U. S COMMISSION OF FISH AND FISHERIES

JOHN J. BRICE, Commissioner.

OBSERVATIONS

UPON THE

HERRING AND HERRING FISHERIES OF THE NORTHEAST COAST, WITH SPECIAL REFERENCE TO THE VICINITY OF PASSAMAQUODDY BAY.

BY

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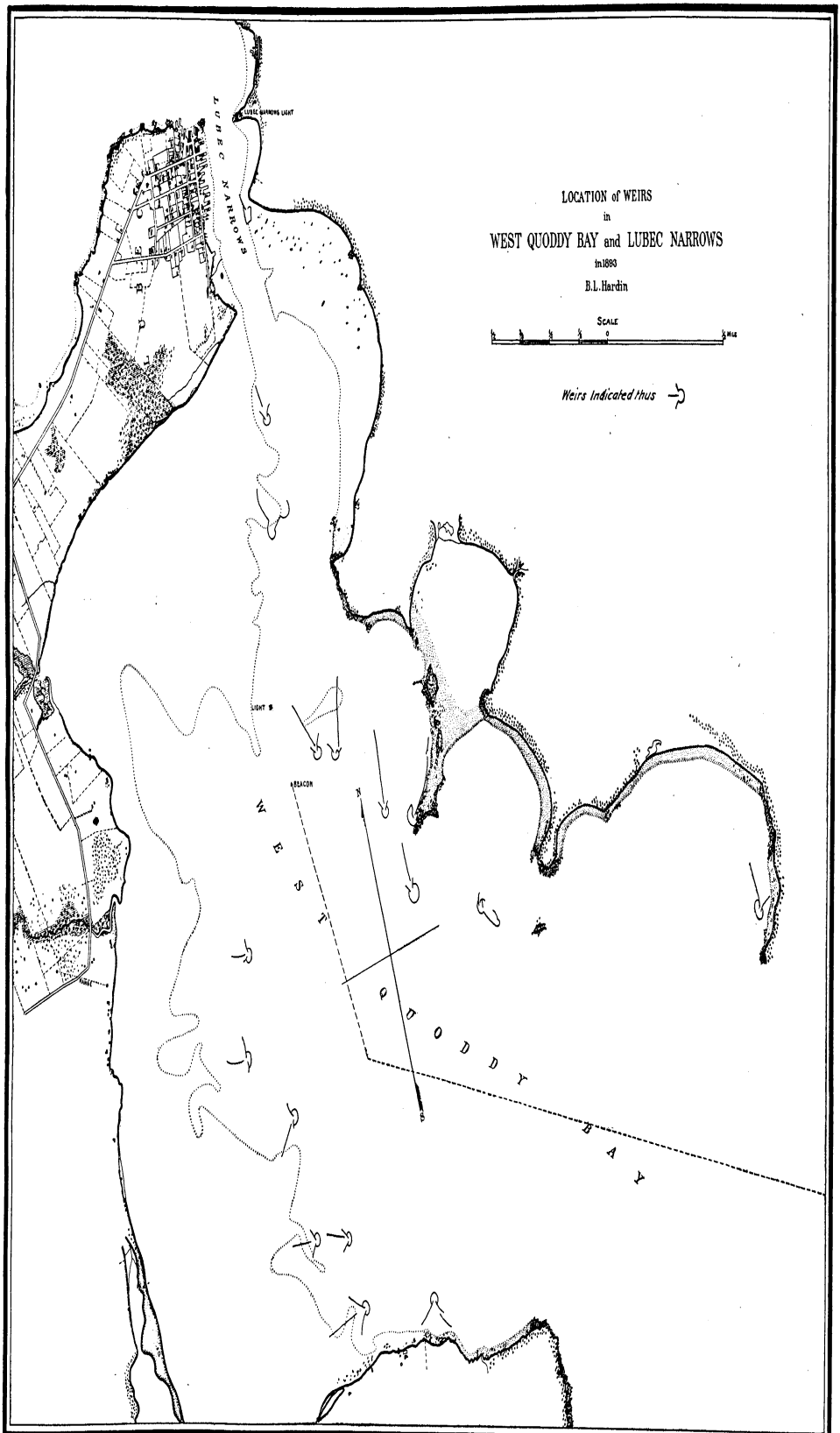
Extracted from U. S. Fish Commission Report for 1896. Appendix 9, Pages 387 to 442, Plates 60 to 62.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1897.



LOCATION of WEIRS
in
WEST QUODDY BAY and LUBEC NARROWS
in 1883
B.L. Hardin

SCALE
0 Mile

Weirs Indicated thus →

9.—OBSERVATIONS ON THE HERRING AND HERRING FISHERIES OF THE NORTHEAST COAST, WITH SPECIAL REFERENCE TO THE VICINITY OF PASSAMAQUODDY BAY.

By H. F. Moore,
Assistant, U. S. Fish Commission.

The observations upon which this paper is based were made while the writer was engaged in investigations in behalf of the joint commission, named by the United States and Canada, to inquire into the fisheries of the waters contiguous to the boundary of the two countries. The studies were carried on during the summers of 1893 and 1895, and extended from Portland, Maine, to St. John, New Brunswick, with special reference to waters on and near the boundary line between Maine and New Brunswick.

For the purposes of the present report it is deemed desirable to consider as a whole all of the region lying between West Quoddy Head, Maine, and Point Lepreau, New Brunswick, including Grand Manan and the St. Croix River as far as Robbinston. The region thus outlined is a natural one from both a geographical and an economic standpoint. The shore line is one of extreme irregularity, the indentation produced by the Passamaquoddy system being the dominant feature.

Passamaquoddy Bay is separated from the Bay of Fundy by a chain of islands, the largest of these being Campobello and Deer islands, and the most important Moose Island, on which the city of Eastport is situated. The numerous small islands lying east and northeast of Deer Island are collectively known as the Western Isles. On its western side Passamaquoddy Bay receives the waters of the St. Croix River, which is a tidal stream as far as Calais and St. Stephens. South and west of Eastport it connects with the intricate ramifications of Cobscook Bay and its numerous arms and tributaries which reach into Maine for a distance of from 10 to 15 miles, to the towns of Pembroke, Dennysville, and Whiting.

The entrance to Passamaquoddy Bay is by two passages, one through Lubec Narrows, between the western end of Campobello and the town of Lubec, and thence by the Western Passage between Deer Island and the Maine shore; the other, Letite Passage, is through the archipelago east of Deer Island. Vessels plying between Eastport and Lubec and points west use Lubec Narrows when the tide is favorable, but as the currents flow with great velocity at certain stages of the tide it is often necessary for them to run around the eastern end of Campobello and enter through Head Harbor Passage, between Campobello and Deer

Island. This route is the one invariably followed by vessels plying in either direction between St. John and Eastport.

Immediately east of the mouth of Passamaquoddy Bay there is a complex series of bays, coves, and channels, separated by headlands and islands, forming Letite and L'Etang harbors, with their approaches. This region and Beaver Harbor, a few miles further east, are important localities in the weir fishery for sardine-herring, and the place last mentioned was a leading center for the now extinct winter herring fishery. Between Beaver Harbor and Point Lepreau are several bays and coves in which weirs are located, but the fishery is not important except in times of scarcity in the region nearer Eastport.

Grand Manan is a large island about 16 miles long and with a maximum width of 7 miles. It belongs to the province of New Brunswick, and lies in the Bay of Fundy, about 7 miles from the southwestern end of Campobello. Its northwestern shore—that facing the mainland—presents an almost unbroken rampart of cliffs about 18 miles long, and in places reaching a height of 400 feet. The only important interruption in this rocky wall is at Dark Harbor, a subtriangular inlet about half a mile wide and almost as long. Over a considerable portion of the area of this basin there is a depth of water of from 35 to 40 feet at low tide.

Except for a narrow opening near the west end, the mouth of the harbor is closed by a natural bar of riprap; the tide rises about 15 feet, and, as the basin fills almost entirely through the opening above mentioned, the currents run in and out with great velocity. Advantage is taken of this fact to utilize the harbor as a huge fish-pond, an arrangement of stakes at the inlet making the entrance of the fish easy and their exit difficult, and as a consequence herring can be taken at almost any season in the weir located on the southwest shore, but as they are often held in the pond for a long time and subjected to a scarcity of food they are frequently in a very poor condition.

The southeast side of Grand Manan is low, and a fringe of small settlements and scattered dwellings skirts its entire length, giving abode to a population almost entirely dependent upon the fisheries. Off this shore lie innumerable islands, rocks, and reefs, inducing intricate and rapid tidal currents, famous in the herring fishery of the region.

Another group of small islands, known as The Wolves, lies about 10 miles northeast of Grand Manan and about 8 miles from the mouth of Beaver Harbor. They are almost uninhabited, but temporary stations upon them are sometimes occupied by fishermen.

One of the most striking features of the Bay of Fundy is the great rise and fall of tides, in the region above sketched the height varying from about 15 to 22 feet. This vast semidiurnal flow of the waters, taken in connection with the intricacy of the channels, produces swift and complex currents, innumerable eddies, and several whirlpools, not without danger to small crafts such as are here in common use in the fisheries.

The international boundary line passes down the St. Croix River and thence through the Western Passage, Friars Roads, Lubec Narrows, and West Quoddy Bay. It is rarely over a mile from the main shore of the United States, and it therefore follows that most of the waters here considered fall within the limits of New Brunswick. Notwithstanding this, however, the interests of the citizens of the United States are of great importance, owing to the fact that the manufacture of sardines from small herring is conducted almost entirely on United States soil, giving employment to many persons of both sexes.

The largest and most important town is Eastport, on Moose Island, a city of above 5,000 inhabitants, having regular steamboat communication with a number of points, and great expectations of some day becoming a railroad town. Lubec is next in importance, other towns being Robbinston and St. Andrews, on the St. Croix River, and Pembroke, Dennysville, and Whiting upon several arms of Cobscook Bay.

GENERAL DISTRIBUTION.

The herring, *Clupea harengus*, is one of the most abundant fishes inhabiting the North Atlantic Ocean. Although it apparently never enters the Mediterranean, it is found sparingly upon the coasts of Europe as far south as the Strait of Gibraltar. From the Bay of Biscay northward it increases in abundance, reaching its maximum in the waters adjoining the coasts of Scotland, Norway and Sweden. It extends its range eastward along the shores of the Arctic Ocean at least as far as Siberia, and in the White Sea it occurs in sufficient numbers to make it the object of regular fisheries in the spring and fall. Commercially the herring is of greatest importance in the North Sea and contiguous waters, where the fishery has been for many years of vast importance to the nations of northern Europe.

During the last two decades the Norwegians and others have developed a herring fishery of some importance upon the coast of Iceland. In Greenland the herring also occurs, but it gives rise to no fishery of value, though it is probable that it is there as abundant as upon the shores of Iceland, where the native population neglected the important product at their doors until their attention was directed to it by the fishermen of Europe less than thirty years ago.

Upon the Atlantic coast of North America the herring ranges as far south as Cape Hatteras, being occasionally caught in the Chesapeake and off the outer shores of Virginia, Maryland, and New Jersey. It never occurs in great abundance south of Block Island, and the principal fisheries are north of Cape Cod. Newfoundland is the northernmost portion of North America in which the herring fishery is persistently and extensively followed, and there are likewise more or less extensive fisheries at the Magdalene Islands and at other places on the Gulf of St. Lawrence, while from the Bay of Fundy to Cape Cod the fishing-grounds are practically continuous. The herring fishery upon the

shores of North America is entirely a shore fishery. With the exception of a few occasionally taken for bait by the line fishermen on the banks, our herring are all caught in the immediate vicinity of the shore, and it was regarded as an undesirable innovation when, in the later years of the winter herring-fishery, the fishermen were compelled to set their nets 6 or 8 miles from land.

The lack of an offshore fishery on our coasts is due not to the absence of the fish, but to the fact that the shore fisheries are amply able to supply the somewhat limited demand. Bodies of herring are frequently seen far out at sea by vessels engaged in other branches of the fishery, and large hauls are sometimes accidentally made by mackerelmen in their purse seines. The herring fishery has never assumed the importance here which has long characterized it in Europe, although in abundance the species is probably not inferior.

HISTORY AND GENERAL CHARACTER OF THE FISHERIES.

The herring fisheries in the Passamaquoddy region are carried on by means of brush weirs, gill nets, and torching. The latter method is the one of most ancient usage and was practically the only method employed prior to 1820, when weirs were introduced. This method of catching the fish is said to be effectual only after the weather has grown cool, and in the neighborhood of Lubec it usually begins during the "September darks"—that is, about the time of new moon during the month of September. Formerly a torch of birch bark was used, but with increasing scarcity of that material and the appearance of kerosene in the markets as a cheap illuminant the latter was substituted. A mass of cotton or similar material is wound about a stick several feet in length and, when saturated with kerosene and ignited, makes a rude but cheap and serviceable torch. This is fixed to the bow of a boat, which is rapidly rowed through the water by several fishermen, while another, provided with a large dip net, is stationed in the bow. The fish rise toward the light in numbers as long as the speed of the boat is maintained, but when the motion ceases they sink back into the depths. They are usually simply bailed into the boat as they rise, and sometimes large quantities are taken in this way. At other times the torch is used in connection with the weirs, the fish being tolled in by their blind pursuit of the light, which is then extinguished, and the operation repeated as often as may be necessary. This method is adopted when the fish for some reason remain in the deeper water beyond the weirs, and is said to be profitable when sardine-herring are scarce and in demand.

Torching in its simpler form is still somewhat extensively followed in the vicinity of Lubec, and before the introduction of pounds into this region was the principal source of supply for smoking-herring. Through the instrumentality of the weir fishermen it has been prohibited by the law of New Brunswick, the objections urged against it being that it tends to break up and scatter the schools, and that dropping oil upon the surface of the water tends to drive the fastidious herring from its haunts.

Gill nets are the most recently adopted of the appliances used by the herring fishermen of Passamaquoddy, being introduced about 1829. Those employed in the limited fishery for Quoddy River herring have a mesh of about 3 inches in extension, but for the winter and spawn runs a smaller mesh has always been used. They are always set at some distance below the surface, the depth to which they are sunk being regulated by the length of the bridles by which they are suspended from the buoys. The nets are anchored at one or both ends, according to circumstances, the former being the method usually pursued near Eastport, where the operation is usually known as drifting. The quantity of fish caught is sometimes sufficient to sink the buoys, and in order that such nets may not be lost it is customary to have a buoy attached to the anchor by a line long enough to reach to the bottom. This is especially necessary during the spawning run, when the schools are often very dense and the catches are correspondingly large. Further details are given in the chapters relating to the Quoddy River and winter herring fisheries.*

The brush weir is an ancient form of fish-trap, invented independently by many peoples of widely separated habitats and of various scales of civilization. There is ample evidence that simple forms of the device were used by the aboriginal inhabitants of the United States prior to the coming of the white man, but it seems to have been unknown, or at least unused, by the settlers on the border between Maine and New Brunswick prior to about 1820.

Concerning the introduction and the early history of this fishery the following account is given in The Fishery Industries of the United States:†

The typical brush weir introduced from Nova Scotia.—According to Mr. D. I. Odell, of Eastport, and Mr. Jacob McGregor, of Lubec, the fishermen of the United States owe their knowledge of the brush weir in its present form to Nova Scotia, where it was in use before the beginning of the present century. According to these parties the date of its introduction into the United States was about 1820, when two or three small ones were built near the western end of Campobello Island and along the shores of North Lubec for the capture of different species. These were not sufficiently successful to warrant their extended use and after one or two seasons' fishing they were abandoned. The first large weir exclusively for herring is said to have been built in 1828, by Mr. John McGregor and his son Jacob, at North Lubec. Mr. McGregor was a native of Digby, Nova Scotia, and had become thoroughly familiar with the brush weir as employed in the fisheries of that region before his removal to the United States several years earlier. Thus far during his stay in Lubec he had been engaged in the smoking of herring, depending wholly upon torching for his supply; but he soon found that the movements of the herring were very similar to those of the school that visited Digby, where the weir was successfully used. He therefore decided, on account of the labor and exposure in torching and the comparatively small quantity of fish taken, to build a brush weir for the capture of the fish. Accordingly he selected Rogers Island as a suitable location and proceeded at once to construct his weir. It was built in shoal water and was much smaller

* For a more detailed account of nets and methods refer to The Fishery Industries of the United States, section V, vol. I.

† Section V, vol. I, pp. 499 and 500.

than the weirs of the present day. It proved very successful in the capture of herring, and other parties soon built weirs of similar size for the same purpose.

Growth of the weir fishery.—From this small beginning the weir fishing gradually spread to the adjoining section, and Campobello, Grand Manan, and the various settlements along the American shore soon had extensive weir fisheries. In 1835 the weir was introduced into the fisheries of Grand Manan Island by Lubec parties. In 1836 the first one was built in West Quoddy Bay, which soon came to be the principal fishing-ground on the American shore; and within fifteen years from that date there were 30 weirs between Lubec and West Quoddy Head, a distance of 3 or 4 miles at most.

In 1849, according to Mr. M. H. Perley, there were 27 weirs at Grand Manan, 21 at Campobello Island, and 7 on the West Isles. We find no printed record of the number on the American shore at that time, but the older fishermen of the region informed us that there were about 45 in the town of Lubec, with 20 additional at Eastport and along the Maine shore between Lubec and Calais. This would give 65 for the American shore and 55 on the English islands, making a total of 120 at that time.

These weirs were all small, and were of the pattern afterwards known as "half tide" or "hedge weirs," being so constructed that the fish could enter them when the tide was past half flood, but from which they could not escape during the later stages of ebb tide, being often left high and dry at low water. Such weirs are still employed in some places, but rarely in Passamaquoddy. They were afterwards improved by the addition of a leader or its equivalent, and were built larger and in deeper water.*

In 1880 there were 142 weirs in the Canadian waters of the region with which we are immediately concerned, located as follows:

St. Croix district	6
Inner Bay, Passamaquoddy	10
Lepreaux, Beaver Harbor, and Letite	16
Deer Island (estimate)	40
Campobello	29
Grand Manan	41
Total	142

In the same year weirs were located in United States waters as follows:

Outer shore of Lubec	4
United States shore of West Quoddy Bay	10
Canadian shore of West Quoddy Bay (owned in Lubec)	7
North Lubec	10
Eastport and small islands in vicinity	17
West shore of St. Croix River, between Robbinston and Eastport	12
Above Robbinston	6
Total	66

Those on the Canadian side of West Quoddy Bay were probably also included in the Canadian record, and allowing for this duplication we may conclude that in 1880 there were about 200 weirs in the waters between West Quoddy Head and Point Lepreau, including Grand Manan. This was at a period when the sardine business had already assumed considerable importance and gave evidence of a greater growth to come. In 1881 the number of weirs in Canadian waters had increased to 240,

*For information concerning the construction of the weirs the reader is referred to pp. 501-504 of the work already cited.

and in 1887 there were 264. In the following year, 1888, the competition for licenses was exceedingly keen, and 327 were issued, a number which has never been exceeded. This year's experience disabused men's minds of the visions of profit which they had heretofore held, and nearly 100 licenses were permitted to lapse in the succeeding year (1889).

In Maine the growth of the weir fishery appears to have been less precipitate, but there is no accurate information upon the subject, as there was no enumeration of the weirs between the years 1880 and 1893. In that year Dr. B. L. Hardin made a painstaking survey of the region, excepting Grand Manan and the vicinity of Point Lepreau, carefully plotting the weirs from angles obtained with a sextant. A reproduction of his chart is published herewith, and will be of great value as a basis for comparison for future studies of the fishery.

In 1893 there were 285 in the entire district with which this report is immediately concerned, 239 of these being under license of Canada and 46 in the United States or owned by United States fishermen.

The Canadian weirs were located as follows:

St. Croix district	5
St. Andrews district (Inner Bay)	35
Lepreau and Beaver Harbor	78
West Isles (including Deer Island)	74
Campobello	23
Grand Manan	24
Total	239

Those upon the United States side had the following distribution:

Outer shore of Lubec (United States side Lubec Narrows)	4
United States shore of West Quoddy Bay	7
North Lubec, Seward Neck, and Johnson Cove	5
Morrison Cove	1
Eastport	3
Between Eastport and Robbinston	9
Pemmamaquan River and East Bay	17
	46
Neglected or abandoned, Eastport	4
Neglected or abandoned, between Eastport and Robbinston	2
Total	52

Comparing these tables with those for 1880, it will be seen that between the years 1880, when the sardine business began its most active development, and 1893, there was an increase of about 50 per cent in the total number of weirs in the region. This increase was entirely upon the Canadian side, the United States waters suffering a decrease in this fishery, at least so far as the amount of apparatus is concerned. This falling off affected principally the immediate vicinity of Eastport, where the greatest activity prevailed at an earlier date. Above Robbinston there were no weirs in 1893 as compared with 6 in 1880. Lubec Narrows about held its own, and Pemmamaquan River and East Bay, where there were none or but a very few small weirs in 1880, had become the scene of the largest weir fishery in the United States waters of Passamaquoddy in 1893, this rapid growth being induced, not by any change in the known habits or distribution of the

fish, but by the demand produced by the establishment of sardine canneries in the vicinity.

The changes in the distribution of the weirs on the Canadian side within the period mentioned were characterized by a heavy reduction in the number at Grand Manan, which, being more remote from Eastport and separated therefrom by open and more or less stormy waters, is not affected by the demand for sardine-herring, the delivery of which brooks no delay or uncertainty. The weir fishery at that place is dependent almost entirely upon the smoked and pickled herring trade and the supply of bait. The increase which has been noted in Canadian waters took place almost entirely in St. Andrews Bay, the West Isles, and in the vicinity of L'Etang; that is, in the sheltered waters more remote from Eastport. It is generally claimed that this eastward movement of the center of the industry was conditioned by a change in the distribution of the small herring. This is no doubt true to some extent, but that the fishery would have shown this tendency to extend even without this temporary change in the movements of the herring, is not to be doubted. Should the distribution of the herring remain as general as for several years past, there will inevitably result a tendency to curtail the amount of apparatus used in waters more distant from the factories, as weirs in such places will not pay when the boats engaged in transportation can procure their fares in more accessible places. The number and distribution of the weirs are undergoing constant fluctuation. A good catch and a steady market in any given locality causes an increase in the following year, and a failure, either in the catch or the market, causes a corresponding decrease, owing to the discouragement of the fishermen, especially in Canadian waters, where it is necessary to procure a license.

DISTRIBUTION AND MOVEMENTS.

If we except the winter herring, which is discussed in a separate chapter, and the spawning runs in spring and fall, there is little evidence to show any definite or extensive migrations of herring in the vicinity of Passamaquoddy Bay. During summer and fall there are more or less extensive local movements of the schools, but they are not of such a character as justify the use of the term migration. They are apparently conditioned entirely by local circumstances, distribution of food, location of enemies, and meteorological conditions, the effects of which are obvious.

The schools of sardine-herring, and the larger individuals which are more or less associated with them during summer and fall, are constantly moving back and forth without apparent system. It appears, however, that the fish found in the waters inside of Campobello usually enter by Head Harbor Passage at the east end of the island. In many cases in 1893 and 1895, it was possible to trace the movements of these schools from the vicinity of L'Etang westward to Deer Island, Cobs-

cook Bay, and the vicinity of Lubec, or northward to the several parts of St. Andrews Bay and the vicinity of Robbinston. Sometimes the schools work out through Lubec Narrows and are caught in West Quoddy Bay.

The small herring, and some of the larger ones, remain in the vicinity throughout the year, and the same statement will hold concerning sardine-herring on other parts of the coast of Maine. During winter they apparently keep in the deeper water, but occasionally catches have been made in the weirs during February. Schools of small fish are seen in the Bay of Fundy throughout the winter and bodies of larger ones sometimes occur in the vicinity of Grand Manan during the cold months, but they do not usually approach the shores and very few are said to enter Dark Harbor after November.

In spring the herring, especially the smaller ones, begin to approach the shores, but they are not caught in the weirs in abundance until July. Some of the fishermen state that prior to about 1883 considerable quantities were caught during March, but that since then the advent of the schools has grown gradually later until at the present time they are not expected until July. Concerning this we find the following in The Fishery Industries of the United States, compiled from information gathered about 1880:

> The fish taken in the early spring are usually quite small, and have little value for smoking or for bait; they are also in such poor condition that they yield but little oil, and it therefore seldom pays to press them. For these reasons, during the early years of the fishery, the weirs were seldom put in order before the 1st of June, and frequently few fish were taken prior to the beginning of September, when the fishing began in earnest and continued till the close of the year. Now, however, owing to the demand for small fish by the sardine canneries, the weirs are usually repaired in the early spring, and the fishermen tend them regularly from the 1st of April till the following January. (Fishery Industries, section v, vol. i, p. 502.)

The records of the catches of individual weirs in 1878 and 1879, published with the foregoing, show that comparatively few herring were taken before July or August, precisely as is now the case. The sardine-packers state that they do not care to begin work before July because of the irregular catch and that in the early days of the business, when operations began at an earlier date, the supply of fish was insufficient for all, and the resulting competition raised the prices to a level which was wholly unjustified, and which would be ruinous at the present price of the finished product. There is no difficulty in securing all the fish needed after July 1, and the comparative abundance and regularity of the catch then renders possible the steady and more economical operation of the factories.

The probability is, therefore, that the herring arrive at about the same time that they always did, that there is no recession of the date such as was noticed in the later years of the winter fishery, and that the weirs are not fished before July merely because there is no demand for the product, and not on account of any change in the habits or distribution of the fish. For the same reason the fishing season of the

weirs does not last as late as formerly, when good catches were often made during December and January. At present the factories usually cease operations before December, but the fish remain later than that and could be caught if necessary, although probably not in such large quantities as earlier in the season.

I am informed that there was at one time, and there may be still, a distinct migration of herring from the Bay of Fundy shore of Nova Scotia across to Grand Manan. The schools, after spawning in the spring, ran over to the Ripplings early in July to avail themselves of the rich food supply which that locality affords. They were formerly followed across by the fishermen of Nova Scotia, a practice which has apparently fallen into abeyance. The evidence, however, makes it by no means certain that the schools in the two places are identical.

The appearance of the "Quoddy River herring" in Quoddy Roads appears to have been the result of a distinct though limited migration, but whence they came or whither they went can not be stated.

EFFECTS OF PHYSICAL PHENOMENA.

Tides.—The movements of herring on and off shore are largely influenced by the tides, this being true at least of such as come toward land for other purposes than for spawning. This statement applies particularly to the sardine herring of the Bay of Fundy, which approach the shores and run into the coves upon the flood tide, but drop off into deeper water when the tide is ebbing. The shoreward movement may be either to procure food for themselves or to avoid becoming food for their enemies, the reverse movement upon the ebbing tide being induced by the instinct of the herring to avoid stranding at low water, a fate which would often overtake it were it to remain in the shallow coves. As both the herring and its principal enemy, the squid, are more active at night, this shoreward movement is then more extensive.

This tidal movement of the herring is quite pronounced in the neighborhood of Eastport, where the difference between high and low water averages 18 feet, and the fact has been taken advantage of by the fishermen, who build weirs in such a manner as to permit the fish to enter the coves on the flood tide but to compel them to enter the weir on the ebb.

The fishermen state that when migrating the herrings take advantage of the currents and eddies to help them on their way, but that when feeding they swim counter to the stream, so that the food may be carried to them, or else lie in an undercurrent and catch the food as the surface current carries it over them. There is no doubt that the herring prefers strong currents and eddies, such as are found at the "Ripplings" off Grand Manan and at the passages between islands in and about Passamaquoddy Bay. They resort to them not because they like swift water *per se*, but on account of the larger amount of food which is found there. Free-swimming and floating organisms tend to collect in such places, each eddy becomes a larder kept filled by the supply car-

ried in by the converging and conflicting currents, and the herrings there find a large amount of food requiring a minimum of effort in its capture.

In watching herring feeding at the surface I have never seen any evidence that they keep facing the current; they attack their prey from all sides. If this be drifting with the current then the fish also drift with the current; if it be stemming the tide the fish follow it up, their aim in either case being to *keep with their food supply.*

What effect, if any, the current has upon the movements of the herring to and from the spawning-grounds, in the Bay of Fundy, is difficult to say; probably it is slight.

The influence of the tides in disseminating impurities supposed to be inimical to the herring fisheries is considered in another connection.

Winds.—The winds affect the distribution of the herring in two ways—by influencing the distribution of food and by the action of the surf and heavy seas in driving them from the coasts and from the surface into the deeper waters. My own opportunities for judging of the effect of the winds upon the distribution of food organisms were slight and the testimony of the fishermen is very contradictory. When the wind has sufficient velocity to make a sea, there is very little life to be found at the surface, and waves of even moderate height render the use of the surface tow-net of but little avail in collecting. There is thus produced a vertical distribution of the herring food, which is doubtless more pronounced in summer than in winter, when surface life is usually less abundant, even in calm weather. It is the horizontal distribution, however, rather than the vertical, which has the greater influence on the fisheries; if the food be by any agency carried offshore or to another part of the coast the herrings, except those engaged in spawning, will surely follow. Owing to the comparative dearth of surface life in winter the influence of the wind in this respect is less than in summer, but even during the latter season I could not observe that it had much effect. As both the Thysanopoda and the Copepoda are found in summer, both at the surface and for a depth of at least several fathoms, it would appear that the winds have not so great an effect on the distribution of food as is generally supposed.

Strong winds have, for another reason, a considerable effect upon the herring, or at least upon the weir fishery. I repeatedly noticed the failure of this fishery during the prevalence of storms and for a day or two afterwards. The herring run into the deeper water, where they can remain undisturbed, and do not come ashore again until the waves have subsided. Heavy seas have the same effect upon the spawn herring in the shallower waters, and it appears that at such times the herring temporarily move off and presumably cast their spawn in deeper water. It is stated that at times quantities of herring, weakened by the act of spawning, are killed by the violence of the waves.

This whole question of the effect of winds upon the herring on our coasts will bear closer scrutiny.

Light.—It has long been recognized, both in this country and in Europe, that light has an important effect upon the movements of the herring and upon the facility with which they may be captured.

During the hours of bright sunlight the herring, with the exception of "brit," keep in the deeper waters and rarely come close to shore or approach the surface. Herring are caught in the vicinity of Eastport in drift nets near the surface, but such nets are never known to catch anything during the daytime. In this locality the water is quite clear, but in St. John Bay, in New Brunswick, it is more or less turbid and dark from the large amount of solid matter brought down by the great river St. John, and it is significant that the only case known to me of herring being caught during the daytime occurred some years ago in St. John Bay. It is, moreover, a fact recognized by the fishermen, and frequently observed by me, that relatively few fish, although they may be playing at the surface, can be caught by drifting upon moonlight nights, and the fishery is not usually prosecuted at such times. This is to be explained by the greater facility with which the fish see and avoid the nets, an explanation which appears the more probable when it is noted that fishing with gill nets is said to be usually poorer when the water "fires," that is when it is strongly phosphorescent, and the nets suspended in it are like a wall of flame, and of course conspicuous to the fish and easily avoided.

Light has about the same effect upon the weir fisheries, large catches being rarely made during the day tides or upon moonlight nights, except when the herring are driven and held in shallow waters by their enemies, as for instance at Magaguadavic in 1894, when they were held inshore by large bodies of squids, considerable quantities were taken in dip nets. The best fishing is usually to be had during dark nights when the high tide occurs between 1 and 7 o'clock in the morning, the time appearing to vary somewhat in different places; near L'Etang, for instance, the later tides are better and in St. Andrew Bay the earlier ones. When the tides occur in the morning during and near full moon the fishing is not so good, but should a cloudy night intervene there is frequently an improvement in the catch for that night or during the continuance of the cloudy weather.

Another curious fact connected with this subject is the apparent fascination which a moving light possesses for the herring. It has long been known that they will follow a light upon dark nights and this habit is taken advantage of by the fishermen in the process known as "torching." This method of catching the fish is elsewhere described. It is sometimes asserted that the rising moon serves to attract herring in a similar manner, but there appears to be little evidence to support the statement.

There is no information at hand concerning the effect of light upon spawning herring and upon the fishery for them.

Sound.—It is well known to fishermen and to all who have studied

the subject that herring are affected by loud noises. I have frequently noticed that a sudden blow upon the thwarts of a boat will cause herring swimming at the surface to suddenly disappear, but they will soon reappear if the noise be not continued. My observations at St. Andrews indicate that such noises as the sounding of a ship's horn or the distant report of small arms are unnoticed by herring at the surface, but the heavy detonations of cannon, as one would naturally suppose, produce a greater effect, and at Bar Harbor the frequent firing of small cannons on the yachts scare the fish, although they do not seem to go very far and soon recover from their fright. The fishermen at Seal Cove, Grand Manan, say that when the Gannot Rock fog gun, 9 miles distant, is fired all the herring at the surface go down at once, and the same thing was noticed at Eastport some years ago when warships were stationed in those waters.

These facts, well established, have been offered in explanation of the failure of fisheries at different places, fog alarms and whistles having been supposed to exert a very bad effect upon the catches of the weirs. Mr. W. B. McLaughlin, the keeper of the light-house at the Southern Head of Grand Manan, an intelligent man, to whom I am much indebted for assistance, is a firm believer in the pernicious effect of loud noises upon the fisheries. In a conversation in 1893, he stated that a weir on Big Duck Island had been known for forty years as a very successful fishery. The owners, as a safeguard to their shipping, were desirous that the Government should place a fog-horn upon the island and, although advised not to do so, made successful application for its establishment. Soon after it was placed in operation the fishery began to fail and was eventually completely ruined. I afterwards heard of this case from others.

Mr. McLaughlin offers the same hypothesis in explanation of the failure of the weirs in West Quoddy Bay. He says that they began to fall off in their catch at about the time the fog-alarm was placed on Quoddy Head, and that the porpoises, which prey upon the herring, made off at about the same time. Indians engaged in porpoise fishing were unable to confirm this statement, and, moreover, the weirs referred to have within the last few years again begun to be profitable fisheries, a fact which can hardly be explained by stating that the fish have become "educated" to the point of recognizing the harmlessness of the whistle.

Many of the fishermen explain the failure of the weir fisheries at Lubec and Treats Island by the terror with which the steamboats have inspired the herring. It is said that the constant churning of the water and the blowing of whistles has driven the herring away, but I have found that the same causes do not produce the stated effect upon other weirs. Those in Friar Bay are exposed to these disturbances as much as or more than is Treats Island; the ferry boats plying between Eastport and Lubec pass many times a day within a few rods of one of these, yet good catches are frequently made, and the owner expresses himself

as well satisfied with the season's yield. The effect of steamboats upon the herring are certainly overestimated, for I have seen them pass within a few rods of herring schooling at the surface, and have noticed no evidence of alarm, although those quite close to the boats disappeared, but came to the surface again as soon as the boat had passed.

Fresh and brackish water.—I have not noticed that the herring show much tendency to run into places into which fresh water is discharged. The fishermen say that in dry seasons they run into coves and mouths of streams in order "to get fresh water to drink." The summer of 1895 was one of extraordinary drought, yet the herring appeared to be everywhere, and by no means confined to places receiving the discharge of streams of fresh water. When they do go to such places it is probably to obtain food or escape enemies, and in spite of the fresh water rather than in search of it. Moreover, the discharge of the streams in the neighborhood of Eastport is so small, as compared with the tidal ebb and flow, that they must have very little effect indeed upon the salinity of the water. In the River Schlei, in Germany, they spawn in water which is practically fresh, and they occasionally run into fresh water in some of the rivers in Maine—in the Kennebec, for instance, which they have been known to ascend as far as Gardiner.

Impure water.—It is a common belief among the fishermen that the herring are affected to a great extent by impurities in the water; that offal and dead fish, the oil from factories, and the use of decaying bait in lobster traps, etc., will drive fish from grounds which they have been in the habit of frequenting for many years. That these statements, so strongly made, have some basis in fact is probable, but that the effects have been exaggerated is beyond doubt. The matter will be more fully discussed in the section treating of the alleged decrease in herring in the Passamaquoddy region.

Temperature.—The effect of temperature upon the incubation of the eggs is mentioned in the section upon spawning, where its probable effect upon the date of spawning is also considered. Sufficient data for the discussion of this subject as relating to our coasts have not been collected. It would require observations extending over a series of years and at different stations to form any satisfactory basis for conclusions, and these observations should embrace the temperature of the air and of the water at the surface and at the bottom, together with a close record of the catch and the distribution of the fish. It is useless to speculate upon the matter in the absence of the data, but, on the other hand, were they in our possession there is but little doubt that they would yield important results.

Rain, snow, and ice.—The effect of these phenomena is closely connected with the effects of light and temperature, and, as in the case of the latter, the proper data for their discussion are lacking so far, at least, as our shores are concerned. Gentle rains and, inferentially, snows have the same effects, apparently, as cloudy or foggy weather without precipitation. In studying these, and in fact all phenomena,

it is necessary to bear in mind the distinction between the fish and the fisheries. It is possible to effect changes in the latter while the fishes are but little affected.

Food.—An examination of the mouth cavity of the herring will disclose a series of long bristle-like processes, the gillrakers, projecting from the anterior face of each gill-arch, like the teeth of a comb. When the mouth is opened widely the tips of the gillrakers stand apart, but when it is closed or partly closed they become more closely approximated and each series is pressed closely against the inner face of the series attached to the arch next in front. There is thus formed a beautifully fine and effective sieve, capable of retaining small bodies contained in the water taken in at the mouth and discharged through the gill-slits.

As would be naturally inferred from the structure of the pharyngeal apparatus just referred to, the food of the herring consists of small organisms, often of microscopic dimensions. It is entirely animal in nature, and in Europe, according to those who have investigated the matter, it consists of copepods, schizopods (shrimp-like forms), amphipods (sand-fleas and their allies), the embryos of gasteropods and lamellibranchs, and young fishes, often of its own kind.

In the examination of about 1,500 specimens at Eastport and vicinity in the summer and early autumn of 1893 but two kinds of food were found. One of these consisted of copepods ("red seed"), which appeared to constitute the sole food of the small herrings, the so-called brit, and a considerable portion of that of the larger individuals from 5½ inches upward. The principal food of the latter, however, were schizopod crustaceans of the genus *Thysanopoda*, known to the fishermen as "shrimp." In many cases the stomachs of the fish were densely gorged with them, and, whenever determinable, *Thysanopoda inermis* was the principal species eaten, as it is also the most common form in the Passamaquoddy region. During the summer and fall dense bodies of *Thysanopoda* are seen swimming about the wharves at Eastport and at other places in the vicinity, and they are also extremely abundant on "The Ripplings" at Grand Manan, which has long been famous as a herring fishery. Excepting the eyes and the phosphorescent spots beneath, which are bright red, the bodies of these shrimps are almost transparent, yet such is the density of the schools in which they congregate that a distinct reddish tinge is often imparted to the water. In the summer and early fall of 1895 they were especially abundant about the wharves at Eastport, and on one occasion, at least, they were left at low water several inches deep over a considerable area of one of the docks.

In summer and fall both shrimps and copepods are found near the surface where the herrings commonly take their food. The former are very active and frequently avoid the rush of the fish by vigorous strokes of their powerful caudal paddles which throw them several

inches above the surface, often thus evading capture a score of times before they finally succumb to their pursuers. To capture such prey requires some address on the part of the herring; they frequently throw themselves almost clear of the surface and their splashings at such times, though not so great as those of a school of pollock, are audible at a considerable distance.

When feeding upon copepods the movements of the herring are less impetuous. They swim open-mouthed, often with their snouts at the surface, crossing and recrossing on their tracks and evidently straining out the minute crustaceans by means of their branchial sieves. As their food drifts the fish follow so that it often appears as if the whole school were carried along at the mercy of the tide. When feeding at the surface, whether upon shrimps or copepods, they are said to be "schooling," a phenomenon more common at night than during the day, and according to the fishermen more prevalent upon moonlight nights than during dark or cloudy ones.

After they have passed the stage known as "brit" (2 to 4 inches long) the herrings appear to feed principally at night, or if they do so to any considerable extent during bright daylight it is at such a depth that they escape observation. I have commonly observed them schooling at sunrise and an hour or two before sunset, but rarely at midday even when surface food was abundant. It is not uncommon, however, to observe brit disporting themselves at the surface at all hours of the day, and in the late summer and early fall of 1895 immense schools of these tender young could be seen daily in the Western Passage and adjacent waters.

At night it is often possible to note the movements of the fish at a depth of several fathoms, and at such times I have seen them swimming back and forth, apparently screening the water, their every movement traced by a phosphorescent gleam, evoked perhaps from the very organisms which they were consuming. As stated above, they are more often at the surface at night than during the day, their presence being made manifest to both eye and ear.

By watching a school of herring feeding upon *Thysanopoda*, it is very evident that they follow their prey by sight, and the fact that these schizopods possess phosphorescent spots may explain the apparent ability of the herring to catch them at night. When feeding upon such minute forms as copepods, it is probable that the herring uses its vision but little, as it appears to pay no attention to individuals, but merely to swim open-mouthed and take its food *en masse*.

The fishermen state that when both shrimps and copepods abound the former is preferred—a statement corroborated by my own observations. Frequently in the same school a few of the fish will contain copepods while the vast majority are gorged with shrimps, and sometimes they will all be found in the latter condition when the tow net demonstrates the presence of copepods in abundance. When brit and larger herring are caught in the same weir, the former—too small to

take large food—are filled with copepods, while the latter contain shrimps alone. The fishermen state that shrimps are rarely seen during the winter, but the examination of specimens caught at that season at Grand Manan shows that even then they form an important item in the herring's diet, although my observations lead me to think that they are relatively less important than during the summer. In the winter the shrimps doubtless frequent the surface less than in summer, which of course explains why they are not observed by the fishermen.

The stomachs of by far the greater number of herring taken in the weirs are empty, this being no doubt due to the absence of food in the weirs, and the rapid digestion of that taken by the fish previous to their capture. When food is abundant in and around the weir the fish are difficult to hold, in eager pursuit of their prey, passing through openings which at other times would be unnoticed.

The remarkable abundance of herring in the vicinity of Passamaquoddy Bay is doubtless in direct relation to its rich supply of nutritious food. The presence of great spawning-beds in the vicinity is also favorable; but the location of these must also be largely conditioned by the lavish provision which nature has made for the support of the progeny in all stages of their career.

ENEMIES.

Upon the coast of Maine and New Brunswick, as elsewhere, the enemies of the herring are numerous and voracious, many of them being of great commercial importance. Most of the species of the cod family, at least the larger members, feed more or less extensively upon the herring and its eggs. Cod and haddock are frequently taken with their stomachs full of herring spawn, and at Cross Island, Maine, during September, 1893, they were found gorged with both the herring and its eggs. At the same place pollock, which had been following the herring in great schools, were found to contain an average of about 6 full-grown and ripe herring, together with quantities of spawn. Cod, haddock, and hake feed extensively on the spawn of herring at Grand Manan and doubtless sculpins, sea-ravens, flounders, and other bottom-feeding species secure their share of the harvest.

Dogfish and silver hake are a source of much annoyance and loss to the gill-net fishermen, the former being particulary destructive to the nets, biting the entangled herring in two and cutting and tearing the twine in their efforts to pull the fish from the meshes. They appear in great schools during August and soon drive all other fish from the vicinity, causing for a time an almost total cessation of fishing with lines and nets. Fortunately their stay is of short duration, lasting usually about two or three weeks. When no other fish are to be had, the fishermen sometimes catch the dogfish for its liver (which is converted into "cod-liver oil"), the remainder of the fish being often spread upon the soil for fertilizer. No use whatever appears to be made of the silver

hake, as its flesh is said by the fishermen to be uncurable by ordinary methods.

The albacore, locally known as the horse-mackerel, feeds largely on herring, but is not sufficiently abundant to cause much destruction, although it sometimes interferes with the fishery by getting into the weirs and chasing the herring. This appears to be the species which some of the fishermen call the "shark." The mackerel is said to feed extensively upon young herring, but now rarely appears in the region embraced by this report.

The squid is probably the most destructive enemy preying upon half-grown herring in the vicinity of Eastport, where they frequently appear in immense numbers. These visitations are often a source of loss to the fishermen, not only on account of the great destruction wrought, but also because they prevent the herring from entering the weirs or even drive them out after they have entered, as when pursued by these foes they pass without hesitation through the numerous openings in the brush. Sometimes, according to the fishermen, the squids drive the fish toward the shore, and thus into the weirs, in such cases tending to increase the catch. They are also of importance to the line fisherman as bait, considerable quantities of them being used at times in the cod and other fisheries. An effort to utilize them as food for man was made at Eastport several years ago. They were canned after the manner of sardines in both oil and mustard, but the experiment was not a success, the product being tough and tasteless.

Porpoises and seals in the Bay of Fundy also feed largely, probably almost entirely, upon herring, but are not sufficiently numerous to cause great harm. They will drive fish away from the weirs, however, and one instance was cited in which a weir was eventually abandoned on account of the seals so continually driving the herring that they deserted the locality. Both porpoises and seals are hunted at Grand Manan and vicinity by small parties of Indians, the former for their oil and the latter for their skins, which are made up into rugs and moccasins and sold to tourists.

Finback whales feed upon herring, but, though occasionally seen in summer, do not appear in numbers before October. A letter from Mr. McLaughlin, dated December 30, says that "for ten days a large school of herring and whales has been off this station" (Southern Head, Grand Manan). The whales sometimes enter the weirs and are killed, but occasionally the result is disastrous to the weir, a fine one at Grand Manan being almost ruined by a whale in September, 1893.

Gulls and other sea fowl no doubt feed to some extent upon the herring, but the great flocks occasionally seen hovering over schools are probably attracted more by the herring food than by the herring themselves.

Another factor which should be considered in connection with a discussion of the herring's numerous enemies is the collateral effect upon that species of the disappearance of menhaden from the Bay of

Fundy. Formerly this species was extraordinarily abundant in that region, but a number of years ago it entirely disappeared and has never returned. During its occurrence it was an important item of diet to most if not all the foes of the herring, and, like the latter, it was fair game to everything that fed upon fish. The attention which was then divided between the two species is now directed wholly, or at least largely, to the herring, and its numbers must to some extent suffer in consequence. At the same time there must now be available for the herring itself a greater food supply, and it would appear that this disturbance of the faunal balance must be greater and more far-reaching in its effects than the pollutions of a few lobster pots or the injudicious use of gill nets here and there along the shore. In speaking thus I have reference to the general effect upon the number of herring at large as distinguished from a purely local effect upon the fishery. The latter would be more quickly noticed and the source of more immediate, because localized, loss.

The enemies of the herring are important factors in governing its local distribution. Except when under the overpowering influence of the reproductive instinct the herring will always give way before its foes if present in large numbers. Individually its only safety lies in flight, but its powers in that direction are so inferior to those of some of its speedy pursuers that were it not for other factors the species would soon perish from the waters. Its ancient lineage, however, shows that it is well able to maintain itself despite all perils.

SPAWNING, GROWTH, ETC.

In the spawning of the herring upon the west shore of the Atlantic two distinct periods may be recognized, one in spring and the other in summer and fall. The two seasons are separated by intervals during which comparatively few ripe fish are found, although it appears that some herring with mature ova may be caught during almost, if not quite, every month in the year.

No records are at hand which show that the herring spawns upon the coast of North America north of Newfoundland, but there can be scarcely any doubt that it does so. At Placentia Bay and other localities on the coast of Newfoundland spawning begins in May and lasts until July. In the Gulf of St. Lawrence there are important spawning-grounds at various places, and here also reproduction takes place in spring only, although the period appears to be of shorter duration than at Newfoundland.

From an early date the herring have been known to frequent the shores of the Magdalene Islands and Anticosti in immense numbers, and at one time the trade in these fish constituted a very important part of the business of Eastport, Me. During the latter part of April and early in May dense schools approach the islands and deposit their spawn upon the sands near the shore. The spawning season lasts about two or three weeks, according to those who were formerly engaged in

the fisheries, and sometimes, after storms, almost incredible quantities of eggs are thrown upon the beaches. During certain seasons ice is said to have prevented the fish from spawning at the Magdalenes, and a fisherman stated that about 1878 the herring, for that reason, ran over to the vicinity of the Gut of Canso and spawned in a locality which they had not been known to use for that purpose before, and that they have since continued to resort to that place yearly. It has not been possible to verify this statement, but it is known that the herring spawned in large numbers upon some portions of the coast of Antigonish, as well as upon the west shore of the Gulf of St. Lawrence, long before the year mentioned.

In the Bay of Fundy both spring and fall spawning schools are found, and, in the main, the grounds resorted to by these two bodies of fish are geographically distinct.

From Briar Island, Nova Scotia, eastward to beyond Digby Gut, a school of herrings arrives about the middle of April and spawns upon the coast, and at Clam Cove, at least until quite recently, there was a limited fishery for spawn herrings during April and May.

I could not learn of any herrings spawning during these months on the coast of New Brunswick east of Beaver Harbor, but it is a matter of common knowledge that formerly large bodies of herring spawned from the latter part of April to the early part of June in the waters of St. Andrew Bay and vicinity. I was informed by an old fisherman at Robbinston, Me., that Oak Bay has been, as long as memory runs, an important spawning-ground in spring during the period mentioned; he stated that "in 1894 the schools were as dense as he had ever seen at the Magdalene Islands;" but even if this be true the actual number of fish must be incomparably smaller than at the Magdalenes, owing to the circumscribed area available. The same informant stated that for at least five years no bodies of spawning herring have been in St. Andrew Bay. Whatever may have been the size of the schools of ripe herring now and formerly occurring in the vicinity, no important fishery for them appears to have been established, and the estimates of their great abundance appear to have been based largely on the amount of spawn which was found adhering to the rodes of vessels anchored there. During the spring of 1895 the total catch of spawn herring in Oak Bay was, I am informed, about 60 hogsheads, a very small quantity, indeed, if the spawning school is as large as has been stated.

Probably the most important of the spawning-grounds of the summer and fall schools is at Grand Manan, but east of that place are several localities where the species has been known to spawn during the summer in limited numbers. The best known of these is Tynmouth Creek or Ten Mile Creek, as it is usually called, a few miles east of St. John, where, until about fifteen years ago, the herring arrived annually during June and cast their spawn during July and the beginning of August. About 1880 they suddenly disappeared and I believe have not returned since.

At Grand Manan there is a close season for herring from June 15 to September 15, the only instance in North America where this species is protected during the spawning season. The protected area includes all waters within 3 miles of shore and between an imaginary line from Red Head to Gannet Rock, and another passing due west from the Southern Cross, a well-known pinnacle rock about one-half mile from Southern Head Light. This area covers about 30 square miles, but the spawning-ground overlaps the boundaries on all sides, both alongshore and seaward. The bottom consists of rocks, gravel, sand, and shells, and during the spawning season is said to be literally covered with spawn from close ashore to far out beyond the 3-mile limit. The schools arrive on the ground in June and spawn from that time until late in the fall, although the heaviest run is during July, August, and early in September. Mr. McLaughlin, the fisheries overseer at Grand Manan, says that until September very few fish are found which are neither ripe nor nearly so, but after the beginning of September unripe fish are more common, these perhaps being those which have already spawned.

Westward from Grand Manan there may be said to be a continuous spawning-ground along the coast to Wood Island, and beyond that place spawning-grounds, more or less limited in extent, are found at intervals as far as Block Island. In the vicinity of Machias Bay the herring usually appear after the middle of July and remain until late in September. In 1893 they came early in August, and during the last week in September were still spawning in vast numbers around all the islands near Cutler and Machias Bay. At Moosabec Reach (Jonesport) in 1893 the dates were about as at Machias, and from the information attainable this appears to be the rule. At Boisbubert, according to Capt. J. W. Collins, they spawn during the latter part of July and beginning of August. If the season ends during August at this place it is exceptional, as at localities on each side the most active spawning occurs during the month of September. At Frenchman Bay the net herring arrive during June and remain until late in October, but the period of active spawning is from August 15 to October 1, although a few ripe fish are obtainable at any time during their stay. At Swan Island the spawn is cast from August 25 to October 1, and at Isle au Haut the season is about the same, although the schools arrive as unripe fish about July 25.

Until about 1880 spawning herring were unknown at Matinicus Island, but they now come regularly about September 1 and remain for three or four weeks. The fishermen from that place formerly resorted to Wood Island, but they now have a supply at their doors, although some of them, after the herring leave Matinicus, still go to Wood Island to take advantage of the later season. No herring are known to spawn at Monhegan Island, but upon the opposite shore, in Penobscot Bay and in Casco Bay, they arrive in September and remain until the end of October, although it is probable that few are

spawning during the latter part of their stay. At Wood Island the fish arrive after the middle of September and spawn in great numbers. Fishermen from Friendship and other places follow the spawning herring along the coast from Mount Desert to Wood Island and even to Gloucester, Mass. The fish reach the eastern coast of Massachusetts about October 1 and spawn during that month, while at No-Man's-Land spawning begins about October 15 to 25 and lasts for three or four weeks. In this vicinity ripe females have been taken as late as November 30, but the males caught with them were all spent. Block Island appears to be above the southern limit of the spawning range of the herring and they are said to spawn there during November.

The places mentioned in the foregoing résumé of the spawning-grounds include only those where the herrings approach within a short distance of the shore. All along the coast of Maine are numerous outlying reefs and shoals, most of which are within a distance of 25 miles from the mainland. Upon many of these herrings are known to deposit their eggs, which are found adhering to rodes of vessels and boats engaged in the cod and haddock fisheries. In all probability many of these banks and ledges are not spawned upon yearly, but from their large extent and the frequency with which the spawn is thus accidentally found, it is a reasonable assumption that no small proportion of the herring upon our coasts are hatched upon these offshore grounds. It may be stated as a fact that from Grand Manan to Cape Cod the herring spawns wherever suitable bottom is found.

It will be noticed that with the exception of the Tynmouth Creek locality, and perhaps one or two others likewise of little importance, the summer and fall schools spawn to the westward of the mouth of the Bay of Fundy, and the spring schools uniformly spawn entirely east of this line. A thorough study of the physical conditions and climatic history of the North Atlantic coast would no doubt throw light on the reasons for this. It will be seen also that the date of beginning of the reproductive act gradually recedes as we pass westward along the coast. At Wood Island the season commences 2½ months later than at Grand Manan, though the fish are still spawning in abundance at the latter place at the time the season reaches its maximum at the former. Between the commencement of spawning at Grand Manan and its cessation at Block Island, there is a term of between four and five months, from July to the end of November or the beginning of December.

A comparison of the spawning seasons upon the two shores of the Atlantic is of interest. Huxley has stated that in Scotland no full herring are found in June or December, and that they are rare in May and early in July, as well as late in November and in the beginning of January. A spring spawning takes place in the latter part of January, and continues through February, March, and April, and an autumn spawning late in July is continued in August, September, October, and the early part of November. February and March are the great months of spring and August and September of autumn spawning.

On the coast of Norway the spawning season is about the same as in Scotland, but on the coast of Bohuslän the bulk of the spring spawning is in April, though to some extent it occurs also in March and May, thus more nearly corresponding to the season in the Bay of Fundy. The isothermal lines extend parallel to the coast of Norway and thence across the North Sea to Scotland, which means that the waters on the two coasts have practically the same temperature, while the spring fisheries of Bohuslän are no doubt influenced by the discharge of cold water from the Baltic, which is frozen during the winter. The later occurrence of our spring fisheries is probably connected with the lower temperature of the waters on our coast in early spring, owing to the influence of the Arctic current flowing southward between the coast and the Gulf Stream. The effect of this is to produce a sharp southerly deflection of both summer and winter isothermal lines, so that they reach the coast in a much lower latitude on the western than on the eastern shore of the Atlantic.

There are no records available which will show the temperatures upon the spring spawning-grounds, but it is probable that owing to the strong tidal circulation the temperature in Oak Bay does not differ much from that at Eastport, where ten years' observation shows that a mean bottom temperature of 40° F. is not reached before the middle of May. The minimum temperature for the year, about 31° F., was observed during March, the mean for that month being about 33.4° F. After March the temperature gradually rises until it reaches the maximum of 52.8° F. in September, the mean of ten years observation being 50.4° F.

The following table gives a record of the mean temperatures of the air and water at Eastport, Me., for ten-day periods from 1878 to 1887, inclusive. The observations were made by the Signal Service, United States Army, daily between the hours of 1 p. m. and 3 p. m.

Date.	Air.	Surface.	Bottom—depth 2 to 32 feet.	Date.	Air.	Surface.	Bottom—depth 2 to 32 feet.
1878–1887.	° *F.*	° *F.*	° *F.*	1878–1887.	° *F.*	° *F.*	° *F.*
Jan. 10	23.52	38.03	38.02	July 9	66.56	46.85	45.87
20	23.13	36.89	36.83	19	66.24	47.93	46.92
30	22.99	36.04	35.89	29	66.47	48.71	47.75
Feb. 9	23.28	34.57	34.40	Aug. 8	67.86	49.71	48.65
19	27.09	34.20	34.01	18	66.21	50.53	49.53
Mar. 1	26.52	33.47	33.34	28	65.25	50.97	50.12
11	28.71	33.39	33.12	Sept. 7	64.08	51.25	50.34
21	32.24	33.72	33.32	17	60.90	51.39	50.63
31	34.71	34.37	33.82	27	58.14	51.11	50.33
Apr. 10	38.04	35.28	34.58	Oct. 7	55.74	51.01	50.36
20	43.47	36.49	35.67	17	53.21	50.49	49.88
30	47.25	37.96	37.04	27	48.76	49.45	48.96
May 10	49.81	38.69	37.93	Nov. 6	44.28	48.23	47.80
20	51.92	40.03	39.31	16	42.68	46.99	46.59
30	54.38	41.01	40.19	26	36.10	45.52	45.35
June 9	57.42	42.40	41.34	Dec. 6	33.43	43.89	43.69
19	59.47	43.86	43.05	16	31.31	42.43	42.18
29	63.86	45.35	44.42	31	24.87	39.88	39.77

The extremes in the water temperatures during the ten years did not differ in any given ten-day period to a greater extent than 5°, and the difference was generally less than 3°.

Reference to page 406 will show that the spring spawning occurs in Oak Bay during a period when the surface temperature at Eastport ranges between 36½° F. and 42° F. It takes place, therefore, on a rising temperature. The surface and bottom temperatures keep pace with one another during their rise and fall, and seldom differ by more than 1° or 2° in the depth attainable from the wharves at Eastport, which varied from 2 to 30 feet.

An examination of the temperature of the water at the spawning season of the fall herrings at various places on the coast of the United States shows some interesting facts. Early in the investigation it was noticed that the spawning time receded in date westward and southward along the coast, and that the temperature of the water at any given time became progressively higher in the same directions. In most cases the temperature observations were not made immediately upon the spawning-grounds, but many of the stations were sufficiently near to make probable but a very slight error in regarding the temperatures as identical.

In order to examine more closely into the relations existing between the temperature of the water and the spawning time, a chart was prepared showing the mean temperature of five years at a number of stations during the first week of each of the last six months of the year, the temperatures of all stations at each period being connected by lines, as shown in plate 61. From the data before given the spawning season at each place was indicated by vertical lines connecting its approximate or average date of beginning and ending and at the same time graphically indicating the temperatures prevailing at the surface of the water during the herring's term of reproductive activity. By an inspection of the chart it will be seen at once that there is an apparently close relation between the surface temperature and the time of spawning. The real relationship is, of course, with the bottom temperatures in which the actual spawning takes place, but as these temperatures were available in but one or two places, and as the surface and bottom readings rise and fall *pari passu*, or nearly so, it was considered that the general effect of the temperature may be shown as well by the one series as by the other. A source of possible error arises from the fact that the readings were not made actually upon the spawning-grounds, and are reported from independent observations. The stations at which the meteorological observations were made, however, are so close to the observed spawning-grounds that there is probably but a small percentage of error from this source, and the bulk of the spawning at the place named may safely be considered as accomplished between the dates and temperatures indicated.

As shown in the chart, the spawning of the summer and fall schools of herring takes place at a temperature between 47° F. and 57° F., independently of the time at which this temperature occurs after July 1. West of Matinicus Island the temperature is within this range in spring as well as in fall, but so far as known no herring spawn in that

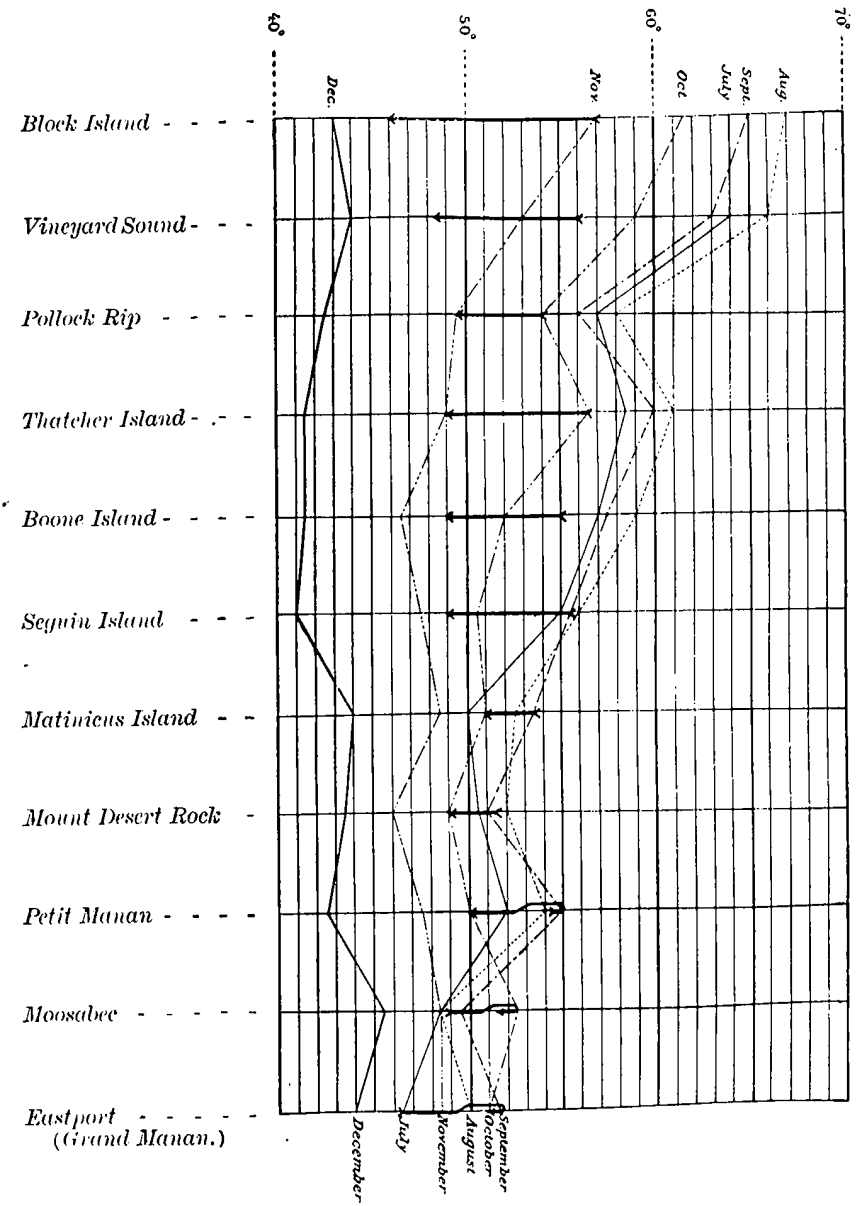


CHART SHOWING THE SEASONS AND TEMPERATURES OF THE SPAWNING OF HERRING.

region during the former season, and this has led to the generalization that the herring spawns on a falling temperature. The chart shows that the statement is true so far as concerns the coast west of Mount Desert Rock, this fact being indicated graphically on the chart by the direction in which the arrow points. At Petit Manan, the next station east of Mount Desert Rock, the herrings begin to spawn about August 15 and continue on a rising temperature until September 1, after which they spawn on a falling thermometer. At Moosabec a larger proportion of the spawning takes place while the temperature is rising, and at Grand Manan, assuming the surface temperatures to be approximately those of Eastport, almost the entire spawning period occurs while the thermometer is rising.

It may be assumed from the facts shown that the fall schools of herring mature only in water approximately of a temperature between 47° F. and 57° F., or if we consider the bottom temperatures, the limits would be between about 45° F. and 55° F. But this range is reached to the westward in both spring and fall, and the interesting question arises, if the herrings of eastern Maine mature when the thermometer reaches 47° and spawn upon a rising temperature, why do not those farther west spawn in spring instead of waiting until late fall or even winter?

The answer to this question will require much more study than has yet been devoted to it. It may be that the wide range in the annual temperature at the western limits of the herrings' spawning range and the comparatively rapid thermometric changes which take place there may produce an effect different from that produced by the more equable temperatures of the Bay of Fundy. At Matinicus Island, however, the temperatures have no wider range between July 1 and November than occurs at Eastport, yet it appears that the spawning of the herring does not begin before September 1, and takes place entirely on a falling temperature. These facts are mentioned here merely to call attention to the need of further inquiry.

In the Bay of Fundy the herring spawn in water from a few fathoms to 30 fathoms in depth, and further investigation would no doubt prove that the eggs are deposited in still deeper water offshore, as in parts of Europe, where, according to Ljungman, they are occasionally hatched at a depth of from 60 to 100 fathoms.

In the Schlei, in Schleswig, the herring spawns in water but a few feet deep, and in the Gulf of St. Lawrence, as is well known, the eggs are deposited in places so shoal that great quantities are sometimes carried ashore by the waves, Perley citing at least one instance of their being used as dressing for the soil. In Oak Bay the water is shoal, in most parts less than 3 fathoms, but in no part of the region here immediately under discussion did I learn of spawn being cast up or destroyed by the waves.

Upon our coasts, so far as known, the herring does not run into fresh, or even brackish, water to spawn. On all of the spawning-grounds

the water is of full oceanic salinity—in the Bay of Fundy being about 1.026—but in the Schlei they are found spawning in water of a density of but 1.0076, which is practically fresh.

In the vicinity of Passamaquody Bay the two sexes of the herring appear to be represented in approximately equal numbers, although observations indicate a slight predominance of the females. In July, August, and September, 1893, record was made of the sexes of 929 specimens selected at random from fish caught at various times and places, with the result shown in the following table:

Condition.	Male.	Fem.
Unripe	288	307
Nearly ripe, ripe, and spent	163	171
Total	451	478

This indicates an average of 106 females to each 100 males, and although the examination of a larger series would doubtless change the result somewhat, this proportion can be asserted with reasonable assurance to be within a small percentage of the truth. The examination of a larger number of herring by Scotch fishery officers gave an average of 99 females to 100 males. The data in the foregoing table must not be adduced to show the proportions of ripe and unripe fish during the season mentioned, as that would depend entirely upon the time and place of capture. Most of the unripe fish examined were below the minimum size of sexual maturity, and were taken far from the spawning-grounds.

During the act of reproduction, as I witnessed it at Cross Island and Machias Bay, the fish were darting rapidly about, and those who have opportunity to see the fish spawning in more shallow waters, where observation is more favorable, state that both males and females are in constant motion, rubbing against one another and upon the bottom, apparently by pressure aiding in the discharge of the eggs and milt.

At the time of extrusion of the eggs they are covered with a sticky mucus which speedily hardens upon contact with the water and causes firm adhesion to the bottom upon which they fall. They are sometimes spread out into thin layers, or they may be in small irregular lumps or masses, according to the circumstances attending their discharge. They measure about 0.05 inch in diameter. In a ripe female the ovaries constitute about one-fifth of the total weight, and according to the investigations of Dr. Wemyss Fulton, the total number of ova ripening annually varies from 21,000 to 47,000, the average being about 31,000.

All the individuals of a school do not ripen at the same time, fish with roes and milts far from mature being associated with those in which the products are loose and free in the glands, but it was observed in 1893 that the proportion of ripe fish in a school increased as the spawning-grounds were approached. For instance, at Campobello, in

September, very few ripe fish were seen; at Northern Head, Grand Manan, about half were ripe a few days later, while upon the spawning-grounds at Machias Bay nearly all were ripe.

It would seem that the more matured individuals in a school, when approaching ripeness, make for the spawning-grounds and carry with them a portion of those less advanced. From time to time during the journey some of these drop off from the school, probably in pursuit of food which proves less attractive to the riper individuals, and thus by the time the spawning-ground is reached few but the riper ones are left. For a time before the discharge of the genital products little or no food is taken, but at the Northern Head of Grand Manan the more immature fish in the schools were found to be still feeding.

The fishermen assume that the herrings return to spawn upon the same grounds upon which they were hatched, but this statement is difficult to authenticate. If the aforementioned account of the origin of certain herring fisheries near the Gut of Canso be true (which I doubt), this tends to confirm the theory, as does also the continued annual spawning in Oak Bay, when apparently equally favorable places in the vicinity are neglected. Upon the other hand, it is well known that spawn herrings will sometimes disappear from their accustomed grounds for a year or a period of years and will then return as abundant as ever. Upon the whole, the evidence upon this point is entirely insufficient, and the fisherman's theory seems somewhat doubtful and but a corollary of a general hypothesis based upon the data relating to the shad, salmon, and other anadromous species.

It is not regarded as at all probable that an individual herring will spawn more than once each year, but it is reasonably certain that it spawns annually for a period of years unless its career is cut short through the agency of the numerous perils which beset it. In all ripe herring of whatever size there may be found, together with the ripe eggs, a large number of very minute ones which are destined in the ordinary course of nature to undergo the ripening process at some future spawning period. These immature eggs exceed the ripe ones in number, though the latter individually and collectively far exceed them in bulk. They are barely visible to the naked eye, but they can be readily detected with a simple lens as minute particles adherent to the walls of the ovary. Through the distension of the ovary by the ripe eggs they appear rather scattered, but in the unripe individual, whether prior to the first spawning or sometime subsequent to the discharge of the ripe ova, they appear densely crowded. The spent ovary is flabby, the vessels are usually gorged with blood, and the finger may be easily run into the cavity of the organ as into the finger of a glove, but in a short time, owing to the contraction of the walls, the organ again becomes firm and apparently solid. Herrings with freshly spent ovaries appear to immediately move off into deeper water, as it was found that very few in that condition were taken in the fisheries.

The early stages in the maturation of the genital glands appear to progress slowly. There is a gradual increase in the size of the organs, and in the case of the ovaries this is accompanied by a great increase in the size of the individual eggs. After they have reached full or nearly full size there is a period of quiescence, followed by a rapid completion of the final processes. The testes become soft and the milt will flow when they are ruptured, while the eggs become clear and loose in the cavity of the ovary. The clearing of the eggs does not take place throughout the whole ovary at once, but usually, although not always, begins at the posterior end and along the outer side next to the body wall; it then progresses forward and inward until apparently the whole ovary is involved, the last stages being the loosening of the eggs in the follicles and their dropping into the lumen of the organ preceding their discharge from the fish.

The rapid development of the genital organs, which, as before stated, when ripe constitute about one-fifth of the total weight of the individual, makes a heavy drain upon the substance and energy of the fish. Any fat which may have been stored up prior to this period tends to disappear, its substance furnishing, in part, the material and energy required in the maturation of the ova and spermatozoa. This calling upon the reserve, and the additional circumstance that the ripe fish take but little or no food, causes the spent herring to be poor and lean, but after spawning they rapidly fatten if an abundant food supply be available.

It appears that herring 8 inches in length are commonly found with ripe spawn and milt upon the coast of Norway and Sweden, but there is a wide difference of opinion concerning the age of such fish, the estimates of different naturalists varying from one to six years. Ljungman estimates their age at three years; Huxley thought the age at which spawning begins to be not more than sixteen to eighteen months, while G. O. Sars thinks that the minimum in most cases is five or six years.

From a large number of herring examined at Eastport in 1893 and 1895, I am led to conclude that ripe fish under 9½ inches, measured from tip of snout to fork of tail, are very rare, and that usually they do not mature genital products before they are 10 or 10½ inches long, while most of the spawn fish observed at Grand Manan and Machias, as well as those brought from Moosabec to Eastport in 1893 and 1895, were about 12 or 13 inches long. These statements apply to the autumn spawning fish only, as no opportunity was had of examining the fish of the spring school, although the fishermen state that the latter are good-sized fish. I believe that the first spawning takes place when the fish is between two and three years of age.

The period of incubation of the eggs varies according to the temperature, cold water retarding and warmer accelerating the period required for the development of the embryo. From experiments made by the United States Fish Commission, it appears that upon the coast of Massachusetts from ten to twelve days elapse between fertilization and

the escape of the larva from the egg, and this is also about the time required upon the eastern portion of the coast of Maine, where the water temperature is about 50° F. during August and September.

As showing the effect of temperature upon the rate of development the experiments of Dr. Meyer may be cited. He found that with a temperature of 38.3° F. the development of eggs takes 40 days, with a temperature of 44.6° to 46.4° F. about 15 days, and with a temperature of 50° to 51.8° about 11 days, and that the influence of temperature upon the eggs of the spring herring does not differ from its influence on the autumn herring.

As soon as the yolk-sac has disappeared, which is in two or three days, the young begin to feed, according to Meyer, their food consisting of copepods and the embryos of gastropods and lamellibranchs. No opportunity was had at Eastport of examining the food of such young fish, but individuals from 2½ to 3 inches long and larger were found gorged with copepods, as were also young alewives, an allied species, 2 inches long. From the abundance of copepods in the neighborhood of the Bay of Fundy it is evident that the newly hatched herrings have available an abundant and suitable food supply.

The young herring grow rapidly, as may be seen from the following table of sizes of herring caught in the Schlei, in Schleswig. It is extracted from Meyer's paper, and the ages of the fish are approximately correct:

Age.	Length in inches.
1 month	0.68 to 0.72
2 months	1.36 1.44
3 months	1.80 2.00
4 months	2.20 2.44
5 months	2.60 2.88

The growth of the herring, as of other fish, is largely dependent upon the abundance of the food supply, and it is unsafe to make comparisons between regions where the biological conditions may be diverse, but a comparison may be made of the several sizes of the brit in the vicinity of Eastport.

On August 2, 1893, large numbers of herring 2 to 2½ inches long were seen in West Quoddy Bay. It is out of the question that these fish could have been hatched from the earlier eggs of the school spawning this year at Grand Manan, and it is equally improbable that they could have grown so little if hatched during the preceding fall, even as late as November. We must suppose, then, that they were derived from eggs deposited in Oak Bay, the nearest spring spawning-ground. The bulk of the herring there appear to spawn in May, and placing the time of hatching of the present specimens at the beginning of that month, we would have three months as an estimate of their age, certainly not any older than this if my information concerning the spring spawning is to be credited. In the latter part of September of the

same year herring about 3 inches long were observed at St. Andrews, and in the middle of September, 1895, large numbers of about this size were seen playing at the surface in the St. Croix River between Deer Island and the "Perry Shore" of Maine, these also being, with little doubt, fish hatched during the preceding May. Comparing these two sizes with Meyer's table, it will be seen that they are equal to the Schlei herring a month older, and this is perhaps not surprising when we consider the great richness of the food supply of the Passamaquoddy district.

On August 2, 1893, the same day upon which the 2-inch herring were taken, large numbers of 5½-inch herring were caught in the weirs at Fry Island, New Brunswick, and in 6 hogsheads of such fish there were but two or three large ones. It seems most reasonable to regard these as fish hatched during the preceding fall, and as they could not have been spawned later than October (about the last of the spawning season in eastern Maine and New Brunswick) they were from 9 to 10 months old at the least.

A few days later (August 8 *et seq.*) large quantities from 6 to 7 inches long—a few of the largest being almost 7½ inches—were taken at various places near L'Etang. Two views of these fish present themselves—either that they were hatched from the earlier eggs of the summer and fall of 1892, or from spring eggs of that year. In consideration of the larger number caught at various places about this time, and of the limited extent of the spring spawning school at Oak Bay, it is the more probable that they are the progeny of the large fall schools, and when compared with the 5½-inch herring before mentioned, it may be fair to assume that they were hatched from the earlier eggs, say in July or August, and are, consequently, 12 to 13 months old. A few herring, 8 to 8½ inches long, with very immature ovaries, were taken with these, and may have been individuals of the spring spawning of 1892, i. e., 15 months old; they could hardly have been as old as two years.

As before stated, the smallest ripe herring seen were 9½ to 10 inches long, and there were few of these relatively to the ripe fish examined. If the ages already assigned are correct, these must be at least 2 years old, and can hardly be more than 3 years. It will be noticed that I assume an increase in length of but 1½ inches in eight or nine months, but it must be remembered that the rate of growth in fish is usually less rapid as they approach maturity, and that the maturation of the genital products makes such a heavy draught upon the nutrition that it in all probability considerably retards the rate of growth.

The vicinity of Eastport presents difficulties in the study of the rate of growth, owing to the extension of active spawning over a period of four months in summer and fall, which with the addition of the spring season makes it possible for fish hatched during the same year to differ six months in age. A great variety of sizes may be taken at almost any time during spring and fall, and standards are difficult to

select. The matter was given considerable attention, however, and large numbers of specimens were measured, and while the reasoning just given partakes largely of speculation, the conclusions are believed to be not far from the truth.

ALLEGED DECREASE.

The complaint of the decrease of the herring in the waters of Passamaquoddy Bay and vicinity is not a new one. In 1850, when Mr. Perley wrote his report* upon these fisheries, the fishermen were already much concerned about this species, as will be seen from the following quotations:

The smaller herrings, such as are generally cured by smoking, were formerly very abundant on the shores of Deer Island. The fishermen of Campobello said that the people of Deer Island had broken up the schools and driven the fish away by the excessive use of small-mesh nets. (Op. cit., p. 115.)

Mr. Chaffey (Indian Island) said that herrings were not so abundant now as twenty years ago; of late years the quantity has fallen off greatly and they are now much smaller. He did not consider the weirs injurious to the fishery, but thought that the mischief was done at Grand Manan. When Mr. Chaffey first went to Indian Island brit were very abundant; they averaged about 5 inches in length. These little fish are exceedingly valuable as food for larger fish, but from some unaccountable cause they have altogether disappeared, not a single specimen having been seen for ten years. * * * This locality (Campobello) was revisited in the latter part of October. Mr. Patch then stated that the herring season was over and that the quantity in the weirs was only about half the usual or average catch. The quality of the fish was good; not many small fish had been caught—he had only thrown away 3 barrels, while his whole catch amounted to 3,000 boxes. (Op. cit., p. 116.)

In 1880, when the volumes upon the Fishery Industries of the United States were being prepared, it seems that the same complaints were heard. We find on pages 505–506 of section V, vol. I, the following:

Are the sardine herring being exterminated? For a number of years prior to the establishment of sardine canneries the weir fishery was less important than formerly. This was by some thought to be due to the scarcity of fish, but it seems more probable that it was owing to the low price both of oil and smoked herring, which made the prosecution of the fishery unprofitable. Many fishermen claim that the herring are rapidly decreasing, and they cite the large quantities taken in former times and the present small catches at Lubec as proving their theory. The fish are undoubtedly less abundant in the vicinity of Lubec and in the waters of Cobscook Bay than formerly; but this seems to be explained by the peculiar method of fishing at that place.

Though the weir fishery had been extensively prosecuted for many years, the catch had not perceptibly diminished up to 1865, when the building of deep-water weirs, which extended so far out into the channel as to nearly meet from the opposite shores, effectually shut out the herring from their usual entrance to Cobscook Bay, which seems to have been a spawning-ground. The herring, thus practically debarred from this entrance, seem to have moved a few miles farther east, and are now more abundant in the vicinity of Deer Isle. In other sections there is no sufficient evidence to show any permanent decrease, though the catch of one year, for various reasons, may vary considerably from that of the following or preceding one.

*Perley, M. H., Report upon the Fisheries of the Bay of Fundy, Fredericton, New Brunswick, 1851.

In 1893 the opinions of many of the fishermen were practically the same as set forth in the foregoing, but it was noticeable that such views were less prevalent in 1895.

A fisherman at Perry, Me., said:

I do not believe that they are as abundant now as they were fifteen to twenty years ago, but even now they are by no means scarce. That the fish have become much less abundant on this shore is certain.

A fisherman at Campobello, one of the oldest in the region, says:

The herring in this region have been decreasing for the past sixty years, and I attribute it to the many weirs catching young fish.

Another man at Campobello, who has been fishing sixty years, states his views as follows:

I think that the herring have decreased. At one time every cove and creek was full of them. Mr. Treat used to catch a great many such as we get now, and I have known him to get 100 hogsheads a number of times on a single haul.

At Eastport, a man who has had wide experience in the fisheries and who, as captain of a fishing tug, has of late had unusual opportunities for observations, very emphatically contended that there had been a heavy decrease in the herring. He says that the weirs do not average as large catches as formerly, and that the increase in the total catch is due to the relatively greater increase in the number of weirs and to their larger size.

The owner of a weir at Kendall Head says:

My weir here at one time had the reputation of being one of the steadiest and best, but it is now an utter failure. I own an interest in four weirs on the west side of Deer Island, New Brunswick, and I have noticed no decrease there in ten years. They have about held their own. The weir at Indian Point, New Brunswick, however, used to catch lots of fish, but it failed, utterly, five years ago.

Similar opinions were expressed by other weir fishermen at various places, and the net fishermen at Grand Manan stated the catch of herring was growing smaller, owing to the young herring being caught up in the weirs.

On the contrary, many men held either that there had been an actual increase or that the decrease has been very slight. This opinion, which, of course, excepts the winter herring, was especially prevalent in 1895, a fact, no doubt, due to the heavy catches which were being made at the time the investigation was being conducted.

A large packer at Eastport says:

More herring have been caught here in the last few years than in any similar period preceding. I doubt, however, if there has been an actual increase in the fish; there are probably fewer than formerly, but the decrease has not been great. The greater catch is due to the increase in fishermen and weirs.

A fisherman at Robbinston thinks that the weirs on the American side of St. Croix River have this year (1895) done as well as ever. Herring were caught steadily between Robbinston and Gleason Cove from June 15 to the latter part of September.

In the opinion of the oldest weir fishermen at Bocabec, New Brunswick, the number of herring in the region has actually increased, notwithstanding the increase in apparatus.

At St. George, New Brunswick, it was said that there were more herring at L'Etang and vicinity than ever before. As far as memory runs, there have been years of scarcity and years of plenty, but there has surely been no decrease.

A boatman said:

> At Deer Island (east side) one weir is said to have stocked $2,500 to $3,000 this season (1895), the fish being taken early, when better prices prevailed. Most of the fishermen have made little money this season, owing to the low prices due to the great supply. There appear to be more fish this year and last than ever before, and this statement is made with a full recognition of the effects of a greater number of weirs.

At Dark Harbor it was stated that there was no great decrease in the herring, nor was any expected so long as the extensive spawning-grounds around the island were protected.

At Lubec it was stated that the weirs in West Quoddy Bay did better in 1893 and 1894 than for many years. More herring were taken in the Quoddy region last year than ever before. In some places the fishery has failed, and in others it has improved.

An octogenarian fisherman near Pembroke says:

> We did not notice any falling off in the catch here after the sardine factories were established, nor do I think that there has been any material decrease in the number of herrings in these waters. I have not caught so many this year, but others have done as well as ever, and I never knew of there being more herring than there are this year. Last year (1894) there were certainly more herring taken into Eastport than have been seen there before.

Another fisherman in the same region says:

> The catch in Pemmamaquan River fluctuates very much. For instance, my weir in 1893 caught but one hogshead during the entire season, and last year (1894) until September it did practically nothing. After that date it fished very well indeed, and there was no lack of fish until the end of the season, and the other weirs in the vicinity also did very well. This year (1895) is the best season which I have ever had, and although others have not done so well as I, the catch is, nevertheless, a very good one.

A variety of opinions have been cited from divers localities in the region under consideration, and it is now necessary to consider the question from an historical and rational standpoint. It is to be understood that the discussion relates solely to the weir fisheries; the winter and Quoddy River herring fisheries have been elsewhere treated of.

It will be most convenient to first consider the matter locally, beginning at West Quoddy Bay and taking up each locality seriatim.

Prior to 1868 great numbers of herring were caught in West Quoddy Bay and Lubec Narrows, but for some reason the fishery failed about that time and the majority of the weirs fell into disuse. In 1865 the herring appeared in West Quoddy Bay about July 15, the usual time, and although the run was very heavy, it lasted but six weeks, the fish-

ing ceasing about the latter part of August. In 1866 the run began June 22, and, being unexpected, the weirs were not ready for use, and many of the fish were lost. At that time there were but two or three weirs in Lubec Narrows, but in 1867 the number was increased to 6 or 8. From 1868 to 1893 the West Quoddy Bay weirs were an almost total failure, but in the latter year the herring again appeared there. They arrived October 16 and were taken nearly every day until November 29, and after that irregularly until December 13. At this time there were 5 weirs above the beacon. In 1894 this experience was duplicated with striking exactness, the fish arriving October 15 and remaining steadily until November 27. In August, however, two small lots were caught. The fish were rather larger than in 1893.

In 1895 up to the close of the investigation, about September 25, no herring were taken with the exception of a few small lots in August, these being similar to the run which appeared simultaneously at Herring Cove. A letter from Lubec, however, states that the herring came in considerable numbers early in October, but as there was little demand, owing to labor troubles, very few were taken from the weirs. It was supposed that the run was about equal to that of the preceding year.

The same informant, in a letter dated August 31, 1896, says:

> The catch on the American side, in the vicinity of Lubec, this year is beyond estimate. Boat loads may be dipped on the shores, in the docks, and in the weirs without the aid of light or seines. The oldest inhabitant never saw anything like it. In Johnson Bay the water is literally alive with herring. Certainly one can say without exaggeration that there are more fish in this immediate vicinity than there has been for the last two decades, put them all together.

Treat Island, about 1 mile inside of Lubec Narrows, was at one time the best fishing location in Passamaquoddy, and I am informed that $25,000 was vainly offered for this property during the height of its prosperity. Catches of 100 hogsheads on a single tide are said to have been not infrequent. The most trustworthy information that I have been able to obtain fixes the date of the failure of this weir at about the year 1870, and it has taken practically no fish since—i. e., to September 20, 1895. It was abandoned for a number of years, but has recently been placed in repair.

In Johnson Bay, the lower part of Cobscook Bay, the weirs were at one time of great value, but they now catch but little. The weir at Shackford Head was a very profitable one, but since 1885 it has failed to such an extent that it has not been kept in repair, and in 1895 was practically wrecked and no effort was made to fish it up to the latter part of September. On the contrary, in the lower portion of Pemmamaquan River, which is practically an arm of Cobscook Bay, there is no complaint. There were a few small "half-tide" weirs prior to about 1882, but there are now about 17 large weirs here and in East Bay, adjoining. There have been fluctuations in the catch from year to year, but there have been no long-continued periods of failure, such as are predicated of the more immediate vicinity of Eastport. In 1894 herring

were abundant, and in 1895 all the upper arms of Cobscook Bay were teeming with them.

On the east side of Moose Island (Eastport) and on the main shore as far north as Gleason Cove the weirs have failed more or less completely, and many of them have been abandoned. Many years ago, at least fifty, a "half-tide" weir was built north of Harris Head. It was a small, cheap structure, but it took great quantities of herring. It sometimes caught more than could be used, and it was then necessary to knock down a section so as to liberate some of the fish and prevent them dying in the weir. This was afterwards replaced by a more elaborate structure, which, like its predecessor, fished regularly for many years, its owner stating that for fifteen years it averaged 300 hogsheads per annum, the catch ranging from 250 to 350 hogsheads. According to the same authority, about three years after the factories were established at Eastport it began to fail, and was soon abandoned and has not been rebuilt. South of Harris Head and on the south side of Kendall Head the experience was the same. North of Kendall Head the weir is said to have failed a little later. In 1894 there were two weirs at this point, but in 1895 one of them had been abandoned. The other had caught nothing up to September 20.

There have been two weirs in Gleason Cove since about 1882 or 1883, and until 1888 they did very well. In 1887 the two caught about 400 hogsheads, the best that they have ever done. Prior to that they caught from 150 to 200 hogsheads per annum. In 1888 there was a sudden dropping off. Since then they have barely paid expenses, and in 1894 the catch was practically nothing. In 1895 nothing was taken up to September 1. The herring usually came here about August 1, and lasted to the end of the season.

About a mile north of Gleason Cove a weir had taken about 100 hogsheads in 1895 up to the latter part of August, and I was informed that from 1,500 to 2,000 hogsheads of herring had been caught in 9 weirs between Gleason Cove and Robbinston prior to September 20, 1895, which catch, my informant claimed, was larger than any during the last decade. It was stated that there were more weirs on this shore in 1885 than at present, but if this be a fact they must have been built between 1880 and 1885. In 1880 there were about as many as in 1895.

From the foregoing it would appear that in 1894 and 1895 there were less herring than formerly on the American shore at Treat Island, in Johnson Bay, the lower waters of Cobscook Bay, and from the mouth of Cobscook Bay north to Gleason Cove. In all other places there was either no decrease or but a very slight one. In 1896 the fish were everywhere abundant, and large schools frequented all of the waters about Eastport and Lubec.

On the Canadian side, beginning with St. Andrew Bay and its several arms, we find almost unanimous testimony to the abundance of the herring during the past few years. On August 29, 1895, the fish-

ermen at Chamcook stated that their weirs had been full of herring for two weeks or more, but they had not been seined, owing to the absence of transportation, the boats getting their fares in more accessible places. The weirs around the entire shore of St. Andrews Bay had been fishing well and steadily wherever they had received regular attention, and at Northern Harbor, on Deer Island, the weir had been catching from 18 to 20 hogsheads of "oils" daily for some time past. After September 1, however, the weirs in St. Andrews Bay caught but little.

There were more fish in these waters in 1894 and 1895 than for many years, notwithstanding the great increase in the amount of apparatus. In 1876 there was but one weir inside of a line drawn from the head of Petite Passage to Clam Cove. In 1878, as nearly as can be learned, there were 7 in the district so defined, and in 1893 this number had increased to about 33.

In 1895 herring appeared at L'Etang and vicinity about July 20, and they continued in abundance during August and September, in the latter month great quantities being taken in most of the weirs. There were many more than could be utilized for food purposes and many were used for fertilizer. They sold for a trifle, and one instance came to my knowledge where 19 hogsheads were sold for $5, or at the rate of 26 cents per hogshead. In other cases they were delivered on the farmer's shore at 75 cents per hogshead. During a large portion of the season many of the weirs, both here and in St. Andrews Bay, were hardly seined at all, although they contained large numbers of herring of marketable size. There was an overplus of fish everywhere and the boats naturally secured their fares at the most convenient places. Few of the fishermen made much money, but it was because the fish were too abundant rather than too few.

At Deer Island and the West Isles the herring as a rule come earlier, usually in June and July, the latter month and August being the best for the fishermen. Here also they were exceedingly abundant, but as there were fewer fish elsewhere at that time some of the fishermen had a profitable season, and one weir is said to have stocked between $2,500 and $3,000. There were also some herring at Deer Island about the middle of September, and one weir took 100 hogsheads on two runs of tide. In 1894 they were also extremely abundant in the vicinity of Deer Island, and considerable quantities of smoking herring were caught, although but comparatively few were taken in 1895.

The following history of weirs 63, 64, 65, and 66, of Dr. B. L. Hardin's chart of 1893, was secured:

No. 66 is a small weir, opposite Kendall Head. In 1886 it caught 40 hogsheads in about three weeks, and since then has averaged 15 to 25 hogsheads per year.

No. 65 got 100 hogsheads in 1893, but in 1894 it did not do so well, getting only 40 hogsheads.

No. 64 got 100 hogsheads in 1894, and in 1895, to about August 20, it caught 40 hogsheads. In 1894 it caught 60 and 40 hogsheads on two tides, but in addition about 60 hogsheads were released, so that the actual catch was 160.

No. 63 got 65 hogsheads in 1894, but in 1895 had caught nothing up to the beginning of September. These weirs, which are on the west side of the island, are all relatively small, owing to the rapid deepening of the water, which prevents their extension far from shore.

On the east side the weirs appear to do much better. Leonard's weir, to August 15, 1895, had sold about 200 hogsheads, and it was estimated that there were shut in at that time about 50 hogsheads, for which no market could be obtained.

At Welch Pool and Herring Cove, on Campobello it was stated by a fisherman of 60 years' experience that—

> We catch nearly as many here as we formerly did, but the season has grown shorter. Up to about 1883 we used to catch them very early; when our weirs were not destroyed by the ice we have got them in March, and about twenty years ago we made a good haul about February 15, when we broke the thin surface ice in the pound, so that we could run our seine. These were smaller fish than the regular winter run, being of a size suitable for smoking. The fish which we formerly got in March do not now arrive until July. This change began about 1882 or 1883, and has been going on gradually ever since. I think that on the whole the herring have decreased.

Another fisherman, who began fishing seventy years ago, says that herring in this region have been decreasing for the past sixty years.

During 1895 considerable quantities of herring were taken at Harbor de Lute throughout the entire month of August, and it was said that a similar run occurred during 1894. They were of a size suitable for smoking, and similar fish were caught by "drifting" at Deer Island at about the same time. In 1895 there appeared to be fewer sardine herring at Campobello than at other places in the vicinity.

At Grand Manan the season of 1895, up to September 25, the time of my departure from Eastport, was a poor one, but 1893 and 1894 were both unusually good. In 1895 the weirs at Seal Cove, High Duck Island, and other places caught very little. At Seal Cove they usually catch considerable quantities of "medium stringing" herring, which were absent in 1895. Mr. McLaughlin, at Southern Head, says (1893):

> The herring are as abundant as ever, and they still appear in enormous shoals in the Bay of Fundy. This conservation of the fishery, in spite of destructive methods, is largely due to the opportunities for spawning enjoyed by the fish during the close season at Southern Head. The fish, however, keep offshore more than formerly and I attribute this to the pollution of the shore waters by lobster pots, trawls, etc.

Mr. Simeon Cheney says (1893):

> The herring are certainly as plentiful as ever in the open waters, but they are kept off shore by pollution of the water.

Captain Pettes, whose observations on the fisheries of Grand Manan extend back many years, states that of late he has seen as large bodies of herring as ever in the Bay of Fundy.

Others added testimony of a similar character, but the gill-net fishermen at Whale Cove stated that there had been a decrease, owing, as they suppose, to the pounds catching young fish.

During my visit, early in September, 1893, there was a very fair run of net herring, but they did not occur in 1895.

On the Canadian side, judging from both observation and testimony, there appears to have been no decrease in herring since the establishment of sardine factories, with the exception of a portion of Campobello, where perhaps a slight decrease may be noted.

Taking into consideration the entire Passamaquoddy region, more herring were taken in 1894 and 1895 than ever before. This was especially the case with sardine-herring, many more being caught than could be utilized by the factories, and this, too, notwithstanding the fact that the pack was unprecedented. In consequence of this, many of the weirs were not seined for several weeks, although containing an abundance of herring.

It may be objected, however, that this is due to a great increase in the number of weirs; that an unwarranted number have been constructed, and that by virtue of this increase there is still an overplus in the herring supply, despite an actual decrease in the abundance of that species. In other words, that there is an increase in the total catch, while at the same time the average catch per weir has decreased. This objection has been urged with some plausibility, but an examination of the records shows it to be unwarranted. As compared with 1879, the total catch in 1895 was proportionately greater than the increase in the number of weirs. According to the estimates made in "The Fishery Industries of the United States," the weirs on Deer Island averaged 100 hogsheads per annum in 1879 and 1880; those on the United States shore above Lubec caught 75 hogsheads each, while at Lubec the average was between 60 and 65 hogsheads in the years mentioned. The estimates are affirmed to include the total catch, and presumably take into account not only the herring used in the manufacture of sardines, but also those larger ones which were smoked. Statistics show that in 1893 the average catch per weir in all the waters between West Quoddy Head and Beaver Harbor was 148 hogsheads, and in 1895 the average for the same region was 171 hogsheads. These figures include only such herring as were utilized in the United States, and do not take into account those Canadian-caught fish which were smoked and pickled in New Brunswick or which were sold as fertilizer.

Distinguishing the weirs by their location, it is found that in 1893 those in United States waters caught 196 hogsheads on the average, while those on the Canadian side are credited with but 134 hogsheads each. In 1895 the catches were 181 hogsheads and 166 hogsheads, respectively. In both years, but especially in 1895, the Canadian weirs caught more than indicated in the returns cited, much of the catch failing to secure a market and some of the balance being used in the home production of smoked and pickled fish and as fertilizer.

The decrease in the catch upon the United States shore in 1895 as compared with 1893 was principally in West Quoddy Bay, the cause being an economic one rather than due to a falling off in abundance. The herring in 1895 came to West Quoddy late in the season, as is their custom, but as the operatives in the sardine factories were on a strike, the fish could not be utilized and were allowed to escape from the weirs.

In the light of all the evidence procurable there is but little to support the view that herring are decreasing in the vicinity of Passamaquoddy Bay owing to vast numbers of young consumed in the sardine business or to the fishing methods to which it has given rise. If interpreted strictly, the figures cited in the foregoing would indicate an actual increase, but as this would be "proving too much" the argument will not be pressed. It can be asserted, however, with perfect confidence, that there is nothing in the recent condition of the fishery to warrant anxiety concerning its future.

Those who have claimed that the herring have decreased have given a number of reasons to account for the falling off. When the fishery in West Quoddy failed in 1868 it was said to be owing to the increased number of large weirs cutting off the ingress of the fish, and it was supposed that this also caused the failure in places in Cobscook Bay. It was claimed that the herring formerly entered Passamaquoddy Bay by this route, and that when the passage was closed up by the weirs the herring moved eastward and entered by the Head Harbor passage. In 1893–94, according to one of the best-informed men in the region, the fish came out of Lubec Narrows, and the same authority states that this is the way they always did, and, moreover, the carefully prepared chart of the region made in the summer of 1893 shows that the pounds are arranged to catch fish passing out rather than in. If this be correct, it indicates that the weirs in Lubec Narrows were not responsible for the falling off in Cobscook Bay.

If the herring had been simply blocked out of the waters by the great number and large size of the weirs in West Quoddy and the Narrows it would seem probable that they would return soon after the number was decreased. The fishery failed in 1868, and after a futile maintenance for several years a number of the weirs fell into utter ruin. Yet, for twenty-five years the number of herring caught there was barely sufficient to pay expenses. The disappearance and reappearance of the herring from this locality is, in the absence of sufficient data, at present inexplicable.

Another hypothesis upon which it was sought to explain the late absence of herring from the immediate vicinity of Eastport is that of pollution of the water by the offal discharged by the sardine factories. It is stated that the failure of the weirs began in the vicinity of the factories and gradually progressed along shore. A number of specific cases were cited as illustrations of this; the weirs at Harris Head, Kendall Head, and Gleason Cove, on the United States side above Eastport, and at Indian Island, opposite Eastport, being examples.

The sardine factories are nearly all located at Eastport and Lubec, and weir owners state that the "gurry" hangs close to the United States side and by its offensiveness drives the herring into Canadian waters and incidentally into Canadian weirs. I was informed that until about 1890 most of the cuttings, etc., from the factories were thrown into the harbor, but at present they are sold to a fertilizer factory and converted into pomace and oil.

Although little refuse is now willfully thrown into the water, it can not be denied that more or less fish heads, oil, etc., eventually get into the harbor. Thin films of oil are frequently observed on the surface in Friars Roads, being readily recognized by the "sleek," as the fishermen call the unrippled surface produced by the oil film. The presence of herring (whitebait) in the estuary of the Thames, polluted, until recently, by the entire sewage of London, throws some doubt upon the effect of such pollution as takes place at Eastport. Granted the effect, however, it may be well doubted if it operates so adversely to American interests and affects those of New Brunswick so little as has been supposed.

The oil must be to some extent distributed over the surface by the winds, but the general body of polluted water is at the mercy of the tides, which are of such a complex character in Passamaquoddy Bay as to secure a very wide dissemination of materials which they may carry.

The flood tide sweeps in at Head Harbor, and, passing down between Deer Island and Campobello, splits at Indian Island, part of the water passing all but two or three of the factories at Eastport and into Cobscook Bay and the other part flowing north between Deer Island and the mainland. During a portion of the flood the tide also flows through Lubec Narrows into Johnson Bay. During flood tide, then, only such weirs as are located in Cobscook Bay will receive the polluted water. During the last of the flood and the entire ebb a strong current flows out of Lubec Narrows, so that the greater part of the time polluted water from the factories at Lubec would be discharged into West Quoddy Roads. But the failure of the weirs there could not have been due to offal from the canneries, for it occurred in 1868, and the first factory at Lubec was not operated until 1880, and it was several years later before they became numerous.

Polluted water from the factories at Eastport south of Clark Ledge would, on the ebb tide, be carried across toward Harbor de Lute on Campobello, where some of the best weirs in the vicinity are located. This deflection of the ebb tide is produced by the great body of water coming down from the western passage around the lower end of Deer and Indian islands and there meeting with the opposing current from Cobscook Bay and Friars Roads. The strongest tides on both flood and ebb are toward the Deer Island shore. Above Clark Ledge, as far as Kendall Head, there is an eddy on the United States side, so that polluted water from several factories located there would tend to circulate along shore. Above Kendall Head is another broad eddy, extending

out almost to the international boundary line and as far up as Pleasant Point. In this region there are no factories, and the current sets south at all times, except on early flood tide. A similar eddy is found from Pleasant Point up past Gleason Cove.

Now, in the light of these facts, let us examine into the specific cases above cited. All the information obtainable concerning the weir at Harris Head points to the conclusion that it failed about the time of the establishment of the factories. It is possible for polluted water from some of the upper factories at least to gain access to the place, and in a cove south of the head I found great quantities of dead fish and offal lying on the bottom.

In regard to Kendall Head weir, it was stated that it began to fail about the time the factories were established at Eastport and that when the factory south of Kendall Head was built the failure became more rapid. It had failed about one-half before the factory was built south of the head. In 1894 the factory was burned, but no fish were caught in 1895. It is doubtful if any considerable quantity of polluted water is able to reach this weir, on account of the character of the tides, and, moreover, no increase has been noticed since the pollution has been lessened by the use of cuttings for fertilizer, which, according to the best authority, began about six years ago.

In regard to Gleason Cove, it was asserted at Eastport that the weirs were built eight years ago, and that they fished very well until about one year ago, when a factory was built in the cove. Since then it had done nothing. Here, it was supposed, was a case where the failure had occurred so recently that it offered a field for close investigation. Upon inquiry on the ground, however, it was found that the weirs were built about 1880 or 1882, and that until 1887 they averaged about 75 to 100 hogsheads of herring per year. In 1887 they caught 200 hogsheads each, but since then they have hardly paid expenses, and in 1894 the catch amounted to nothing. I am convinced that no great quantity of polluted water from any of the factories has reached these weirs at any time, and, moreover, the greatest catch was made at a time when the factories were almost as numerous as now, and when relatively and absolutely more offal was discharged into the water. The factory at Gleason Cove has had no influence upon the weirs there.

Concerning Indian Island, Eastport informants said that this weir has been falling off ever since the establishment of the factories at Eastport, and that the fish never entered it when the wind was southwest and the oil and "gurry" was carried over from Eastport. Inquiry from the man who fishes this weir disclosed the fact that the catch had fallen off of late years, but the direction of the wind had no effect, so far as he had noticed. It may be observed that the direction of the wind can not affect to any great extent the distribution of the polluted water, but only the surface oil film. The evidence, so far as it was possible to sift it in definite cases, did not point to the fact that the offal was largely responsible for the falling off in the catch of the weirs on the United States side in the vicinity of Eastport.

Moreover, there is good reason for believing that at the time to which most of the dissatisfied ones point as the period of greatest abundance there was greater pollution of the water than at present. Of recent years but little of the offal of the factories at Eastport has been willfully thrown into the water. That which is so disposed of results entirely from the washing of the factory floors and the tapping of the tanks used in washing and salting the herring. As before mentioned, the heads and other refuse from the fish are sent to the fertilizer factory, and such materials only get into the water by accident. This practice has been adhered to since about 1890.

The older fishermen refer to the period between 1855 and 1870 as the time when herring were most abundant. Prior to the first date given no use was made of the small herring, such as are now used for oil sardines, but about that time Mr. Treat, who owned the famous Treat Island weir, began pressing such fish for oil. It was at the time a profitable industry; the fishermen at once took hold of the new idea, and it is estimated that within the next decade at least 100 presses were constructed by the fishermen of Quoddy. During and just following the civil war there was a great demand for fish oil, and for awhile it paid better to press even the large herring than to smoke them.

Large quantities of pomace resulted from this industry, and for a considerable period following 1855, but a relatively small proportion of it was used for fertilizer. In some places this refuse was thrown into the water; in other localities an effort was made to keep it above the tide level, but it is said that even then a considerable amount found its way into the tide together with the water from the butts. Of course, as much of the oil as possible was saved, but with the crude methods then in use there was no doubt considerable discharged with the refuse.

All of this matter could not have been thrown into the water without producing an amount of pollution equaling or exceeding that now produced by the factories. Before the manufacture of fertilizer from the cuttings the pollution resulting from the manufacture of sardines was perhaps appreciable, but it is not so in the vicinity of Eastport at the present time. It may be that the recent abundance of young herring in the vicinity of Eastport and Lubec is due to the improvement in the character of the water since the cuttings have been disposed of otherwise than by being cast into the harbor. The improvement in the catch, however, has been delayed too long after the application of the supposed remedy to make the supposition very probable.

The sardine canneries are not alone held responsible for the pollution of the waters. Occasionally, through neglect, or on account of stormy weather, a weir is not fished; and if the water be shallow, fish will sometimes die in numbers at low tide. It is stated that if these dead fish be not removed no herring will enter any of the weirs to which the polluted water is carried by the current. After the removal of the source of offense they will fish as well as before. It is said frequently to happen, where there are strong tidal currents, that the weirs above, and

even the contaminated weir itself, will fish as usual, while all weirs downstream will fail. Southeast of Grand Manan many of the weirs are built in the tideways between the islands, and I was told by a number of credible persons that the facts above stated were frequently observed.

The importance of careful attention to the weirs is conceded by the Canadian fisheries regulations, and penalties are imposed upon those whose carelessness permits fish to die in the weirs. The latter are provided with gates, so that the surplus fish may be liberated should more be caught than can be utilized. It is customary for the fishermen to visit the weirs at about half ebb, when the tide serves, so that the probable catch may be estimated and exit given to the surplus should it promise more than is desired for immediate use.

Some of the fishermen at Grand Manan think that the lobster and trawl fisheries are prejudicial to the shore fisheries for herring. The former was particularly objected to on account of the alleged practice of using putrid bait in the traps. I had no opportunity of judging for myself, as my visit was made during the close season, but I was told that the waters all alongshore are sometimes polluted by the decaying bait, and that the constant hauling of gear tends to frighten herring and keep them off shore. My own impression is that it would require many more lobster pots than are now fished in the Bay of Fundy to effect any serious pollution in a region where the volume of water is so large and the currents so swift. The same may be said of the trawl lines.

Many of the weir owners and others state that the gill-net fishery aids materially in driving the herring from the shore waters, and in Machias Bay a township ordinance prohibits entirely this method of taking herring. In some places and at some times the gill-net fishing is of a character to warrant opposition. In September, 1893, herring were spawning at Moosabec Reach in great numbers, and many gill netters resorted there. The gill nets over night became laden beyond their strength, and when the attempt was made to haul them in they parted, and the pieces, with hogsheads of herring, were left to rot on the bottom. It is said that the herring are sometimes driven from their spawning-grounds by this means, and that after such an event they often remain away for years.

A. J. Meloon and others, of Cutler, Me., say that about 1873 Great Head was noted for the abundance of spawn herring, but, presumably owing to the great numbers of dead fish left on the bottom in pieces of nets, they forsook the locality, and have since then only occurred in small numbers until 1893, when they were again abundant. The same informant said that eight years ago spawn herring occurred in great schools at Ingalls Island, Machias Bay. He took 50 barrels out of one 50-fathom net, which was torn all to pieces. Barrel after barrel of herring could be hauled up from the bottom by grappling for the torn nets, and as a consequence of this destruction they did not again appear in numbers until 1893. Libby Island, also in Machias Bay, was given

as another instance of the disappearance of the herring as a result of the abuse of the gill nets. I afterwards learned, however, that there are no weirs upon the island, and as the use of the gill nets is prohibited it is not really known whether or not the herring have appeared there since.

I believe these statements of the effects of lost gill nets to be overdrawn, and that the absence of the herring for a long time subsequent to such loss is due to accident or to other causes than the pollution of the water. When the pollution has been excessive, there is, no doubt, some effect for the time being, but it is impossible to believe that the pollution can last for more than one season, and if not it is difficult to understand why the herring should avoid the locality thereafter unless we attribute to them a high order of memory.

Instances are constantly occurring where the herring have ceased, for a year or a period of years, to spawn in certain localities where the pollution of the bottom could have no bearing on the matter. Heedless and unnecessary waste of food-fishes is to be deplored, but it seems unwarranted to assume that dead fish strewn upon the bottom will keep the fish away for periods of from five to twenty years thereafter.

Other fishermen place stress upon the injury effected by the capture of spawning fish in the gill nets. As has been argued elsewhere, there is no greater damage done by catching the fish during the spawning season than by taking them at any other time—for instance, just before spawning. It seems that these accusations are but a manifestation of the universal warfare between the users of fixed and portable nets.

On the other hand, it is claimed that the continued catching of immense numbers of young fish for the sardine industry must produce a decrease in the herring and that it is only a question of time when this decrease will make itself manifest if it has not already done so. At first sight it would seem that this might be reasonable, and the only reason that such a decrease has not taken place is no doubt because the number of herring killed by man is insignificant when compared with the total number of this species in the seas and the number which yearly fall victims to the various natural dangers which beset them.

In discussing the effects of physical phenomena other theories regarding the failure of the herring fisheries in certain localities have been amply considered. Such theories are that the fog-alarms have scared the herring away from the vicinity of West Quoddy and other places and that the failure of Treat Island weirs is due to the noises and the disturbance of the water caused by steamers passing to and fro between Lubec and Eastport and through Lubec Narrows.

When all the factors in the case are reviewed, I think that it has been shown that not only has there been no decrease in the sardine-herring in the region under discussion, but that there are at present no practices connected with the fishery which are liable to seriously affect their future abundance.

WINTER HERRING.

From the early part of the present century herring were known to frequent portions of the coast between Quoddy Head and Lepreau during the winter months. They came in large numbers, and although certain localities appear to have been for a time deserted by them, there is no tradition among the fishermen that there was ever a period until recently when the winter school of herring did not occur in some portion of the region embraced in this report.

Mr. Perley, in a "Report upon the Fisheries of New Brunswick and Nova Scotia," written in 1850, mentions their sudden and unprecedented appearance in the neighborhood of Lepreau during the winter of that year. In any attempt to account for the disappearance of the "winter herring" from our coast it would be of the utmost importance to establish such a sudden appearance of the species at an unusual season. Careful inquiries were therefore made, especially among the older fishermen, whose recollections antedated the time of this alleged first known run of winter herring. Special attention was called to the statements of Mr. Perley, and the fishermen were asked if they could verify them. In every case it was stated that the herring were known to occur on the coast in winter long before the date mentioned. An old and experienced fisherman, who was for a number of years the Canadian fisheries overseer at Lepreau, and who in his boyhood lived at L'Etang, said that he could remember herring along the coast during the winter months since 1829 and that the fishermen of that day appeared to regard their presence as a matter of long-established fact. These herring were apparently of the same character, with reference to size and condition, as those which afterwards became the object of pursuit in the important frozen-herring trade.

Another fisherman at Campobello, who began fishing seventy years ago, says:

> I think that until the last six years there never was a time, with occasional exceptional years, when the herring were absent from this coast in winter. Mr. Perley was mistaken when he said in his report that the herring were unknown inshore in winter prior to 1850. There was never much fishing for them before that time, but they were here, nevertheless, and I distinctly remember their presence in the winter of 1840. I can fix that date from the circumstance that I built a vessel during that year.

This and similar testimony from others, as well as the fact that even the older fishermen know of no traditions of the sudden and unusual appearance of herring in winter, point to the probability that these winter schools were well-established phenomena as long ago as the beginning of the century, and perhaps at the time of the first settlements of English-speaking peoples. There may have been single years or periods of years when the herring did not come ashore in certain rather circumscribed regions, but this is a phenomenon observable in almost all fisheries. It is stated traditionally that herring ran into

L'Etang in winter at the time of the first settlement of the country, but that for a series of years at the beginning of the present century they were totally absent from that region during the winter months. The period of their absence appears to have been about twenty years, and they must have returned a number of years prior to 1829, for, as stated above, they were at that time regarded as well-established winter visitors. Perley, who, as stated, regards their appearance on other portions of the coast as unusual, says that they frequently ran into L'Etang in the winter in great bodies.

However far back in time we may place the first appearance of herring upon this coast in winter, the fact remains that it was not until within the last thirty years that a consistent effort was made to render this vast food supply widely available.

From the early part of the present century, if not before, limited quantities were caught and prepared for home consumption or to serve as bait for the line fisheries. The fish intended for food were at first usually prepared by smoking, the method of freezing the fish not being adopted until larger markets for winter herring presented themselves and shipments began.

At first the fish were taken solely by torching, a method which is elsewhere explained. No gill nets whatever were used in the herring fishery in this region until 1829, and they were not introduced into the winter fishery until about 1845 or 1850. About that time Messrs. Greenlow, of Deer Island, New Brunswick, began to use nets of about 2-inch mesh for winter herring, smoking the fish for market, but soon afterwards the fishermen began a limited trade in frozen fish with St. John and the tributary region. This domestic trade in frozen herring gradually grew, but owing to the limited market it never became very extensive.

In the meantime the American vessels from Gloucester had developed an important market for frozen herring in the United States. In 1854, according to a Gloucester authority, a partial fare of frozen herring was brought from Newfoundland by a Gloucester master, and with some effort was disposed of, some as bait for the Georges men and some as food, the latter being peddled through the country. The following year several vessels made the venture to Newfoundland, and, the product being well received by the fishermen and the public, the trade soon developed into one of considerable importance and profit, and in a few years gave employment to a large fleet of stanch vessels.

About 1864–65, the abundance of winter herring in the Bay of Fundy having become known, a vessel made a trip to that region with excellent pecuniary results, and the fishermen and vessel-owners were not slow in seeing the advantages to be gained by developing the trade. The voyage to Newfoundland, being made at the most inclement season of the year, was attended not only with the risk of maritime disaster, but, as some found to their cost, there was always the possibility of a

bad season and the loss of a fare even after the outward voyage had been successfully accomplished. The trip to the Bay of Fundy was shorter, and the vessels being always within reach of a sheltered harbor, it could be attempted in inferior crafts.

It is stated that the first fare of winter herring shipped to the United States from the vicinity of Quoddy was carried by a Captain McCrea, of Gloucester. Be that as it may, he was soon followed by many others, and frozen herring from the Bay of Fundy soon largely supplanted the Newfoundland herring in the markets of the United States. The fleet sailing to the former region was steadily augmented, while that in the Newfoundland trade as steadily declined. On account of the severe weather they had to encounter, the Newfoundland vessels were stanch and able seagoing craft, while many of the Bay of Fundy vessels were old and small.

Some of the fishermen fished from small boats only, making their headquarters ashore and not going far from home, but most of them used sloops and small schooners, ranging from 8 to 35 tons burden, in which they could follow the schools about from place to place during the season. There was considerable improvement both in model and build of the vessels as the fishery became better established, but the size remained about the same. The smaller vessels usually carried a crew of three men and one boat; the largest had seven men and three boats. Vessels of from 15 to 20 tons were the most common, and such a craft usually carried a crew of five men, who used two boats in attending their nets.

The fishery was commonly conducted on shares; the owners of the vessel receiving one-seventh of the catch, the remainder going to the captain and crew, who "found and grubbed" themselves. At the approach of the season for winter herring the crews of each craft would come together and fit out with the necessary provisions, nets, and gear. The vessel then repaired to some convenient harbor and awaited the arrival of the fish, the fishery beginning as soon as the herring came in and the weather became sufficiently cold to freeze the fish when exposed to the air.

The presence of the fish was detected by fishing trial nets, each vessel setting a net or two nightly. As soon as it became known that any of these nets had taken herring, there was great activity among the fishermen. Each boat was sent out with two men and its complement of nets. In the first years of the fishery each man fished two nets, but afterwards the quota was increased to three per man. The nets were 30 fathoms long and 150 meshes deep, the mesh being 2¼ inches. Those first used in New Brunswick were Scotch nets of linen, but afterwards cotton nets were adopted, owing to their cheapness and the greater ease with which the fish could be shaken from the meshes. Until about 1880 they were set near shore, in about 10 to 20 fathoms of water. The vessels lay in the harbors, one man remain-

ing aboard to cook and take care of the fish, and the remainder of the crew rowing back and forth to their work. During the last six or seven years of the fishery, when the nets were set 5 or 6 miles from shore, the distance became too great for the men to row, and the vessels would then run out and drop the men to set or lift their nets, picking them up again when they had completed their task. When the men first began to fish in the deep water at a distance from the shore their inexperience often caused them to lose their nets and gear, but afterwards they grew more accustomed to the changed conditions and were able to avoid such losses.

The nets were set in the afternoon and were lifted the following morning. The herring would rarely enter them during the daytime, and it was observed that on dark nights the fishing was better than when it was moonlight.

The fishery for winter herring being principally within the waters of New Brunswick, most of the fishermen were citizens of that province; but a number of Americans engaged in it, especially during the latter years of the fishery, often setting their nets close inshore and freezing their fish either ashore or on the decks of their vessels. In addition to the regular fishermen, many farmers and mechanics who had no work during the winter followed the fishery with considerable profit. The winter fishery for herring was the most important and profitable fishery, especially on the "North Shore" between Beaver Harbor and Lepreau, and the fishermen cared but little for the failure of the summer fisheries if they were assured of a good run in winter.

The Americans were interested more extensively in buying than in catching the fish. As already stated, prior to 1860 comparatively few fish were sold as bait, but at about that time that market became very important, and large numbers were sold to Nova Scotia fishermen and to Americans engaged in the trawl and hand-line fisheries on the Georges Banks. Before the days of the frozen-herring trade it was customary for the bank fishermen to carry several nets for the purpose of catching bait. Herring were often found on the Georges Banks in winter, sometimes in vast schools, but the practice of catching them was abandoned when the line fishermen found that they could obtain bait with more certainty and greater dispatch by purchase from those engaged in the frozen-herring trade. When vessels from Gloucester and other American ports began to regularly engage in the business, they soon absorbed the bulk of the catch, although a considerable number of fish still went to Nova Scotia. These vessels bought the fish from the local fishermen and carried them to the great fish markets, whence they were transshipped as bait or were sent over the country as a cheap fish food for man.

The frozen herring were always sold by count, never by weight or by the barrel, and the price ranged from 15 cents to $1 or more per 100, according to the weather and market. The first fish usually brought

a higher price, and last winter (1894–95) the first frozen herring from Grand Manan sold for $1 per 100. The average price paid was about 25 cents per 100, and at this rate the "stock" per man fishing the whole season was between $150 and $200, some making more and some less than the figures given, according to their skill and industry.

Frequently, when a sudden thaw made it impossible to freeze the fish, the fishermen were willing to sell the herring for a mere song in order to avoid having them spoil on their hands. Considerable loss was sometimes sustained through the occurrence of mild periods and warm rains in midwinter. When the fish had been partly frozen before the thaw, they could often be kept in good condition for three or four days by placing them in the hold and closing the hatches. If the weather then grew colder they could be again brought on deck and the freezing process concluded, until they were quite stiff and brittle. Constant attention was required, as a sudden thaw or rain might in a few hours cause much loss.

American vessels came from Boston, Gloucester, Portland, Isle au Haut, and other places to purchase the herring from the local fishermen, and when the fishery was at its height as many as 125 cargoes were carried to American ports, in addition to a considerable number shipped in barrels from Eastport in steamers. Vessels missing their fares at Newfoundland often came to the Bay of Fundy to pick up a cargo before returning to Gloucester. The vessels commonly resorted to Eastport, where they would wait for the fishermen to come to sell their fish, or more frequently they would run to some harbor in the vicinity of the fishing fleet and would there purchase the herring as they were frozen. The latter was the usual procedure, especially during the latter years of the fishery, when the competition for fares was often very brisk.

Between 1845 and 1855 the frozen-herring trade for the market was confined to the shore between Sand Cove and Point Lepreau, but about the latter year it extended westward to Beaver Harbor and Grand Manan, and later to Eastport, and even to some extent as far as Cutler. The herring were found in winter from St. John to Cutler and from Grand Manan, in the Bay of Fundy, to St. Andrews, in Passamaquoddy Bay. They were not found every winter throughout this entire region. Sometimes they would not enter St. Andrews Bay at all, but at other times they would be found there in great numbers, and almost the entire fleet would fish there all winter. As many as 14 vessels have been known to leave there with full fares in one day.

The winter run of herring did not strike the whole coast at once; they usually first appeared on the outer or Bay of Fundy side of Campobello and thence extended eastward and to a limited extent westward. A school of fish usually arrived on the shore at Herring Cove early in October, and remained about three or four weeks. This school appeared to be distinct from the true winter herring, which, before 1880, reached

the place mentioned with fair regularity about November 15, and remained until late in December, when they began to slack off, although some were usually to be found there throughout the winter. The fishermen from Beaver Harbor came down to Campobello for a fortnight's fishing early in the season, as the schools did not strike Beaver Harbor for about ten days after their arrival at Herring Cove, and it would not be until about the first week in December that they would reach the neighborhood of Point Lepreau.

It would appear, then, that these schools of winter herring arrived first at Grand Manan, soon afterwards at Campobello, and thence they extended gradually up the Bay of Fundy to St. John, or entered St. Andrews Bay via Head Harbor and the Eastern or Letite Passage. At the eastern end of Campobello, at Head Harbor, the migrating schools had two alternatives, they could either continue up the Bay of Fundy or could enter St. Andrews Bay. When they took the latter course in large numbers there was a corresponding dearth upon the Bay of Fundy shore, but sometimes the schools would divide, a portion taking each route and the fishery becoming more widely distributed.

The foregoing is a general statement and does not strictly describe the migration every season. Sometimes they were first caught nearer the eastern end of Campobello, and there were always more or less extensive local movements which tended to affect their distribution. They often moved about from place to place according to no observable system, but the fishermen were able to follow them with more or less certainty by observing the movements of the schools of whales and flocks of gulls. For instance, in 1877 there was good inshore fishing at Campobello up to the middle or latter part of December, but during the rest of the winter they were offshore, and it was during that winter that the fishermen gained their first experience in deep-water fishing, at some expense of nets and gear. West of Beaver Harbor the principal schools were that year found about midway between the main shore and The Wolves, but farther eastward, at Popologan and Lepreau, they were closer inshore.

It is probable that temporary disappearances of the winter herring from the coast in previous years were due to their dropping offshore into the deeper waters of the Bay of Fundy, but the fishermen appear to have been unaware of the fact until 1877, although large numbers of whales and gulls, which accompany the schools, were often observed. In the following year, 1878–79, the schools were as close in as ever, and the fish were especially abundant in the vicinity of L'Etang. In 1879–80 they appeared inshore in great numbers and were quite generally distributed along the coast, and the same may be said of 1880–81 and 1881–82; but in 1882–83 they were principally offshore throughout the whole coast, and they did not again appear, to stay, in shallow waters up to the time when they finally disappeared, in the winter of 1889–90.

Coupled with this apparent reluctance to come inshore, the latter years of the fishery were characterized by a gradually later and later date of arrival. The schools were not preceded to any extent by stragglers, the bulk of the fish arriving in a body, and consequently the date of their arrival was well defined. As already stated, prior to 1880 the winter herring arrived at Herring Cove about November 15, but by 1887 their arrival was delayed until January 6, and in 1888–89, the last year of the fishery, they did not come until January 10. In 1887 they were caught at Grand Manan before they reached Campobello, but for three or four years they did not arrive at Point Lepreau until February, and in 1888–89 it was almost March before they were taken at the latter place. In 1889–90 a few were caught at several places on the "North Shore," but not enough to pay expenses, and from that time to this none have been caught in that region, although lobstermen every winter set a few nets in the hope of catching bait for their lobster traps.

It is stated that at Grand Manan the winter herring disappeared a year or two before 1889–90, but it appears that the fishermen from that place did not set their nets as far from shore as did those on the mainland, and this probably accounts for the difference. Since then there have been several short runs or "spurts," and in the winter of 1894–95 for several weeks between December 22 and January 10 the fishing was as good as ever. Considerable quantities of herring are still taken from Dark Harbor during the winter, but these are, no doubt, fish which have run into that almost landlocked pond earlier in the fall and have been unable to find their way out. They are consequently not to be considered with the winter herring, although small bodies of fish are said, by those in charge of the fisheries, to occasionally run in during the winter months. There appears to be some doubt as to whether the fish left earlier or later toward the last or whether the change was only in the date of their arrival.

During the last three or four years of the fishery the numbers of the herring appeared to be about constant, but before then there had been a gradual decrease since 1880 or 1881, or at least the catch was more irregular and uncertain. This, however, may not have been due so much to a decrease in the size of the schools as to the greater difficulty in the way of catching them. When the fishermen had to set their nets 4 or 5 miles offshore there would be, of course, much greater liability of some of them missing the school than when the fish covered the more circumscribed area nearer shore, and this would lead many to suppose that a greater decrease had occurred than was actually the case.

As already stated, the schools of winter herring were detected by means of trial nets, although their presence was often indicated by the accompanying whales and gulls which feed upon them. These, however, also feed upon the small herring which likewise are found in the bay in winter. These small herring are often seen schooling—that is,

playing at the surface of the water—but the regular winter schools rarely appeared at the surface, and then only when driven by their enemies.

There appears to be considerable difference of opinion concerning the effects of winds and weather upon the movements of the winter herring. According to some the herring is a "leeward fish"—that is, it drifts to leeward in pursuit of its food—and consequently mild southerly and southwesterly winds were the most favorable, bringing the schools toward shore. Others insist that the cold northerly winds brought the best inshore fishing, and still others state that great bodies were at different times seen inshore in all kinds of weather. Indeed most of the more intelligent and better-informed fishermen will agree to this last statement when questioned, and it seems probable that it is the most consonant with the facts of the case. Probably strong northerly winds were better than corresponding southerly winds, as then the boats could run out and in under the lee of the shore, this being a matter affecting the distribution of the fishery rather than of the fish.

The herring of the winter school were usually rather lean and poor and of moderate size; rarely a few fairly fat ones were caught, and they remained in about the same condition until spring. The fishermen state that their stomachs contained shrimps and red seed, and this statement is confirmed by the contents of a few stomachs obtained at Flaggs Cove and Long Island, Grand Manan, about the middle of January, 1894. Six of these contained copepods (red seed), and another was gorged with Thysanopoda, the "shrimp" of the herring fishermen. During the summer these shrimps are extraordinarily abundant in the Passamaquoddy district, but it is said that they are not often seen at the surface in winter; but if this be true, they no doubt abound at a distance from the surface where the temperature is more equable.

In December the genital glands of the winter herring were very small, but in March some were always found with these organs in a well-advanced state, though by no means ripe. A specimen taken at Grand Manan in January, 1894, had testes about 1 inch in breadth and quite thick, a condition which throws doubt rather than light upon the question of the spawning period of these schools. Such a specimen might be either an autumn spawner whose development had been delayed or a precocious individual whose normal time of reproduction was in the spring, in either case a condition not rare.

In attempting to coordinate these winter schools with others occurring in the Bay of Fundy considerable difficulty is encountered. As the winter herring no longer occurs upon the coast, the investigation must depend almost entirely upon the testimony of the fishermen, whose information is naturally largely restricted to the requirements of their calling, and who usually bother themselves but little with the history of a species as long as it maintains its abundance. Most of them have opinions upon the subject of the relations existing between the different

schools, but when they are pressed for reasons it is found that their theories are based upon insufficient data. Some of those whom circumstances caused me to regard as the most observant and better informed among them frankly confess themselves unable to state whether these winter herring belong to the school which spawns at Grand Manan in summer and fall or to that which formerly spawned, and to some extent still spawns, in St. Andrews Bay and Oak Bay in spring, during the latter part of April and early in May. That these two spawning schools are not composed of the same fish is unquestionable, but it is possible, though not very probable, that the winter herring may comprise members of both of these schools attracted shoreward for the sake of the food to be there obtained.

The shoreward movement of schools of herring is usually conditioned by one of two desires—the instinct of reproduction or the desire for food. As the winter herring always arrive with very immature genital glands, it is evident that the first of these is not to be considered in this connection, and we must assume that the desire for food is the impelling motive to which the fishermen have been, until recently, indebted for this profitable fishery, though, as will be shown, some at least probably remain to spawn.

As before stated, there is a run of herring at Herring Cove and the neighboring portions of Campobello in October. According to the fishermen, these fish are still caught as usual and are similar to a school which appeared at the place mentioned in September, 1895. These herring were evidently spent, and no doubt had just arrived from the spawning-grounds at Grand Manan or elsewhere, and the October school should doubtless be traced to the same source. After the October school left there was an interval of about a week or a fortnight before the arrival of the regular winter school, which, the fishermen say, differed in appearance from those which came earlier. This difference, however, may be due solely to difference in condition caused by relative remoteness from the spawning season, amount of food, etc.; but if we accept the statement that the roes and milts are small in November and well developed in March, it would establish a distinction between the schools of October and of the late fall and winter. The same herring does not spawn twice in a season, and those spawning at one time do not apparently associate with those spawning at another; in other words, the schools of adults tend to remain distinct, and not only spawn at different times, but select different grounds for the purpose.

It is well known that the winter herring remained in St. Andrews Bay usually into the month of April, though the testimony of the fishermen would indicate that they sometimes did not go there at all, or at least during cold weather. It is equally well known that they spawned in St. Andrews Bay and Oak Bay about the beginning of May, and this date would about correspond with the spawning season of herring which contained large but hard spawn in March.

These several facts, then, would tend to induce a belief that the schools, or at least a goodly portion of them, which frequented the coast in winter spawned in the vicinity of St. Andrews Bay. It is admitted by all that the herring some years ago ceased to spawn in those waters except in limited numbers, and as nearly as the date could be fixed from rather vague information, the time of cessation corresponds approximately to the time of disappearance of the winter herring. It was found impossible, however, to get very accurate information concerning this spawning-ground, and apparently the fish were not the object of close pursuit at that time. A school of herring continued to spawn in Oak Bay, a few miles above St. Andrews Bay, up to the spring of 1895, a fact which may to some extent throw doubt upon the relationship between the schools which is indicated above.

The segregation of the herring of this region into schools, spawning at different times and places, has undoubtedly established slight structural changes, sufficient to constitute a racial difference capable of demonstration in a large number of specimens. If there should ever be afforded an opportunity of comparing a considerable series of winter herring with extensive series from the two spawning schools, it may be possible to determine with certainty the relations existing between them. Until the winter schools again return to our coast all inquiry into this matter must partake largely of speculation.

With the scant information at hand concerning the winter herring fishery of the Bay of Fundy, it is impossible to assign any satisfactory cause for their disappearance. There appears to be no warrant for the assertion occasionally made that they have been practically exterminated by overfishing. Most of the fishermen in the region, regard such an explanation as untenable. It is true that a falling off in the catch was noted during the last few years of the fishery, but this appears to have been due to irregularities in distribution rather than to an evident decrease in numbers, as when the schools were located the fishing seemed to be as good as ever. This is precisely what would be expected, on *a priori* grounds, if a given body of fish accustomed to frequent the immediate vicinity of the shores were to become distributed over the more open waters, where they would not only be more scattered, but also more difficult to locate and catch.

During the last year of the fishery there were yet a large number of herring, and it is utterly impossible to believe that these were so preyed upon by the fishermen as to be practically exterminated, so that none were left to return the following year. If they have not been caught out they must have left the coast as a body; but the reason for their desertion of their inshore haunts is also difficult to understand, and where they have gone since their total disappearance from the Bay of Fundy is equally lacking in elucidation. Extensive fishing might possibly cause the schools to forsake the shores at a time when they were not driven by the overpowering stimulus of reproduction, although

it is doubtful; but it could hardly be sufficient to drive them entirely from the broad waters of the bay, nor would it be likely to actuate them to remain away after the cause had ceased to operate, unless we attribute to them a higher order of psychological development than most persons are willing to admit. The recollection of impediments in their path is not a sufficient reason to explain why they should avoid a locality after those impediments are removed. If, however, these winter schools were composed of fish which spawned in St. Andrews Bay in spring—a probable connection yet by no means established—then by preventing the access of the fish to the spawning-grounds the nets might, after compelling the schools to spawn elsewhere for several years, gradually change their distribution. This is an explanation offered by some, but in addition to the several hypotheses which it involves, it also has the well-nigh fatal defect that it does not explain the reason why the fish could not pass to the spawning-grounds after the cessation of the winter fishery on account of warm weather. The spawning season appears to have occurred in May, and as there was practically no fishery in most years after March 15, there was ample opportunity for the fish to come ashore in the meantime if such were their habit or desire.

After considering the several phases of the matter presented by the information at hand, the most that can be said is that we do not know any good reason for the disappearance of these schools and the loss of an important industry to the fishermen of the Passamaquoddy region.

An important question in connection with the winter herring is whether or not we are justified in expecting their return, and in this connection it may be well to examine experience elsewhere. In several places in Europe, but especially upon the shores of the Kattegat, in Sweden, there are herring fisheries which have long been known to be periodical. "They are called periodical because, as far as known, they have only lasted from twenty to eighty years, with intervals of sixty to one hundred, or an average of seventy years." It has been observed that toward the end of these periods the herrings have always arrived later and later in each successive year, and that they have at the same time kept farther and farther away from the coast. This appears to have been the case with each successive period during hundreds of years, and when such retardation begins to manifest itself in the fisheries of Bohuslän it has been customary to predict with certainty the approaching loss of the fishery.

Our herring fisheries, and especially the one with which this chapter deals, are recent as compared with those of Europe. We have no records running back for hundreds of years, and there is yet no data for asserting the periodicity of any of our herring schools, but it will be observed that the conduct of the winter herring prior to their disappearance might be described in the exact words applied to the herring of Bohuslän.

QUODDY RIVER HERRING.

The justly celebrated herring which were known in the markets of the country under this name appear to have occurred practically nowhere but in "Quoddy River," the waters lying between Campobello on one side and Deer Island and the shores of Maine on the other.

The fishery began in 1829, although the fishermen appear to have been aware of the occurrence of these large fish prior to that. In the year mentioned Mr. Parker, a fisherman, brought a gaspereau net from St. John and determined to catch these herring for the market. This was the first net used in the herring fishery in the Passamaquoddy district, and it met with immediate success. The large herring were found to be more abundant than had been supposed, and the pecuniary results were such that in the following year fishermen came from St. John to get their share of the fish which found such a ready market. The local fishermen, not to lose such an opportunity, soon provided themselves with nets, and the fishery developed within a few years to such an extent that 40 or 50 boats were engaged almost nightly, the herring being caught by "drifting." The fish arrived in August and continued through September and October each year until 1877, when they rather suddenly disappeared. It was not until 1892 that they were again caught, but in that fall they again appeared in limited numbers and have since come each year without any increase in numbers.

The Quoddy River herring were very large and fat and always brought high prices. They were usually pickled, and in 1894 eighty-nine selected ones filled a half barrel, and after taking first prize at the New Brunswick Fishery Fair were sold for $5. The nets used had a 3-inch mesh and were 30 fathoms long and 150 meshes deep—about 2½ fathoms when hung.

These large herring never contained spawn, but spawning fish were sometimes mixed with them.

It is impossible at present to establish the relations of this school to the others in the vicinity, and no good reason can be assigned for their disappearance. At all times the school was a small one, and fish of similar character were rarely caught elsewhere than in the waters mentioned.