Fundulus embryos.[5]

There is a large mortality among these eggs when hatched in the tap water of New York City, due to the higher temperature and impurities. They hatch better in water redistilled in glass or quartz.

The eggs before being laid contain considerable amounts of sea salts and have an osmotic pressure equal to about half that of the sea. I was interested in determining whether the salts diffused out of the egg when laid in fresh water, as seems to be the case with frogs' eggs, or whether they were retained, as I found to be true of the eggs of the marine killfish (*Fundulus heteroclitus*).

Thirty grams of eggs were soaked 14 hours in 250 grams of distilled water. The water was then analyzed and found to contain only two one-thousandths of a gram of common salt. It is evident that most of the salts are retained by the eggs.

Since the eggs retain the salts in the same way that the adult fish does, it would seem probable that the eggs would live better in salt water than in fresh water. From the experiments with other marine bony fishes, it is probable that the smelt would live indefinitely in more or less diluted sea water, but not in fresh water, although they are normally in fresh water during the short breeding season.

I placed smelt eggs in sea water and in sea water diluted with various proportions of water redistilled in a quartz still. The eggs in sea water developed for three or four days and then died. Eggs in one-half sea water (which is of about the same salt content and osmotic pressure as the blood of the mother), developed much better than in fresh water. This is probably due to two causes: First, the salt in the water being of the same concentration as the salt in the egg, any loss of salt from the latter is prevented. Second, the growth of mould (Saprolegnia) is retarded by the admixture of sea water. Even $\frac{1}{6}$ sea water preserved the life of the eggs better than fresh water.

It is suggested that in the hatching of smelt eggs, when the mortality is considerable, that the jars be supplied with a mixture of sea water and fresh water in the proportion of one part of sea water to from one to four parts of fresh water. The water might be mixed by simply connecting the salt and fresh water pipes to the pipe leading to the hatchery by means of a T joint. Care should be taken to maintain a regular flow in both pipes, and the flow of the sea water should never exceed that of the fresh water. The proportion of sea water should be gradually reduced just before the time of hatching, as the eggs hatch better in one-fifth sea water than in one-half sea water. Perhaps it might be more convenient to reduce the proportion of sea water to zero before the eggs hatch.

I am indebted to Mr. Walters, superintendent of the New York State fish hatchery at Cold Spring Harbor, Long Island, for the material on which these experiments were made.

From the department of anatomy, Cornell University Medical College, New York City, April 4, 1913, McClendon sent in an additional note on the same subject, which follows:

This year I installed apparatus for circulating brackish water (and fresh water for a control experiment), using miniature hatching jars. However, the expense of keeping the temperature low in this laboratory would have been great and if exact data are to be obtained experiments should be made at Cold Spring Harbor.

[5] McClendon, J. F.: An attempt toward the physical chemistry of the production of one-eyed monstrosities. American Journal of Physiology, Vol. XXIX, No. III, Jan. 1, 1912, p. 289. Boston.

At this higher temperature there were more deaths in fresh water than in a mixture of one part sea water (from the New York aquarium) and three parts fresh water. Last year I obtained more deaths in fresh water than in equal parts of fresh water and "sea water." But this sea water was surface water of Long Island Sound during the period of heaviest rains. In equal parts of fresh water and sea water of normal density there were as many deaths as in fresh water, and also a large number of abnormalities.

The procedure in the propagation of smelts in Massachusetts was described in some detail in the report of the Massachusetts commissioners on fisheries and game for 1918. This discussion follows:

The method of taking spawn varied according to the purpose for which it was to be used, namely, whether for transfer to the Palmer Hatchery for hatching in the batteries, or whether collected on burlap for planting as spawn. For the benefit of those who are unacquainted with fish-cultural processes a description of the routine is given.

For Hatching in the Palmer Hatchery.—The crew, equipped with rubber clothes, took their stations at the Weir River Falls about dark, and arranged their outfit to be in readiness for the appearance of the fish, which came any time from 7 p. m. to 3 a. m., according to the stage of the tide and the temperature of the water.

Two catchers, with dip nets, took their places at the falls. At the side of the river, close to the water, the sorters were stationed beside two tubs, one for male and one for female fish. Between the tubs sat the strippers and the hardeners occupied the portable house.

Catching.—The catchers, selecting the spots frequented by fish of the sex desired, dip them up in the nets and carry them to the sorters. The males prefer the boisterous waters above, while the females frequent the quiet eddies. By rearrangement of the rocks in the rapids, the number of such eddies was increased, to the advantage of the work. Taking by dip nets was found to be the best method.

Sorting.—The sorters on receipt of the fish from the catchers place them in the appropriate tub. A fish culturist easily recognizes the sex of the fish, both by appearance and by feeling.

Stripping.—This process consists of removing the spawn or the milt, as the case may be, from the fish. Holding the fish in the left hand over a 4-quart pan containing a few drops of water, with the thumb of the right hand bearing on the upper side of the fish, the index finger is allowed to follow down the fish from head to tail, thereby removing the few drops of ripe milt or eggs. The process is repeated until the bottom of the pan is barely covered.

Last year the stripped fish were distributed among the needy of the town, in the belief that the fish died after spawning. This year an experiment of "half stripping" (taking only about half the spawn, and using little pressure) was tried on 300 fish which were afterwards held under observation in a tank. After four days but 2 per cent had been lost, demonstrating that a large proportion, if handled carefully, could be returned to the water after serving our purpose This method was adopted, and we believe that at least 90 per cent of the stripped fish survived.

Hardening.—The spawn when first taken from the fish is exceedingly soft and sensitive, and must be handled with the utmost care. It is also very adhesive, and when deposited in the natural way in the brooks it immediately attaches itself to the bed of the stream. In taking eggs for artificial hatching it is of the utmost importance to prevent adhesion and one of the biggest problems has been to keep the eggs from forming into masses, which, once formed, cannot easily be broken up. Until this tendency could be overcome, successful transportation was out of the question. For this trouble the remedy is soaking in fresh water three or four hours, changing the water frequently to thoroughly clean the eggs of the superfluous milt and the gluey substance which covers the eggs. The eggs increase during the process to six or eight times their original size. After repeated experiments it was found that if pans and other utensils were first treated to a coat of melted paraffine the eggs would not adhere.

All eggs hatched at Palmer were collected and prepared for shipment under the direct supervision of the foreman of that hatchery.

Two methods were tried this year of caring for the eggs when taken from the fish. By one method the eggs were stirred in the pans very little in the hardening process. This lot gave the greatest difficulty, as the eggs stuck together so badly that they had to be separated by putting

them through a screen two or three times, and they would not work so freely in the jar; but the per cent of hatch was nearly the same. The other method was to constantly stir the eggs in the pans of water until time to can them for shipment. These did not adhere or bunch up, and though it required more work at the spawning grounds at time of stripping, it saved much labor at the hatchery.

The foreman as a rule arrived at the Palmer Hatchery with a consignment of eggs about 11 a. m. The eggs were at once placed in large pans and the water changed frequently until 4 p. m. Then they were placed in the hatching jars, 24 ounces to each jar, and from that time until they hatched had to be watched constantly, night and day, to be sure water was running through each jar and that the eggs did not bunch up and smother. The average temperature of the water during the hatching period was 57°; period of hatching, thirteen days.

The capacity of the battery at Palmer is 42,500,000 eggs. Immediately after hatching begins distribution should be started, else the tank will be too full of fish and the screen become clogged, though smelt, being more lively and better swimmers, can be held longer in the tank without loss than either yellow or pike perch.

Of the 110,000,000 eggs received at the hatchery there were hatched and planted 76,125,000 with about 30 per cent loss. In view of the fact that the work is still experimental (last year but a few ounces of eggs were handled, merely to determine whether the fish could be stripped and eggs hatched) the number of fry produced can be considered very satisfactory. With the necessary facilities it would be an easy matter to hatch 200,000,000 instead of only a few fish.

A brief note appeared in the Massachusetts report for 1921 to the effect that a little experimental work was done in hatching spawn in jars at the Weir River field station, using pond water, and 3,000,000 hatched in this way. The spawn hatched in 13 days, a shorter period than when handled in the batteries at Palmer. The fry were permtted to pass directly from the hatching jars into the river.

The United States Bureau of Fisheries has propagated smelts at Green Lake, Me., for a number of years. As has been noted, at Green Lake there are two size classes of adult smelts that constitute distinct runs, the larger form ascending the brooks earlier than the smaller one. According to the superintendent of the station at Green Lake the first of the run of each form is composed almost entirely of males. A descriptive circular concerning the process of collecting the eggs and hatching the smelts at the station says that careful daily observations have to be made in order to determine when sufficient females are present to warrant operations. As soon as the sexes appear to be about equal in number the fish are collected in small dip nets, carried in 10-quart pails to the hatchery, and placed in ordinary hatching troughs, six pails to a trough. Here they remain undisturbed a sufficient length of time to insure the casting and fertilization of their spawn, which usually occurs within two or three days. The fish are then liberated and the coating of spawn at the bottom of the troughs is gathered up by means of a net frame which is of the same width as the trough and tightly covered with cheesecloth. As the eggs tend to adhere to the surface of the trough, special care must be exercised in this process to avoid injuring them. They are placed in large pans and the lumps smoothed out with the bare hands, after which they are measured and installed in hatching jars similar to those used in the whitefish and shad work, about one quart of the eggs of the "large smelt" being placed in a jar, with a water circulation of 3 quarts per minute. It has been customary in the past to allow 1½ quarts of eggs of the "small smelt" per jar, but recently the number had to be increased to 2 quarts owing to a shortage of hatching facilities, and the results were just as good as formerly. On account of

the small size and adhesive nature of the eggs, they are liable to form into clusters after being installed in the jars. This difficulty may be overcome by emptying the jars and running the eggs through a fine screen, and then returning them to the jars.

Some fish-culturists are of the opinion that strong light is injurious to the eggs, and that the rays of the sun should be carefully excluded from the room in which they are undergoing incubation. The incubation period covers about 19 days in a mean water temperature of 42.5° F. The newly hatched fry are so very small and delicate that the bottom and sides of the receiving tank are lined with a sack of bleached white bunting, so shaped as to conform to the outlines of the tank. This not only constitutes a suitable and convenient container for the fish, but is useful for conserving any eggs that may pass from the overflow into the tank. The fry are planted in the natural spawning grounds in Great Brook within a day or two after hatching.

An experiment in the propagation of the "large" Green Lake smelt was described by Supt. E. E. Race in a letter dated March 27, 1909. A few of the females and males were stripped simultaneously in a pan, and the eggs were found to be as well fertilized as those naturally deposited in the troughs, but they could not be separately followed, as it was necessary to hold them with others on the cheesecloth bottoms, the wire being too coarse and only two troughs having been fitted with cheesecloth.

It was found necessary to separate the eggs several times by forcing them through fine netting to break up the bunches, but they seemed to do well in hatchery jars. Race wrote also that he had experimented with eyed eggs and had found that prior to eyeing the more they were handled the better the results. He said that they could be taken from the jar at any time before they were eyed and rubbed through a fine wire screen with the fingers without injuring any of them. As soon as they were eyed they were more sensitive but could be separated from imperfect eggs if care was taken to have the screen mesh a little larger than the egg and the stage of advancement had not softened the shell too much.

It appears that at present the Bureau of Fisheries propagates smelts at Green Lake only. Something of the extent of the operations may be learned from the following reported data: In 1923, 4,300,000 eggs of the large smelt were collected. The loss in hatching was 20,000 and 4,280,000 fry were planted. Of the small smelt 42,000,000 eggs were collected; loss, 1,250,000; shipped 12,750,000; and 28,000 fry planted. In 1924, of large smelt, 18,000,000 eggs were collected; the loss was 700,000; 8,000,000 were shipped; and 9,300,000 fry were planted. No small smelts were handled.

ANATOMY OF THE REPRODUCTIVE STRUCTURES

The gonads or reproductive glands (ovaries and spermaries) of the smelt are unsymmetrical organs, one on each side of the abdominal cavity. The organ of the left side is very much larger than that of the right, and instead of being approximately opposite each other, as in Salmonidæ, they are situated one behind the other. The left gonad is much the larger in both sexes, the right being quite small and not far behind the outlet. Both organs are inconspicuous in an immature smelt, but as the season advances they enlarge and some months prior to the breeding season become quite conspicuous, so much so that often in the fall of the year the smelts have been

thought by fishermen to be in breeding condition. At this time, however, they are much smaller than at the breeding season. Even in the fall the eggs are often bright yellow and the spermaries or milts are white.

These organs are suspended from each side of the air bladder at the upper surface of the abdominal cavity by a thin membrane (figs. 23 and 24), which forms the enveloping membrane of the organ. In the male it completely envelops the spermary, but in the female the ovary is not completely covered by it. If, say in December, the ovaries of a smelt that would have spawned the next spring are carefully examined, it will be seen that the membrane forms the surface of the organ facing the median axis of the abdominal cavity and extends around and up for about one-third or more of what appears to be the other side of the ovary as it seems to be hanging in the abdominal cavity. There is thus a surface apparently not covered by the membrane. As a matter of fact the membrane is not a cover or envelope but is a part of the ovary, and the eggs are formed in crosswise folds of the ovarian membrane. As the eggs develop the ovaries enlarge and may be said to stretch (as do the spermaries also) and gradually come to almost fill the abdominal cavity.

The edge of the membrane, which seems to limit the uncovered egg surface, continues backward from the posterior end of each ovary and is diverted to one side and is attached to the lateral wall of the abdominal cavity forming the lower surfaces of the egg channels, which unite in a common channel (figs. 22, 23, and 24 *g*) near the outlet. Both of these channel membranes, which have been incorrectly termed "funnels," when not containing eggs lie against the membrane of the air bladder, which forms the roof of the so-called "funnel."

The gravid ovaries fill all the space in the abdominal cavity not occupied by other viscera. Upon opening the fish from throat to vent along the median line of the belly and laying the lateral walls aside, at first glance there appears to be one single mass of eggs, in front of which is the liver; posteriorly a small portion of the intestine may be visible. The greater portion of the egg mass is the anteriorly situated left ovary, which extends from the liver to some distance beyond the base of the ventral fins (fig. 22 *a*). Placed closely to the posterior end of the left ovary is the right ovary (fig. 23 *b*), which extends nearly to the vent. The dividing line, which is often difficult to discern, beginning perhaps a little in advance of the ventral fins, extends obliquely from the right side (left as observed) backward to the left side (right as observed). Both ovaries are ventrally convex from side to side, and concave above, thus forming a broad, more or less triangular groove, in which anteriorly the stomach lies. The intestine, at first above the stomach, finally lies in the grooves of the left and right ovaries. These grooves are formed by the left ovary curving over so that the so-called "lower edge" is in contact, or nearly so, with the dorsal surface of the abdominal cavity on the right side, the left ovary curving in like manner in the reverse direction.

The ovarian membrane is so thin that it is easily broken or rubbed off in examination or handling, so that one may easily be deceived into believing that there is no membrane and that the eggs are free in the abdominal cavity.

If the ovaries of a December smelt, previously mentioned, are compared with those of a gravid smelt in April, one is likely to wonder how the comparatively small

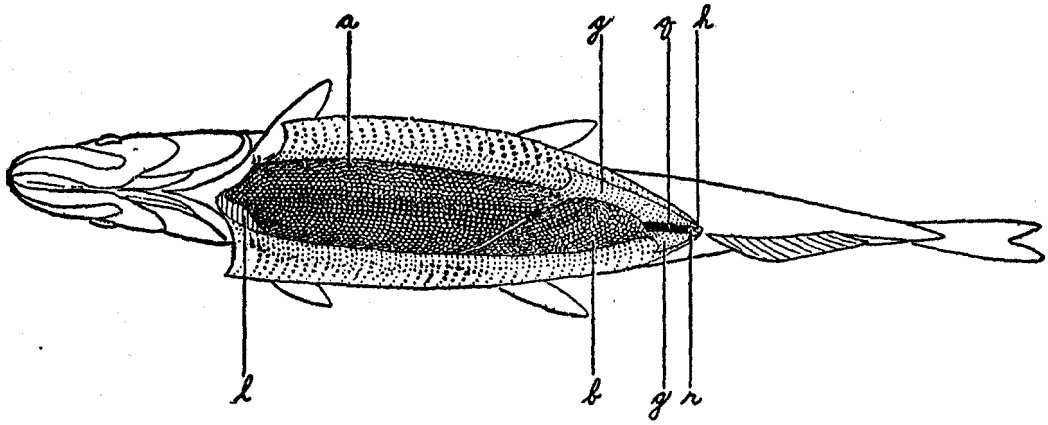

FIG. 22.—Semidiagrammatic drawing made by Walter H. Rich, from dissection by William C. Kendall. Specimen from Sebago Lake, Me. Ventral view of ovaries and oviducts of smelt (*Osmerus mordax*). *a*, Left or anterior ovary; *b*, right or posterior ovary; *g*, lateral expansions of mesovaria and ovarian membranes joining peritoneum of abdominal walls to form oviducts; *h*, genital pore; *l*, liver; *q*, intestine; *r*, anus

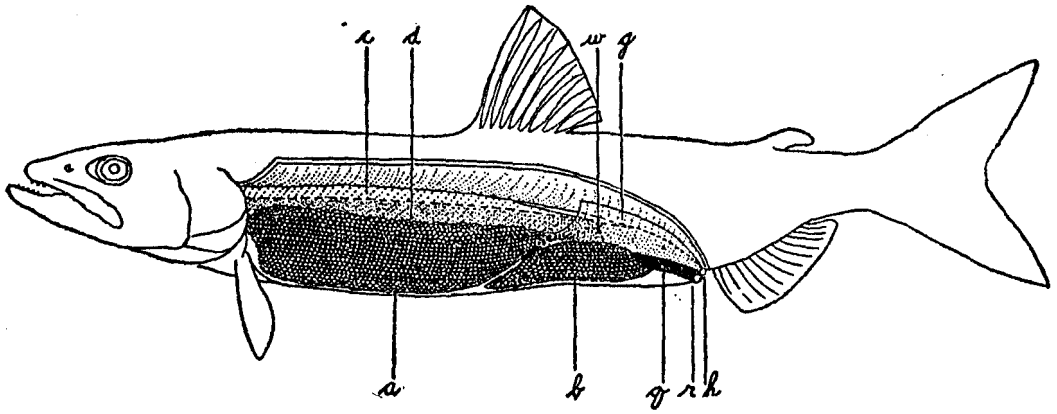

FIG. 23.—Left view of ovaries and membranes of same as Fig. 23. *a*, Left ovary; *b*, left side of right ovary bending up on left side so that its lower portion is dorsally situated; *c*, left mesovarium; *d*, outer edge of ovarian membrane; *g*, posterior lateral expansion of mesovarium and ovarian membrane forming left oviduct; *h*, genital pore; *q*, intestine; *r*, anus; *w*, posterior end of intestinal mesentery with confluent mesovaria

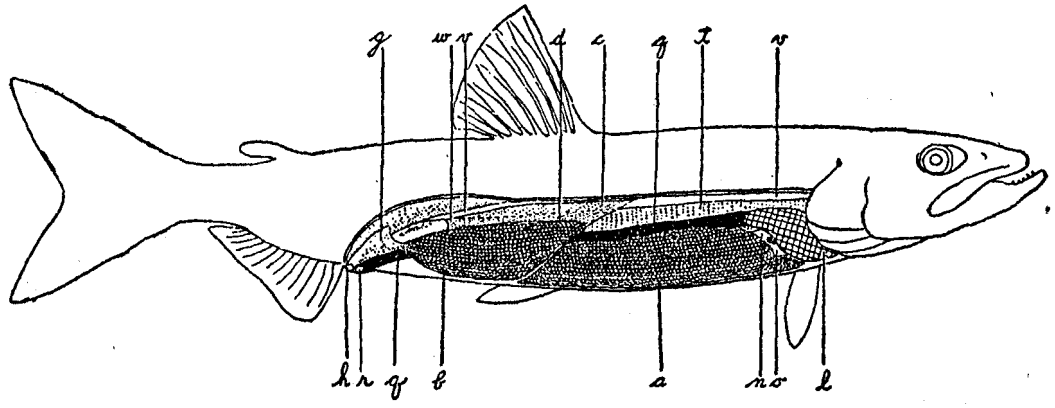

FIG. 24.—Right view of same as Fig. 24. *a*, Left ovary bending up under stomach and intestine forming a groove in which the viscera extend; *b*, right ovary; *c*, mesovarium of right ovary; *d*, outer edge of ovarian membrane, between which and the mesovarium the egg surface not covered by membrane other than the mesovarium is situated; *g*, right posterior expansion of the mesovarium and ovarian membranes forming the short right oviducts or practically the right side of the common oviduct posterior to *w*; *h*, genital pore; *l*, liver; *n*, upper or cardiac arm of stomach; *o*, lower or pyloric arm of stomach; *q*, intestine; *r*, anus; *t*, intestinal mesentery; *v*, air bladder; *w*, posterior end of intestinal mesentery with confluent mesovaria

December organ could produce as many eggs as are present in April. The fact appears to be that as the eggs develop and increase in size the outer ovarian membrane and the egg-bearing cross partitions are so stretched downward that, following the contour of the abdominal wall, they turn up and approach the dorsal surface of the abdominal cavity, so that what may be regarded as the bottom of the ovary is sometimes nearly on a level with the top. The "top," or that portion of each ovary that is not invested with adherent membrane, consists of a narrow dorsal area that is tipped in against the suspending membrane of the ovary. In these passages, formed by the investing membranes, the eggs pass backward into the egg channels previously mentioned. Here again one may wonder how the eggs manage to find their way into these channels from such apparently distorted ovaries. But the problem is not quite as difficult as it would be to try to account for their manner of exit if they were lying loose in the abdominal cavity. At least it may be suggested that near the posterior end of the ovary and close to the mouth of the egg channel, as the eggs pass into the channel, the ovarian membranes and cross partitions shrink or contract so that the eggs are brought necessarily from the "bottom" and the front into line with the channel.

If the eggs are set free in the abdominal cavity, as has been claimed, there appears to be no conceivable way by which they could be extruded, for the reason that, as previously stated, before the eggs of the left ovary have entered the egg channel the gravid right ovary presses the left egg-channel membrane (fig. 23 *g*) against the air bladder and left abdominal wall.

So it seems that the eggs of the small right ovary must ripen and be deposited before the eggs of the left ovary can fill its egg channel. As the eggs of the left ovary enter its egg channel the empty right ovary is compressed between the distented left egg channel and the right abdominal wall. As the right egg channel and ovary are emptied the left egg channel becomes entirely filled with eggs, and these, with the remaining eggs in the left ovary, have the appearance of a single continuous ovary. When both ovaries are emptied the collapsed organs have contracted so that the left is again small and considerably in advance of the right ovary. Both contain visible though minute eggs, which constitute the future crop.

FECUNDITY

The number of eggs deposited by an individual depends upon its size, varying from a few hundred to thousands. According to Smitt (1895), the number of eggs carried by a female European smelt 18 to 20 centimeters (about 7 to 7.8 inches) long was estimated by Norbäck at 50,000 and by Olson at 36,000. Mather (1885) said that he took from a "dead female" 30,000 eggs, and Mr. Walters took about 50,000 from a "weak female." In 1887 he wrote that the little smelt carries from 30,000 to 60,000 or perhaps more eggs, and that from 100 ripe females of good size probably 5,000,000 eggs could be obtained.

A fresh-water smelt 4⅝ inches long received by the present writer from Toddy Pond, East Orland, Me., was found by actual count to contain 5,893 eggs.

In a letter dated March 27, 1909, Superintendent Race of the Bureau of Fisheries' Green Lake (Me.) station, stated that from March 8 to March 19, inclusive, 425 large smelts had been collected; of which, so far as could be ascertained, 200 were

females. The fish ranged in size from five or six to a pound to half a pound each, and averaged about three to a pound. From them 3,460,000 eggs were collected, which would make the average number of eggs per female 17,300.

CHARACTER OF THE EGGS

Smitt (1895) says of the ova of the European smelt that they are light yellow, and their diameter was estimated by Benecke at 0.6 to 0.8 millimeter; but Meek (1916) states that the ova are light yellow in color, but he says they measure about 1 millimeter, which undoubtedly is incorrect.

According to Berkhous (1908), at the Torresdale (Pa.) hatchery, eggs obtained from Cold Spring Harbor were estimated at 500,000 to a quart. This would amount to 15,625 to a fluid ounce.

Superintendent Race of the United States Fisheries station at Green Lake, Me., said that a careful measurement of the eggs of the "large" form of fresh-water smelt showed 31,250 to a fluid ounce, and of the "small" form 46,250 to a fluid ounce.

The eggs are often spoken of as being glutinous or sticky, for which reason they become attached to anything with which they come in contact. Cunningham (1896) describes the means of attachment in an entirely different manner. He says that the outer of the two layers of the egg bursts at one point and separates, turning inside out as it does so and remaining firmly attached to the inner layer over one small circular patch. The separated membrane is adhesive when the egg is first shed, and attaches itself to objects in the water, for example the piers of bridges or posts in the river where the fish spawns, or the stones of the river bed. The eggs are thus suspended from their support by the flexible outer membrane. He states that the micropyle is in the center of the circular patch over which the suspending membrane remains attached. This description appears to be based on Ehrenbaum's account (1894).

After fertilization a considerable space is formed between the inclosing membrane and the body of the egg. The shape is round and the breadth of the inclosing membrane varies from 0.9 to 1.3 millimeters (about 0.04 to 0.05 inch). The yolk is composed of small globules, and contains several oil globules of different sizes. The whole egg is fairly transparent but less so than marine buoyant eggs.

INCUBATION

It is estimated that it requires from 2 to 6 weeks from the time the eggs are deposited until they hatch, according to the temperature of the water. Smitt (1895) says that according to Blanchère the eggs are hatched in 8 to 10 days; according to Feddersen in 12 days; and according to Sundevall in 18 days, "a discrepancy of observation which in all probability depends on the different temperature of the water during the period of incubation." Cunningham (1896) says:

> The development is rather slow and took at a temperature of 46° to 53° twenty-seven days. In the earlier part of the spawning season, from the end of March onwards, the water being colder, the development would take longer.

Regan (1911) says that the eggs hatch out in from one to three weeks, according to the temperature. Meek (1916) says that there is much variation in the time

of development due to differences in temperature, but that it may be said to be from 8 to 27 days. Concerning the smelt of the Elbe, Ehrenbaum (1894) says that four to five weeks are necessary.

In one of Mather's experiments (1885) it seems that the eggs began to hatch in 36 days, the temperature of the water ranging from 40° to 42° F. In another they hatched in 30 days with the temperature at 37° to 58° F. At five days old the formation of the embryo was visible by means of a microscope, and in 15 days the embryo could be seen with the naked eye. In another they also hatched in 30 days with temperature ranging from 40° to 65° F.

Concerning the smelt of Finland Reuter (1883) stated that the roe is developed in about three weeks.

In 1909, Race wrote that the incubation period of the "large" form of the fresh-water smelt at Green Lake, Me., was 30 days with a range of temperature from 33° to 34° F. The period of the "small" smelt was 24 days with the temperature ranging from 45° to 48° F.

In his report for the fiscal year ended June 30, 1922, Superintendent John A. Story of the Green Lake (Me.) station of the Bureau of Fisheries wrote:

> The advance run of smelts was very favorable. On April 26 many smelts were in the brook and 40 quarts were caught. More could have been caught, but on careful examination it was found that nearly all were males, there being about 25 males to one female, and it was decided that the next night would be the proper time to take them, as more females would then be in the brook. That night a cold rain set in, continuing all next day, which drove all the smelts back to the lake and practically no smelts came back into the brook. Other brooks were visited, but very few smelt eggs were obtained from the smelts caught April 26. These were left to hatch in the trough in which they were deposited. The dam board at the foot of the trough was removed to make quick water over the eggs and allow the fry to run out as fast as hatched. These eggs hatched in 18 days with practically no loss, the temperature registering 51.55° F.

In the report of the same station for 1924 Mr. DeRocher stated that in the case of the large smelt "eye spots" appeared in 20 days.

DEVELOPMENT

According to Cunningham (1896) the newly hatched larva is 5.5 to 6 millimeters long (0.24 inch, or less). The mouth is already open, but beneath the head; the yolk is much reduced, and the oil globules all united into one, which is situated near the front end of the yolk sac. The primitive fin membrane is narrow; the intestine ends near the end of the tail, far behind the yolk sac, as in the larvæ of the herring family. The pigment is very scanty; there is some in the eyes and specks on the yolk sac and along the lower edge of the body. The whole larva is delicate and transparent.

The present writer's observations upon the American Atlantic smelt, which have been in comparatively small brooks, indicated that the tiny transparent young do not remain long in the place of their birth. Probably, because the eggs are more or less suspended above the bottom, the current of the water takes the majority of young smelts downstream almost as soon as they are hatched, thereby being subjected to all sorts of vicissitudes, and comparatively few survive to attain the adult age. It is a provision of nature to offset such contingencies that the smelt is so

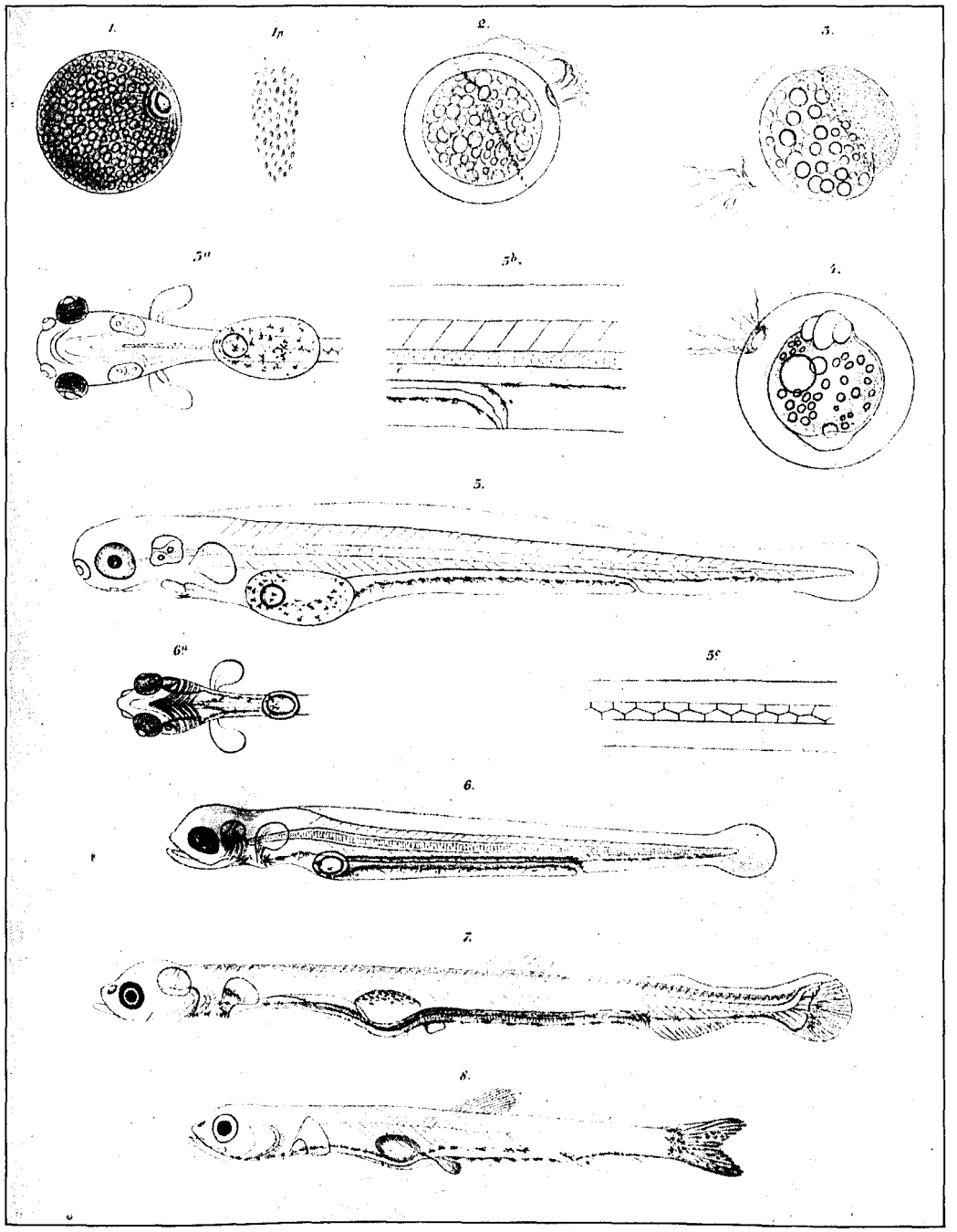

FIG. 25.—Embryology of the Elbe River smelt, from Ehrenbaum. 1. Mature, unfertilized egg, collected before absorption of water. Diameter 0.75 millimeter. 1*p*. The pores of the *zona radiata externa* of the egg greatly magnified. 2. Mature egg immediately after placing in water containing sperm; the *zona radiata externa* is ruptured and on the point of turning back on itself, whereby it remains only near the micropile, suspending the egg. 3. Egg with developed (yellowish) transparent yolk, 6 hours after fertilization. Diameter 0.90 millimeter. 4. Egg with embryo of 9 days; large yolk and few oil globules. 5. Smelt larva immediately after hatching on April 19. Length 5.5 millimeters. 5*a*. Showing underview of anterior portion of the same larva with its inferior mouth and extended pectoral fins. 5*b*. Posterior portion of same larva greatly magnified, also the corda cells. 5*c*. Underview of the corda of the same larva. 6. Smelt larva of April 24, 6 days old. Length 6.3 millimeters. 6*a*. Anterior portion of the same larva. 7. Larva of May 27, 15.5 millimeters long. 8. Larva of June 17, 28 millimeters long

prolific. Notwithstanding the adversities they encounter, their rapid migration, whether active or passive, is necessary for the survival; for the conditions of their birthplaces do not afford the requisite quantity of suitable food, which is to be found only in more open or tidal waters.

Observations by Ehrenbaum (1894) upon the smelts of the Elbe River showed that the newly hatched fry were 5 to 6 millimeters (about 1/5 to nearly 1/4 inch) in length. They were found to attain from a little over 0.55 to 0.7 of an inch in length in one month. In three months they reached 1.25 to 1.45 inches. In five months the lengths were found to range from 1.73 to 2.36 inches. In the month of August the range of length was from 1.57 to about 2 inches. It was determined also that the smallest mature smelt was about 4 inches long and 2 years of age, but many larger fish were found to be immature.

According to Sundevall, on their first exclusion the fry of Swedish smelt are 5 millimeters long and perfectly transparent; they are characterized by the universally backward position of the vitelline sac (yolk sac), the distance between it and the insertion of the pectoral fins being more than half of that between these fins and the tip of the snout. In August, according to Yarrel (1836), the English smelt has attained a length of 75 millimeters (nearly 3 inches).

Cunningham stated that the larvæ of smelts (*O. eperlanus*) have been kept alive for 15 days after hatching in an aquarium. On the sixth day by the growth of the ower jaw the mouth had become terminal and the yolk was nearly all gone, but the fins had not begun to appear. The larva at this age was 6.3 millimeters long (1/4 inch). The youngest larvæ captured in the river were taken on the 5th to 8th of May and were 6 to 8 millimeters long (the largest nearly 1/3 inch), and had begun to feed on the minute Crustacea, called "copepods," the usual food of young fishes. The larvæ were extremely abundant in the estuary of the Elbe. A small net only 2 feet 8 inches across the opening placed in the current for a quarter of an hour captured on one occasion (May 28) a number calculated to be 107,000. These specimens were 14 to 20 millimeters long (three-fifths to four-fifths inch) and were still very transparent, but the first dorsal and the ventral fins had appeared. These larvæ were still very slender in proportion to their length and were remarkable for the great size of the air bladder. In the middle of June the little fish were four-fifths inch to 1 2/5 inches long and had nearly reached the form and character of the perfect smelt. They were still, however, transparent and without scales and silvery coat. Even in August the young smelts, now 1 2/5 inches to 1 4/5 inches although more pigmented and less transparent, had not acquired their scales and silvery garment. The development of these last characters of the perfect fish takes place in September and October, when the young are 2 inches to 2.4 inches long.

In 1913 Masterman, from a study of the scales of British fish, indicated that smelts 1 year old averaged 4.48 inches, 2 years old 7.24 inches, 3 years old 7.55 inches, and 4 years old 8.85 inches. From the foregoing figures, then, it may be concluded with a fair degree of safety that the Atlantic smelt of American rivers spawn at the end of the second year and may average at that age between 6 and 7 inches.

According to Cunningham "after October the smelt, young and old, descend toward the sea, and return toward fresh water at the end of February and in March.

In the Elbe Ehrenbaum found that while the smallest ripe fish were 4 inches long, others which were as large as this were immature. He also observed that in the first half of the summer, before the young of the year had got beyond the larval stages, young immature smelt of 2⅘ to 3⅗ inches in length were very abundant, and also caught in very large numbers for eel bait. This shows the usual growth of the year-old fish, some of which spawn for the first time when two years old and 4 inches to 6 inches long."

The growth of the smelt from the fry stage is comparatively rapid, though the size attained in a given time is variable, as indicated by the following measurements:

Smelt fry obtained from the stomachs of sticklebacks (*Gasterosteus*) in the tidal portion of Casco Bay, Me., creek, only a short distance below high-water mark, on May 13, averaged less than 0.2 inch in length. Judging from the presence, in some instances, of incompletely absorbed yolk sac the fish could not have been hatched long.

On August 3 translucent young smelts, ranging in size from 1.2 to 2 inches, were caught at an island in Casco Bay several miles from any possible breeding place. On October 14 young smelts, still translucent, caught in the same bay, ranged from about 2 to 2.56 inches in length. On December 11 others, also translucent, ranged from 2.4 to about 3.6 inches long.

Again, on the following February 10, similar young smelts ranged from about 2.6 to 3.56 inches in length. Still again, on March 5 following, specimens ranged from 2.4 to about 3.75 inches in length. While only the last three collections were consecutive in the same period, inasmuch as they represent a brood of the year previous to the one just considered—that is, fish about 15 months old—they are probably fish that would breed for the first time in the following year—that is, at 2 years of age.

In the same brook, on April 20 of the same year in which the previously mentioned newly hatched fry were obtained, 12 breeding smelts were taken, consisting of equal numbers of males and females that ranged from about 6 to 7.8 inches and averaged 6.52 inches in length. They represented the smaller fish and at the same time the size of the majority, but not necessarily the average, for probably some larger fish that may or may not have been older were present. This would indicate a gain of 3.28 inches in about eight months from the preceding August.

As the foregoing figures are not exact, and as only the last three periods mentioned in reference to the series of young fish were consecutive in the same year, they might be considered insufficient data upon which to base a generalization. However, the figures so closely approximate conclusions reached by certain European authorities respecting the common smelt of northern Europe, that they may be regarded as to some extent representative of a general situation. In this country, at least, virtually no observations upon the rate of growth of the fresh-water smelt have been made.

Concerning the smelts of Finland, presumably a fresh-water form, Reuter (1883) said that the fry grows rapidly where there is abundance of food, but under other circumstances its growth is easily stopped.

Young smelts obtained from the stomach of a trout (*Salvelinus fontinalis*) in Sunapee Lake, N. H., by the present writer on August 13, 1910, measured 1.1 to 1.4

inches. Several picked up from a beach at the same lake on October 15 and 26 measured from nearly 2 to 2.28 inches. This possibly indicates an increase in minimum and maximum lengths, respectively, of 0.9 to 0.88 inch in a little over 2 months.

At Sebago Lake, Me., in July (18 to 29) of various years, young smelts were found to range from 1.2 to 1.5 inches; in August (8 to 28) they ranged from 1.4 to 2.5 inches; and on September 10 in one year 109 specimens from the stomach of a yellow perch measured from a little over 1 to 1.9 inches, averaging 1.7 inches. There is no way of telling whether only one or both classes of these "large" or "small" smelts were represented. The figures would suggest that both were represented.

It has been indicated already that the marine smelt appears to attain maturity at 2 years of age. From the report of the New Hampshire commissioners of fisheries, for 1872, it would seem that this obtains with fresh-water smelt. The report says:

> Two years since we placed some of the ova of the smelt in some brooks running into Massabesic Lake, as a matter of experiment, and we have reliable information that full grown smelts have made their appearance in one of those brooks, for the purpose of spawning, this spring. As there were no smelts there previous to placing their ova in those brooks, we learn the fact that the smelt matures in two years.

STOCKING WATERS OR TRANSPLANTING

Bloch (1796) wrote that it was possible to transfer and stock other waters with the éperlan, provided that the place where they were sent was deep and the bottom sandy. He said that the fish was so common and so cheap that it was hardly worth transporting, but as it was very prolific it might serve as food supply for Sandre and trout.

Smitt (1895) said that in lakes where the smelt is wanting it may easily be introduced and is very useful as food for other fishes, particularly the pike perch, as Nilsson pointed out. He said that the impregnated eggs may be transported from one lake to another or, with a little care, the spawning smelt may be conveyed alive during the cool season in vessels filled with pure water.

On this point Reuter (1883) wrote that smelt propagation is best managed by fructified roe, or also by transportation of adult fish, but as the smelt lives only a short time if it is taken from the water the transport ought to be made in roomy vessels and during low temperatures, and the fish to be transported should therefore be caught from among younger, earlier spawning individuals.

Day (1884) related that Colonel Meynell, of Yarm, in Yorkshire, kept these fish for four years in a fresh-water pond, which had no communication with the sea; and he observed that Yarrell states that they continued to thrive and propagated abundantly. He said that the pond being frozen over did not affect them, and they did not lose either flavor or quality (Wern. Mem. December 17, 1825). Day further remarked that according to Southwell, Mr. Egerton acclimatized smelts in fresh water in a lake at Roselherne Manor, Knutsford, Cheshire, and that many were kept alive in tanks in the Norwich fish market until required for use.

Concerning these fish Day said that W. Wankly of Grange-over-Sands, Lancashire, sent an account of them to Land and Water, and observed he was much struck with the very rapid growth of the sparling from October to March—in October,

10 or 12 together weighed no more than 1 pound; in March the fish were 4 ounces to 6 ounces each, and occasionally one or more in a take weighed close to 8 ounces.

In this country there are not many reports concerning rehabilitation of coastal streams with smelt by fish-cultural operations. Mather (1894) gave a table showing the number of fry and eggs planted in one stream in Connetquot River, a small stream rising in the center of Long Island, north of Yaphank, and flowing into Great South Bay near Bellport, from 1885 to 1894, both inclusive, amounting to 55,000,000. Concerning these facts Mather said:

> That we have made rapid strides in the work of smelt hatching is shown by the table giving our yearly plantings, where it will be found that of the 55,000,000 fry and eggs distributed in ten years almost half the number was sent out this spring. It should also be borne in mind that this great result was obtained from an insignificant stream that never contained smelts before—is was stocked by the New York State Fishery Commission.

In this country, too, there are a few instances of the successful transplanting of marine smelts into fresh water. The report of the commissioners of fisheries of Massachusetts for 1868 (p. 20), states that smelt were introduced in Jamaica Pond near the close of the preceding century, and live there entirely cut off from salt water.

The Massachusetts report for 1870 stated that a number of mature smelts had been put in Flax Pond, in Wareham, the preceding spring, and that fall great shoals of little smelts were seen about the edge of the pond, showing the success of the attempt.

The possibility of the natural occurrence of fresh-water smelt in Massachusetts is suggested by an article in Forest and Stream for April 18, 1889 (p. 259), which said:

> From Cape Cod, Mass., we have received some specimens of a fish known there as fresh-water smelt. The examples are about 5 inches long and represent about the average size of the fish. The species is found in two or three large, perfectly landlocked ponds, which have no visible outlet and are remote from salt water. We are informed that no stream ever has connected these ponds with the ocean. The fish are never seen except for a few nights during the first week in April, when they come to the shore to spawn. They can readily be taken with dip nets or landing nets. Under proper conditions bushels of them can be taken in a single night. Few persons know of their existence. Unless the ponds are visited at just the right time, and with a light, the fish can not be seen. This fish is a very delicate and toothsome little species, having the flavor of a salt-water fish. * * * . The only changes that we can observe as the result of landlocking are a reduction in size and the strength of the teeth. The specimens obtained were caught on the night of April 3 and appeared to be spent females.

Of course, if the ponds never had any outlets the smelt must have been introduced by some means or other, perhaps by the hands of man or possibly by the feet of birds.

It appears that smelts have been introduced with some success into other ponds of Massachusetts, of which Onota Lake near Pittsfield, is a notable example.

Fresh-water smelts appear to be unknown in Rhode Island and Connecticut, and in Vermont are recorded only from Lake Champlain. In New Hampshire they occurred naturally in Winnepesaukee and connecting waters; and, according to the reports of the commissioners of fish and game, they have been successfully transplanted into some other waters of the State.

In Maine there are numerous instances of successful introduction, as in Moosehead, Rangeley Lakes, and the Eagle Lakes in northern Aroostook County. There appear to be no records of successful plantings of the fresh-water smelt in New York waters, but there are a few records of the transplanting of the salt-water smelt, some of which were unsuccessful and others at least temporarily successful.

A correspondent of the American Angler on October 7, 1882 (p. 228), stated that some smelt furnished by a Mr. Blackford were put into Otsego Lake, which seemed one of the best to test them, but that circumstances not favorable to a successful plant may have prevented success in this case, as none of the product had been seen in the lake. He regarded the experiment as worth repeating.

Early methods of transplanting consisted of transplanting eggs or adult spawning fish, as indicated by a correspondent of Forest and Stream on October 23, 1890 (p. 271), who said that the smelt usually were transported as fish but that a Mr. Aiken had established them in Webster Lake, N. H., by the "novel method of taking the fertilized eggs after they had been glued to stones in the spawning brook. Stones with the eggs upon them were placed in a little tributary of Webster Lake, and now the waters are teeming with smelt."

Another method was mentioned by Cheney (1876), who wrote:

> Commissioner Stanley told me in New York recently that he could stock any lake with landlocked smelt for $25. So the question of food for salmon is not a difficult one. In some localities where the landlocked smelt abound there are no facilities for hatching the eggs artificially for the purpose of transplanting. Where such is the case and it is desired to transplant smelt, brush may be cut and thrown into a stream where the smelt run to spawn, and the eggs adhering to the twigs can be transplanted in cans of water to the stream or lake to be stocked.
>
> Commissioner Wentworth, of New Hampshire, told me that at Sunapee Lake, N. H., smelt were caught for salmon bait and put into an old half-sunken row boat near the shore. The smelts spawned in the boat and the fry hatched and literally swarmed in the boat after the parent fish had been used for bait. I have seen young smelts at the mouths of the streams in the same lake in myriads in spite of the number of fish ready to prey upon them.

Another interesting but short-distance method is described in the report of the Massachusetts commissioners for 1918, page 145, as follows:

> *Experiment in collecting and shipping Spawn on Burlap.*—Last year the smelt spawn was collected by placing the burlaps on the bottom of the river and allowing the smelt to deposit the spawn thereon naturally, with the result that the eggs were laid unevenly and a large percentage infertile. Attempts were made this year to devise a more satisfactory method by stripping the fish, fertilizing the spawn and spreading it in the quantity desired. It was done in this way. The spawn immediately on being taken from the fish is brought to the spreader, who is stationed before a tank of water 8 inches deep, of just the size to hold horizontally the sheets of burlap. These are 16½ by 20 inches in size, with a strip of lath tacked at two opposite ends to facilitate handling. Quick action is required or the eggs, fresh from the strippers, will lump together and be spoiled. A small quantity of eggs is mixed in a bucket of water and poured into the tank. The eggs settle as sand would do, and adhere wherever they touch the burlap which lies at the bottom. The success of this work depends upon keeping the water moving so that the eggs will settle in a thin, even layer, and not on top of each other, or too many in one place. After allowing one minute for the spawn to settle, the burlap is turned over and an ounce of spawn placed on the other side. A second burlap is put in over it (the tank has a capacity of ten), and the process is repeated until the tank is full. One pan of spawn covers three burlaps. When the tank is full the aprons are transferred to a frame which holds them straight and smooth, and placed in the "Jumbo Hatcher" in which the hardening process is continued further. This piece of apparatus consists of a tank equipped with running water (piped in from the pond), so arranged that the water will run evenly on both sides of the ten

burlaps which are arranged to fit into it. This apparatus could be used for hatching if desired, but this year was utilized only for hardening. The eggs are left to harden from twenty-four to seventy-two hours, at the end of which time the spawn may be transported, but has not reached the eyed stage.

The burlaps were shipped to applicants by express prepaid, packed in baskets of sphagnum moss, which holds the moisture and maintains an even temperature. This method of shipment proved satisfactory only for nearby waters. Considering the slowness of transportation by express, and the present condition of railroad facilities, distribution by automobile would be the best method. Planting is accomplished by the simple method of selecting a place where the water has a fairly swift current, and placing the burlap on the bottom, weighted down with stones at each end.

The report for 1921 states that "several bushels of spawn-covered grass were planted in the Jones River, Kingston, as has been done yearly since 1917."

While considerable success has attended the attempts to stock New England waters with smelts, it appears that some difficulty has been encountered in efforts to stock waters at a greater distance from the source of supply. While living adult fish possibly might be transported, it would hardly seem feasible to transfer them in sufficient numbers to stock a lake, especially one in which predatory fishes occur, for it is likely that all would be devoured before they could breed, although an initial stock of smelt in a small pond might be established if there were no other fish to eat them. To transport fish in breeding condition would be still more difficult, and even if they endured the journey and did not spawn on the way they would not be likely to spawn after they were planted. The most practicable way appears to be by transfer of eggs, in which the difficulty lies in the shortness of the incubation period and the danger of the eggs hatching before arrival at their destination.

The most signal success in stocking distant waters that has come to our attention is that of Crystal Lake in Michigan. It appears that of 20,400,000 eggs shipped to the Michigan Fish Commission from the Green Lake station of the Bureau of Fisheries in April, 1912, 16,400,000 were planted in a tributary of this lake.

In 1922 the result of the introduction was manifested by the appearance of breeding fish in tributary streams of the lake. The Rev. J. Warren Leonard, of Lansing, who was interested in stocking the lake, informed the writer that the smelts ascended one of the streams tributary to Crystal Lake to spawn in such quantities that they were drawn away by wagon loads to be used as fertilizer. This seems like "old times" in the East. The size of the fish was reported to be as large as 9 inches in length. The smelt eggs in this case were of the "large" smelt of Green Lake.

Creaser (1925) shows that on April 4, 1912, 6,000,000 eggs were deposited in Torch Lake, Antrim County, and on April 6, 1912, 16,400,000 eggs were placed in Crystal Lake, Benzie County, Mich. Eggs were planted elsewhere in Michigan, also, of which there is no definite information of locality or results. About 200,000 eggs were sent to the Huron Mountain Club of Marquette County, which were planted in Howe and Trout Lakes in that county. According to Creaser, specimens have been taken or recorded from the following places in Michigan:

1. Crystal Lake, Benzie County, Beulah, Mich. Specimens have been taken in the lake proper in summer and winter and at a great range of depths; from a tributary, Cold Creek, at the village of Beulah; and from the outlet, East Betsie River, which runs into Lake Michigan.

2. Lake Michigan, 5 miles south of Frankfort, Mich., and 1½ miles out in the lake. A specimen was taken in a gill net by commericial fishermen, who report that the smelt is abundant in Lake Michigan, off Frankfort.

3. Howe Lake and Trout Lake, Marquette County, Mich. Dr. Walter Koelz made a trip into this region from August 23 to September 2 and caught smelt in both of these lakes. They were 1 to 4 years old, which indicates that they are established in these lakes. Howe Lake has no outlet, but Trout Lake drains through Pine Lake to Lake Superior. The presence of smelt is accounted for by the egg plantings of 1912 and 1918.

4. Lake Michigan at Northport, Leelanau County, Mich. Dr. Koelz interpreted a description of a strange fish caught by fishermen of this region as that of a smelt.

Creaser states that the foregoing constitutes the knowledge of the distribution of smelt in the upper waters of the Great Lakes. He says that fine mesh gill nets, which caught smelts at Crystal Lake, failed to take them in Torch Lake, Antrim County, which was planted at the same time that Crystal Lake received eggs.

As previously mentioned, the most marked results of these attempts at acclimatization of the smelt in this region appears to be in Crystal Lake. Creaser decided from age determination made from their scales that the smelts of April 17, 1923, were the product of natural spawning in the spring of 1919, 1920, and 1921. He states that large breeding runs in and about Beulah have occurred every spring since 1919. Many 2-year-old fishes were taken April 6, 1925, which were hatched in the 1923 run.

Creaser says that smelt are very abundant in Crystal, Howe, and Trout Lakes, and at Crystal Lake they are caught at all seasons of the year with hook and line, most frequently, however, in the winter through the ice by the perch fishermen. In the winter of 1924 they reported that one-half of their catch was smelt.

He writes that the Michigan State Department of Conservation, through Mr. Craw, tried to catch all the smelt that came into Cold Creek at Beulah during the spawning run of 1925, but for what reason is not stated. Each person was allowed 20 pounds. The game warden kept an account of the number of men at work, as nearly as possible under the circumstances. From those data, on the basis of an average of six smelts to a pound and the prevailing price of whitefish, it is estimated that in seven days 16,000 pounds, or 96,000 individuals, valued at $5,600, were caught. It is quite evident, therefore, that the smelt has become completely established in Crystal Lake, as Creaser says.

A letter from Carl L. Hubbs, University of Michigan, dated April 26, 1924, says: "Just recently we have received a smelt from Green Bay, across Lake Michigan from Crystal Lake. It is evident that the species is spreading in the Great Lakes region."

In a letter to the United States Commissioner of Fisheries, dated March 27, 1909, E. E. Race, then superintendent of the Green Lake station, referred to an experiment that had been undertaken for the purpose of determining how long smelt eggs could be kept alive in transportation. Mr. Race wrote:

> March 17th, in compliance with instructions we packed about 15,000 as taken from the troughs in bunches, and a few that were separated, in a common shipping case with ice hopper. These have been examined several times, and ice added when needed. There are eight trays in the stack, and

the eggs were placed on the second tray under the ice hopper and the last tray near the bottom part of the stack. Yesterday they were found in excellent condition. There was no noticeable difference in the eggs on the two trays, except that on each tray the eggs that were separated showed a larger loss than those which were bunched, and the losses apparently larger on the bottom tray. We estimated that the total loss is less than 5%. Did not count the dead eggs, as it seemed best to close the case at once, and we don't know the exact number in the case, as the number in bunches could not be counted or measured, but approximately the losses thus far have been on the entire lot about five per cent of the number packed.

In another letter, dated April 26, 1909, Race further described the developments in the experiment. He said that the 15,000 smelt spawn packed in one of the regular transportation egg cases, with exactly the same care with which other classes of eggs are packed for long shipments, plainly showed that by packing them as soon as taken and without trying to separate the bunches they can be transported safely a long distance, provided they are kept well iced in transit. The last eggs in the bunches died 3 days previous, having become somewhat foul or sour from being closely packed, and this would seem to indicate that by repacking or giving them a little fresh air daily, 45 or 50 days' shipment would show good results on arrival. The separated eggs all died, while the bunched eggs were still in good condition.

In April, 1912, also, several million smelt eggs were planted in Torch Lake, also in Michigan. On May 18, 1916, 10,000,000 were placed in the waters of St. Mary's River, and on May 30, 1921, 200,000 were deposited in Sturgeon River of the same State, all from Green Lake, Me.

It is quite probable that at least the earlier shipments to Michigan were made under the conditions mentioned above, but the time in transit could not have been more than a few days. The smelt eggs of the first two lots—that is, Crystal Lake and Torch Lake—were all of the same shipment and doubtless were eggs of the large smelt. The others probably were the eggs of the small smelt.

The incubation period of the large smelt is about 30 days with the temperature of the water around 34° F. The incubation period of the small smelt in the same season is about 24 days with water temperature around 48° F.

In Race's experiment, evidently with eggs of the large smelt that had been packed on March 17, the last eggs were dead on April 23, a period of about 37 days, or a week over the incubation period. This would seem to suggest that by keeping the temperature down by means of ice, the limit endurance had been reached, and it is hard to see how it could be expected that under any circumstances eggs could be retained without dying or at least hatching for a period of five or six weeks beyond the incubation period.

It would appear that long-distance transportation of smelt eggs, the incubation period of which is so short at a temperature so near the freezing point, could not be greatly prolonged by reduction of temperature. In the case of eggs of the small smelt it would seem that a reduction of temperature to near freezing, if it did not kill the eggs, would simply serve to prolong the incubation period to the same length of time as was effected in the case of the large smelt.

If it seems desirable and a good policy to stock distant waters, as those of the far West for example, about the only practicable way to transport the eggs that occurs to the writer at this time would be by relays, now "taking departure" from

Crystal Lake, Mich., for example, and stocking some waters farther west, and so on until the most remote point is reached. This procedure would take time and money. Would the desired results, if attained, be commensurate with the cost?

DEPLETION

Seventy-five years ago the early depletion of the smelt fishery was predicted. In 1849 Frank Forester (Herbert, 1849), referring particularly to the smelt of the Passaic River in New Jersey, said:

> The run of them is becoming less and less numerous every successive season, and it is to be apprehended that ere long they will cease to visit us at all.

Twenty-seven years later, according to Thomas (1876), the fish were scarce enough to give rise to his query: "Why can not these fish be made more common?" Nearly a decade later than this, Mather (1885) wrote:

> The catch has been gradually decreasing for the past few years, not only at Locust Valley, but on all Long Island streams * * *.

Some 15 or 16 years after Mather's experiences at Long Island, Cheney (1901) wrote:

> For two years past the State of New York has been unable to obtain smelt eggs on Long Island, though in former years they have been obtained by the millions, as the plant of fry in 1896 was 34,000,000, in 1897 45,000,000, and in 1898 48,000,000, all from eggs taken in Long Island streams. There was a falling off in 1899 to a very few millions, still worse in 1900, and this year [1901] none at all, though the north and south shores were explored at the usual time for smelt to run.

The decrease in the smelt fishery of Massachusetts has already been discussed in preceding pages, but in recent years it has been seen that there were a few abundant local runs.

In Maine, as long ago as 1869, Atkins (1869) said:

> The impression has been quite general that the smelt fishery is over-done, and that unless some radical measures are taken, it will soon fall into as great decay as have the salmon and alewife fisheries. Indeed, in some parts of the State the decline has already commenced, and even where the numbers of the smelts have shown as yet but little diminution, the decrease in size is very marked.

Whether or not the radical measures were taken, for more than 30 years the smelt fishery of Maine continued to yield considerable though fluctuating quantities of smelts, as has been seen from the discussion of the commercial fishery. However, in 1920 the director of sea and shore fisheries of Maine (Crie, 1920), after discussing the probable cause of the depletion of the smelt fishery, expressed the following sentiment:

> Therfore it is quite apparent to anyone who will give the subject the attention it merits that the smelt fishery of Maine is depleted and on the wane and it seems to this Commission that, after God had furnished this great and abundant food supply to the inhabitants of the State of Maine, we are not doing justice to the State or to ourselves unless we enact laws, good rigid and enforceable ones, to protect the smelt in it's season of reproduction, i. e., the spawning season.

Whenever there has appeared to be a falling off in the smelt fishery, as in some other fisheries, quite generally the fact has been attributed to overfishing, although at times some curious opinions concerning the cause of scarcity have been offered.

In explanation of the scarcity on Long Island, N. Y., Cheney (1901) wrote:

> In 1900 it was thought that the heavy storms which prevailed at the spawning season prevented the smelts from running into the streams where they were in the habit of spawning, but this would not be an excuse this year. Talking with Mr. DeNyse, he said, quite positively, that he believed the codfish artificially hatched by the United States Fish Commission and which now swarmed in Long Island waters, had preyed upon the smelts to such an extent that they were practically destroyed where they were formerly so abundant. He did not say what evidence, if any, he had of this, except the presence in vast numbers of the young codfish, where formerly smelts were plentiful, but it may be a reasonable explanation of the disappearance of the smelt.

According to Atkins, the scarcity of smelts in the spawning season at Surry in 1878 was attributed by N. Hinckley, Esq., to too much dipping when the tide was out and the fish collected in bodies in tide pools; while in the same year, in the case of Lawrence Brook, Atkins stated that Billy Harriman thought that eels kept the smelts out of the brooks, as, he said, when eels get into the brooks first, as they did this year, it often happens that there is a scarcity of smelt.

Mather (1885) attributed the growing scarcity of smelts of Long Island to overfishing during the breeding season. He said:

> Their habit of ascending streams at night and returning to salt water before day renders them liable to capture both ways * * *.

In his notes of 1910 the present writer finds the following remark:

> So many boys were after smelts on Porter's Landing brook [Freeport, Me.] that the fish got but little chance to spawn. However, some smelts probably would have been able to ascend if it had not been for the seining in the creek and river just below the brook. Spring seining should be prohibited from March 1.

As elsewhere stated, it has been observed that smelts congregate at the mouths of streams even before the ice is out, for some time before ascending to spawn. It was this fact and the seining of those fish at the time that gave rise to the foregoing remark. That there has been more or less general decline is evident. This and the total depletion of the smelt fishery in some localities are attributable to one or more, and in some instances perhaps to all, of several causes, which may be classified, at least in part, as follows: (1) Interference with reproduction; (2) excessive and wasteful fishing

The first class comprises obstruction and pollution of streams formerly frequented by smelts for breeding, and uncontrolled fishing during the runs in the streams at spawning times. The second principally involves destruction of immature fish in the course of legal net fishing during the open season.

Dams have formed the principal obstructions in many streams, and they are too general for specific citation. Instances of pollution of streams affecting smelts are not as numerous, but the Passaic River in New Jersey is a conspicuous example.

The destruction of smelts on and near the breeding places during the breeding season, formerly a common practice, has been stopped in some localities but still obtains in others. In almost all of the present smelt fisheries, excepting the hook-and-line fishery, destruction of immature fish, especially those about 1 year old and upward, prevails. Every year during the open season, wherever seines are used in the capture of smelts, a vast number of immature smelts and those that would

spawn for the first time in the following spring are caught. In late years there has been a market for these little fish, but usually they have sold for a comparatively very low price. In Boston the tiny smelts are known as "cigarettes," and to the writer one wholesale dealer expressed the wish that the capture and sale of the fish of this class could be prohibited. The market for the "cigarettes" is not constant, consequently many that are caught are thrown away after culling out the larger fish.

In December, 1924, the writer bought 1 pound of these tiny fish in a retail store in Portland, Me., for 30 cents. Forty-one fish made the pound. Amongst the fish there were only eight that showed by the condition of the roes and milts that they would have spawned the following spring. The 8 comprised 2 females each slightly over 5 inches long, 1 female about 6.4 inches long, and 5 males a little over 5¼ to nearly 6 inches long, averaging about 5½ inches. The other 33 specimens ranged in total length from a little over 4½ to about 5.7 inches, averaging not quite 5 inches.

It is almost impossible to avoid taking large quantities of these little fish in drag seines, whatever the size of the mesh, if the mesh is small enough for ordinary smelts. When the seines is hauled the meshes draw together and the small smelts are caught in the jam of larger ones and other fish incidental to the haul. They are all killed, and so long as general and unrestricted seining is allowed great numbers of the fish must be killed and it would be an economic waste to prohibit their sale. Of the North Atlantic smelt-producing States, Maine alone still provides a fishery of considerable commerical importance and value, notwithstanding the long-standing and oft-repeated warning that its exhaustion is imminent. The expressions of alarm concerning the possibility of a ruined fishery have been based upon some notable local or general decline in the fishery, and when the fishery showed marked improvement the improvement usually has been attributed to some beneficent human action.

Apparent declines have been ascribed to sundry causes, as previously mentioned. As a matter of fact, a small catch or a small breeding run in any year may have been or may be, in many instances, due to natural causes. A generally poor breeding season in one year, for instance, might be followed by a poor supply of adult fish, as manifested both by the fishery and the breeding runs two years hence.

A phenomenon well known to smelt fisherman is that of a marked scarcity of small adults smelts and a comparative plenty of large sizes. Such a condition may be occasioned by a poor breeding season two years prior to the occurrence, resulting in a small number of 2-year-old fish but with a normal survival of older fish that have increased in size. Conversely, another manifestation is that of a great abundance of small fish and perhaps a scarcity of large fish, which is the outcome of a good breeding season two years or so prior thereto with a consequent large number of smelt of smaller sizes, the large fish having diminished in number for one reason or another. These two examples will suffice to illustrate how the fishery may be affected by natural fluctuations. Poor as well as good breeding seasons, however, may be influenced both directly and indirectly by the act of man. One of the most potent and disastrous adverse influences is that of interference with the fish during the breeding season.

Foster and Atkins (1868a, p. 29) reported that there was a complaint against Androscoggin fishermen. They wrote:

> It is said that at the mouth of a small stream, somewhere above Bay Bridge, where the smelts are accustomed to run in the spring to spawn, and where it has been the custom to dip them, for several years a seine has been used, and tons of them were taken out when nearly worthless for food. Many were shipped to New York, and commanded a price that hardly paid for transportation.

The present writer has knowledge of similar instances. In some localities smelts are known to congregate in suitable places, usually near or at the mouths of the streams, prior to ascending them when they become favorable. In Casco Bay there are several such localities. There the drag seine is used up to the very last day of the open season (March 31). In Freeport, on one occasion, as soon as the place was free from ice so that the seine could be hauled, one seiner got, in a single haul, a catch of smelts for which he realized $200. It has been customary to seine this place every year just before the spawning run should take place, and this has resulted in a diminished run. This custom, together with the customary intensive and highly destructive dip-net fishing in the fresh-water portion of the brook, could not but seriously affect the number of smelts in the region. Not only were great numbers of smelts prevented from ascending the stream, but those that did ascend were prevented from spawning.

In all the reasons given for poor breeding seasons or scarcity of smelts fault seldom has been attributed to the dip net, but almost always the seine has been the object of attack. The seine has been accused of being one of the most destructive appliances used in the smelt fishery.

This belief is one of the long standing. In a discussion of Mather's paper on smelt culture (1885), Theodore Lyman, formerly one of the commissioners of fisheries of Massachusetts, said that a decline of the smelt fishery some 20 years before was supposed to have been due to the capture of the fish by means of nets stretched across brooks, which prevented the fish from ascending the stream. In an edition of "American Fishes," by G. Brown Goode, which was revised by Theodore Gill and published about 1904, on page 506 a reference is made to the smelt fishery in Casco Bay. It says:

> In this locality twenty or thirty years ago and perhaps later, brush weirs were used to some extent during the fall. There was then a profitable fishery. At the present time there are but two or three weirs, which do a very small business. I know of several weirs that have been abandoned as unprofitable, notwithstanding the cheapness of their construction. They have not paid, of late years, for the labor of erecting them and the time expended in tending them. The seine fishermen do better. These fishermen usually have a large boat or scow, which they can move from place to place, and fish the various arms of the bay, coves, and creeks. Some fishermen get a good many smelts on the beaches of some of the islands without going far from home. [Cf. W. C. Kendall.]

If seine fishing is more destructive than other methods it must be because of some element not possessed by other methods. It is true that the drag seine forms one of the most intensive methods employed in the fishery in Maine, for it is a movable fishery and not restricted to a particular spot, as is the weir or pound net. In order to be caught the smelt is obliged to go to the weir, but the seine can go to the smelt.

The table given on page 256, showing the quantities of smelts taken by the various methods employed in Maine from 1887 to 1908, shows that in 1887 and 1888 the hand line far exceeded the seine in number of pounds caught. In 1898 the seines exceeded the hand lines by a comparatively small margin. In 1905 hand lines again were somewhat ahead, but in 1908 seines far exceeded the hand lines. In 1887 and 1888 bag nets and dip nets were next to hand lines (which were first) in the amount of smelt taken, and took more than double the quanity caught with seines. In 1898 and 1905 bag nets were third, and in 1908 they were the lowest of the six categories. The fact that in the earlier years seines were secondary to the hand lines might suggest that fewer seines were then used than in later years, which is probably the case, and perhaps they were not as effective in taking the large fish then demanded by the market.

While a casual examination of the statistics given in the table on page 257 does not show a positive and permanent decline in the smelt fishery of Maine up to 1916, a closer scrutiny of the statistics, considered with recent verbal reports and opinions of the fisherman and observations in the field, does indicate a decline. A falling off in the line fishery indicates a relative scarcity of fish of the larger sizes, which constitute the catches by that method; and while the gross quantity caught by all methods perhaps does not show such an alarming falling off, the decrease in size of the bulk of the fish marketing, taken by other methods than by line, together with the falling off in the line fishery, is very strong evidence of a declining fishery.

Cases of local depletion and even exhaustion of the fresh-water smelt are on record. The only methods of taking the inland fish have been by hook and line and by net in the breeding season. The line fishery can make no very appreciable reduction in the number of smelt, but fishing during the breeding runs is as destructive in inland waters as it is along the coast.

CONSERVATION

In various States, particularly in Massachusetts and Maine, for many years legislative measures have been enacted aimed at better protection of the smelt and improvement of the fishery, but for one reason or another the desired results have not been attained, as indicated in the foregoing discussion of depletion. In Massachussetts the act approved April 9, 1874, says:

> First, whoever within the Commonwealth offers for sale, or has in his possession, any smelts between the 15th day of March and 1st day of June in each year, shall forfeit for each and every smelt so sold, offered for sale, or had in his possession, the sum of one dollar. Second, whoever takes or catches any smelt or smelts with a net of any kind, or in any other manner, shall forfeit for each smelt so caught or taken the sum of one dollar (proviso—not to apply to smelts caught in Bristol, Barnstable or Dukes counties by persons lawfully fishing with net for perch, herring, and alewives); and in all prosecutions under this act the burden of proof shall be upon the defendant to show that the smelt or smelts, the offering for sale, possession, or catching of which is the subject of prosecution, were legally caught.

Referring to this law, in a discussion of Mather's paper on hatching of smelt (1885), Theodore Lyman, formerly a commissioner of fisheries of Massachusetts, said:

> As you will all recollect, some twenty years ago or rather more, in Massachusetts the smelt fishery had greatly declined. It was supposed to be due to the capture of the fish by means of

nets stretched entirely across the brooks, which prevented the fish from ascending the stream. The law to which Mr. Mather has referred was passed on the recommendation of the Fishery Commissioners of Massachusetts. In two or three years the catch of fish was very greatly improved, so much so, that the bays and streams which had been nearly depopulated, once more became filled with valuable fish. Ever since then, we had a pretty good supply of smelt in our State.

The good results mentioned by Lyman apparently were very local and temporary, as is learned from the more recent reports of the Massachusetts commission, that of 1916 saying in effect that the fishery was in a depleted condition and calling for strenuous and radical measures for its restoration.

In Maine, as early as 1869, a law was passed locally restricting smelt fishing to hook and line, according to Atkins (1869). He wrote:

The act "to protect smelts in the waters of the Kennebec and Androscoggin rivers", approved March 4th, 1869, aims to lessen the catch by prohibiting the use of any implement but hook and line every alternate year, and at the same time allow the fish to ascend these rivers to the points where they were wont to be taken with hook and line. Undoubtly the first mentioned object would be attained, but whether the latter would is uncertain. It is desirable to substitute for this some act of wider application, and consequently bearing more equally on all who are engaged in this fishery. I suggest whether a prohibition to take smelts except during December, January and February, by any other mode than hook and line and perhaps the dip-net, would not apply well to the whole State. The smelt fishery now commences much earlier in the fall than is for the advantage of the fishermen themselves even,—frequently in October, when fish are with difficulty marketed in good condition, and a great waste and deterioration is the consequence. So in the spring, also, the facilities for marketing in a frozen condition are not good, and as the spawning time approaches the quality deteriorates; yet there are some localities on the coast where the smelts appear in small streams only in the spring, and would be of no use if they could not be taken at that season.

This law appears to have been of local application and intended for the benefit of one class of fishermen only. The shortening of the season would no doubt be of benefit to the smelt, as would the restriction to hook and line and at that time perhaps would not have been very unfavorable to the fishermen. In late years, however, the matter of marketing and deterioration is not so doubtful owing to refrigeration facilities. One of the most striking statements in this discussion is that of the qualifying suggestion that there are some localities on the coast where the smelt appear in small streams in the spring, and would be of no use if they could not be taken at that season. As the smelts appear in such streams in the spring for breeding purposes, it is hardly necessary to indicate in what way they would be of use if not taken. The harm done by taking them at that season in such places has already been shown.

Previously the same commissioner had remonstrated against seining at the mouth of a stream, but while indicating that dip nets were used there nothing was said against the practice. However, later he wrote (Foster and Atkins, 1868a, p. 29):

We think no smelts should be taken during the spawning season—say from April first to June first. Enough can be taken in the fall and winter, when they are in good condition, and it is wonderful that they can stand the draft that is then made on them.

Commissioner Counce, of the sea and shore fisheries commission of Maine (1888), stated that section 5, laws of 1887, provided that no smelts caught in weirs after the first day of April should be sold or offered for sale in the State, nor should smelts

caught in any manner between the first day of April and the first day of October following. He said:

It will be seen by the above that no smelts can be sold in this State after April 1st, caught in any manner except by hook and line. Many complaints have been made to me by people that could not get smelts to eat unless they were made liable to fine, as the ice seldom leaves our bays and brooks in season for smelts to come up before April 25th, and it would seem that the time should be extended for taking smelts in the spring by dip-net to May 1st. It was formerly May 20th, but was changed to suit the weir men, and certainly it would look hard that the spring fishermen should be entirely shut off that fall fishermen should gain.

Large quantities of smelt were caught in dip-nets last spring and left to lay on the ground to rot, when they might have been sold for $2.00 or more per bushel if allowed to be sold. Therefore I would recommend that dip-nets may be used to May 1st, and that smelts caught in this State may be sold up to that time.

In his report for 1889–90 this commissioner made the same statement and recommendation. The first part of the criticism of the law is quoted verbatim from a recommendation of one of his wardens or deputies, O. S. Despeaux (report of the commisioner of sea and shore fisheries of Maine for 1886, p. 46). His final statement and recommendation should be compared with the same commissioner's statement and recommendation on page 38 of his report for 1886, where he says:

I would recommend that no smelts be sold between the first days of April and October, under penalty of not less than $10 nor more than $30 for each offense, and a further penalty of twenty cents for each smelt so sold except caught by hook and line. Provided, that dip-nets may be used between April 1st and May 1st.

Counce's discussion of the situation is astonishingly inconsistent. His recommendation for an open season during the breeding season of the smelt appears to be based upon local if not merely individual sentiment. Excruciating logic is shown in the argument in favor of the measure, in the allegation that people could not get smelts to eat unless they were made liable to a fine, while large quantities were caught in dip nets and left on the ground to rot. Was it not as illegal to catch them as to sell or eat them? The following discussion is a more rational statement of the case:

Commissioner Donahue (1908) of Maine, in his report for 1907–8, wrote:

The smelt is one of our smallest but also one of the best food fishes, and while it is not of so much commercial value as some of the others it is one that furnishes employment for a large number of men in the winter time, when other employment is not obtainable. The laws regarding this industry come mostly under the head of special laws, which have been passed at the instance of residents of particular localities where the fish are abundant. In other sections of the State, where this fish is not plentiful, little attention is paid to the industry. I assume that these localities where special laws apply are satisfied, and, therefore have no recommendations to make, otherwise than to repeat what I have said in connection with another industry; viz., that the laws are in a very chaotic condition, and for the interest of all concerned parties especially interested in the smelt fisheries should see to it that the present special laws are more accurately drawn and defined.

In this manner the laws of various States differ in the prescribed restrictions and limitations respecting the fishing season, methods of capture, etc. In fact, they differ widely and, it may be said, sometimes inconsistently within the bounds of the same State, and sometimes from one session of the legislature to another.

Again Donahue wrote (1913):

There are innumerable laws, both general and special, governing the catching of smelts; and it is practically impossible for smelt fishermen, when changing from one section to another, to know

when they are violating the laws, as the law between two specific points on the coast in one section is entirely different from that in another section but a few miles distant. The legislature in 1911 passed a law that prohibited taking smelts in any other way than by hook and line or weirs or set nets through the ice, within one-half mile of the coast line at near high water mark, from Cape Small Point on the west bank of the Kennebec and continuing easterly along the coast of Maine to Owlshead on Penobscot Bay. The law is very unsatisfactory and is working great injury to the smelt fishery in the rivers between those two points, as it allows the smelts to be taken in weirs and with set nets through the ice in rivers which are so narrow that such devices catch practically all the fish that come into them. I would advise that the law be repealed and that a new general law be passed, prohibiting the catching of smelts in any river or bay the entrance to which or any part thereof is less than one-half mile in width, in any other way than by hook and line. The present method of catching, viz., with nets and weirs, in those small rivers and bays which the smelt frequent for the purpose of spawning will ultimately destroy the species. There seems to be no good reason why one general law can not be framed that will apply to all sections of the State.

In 1917 the general law of Maine (P. L. 1917, chap. 71, sec. 74) provided that:

No smelts shall be taken or fished for in tidal waters, nor in any brook, stream, or river emptying into tide waters, within one thousand feet of tide water, except by hook and line, between the first days of April and October, under a penalty of not less than ten, nor more than thirty dollars for each offense, and a further penalty of 20 cents for each smelt so taken; and all weirs for the capture of smelts shall be open and so remain, and all nets used in the smelt and tomcod fishery shall be taken from the water on or before said first day of April under a penalty of not less than twenty, nor more than fifty dollars, and a further fine of five dollars for each day that such weir or net remains in violation of the law. But weirs with catch pounds covered with nets, the meshes of which are one inch square in the clear, or greater, or weirs with catch pounds covered with nets which are erected and used for the catching of herring are not subject to this section. But no smelts caught in such weirs after the first day of April shall be sold or offered for sale in this State, nor shall smelts caught in any manner between the first day of April and the first day of October following be offered for sale, sold, or shipped from the State under a penalty of twenty-five dollars for each offense.

Then follow a dozen or more exceptions and no less than 18 special laws applying to separate localities. These laws were in force until the legislature attempted to amend them in 1923.

Chapter 132, Public Laws 1923, "An act to repeal sections seventy-four, seventy-five, seventy-six, and seventy-seven of chapter forty-five of the Revised Statutes, and enacting a new law for the better protection of smelts," says:

Section seventy-four as amended by chapter seventy-one of the public laws of nineteen hundred and seventeen, and sections seventy-five, seventy-six, and seventy-seven of chapter forty-five of the revised statutes are hereby repealed and in lieu thereof the following is substituted:

No smelts shall be taken or fished for in any waters of the state between the first day of April and the first day of October of each year, except by hook and line. Anyone violating any provision of this act shall be punished by a fine of one hundred dollars for each offence. Nothing in this act shall apply to smelts taken in fish weirs or traps maintained and operated for the catching of sardines and herring.

The inland law pertaining to smelts (sec. 26, chap. 219, P. L. 1917, as amended by chap. 244, P. L. 1917, and chap. 196, P. L. 1919, and chap. 218, P. L. 1921, and chap. 32, P. L. 1923), which stated that "it shall be lawful, however, to take smelts in all the inland waters of the State above tide waters with a dip-net in the usual ordinary way," etc., remained in the Revised Statutes.

This act of 1923 resulted in confusion and final announcements by the attorney general and the director of sea and shore fisheries that the law was invalid, with the consequence that there was unrestricted fishing in the brooks flowing into tide water.

The foregoing "samples" of legislation and recomendations pertaining to legislation have been given and discussed to bring out the point that laws have not always been based upon knowledge of actual conditions; and, added to ignorance of conditions, often sectional and political interests were, and still are for that matter, principal considerations in the formation and enactment of laws. This fact has resulted in the multiplicity of laws of local application to the detriment of the general smelt fishery, as indicated by Donahue.

There is no doubt but that a more or less waning smelt fishery has demanded and still demands conservative attention. There are evidently errors of administration of the fisheries that need to be rectified. Laws are necessary but they should be based upon exact knowledge of the conditions and needs of the fishery. This is not all, however. If the laws are to be effective, strict compliance with and rigid enforcement of them are requisite corollaries. Corrective measures must be based upon recognized causes and aimed at them. While individual cases call for more stringent measures than do others, uniformity in intent of purpose is indicated.

There are many adverse conditions affecting the fish supply, and consequently the fisheries, which the most well-observed or rigidly enforced laws can not wholly remove if any fishery at all is to be permitted, but most of them are remediable. Certain of such adverse conditions as may affect the fishery more or less have been suggested in the discussions of the fisheries and of depletion. They are not all, and probably all are not known.

Forty-seven years ago the fishery inspector of New Brunswick (Venning, 1879) wrote that the wasteful and destructive mode in which the smelt fishery was then carried on called loudly for some restrictive measures. He called attention to the enormous waste of young smelts and other fishes that were caught with the marketable fish, saying that he was led to believe that for every ton of marketable smelts exported nearly half a ton of small smelts, young bass, tomcods, and flatfish were wasted. He saw vast quantities of small smelts and tomcods lying on the ice and near the packing house, which he was informed were sold at 10 cents per barrel for the purpose of making compost for manure.

After referring to the enormous waste of young smelts, the destruction of which he believed must have a seriously injurious effect upon the coast fisheries by materially depriving other commercially important fishes of their food, he said that the mode of conducting the fishery should be restrained, and that it was a question for grave consideration whether the proper protection of the fisheries would not require the prohibition of bag nets everywhere, for no fishery could long stand so large an annual drain upon it. He said:

> This is no mere assertion, for we have the experience of the neighboring States in this very fishery, as a warning of the inevitable consequences. In Maine, Massachusetts and New York, where formerly the fish was almost as abundant as it is now in our waters, smelts have become very scarce from the same causes that are at work in this Province. These States are now dependent on our fisheries for their supply, Boston and New York furnishing the principal markets for our

shipments. These States have found it necessary to make stringent laws for the preservation of the species in their waters, and we should not ignore the lesson they teach us.

After quoting certain State laws that restricted smelt fishing to "naturally or artificially baited hook," and from a local newspaper that also decried the conditions described by Venning, he went on to say:

In view of these facts, the time has come when this monstrous waste ought to be looked at with the eye of common sense. What are the facts? This is but the third season of its existence as a systematic and organized fishery. The returns in the table show that in these three seasons it has grown from nothing to its present vast proportions. These returns, which fall far short of the whole catch, show that 1,213 tons of smelts have been shipped. Add to this large quantity half as much more for small smelts, young bass and tom-cods wasted, and take into account that these returns are only made up to 31st December, that two months more of this destructive work will continue, and we will have the astounding quantity of at least 2,000 tons of smelts and young bass, tom-cods and flat-fish taken from our waters in a single winter. Is it creditable that any fishery can stand this drain?

When one reads this article of Venning's upon the smelt fishery of New Brunswick, and his emphatic warning concerning the imminent exhaustion of the fishery, if he makes a comparison of the statistics representing the period from 1871 to 1878 (p. 261) with those of the period from 1913 to 1924 (p. 262), he will wonder if Venning's alarm, as well as that frequently expressed in this country, was not all "bunk." For it is seen that after a lapse of 35 years, from 1878 to 1913, or the beginning of the period shown by the table on page 262, which represents the export smelt trade of Canada, no evidence of depletion was shown by the quantities of smelts caught. Instead of the 1,213 tons of 1878, mentioned by Venning, in 1913 there were shipped from New Brunswick alone over 3,000 tons of smelts.

In the period from 1913 to 1923 the largest quantity was taken in 1918, amounting to about 3,496 tons. It is true that in 1923 there was a falling off in the quantity to the smallest amount in the 11-year period, but even so over 2,160 tons were shipped. There is no doubt in the present writer's mind but that Venning's expressed alarm was well founded; but if there was that danger of depletion in 1878 the question arises as to how the fishery was not merely maintained but greatly increased in magnitude of annual catches in the latter period.

There is no evidence of much, if any, modification in fishing apparatus, and there was no restriction of the methods to hook and line fishing. An increase in the number of fishermen and the intensity of fishing might account for larger catches but not for the almost uniform quantities for the 11 years, to say nothing of the quantities taken in the 35 years intervening between the two periods represented by the tables. While other factors may have been concerned in the preservation of the Canadian smelt fishery, there are two that appear to be paramount. One is the protection of the fish during its breeding season, and the other is the short fishing season, which extends only from December 1 to February 15 following, a period of two and one-half months, against the season of six months in Maine, with absolutely no protection during the period when, by propagation, the smelt is striving to do its part toward the maintenance of the fishery. In 1878 Venning advised drawing a lesson from the New England States; it now is strongly advised that New England, and Maine in particular, learn a lesson from New Brunswick.

In comparatively recent years a serious decline in the smelt supply of Massachusetts was noted, and the commissioners were concerned with ways and means of rehabilitating the waters. The proposed procedure pertained to accessibility of streams to the smelts for reproduction. Under the heading "The problem of restoration," the report of the commissioners for 1917 (p. 78) said:

> The real problem confronting the Fish and Game Commission is that of providing a spawning ground equal, as far as possible, to that which the smelt enjoyed before the day of dams and pollution, and to institute methods of saving a large per cent of the spawn wasted at present in such places as Weir River. To remove the pollution from the streams entering Boston Harbor will require considerable time, and probably never will be accomplished if present conditions are any criterion. The enlargement of the spawning grounds by removal of dams or installation of suitable fishways is likewise a work of years. The immediate relief of the smelt problem which will save the species from commercial extinction in Boston Harbor consists in saving natural waste of surplus smelt eggs by artificially enlarging the spawning grounds to accommodate the number of smelt which frequent them.

Referring to fishways, the report said:

> In general a fishway is not a practicable contrivance for smelt. At Weir River smelt were observed to shoot some very sharp falls. If the fish could get over the first dam they could reach extensive spawning grounds. However, the return over the dam would probably injure the delicate fish, and therefore it would be necessary to screen the spillway.

In the matter of the installation of fishways for any fish there appears to be a point that has not been taken into consideration. A screen might divert adult fish into a fishway or other passage on their return to the sea, but no practicable screen would prevent the young fish, particularily the very delicate fry of smelt, from going over the falls or dam if there is any overflow whatever. However, in Maine there is probably no lack of suitable spawning places for smelts, because, as has been seen, they ascend mere rivulets even; and probably there are but few instances of serious pollution or obstructions requiring a fishway, except in the rivers, even were fishways practicable. However, while Massachusetts has endeavored by legislation to protect smelts in the spawning places, Maine never has done so. Whatever the extent of natural breeding places, adequate natural breeding by the fish can be assured only by protection at the breeding season, and such protection must be afforded by leaving the fish and eggs undisturbed at the time. The law that permitted the use of the dip net in fresh water beyond 1,000 feet of tide water, and prohibited its use in tidal water, afforded no protection to spawning smelts except in the very few instances where the fish could not ascend above the high-tide limit. If the law had been reversed in its application, and the fishing in fresh water above tidal water and for 1,000 feet below high-tide limit had been prohibited, with a certain amount of dip-net fishing permitted below the 1,000-foot limit below mean high-water mark, the smelt would have stood a much better chance. For in most instances many smelts would have been able to ascend into the protected section of the stream before the use of the dip net would have been practicable below. Those fish would have then been able to spawn and the eggs could have incubated and hatched undisturbed, providing the law had been observed or enforced.

It is suggested, therefore, that all smelt fishing in fresh waters flowing directly into tidewater frequented by marine smelts for reproduction be prohibited during

the reproductive period from March 1 to May 31, and that regulated dipping be permitted in tidal portions of those streams 300 feet below mean high-tide mark three hours after high tide. The size of the dip nets should be regulated and the quantity of smelts that may be taken in any one night by each person should be prescribed. Furthermore, the season of such fishing should be limited according to conditions existing in any locality, and the closed season against all other methods of fishing should begin as early as March 1.

The writer is inclined to believe that some such law would afford ample protection to breeding fish, providing always it is properly observed or enforced. It would be more likely to be observed than would a law aiming to prohibit all "dipping" in the spawning season, for there are local residents near such streams or creeks who, as Counce said, are unable to get a mess of smelts at any other time, and who would be able to secure the fish legitimately under such a regulation, some of whom however, might be tempted to get their smelts anyway, if the law forbade all fishing.

This is not recommended on the ground that because some individuals will steal they be allowed a certain privilege so that it won't be necessary for them to steal, but because of the fact that it does not appear necessary wholly to withhold the dipping privilege from such persons as have regarded the spawning runs of smelts as their opportunity, and who in the nature of the case have nothing in common with the professional smelt fishermen or the smelt industry.

While such fishing should be properly and adequately regulated, there are other factors to be considered in a decline in the number of smelts, and doubtless some of them may be laid at the door of other methods and times of fishing. Sometimes it appears that the professional fisherman is as heedless regarding the perpetuation of the fish supply as is the most wanton youth on a smelt brook. Such being the case, his methods also call for regulation.

Commissioner Donahue referred to the employment of certain devices in rivers so narrow that the gear caught virtually all of the fish that entered them. Reference might have been made to the use of the drag seine in similar places elsewhere, and to the capture of smelts in places where they congregate just prior to ascending the streams in spring, as well as to the great quantities of young smelts caught by seines along with adult fish in the fall. How properly to regulate this factor in the depletion of the smelt supply certainly is a problem unless seining is prohibited. As in the case of dipping it does not seem necessary to abolish seining, but it should be regulated. In fact, all methods of fishing should be regulated. There is a prescribed open season for all methods, but for reasons previously given it should be shortened so as to terminate March 1.

Conservation does not necessarily signify suppression of fishing or prohibition of any particular method of fishing. It does, however, demand proper regulation of time or methods, as well as protection of the fish at critical periods in their life history, in order that the yield of the fishery may be maintained commensurate with the market demand and consistent with the economic preservation of the species.

Obstruction and pollution of many otherwise accessible breeding places may be corrected. The capture of smelts as they ascend the streams at spawning time, as already pointed out, is preventable to a considerable extent. Although the duration

of the breeding season is more or less variable on the coast, to some extent according to seasonal climatic conditions, a closed season sufficiently long to embrace the breeding season of the fish along the entire coast of each State may be prescribed. It may be a question of preventing more or less destruction of immature smelts by present methods of capture. However, reduction in the amount of destruction is possible, perhaps by adopting a modification of the suggestion offered by Donahue; that is, a general law prohibiting the catching of smelts in any river, brook, tidal creek, cove, arm of a bay, or estuary where such places are one-half mile or less in width between mean high tide marks. If, then, the previously mentioned measures pertaining to breeding places and season are observed and enforced, the loss from this source will become less appreciable and great improvement of the fishery will follow. The fact that in spite of so many years of adversity the smelt has endured to the extent that it has indicates that given an even chance it can "come back."

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