Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

- [ ] Coloured covers/ Couverture de couleur
- [ ] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [x] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [x] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [ ] Bound with other material/ Relié avec d'autres documents
- [ ] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distortion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments:/ Commentaires supplémentaires:

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [ ] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [ ] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [ ] Includes supplementary material/ Comprend du matériel supplémentaire
- [ ] Only edition available/ Seule édition disponible
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

- [x] This item is filmed at the reduction ratio checked below/ Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
										✓	

Bundle no 4
Piece 1

PART II.

Fishery Commission, Halifax, 1877.

THE EFFECT

OF THE

FISHERY CLAUSES

OF THE

TREATY OF WASHINGTON

ON THE

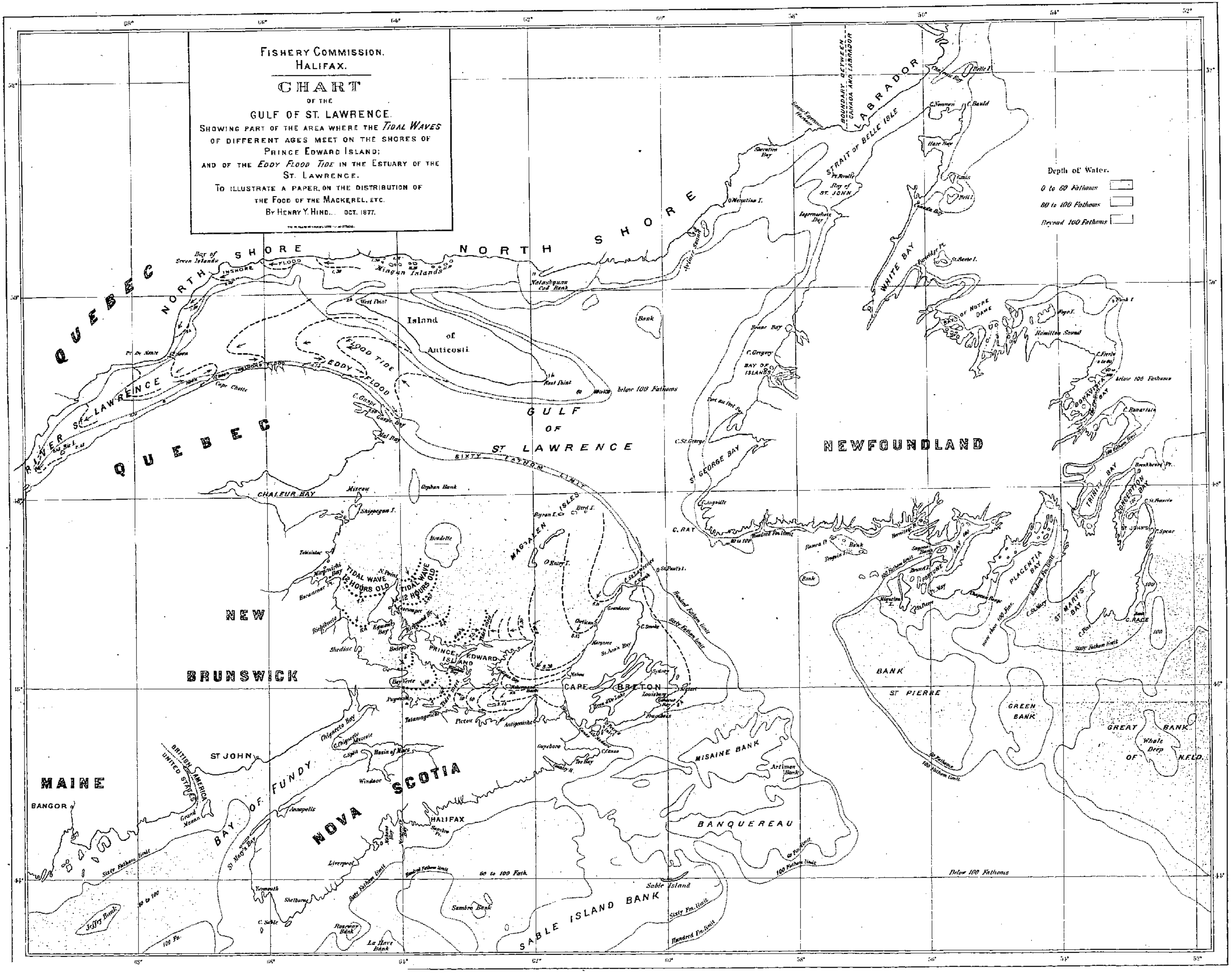
FISHERIES AND FISHERMEN

OF

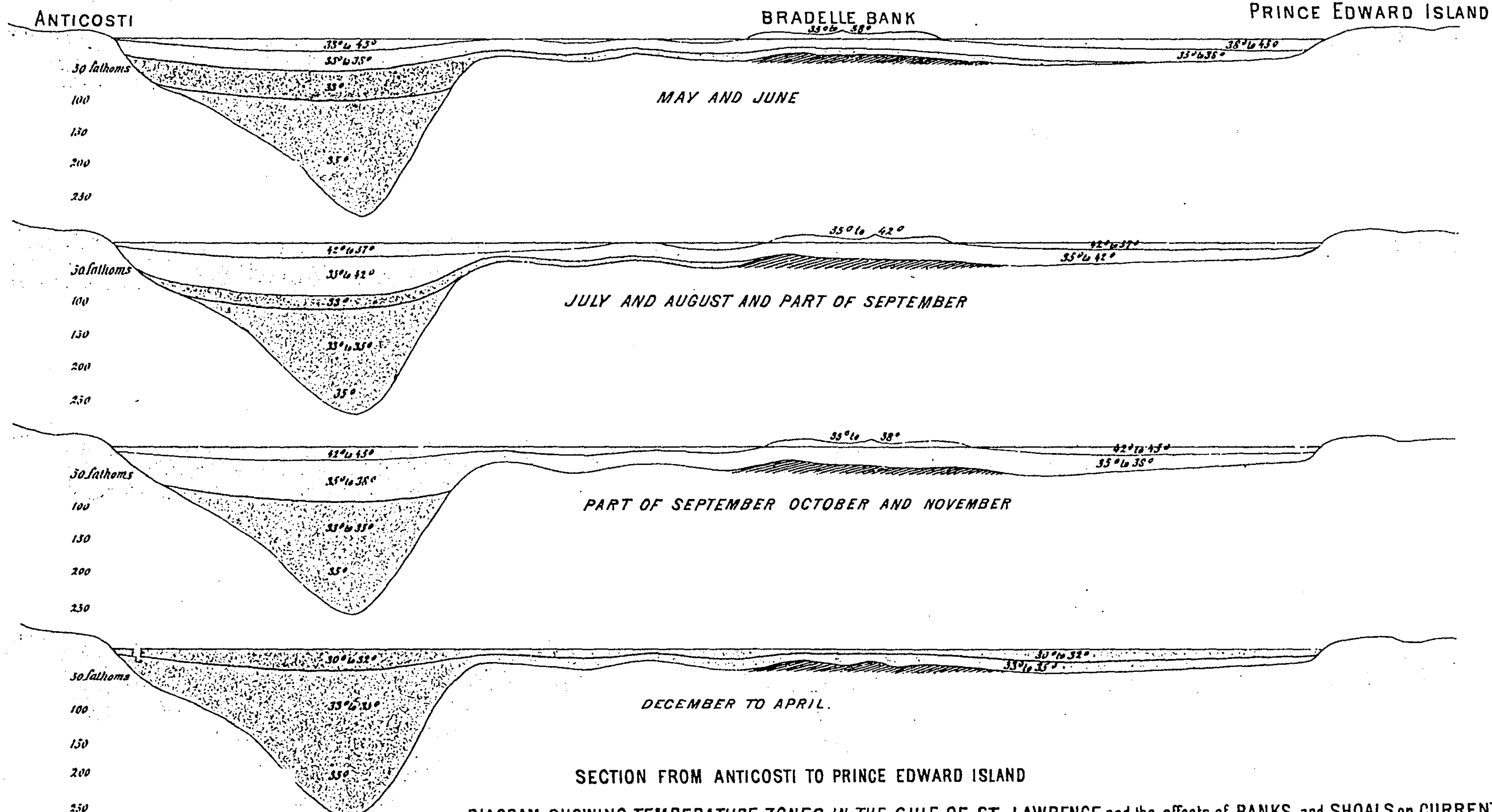
BRITISH NORTH AMERICA.

BY HENRY YOULE HIND, M. A.

HALIFAX, N. S.,
PRINTED BY CHARLES ANNAND,
1877.



Fishery Commission.
Halifax.
Chart
of the
Gulf of St. Lawrence.
Showing part of the area where the Tidal Waves of different ages meet on the shores of Prince Edward Island;
and of the Eddy Flood Tide in the Estuary of the St. Lawrence.
To illustrate a paper, on the distribution of the Food of the Mackerel, etc.
By Henry Y. Hind... Oct. 1877.
Depth of Water.
0 to 60 Fathoms
60 to 100 Fathoms
Beyond 100 Fathoms
QUEBEC
NORTH SHORE
LABRADOR
BOUNDARY BETWEEN CANADA AND LABRADOR
STRAIT OF BELLE ISLE
Island of Anticosti
EDDY FLOOD
FLOOD TIDE
INSHORE FLOOD
Mingan Islands
West Point
East Point
below 100 Fathoms
GULF OF ST LAWRENCE
SIXTY FATHOM LIMIT
RIVER ST LAWRENCE
CHALEUR BAY
Orphan Bank
Bradelle
MAGDALEN ISLES
TIDAL WAVE 12 HOURS OLD
NEW BRUNSWICK
PRINCE EDWARD ISLAND
CAPE BRETON
NEWFOUNDLAND
WHITE BAY
BAY OF NOTRE DAME
BONAVISTA BAY
TRINITY BAY
CONCEPTION BAY
ST GEORGE BAY
BAY OF ISLANDS
FORTUNE BAY
PLACENTIA BAY
ST MARY'S BAY
C. RAY
C. RACE
ST JOHN'S
BANK ST PIERRE
GREEN BANK
GREAT BANK OF N.FLD.
Whale Deep
MISAINE BANK
BANQUEREAU
SABLE ISLAND BANK
Sable Island
Sambro Bank
MAINE
BANGOR
ST JOHN
BAY OF FUNDY
NOVA SCOTIA
HALIFAX
BRITISH AMERICA
UNITED STATES
Grand Manan
Jeffry Bank
C. Sable
Yarmouth
Liverpool
Annapolis
Windsor
Pictou
Antigonishe
Canso
Louisburg
Sydney
Below 100 Fathoms
60 to 100 Fath.
Hundred Fathom limit
Sixty Fathom limit



SECTION FROM ANTICOSTI TO PRINCE EDWARD ISLAND

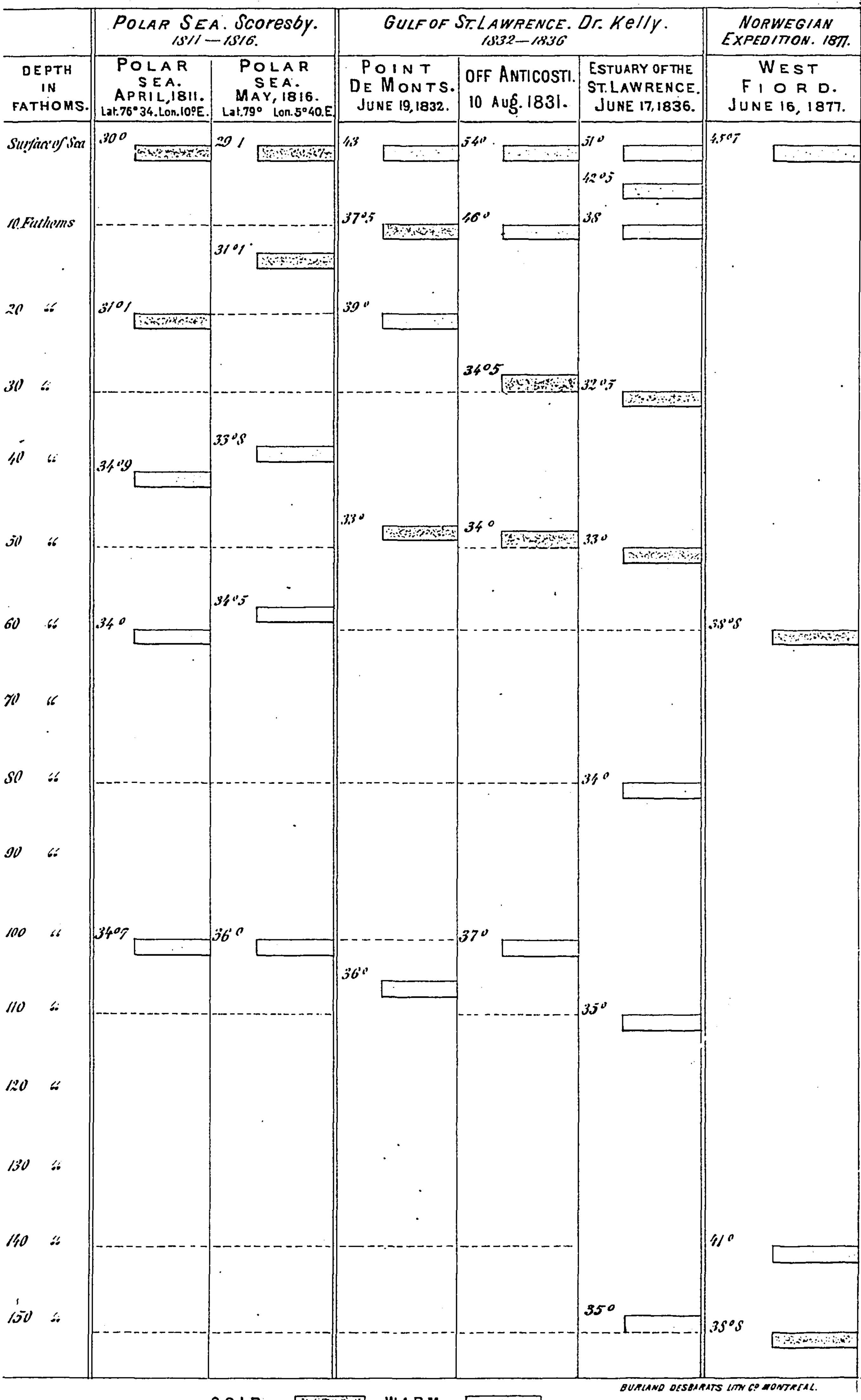
DIAGRAM SHOWING TEMPERATURE ZONES IN THE GULF OF ST. LAWRENCE and the effects of BANKS and SHOALS on CURRENTS.

IN BRINGING COLD STRATA TO THE SURFACE

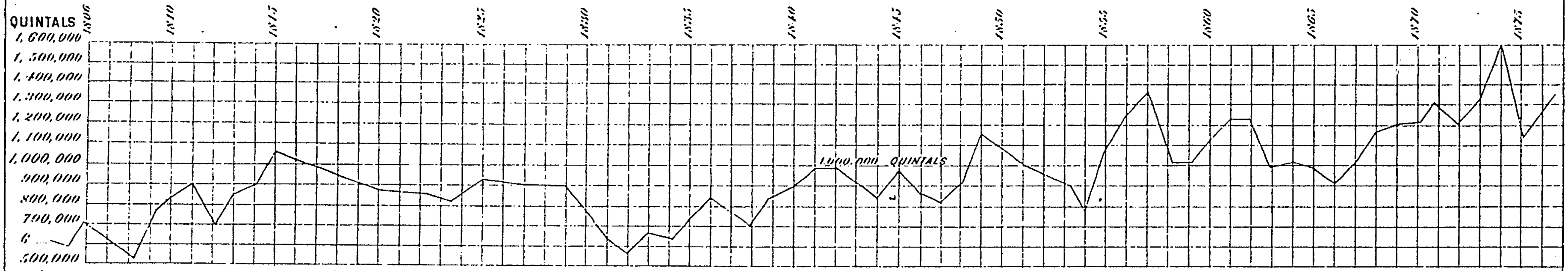
30° to 33° 33° to 35° 35° to 42° 42° to 57°

BURLAND DESBARATS LITH. CO MONTREAL.

DIAGRAM SHOWING THE DISTRIBUTION OF TEMPERATURE STRATA.



BURLAND DESBARATS LITH Cº MONTREAL.



CURVE SHOWING THE ANNUAL FLUCTUATIONS IN THE EXPORTS OF CODFISH FROM NEWFOUNDLAND DURING THE YEARS

1804 TO 1876

PART II.

Fishery Commission, Halifax, 1877.

THE EFFECT

OF THE

FISHERY CLAUSES

OF THE

TREATY OF WASHINGTON

ON THE

FISHERIES

AND

FISHERMEN

OF

BRITISH NORTH AMERICA.

BY HENRY YOULE HIND, M. A.

HALIFAX, N. S.
PRINTED BY CHARLES ANNAND,
1877.

CONTENTS OF PART II.

I. The relations of the movements of Mackerel in the Gulf of St. Lawrence to Tidal Currents

a.—The Prince Edward Island Double Tide.

b.—The Eddy Flood Tide in the Estuary of the St. Lawrence.

II. The Food of the Mackerel.

a.—In European Seas.

b.—In American Waters.

III. The appearance of Mackerel in the Gulf of St. Lawrence.

IV. Relation of the supposed Migratory movements of Mackerel to Isothermal lines.

V. Movements of the Mackerel compared with the movements of other Fish.

VI. Interpretation of the movements of the Mackerel.

VII. Causes of the alleged annual variations in the number of Mackerel observed.

VIII. On Temperature Strata, and their influence on the habits of Fish.

IX. Influence of the different forms of Ice.

X. Illustrations of the effect of extreme low temperatures upon the movements of Fish.

a.—As affecting the Cod.

b.—As affecting the Herring.

c.—As affecting the Mackerel.

XI. Recent Scientific Enquiries into the Sea Fisheries.

XII. Synopsis of the extent and character of the British American Fisheries, compared with those of other Countries.

APPENDIX.

THE RELATION OF THE MOVEMENTS OF MACKEREL IN THE GULF OF ST. LAWRENCE TO TIDAL CURRENTS.

The fishing grounds for mackerel in the Gulf of St. Lawrence are so well defined from year to year that physical causes must affect, in a very large degree, the distribution of the food which attracts this fish, and either brings them to the surface or lures them to particular coastal areas.

There is perhaps no part of the world where the tidal waves and resulting currents are distributed in such a remarkable manner as in the Gulf and estuary of the St. Lawrence.

The meeting and overlapping of tidal waves of different ages, that is to say, the tide of to-day meeting the tide of twelve hours ago, and producing a double overlapping tide, is of rare occurrence, and is due to the configuration of the sea bottom conjointly with the relative position of islands and neighbouring coastlines.

Northumberland Straits and the north shore of Prince Edward Island afford the most remarkable instances on the American continent of the meeting of tides of different ages, and it can scarcely be doubted that the long and continuous line of inshore eddies, produced in a large measure by this singular confluence, conjointly with the low temperature resulting from the mixing of cold underlying, with warm surface, sea-strata, is the chief cause why mackerel fishing grounds should be there so close inshore with such undeviating constancy.

a. THE PRINCE EDWARD ISLAND DOUBLE TIDE.

The tidal wave entering the Gulf of St. Lawrence between Cape Breton and Newfoundland rushes with great rapidity along the edge of the bank forming the boundary of the sixty fathoms line of soundings.

It sends off lateral waves towards the Straits of Belle Isle, and towards Prince Edward Island, while the main wave, following the deep water at the edge of the sixty fathoms line of soundings, pursues a rapid course towards and up the Lawrence estuary, and reaches Cape Chatte and Point de Monts precisely at noon on the days of full and change of the moon.

Regarding for the present, the lateral wave which strikes off towards the south-western portion of the Gulf, we find it split into two portions by the Magdalen Islands; one half, namely the eastern part, sweeps past the shores of Cape Breton and reaches the east point of Prince Edward Island at 8 hours 30 minutes, Cape Bear at 9 hours, and the middle of the straits opposite Hillsboro Bay, at 10 hours. Here it meets a flood tidal wave coming down Northumberland strait from the north-west, but this wave is not the other half of the wave which was split by the Magdalen Islands two hours before, it is the tidal wave twelve hours old which has been delayed in its detour round the north part of the Magdalens and over the shallows of the Bradelle and Orphan Banks. A line drawn through the Magdalen Islands, Roche's Point and the mouth of Hillsboro River in Prince Edward Island and Wallace Harbour in Nova Scotia, will pass through the places where the overlapping of the confluent tidal waves takes place, at the full and change of the moon, near the shores of Prince Edward Island.' Admiral Bayfield, who first discovered this meeting of waves of different ages on the coast of Prince Edward Island, describes with some minuteness this remarkable phenomenon.

"The principal tide wave after entering the Gulf between Cape Breton Island and Newfoundland, sends off, laterally, waves to the south-west, on either side of the Magdalen Islands.

"The first of these, the eastern wave, coming from between those Islands and the western shore of Cape Breton Island, arrives at the eastern entrance of the strait soon after 8 o'clock, and proceeds to the westward, making high water later in succession from east to west as far as Pictou, which it reaches at 10 hours. At the same nominal hour, but 12 hours later, the other or western wave arrives at Cape Tormentine, having been retarded by the long detour which it has taken to the northward and westward of the Magdalens, and by the great extent of comparatively shallow water which it has passed over in its subsequent progress to the south-west.

"This wave makes high water later in succession at places along the eastern coast of New Brunswick as we proceed to the southward, and after entering the straits from the north-west to south-east, contrary to the course of the other or eastern wave.

"Thus it is high water on the full and change of the moon at Miscou at about two and a half hours, at Point Escuminac and the northern point of Prince Edward Island, forming the western entrance of the strait soon after 4 hours; at the western point of Prince Edward Island at 6 hours; at Shediac at 8 hours and at Cape Tormentine at 10 hours.

"When, therefore, the eastern wave arrives between Pictou and the Wood Islands, the western part of the preceding tide wave arrives between Cape Tormentine and Cape Traverse. They then meet and combine to make high water at the same hour, namely, 10 hours, or a little later, in the harbours all over the central portion of the strait from Pictou to Cape Tormentine, causing also an amount in the rise of the tides everywhere, more than double, and in some of the harbors, nearly three times as great as that which occurs at either entrance of the strait.

"The eastern flood-stream enters the strait from the north-east, running at the rate of two and a half knots round the eastern point of Prince Edward Island, but is much weaker in the offing and over towards the southern shore. It runs round Cape Bear, and with an increasing rate along the land to the westward is strongest in the deep water near the land, and runs at its extreme rate of three knots close past the Indian Rocks and Rifleman's Reef. Losing strength as it proceeds farther to the north-west it is quite a weak stream when it meets the other flood-stream off the Tyron Shoals. This eastern flood-stream is not so strong along the southern or Nova Scotia shore unless it be in Caribou Channel for a short space near Caribou Reef, and it is weak, not generally exceeding half a knot in the middle of the strait.

"The other or western flood-stream comes from the northward along the western coast of Prince Edward Island, sweeping round West Point and running strongest in the deep water near West Reef where its rate is two and a half knots. Over towards the New Brunswick shore its rate seldom exceeds one and a half knots, and this is its average speed as it pursues its course to the south-east until near Cape Tormentine, where the strongest part of the stream runs near the Jourimain Shoals, and thence to the southward, round and over the dangerous Tormentine Reefs with a great ripple and at the rate of three knots.

"From this account of the tidal streams it appears that a fast-sailing vessel under favorable circumstances might enter the strait with the flood, and arriving at Cape Tormentine soon after high water, might there take the ebb and thus have the stream with her with but slight interruption from one end of the strait to the other.

"Or a vessel with a beating wind might so time her arrival at the same point as to be able to continue her voyage in the same direction with the ebb." (1)

Admiral Bayfield is of opinion that these waves of different ages, one being 12 hours younger than the other, meet on the north side of the great Bight of Prince Edward Island, between Tracadie Harbor and Savage Harbor. On the Admiralty charts this locality is designated by the words "Tides Meet." The current is inshore towards this point, both from North Point and East Point, and the effect of the indraught is to determine towards the coast line the floating or free-swimming food of the herring and the mackerel. The great Bight formed by the concave northern coast line of Prince Edward Island, is the result of

1. 'Sailing directions for the St. Lawrence.'— *Bayfield.*

ages of action on the part of these confluent tidal waves dragging along the sloping beaches, and washing away the resulting debris from the sandstone rocks, of which a large part of this coast line is composed. The ceaseless operation of these forces is thus manifested in the wearing away of the shores most subject to their influences. (See diagram.)

b. THE EDDY FLOOD TIDE IN THE ESTUARY OF THE ST. LAWRENCE.

According to Admiral Bayfield, the flood tide in the estuary of the St. Lawrence, beginning at Anticosti and proceeding some miles above Bic, rushes up the broad Mid Channel as far as Red Islet and Green Island, where part of it, being obstructed by the Islands, turns round and, as an eddy flood tide sweeps along and down the southern coast as far as Gaspe Basin, only a thin and narrow band of flood tide running upwards between the eddy flood and the coast line.

On the days of full and change of the moon, it is high water at noon both at Point de Monts and Cape Chatte, and high water later and later down the coast, so that at Cape Rozier it is 1 hour, 30 minutes before it is high tide there.

In other words, the flood tide rushing up the deep mid channel between Cape Rozier and Anticosti Island, passed up more than an hour and a half before the eddy flood tide returned coastwise to Cape Rozier.

Bayfield states that there is a very narrow flood tide close inshore running westerly along the Gaspe coast inside of the eddy flood. These currents moving so constantly in opposite directions and close inshore, tend to produce the continuous line of eddies which cause the free-swimming food of the mackerel to be found near to the land, and make that portion of the estuary a mackerel ground.

On the north shore of the estuary, between Mingan and Point de Monts, the periods of high water at full change of the moon are altogether different. The tidal wave reaches Mingan Island at 1.30, Seven Islands at 1.40, Cawee Island at 1.50, English Point at 2, and a few miles further on it meets the ebb tide two hours old sweeping past Point de Monts

The flood tide on the north shore is only about 3 leagues broad. The strength of the stream is greatest inshore, and beyond 3 leagues from the coast it becomes insensible. (1)

The eddies produced in the bays between Moisie and Point de Monts by this inshore flood tide throw in and keep the food near the coast line.

Hence it is that the flood tide on the north shore flowing westerly, and the eddy flood on the south shore flowing easterly, with a thin belt of westerly flowing flood between it and the land, produce inshore eddies, which concentrate the free swimming food of the mackerel, hereafter described, on these coasts.

The strength of the current in deep water offshore, on the south coast of the estuary of the St. Lawrence, is stated to be sufficient to prevent fishing operations there, thus offering a practical difficulty, which is repeated on some parts of the northern shore during high tides.

In the Bay of Chaleurs, where the tides are regular, the mackerel ground of the day depends upon the wind. A southerly wind converts the south side of the Bay into a lee shore, and the fish are found chiefly on that side, especially towards Nepissiguit Bay. When the wind is northerly the Gaspe coast becomes a lee

(1) Sailing directions for the St. Lawrence.

shore, and the fish are chiefly found between Bonaventure Island and Paspebiac, and on towards Cascapedia Bay. It has already been observed that mackerel and surface feeders generally, swim with open mouths against the wind and tide. The cause which brings the mackerel from the south shore to the north shore, arises from the fact that in the natural pursuit of their surface food against the wind they are brought up by the land, and finding food in the tidal eddies there, they pursue their course inshore against the tidal currents, until a change in the wind induces them to cross again to the opposite shore, where similar conditions prevail.

On the Gulf coast of Cape Breton the set of the currents is oftentimes inshore, and is described by Admiral Bayfield as given in the footnote (1). The influence exercised on temperature strata will be noticed subsequently.

---

1. "At Cape Linzee 1½ miles northward from Port Hood, the west coast of Breton Island trends away to the north-east by east, continuing in that direction to Cape St. Lawrence a distance of 73 miles without either harbour or safe anchorage for ships. The general character is high and bold, the dangers being few and close inshore, but it is nevertheless a dangerous coast to be near in Autumn or early Winter, when the prevailing north-west winds send in a heavy sea and the set of the current is often in the same direction. The swell frequently precedes the wind by many hours, and, as there is no good holding ground, becomes dangerous to vessels caught close inshore. Even with a smooth sea and in fine Summer weather, vessels are set in towards this coast, an effect which seems to be due sometimes to the general current from the north-west coming from between the Magdalens and Prince Edward Island, and at other times to the direction of the ebb-stream from the Strait of Northumberland inclining towards these shores.

"These streams being inconstant and irregular, both in strength and direction, are therefore the more dangerous and require the more to be guarded against. In the Summer months, however, the rate of the current or tides will not be found to exceed one knot even close inshore; excepting round Cape St. Lawrence and Cape North, where it sometimes runs at the rate of 2 or 3 knots, causing a heavy, breaking sea. Its direction for three-fourths of the time is from the westward. This appears to be due to the combined action of the current and ebb-tide predominating over the flood stream from the north east, so as to render it nearly imperceptible, excepting at or near the Spring tides.

"There is no doubt that winds present, or at a distance, also influence these streams, as they have been observed to do in all parts of the Gulf."

II.—THE FOOD OF THE MACKEREL.

a. IN EUROPEAN SEAS.

"Mackerel mint" is the popular name given to the chief food of the mackerel in European seas. During certain seasons of the year this consists of Launce and the fry of other fish, especially of the Herring and Sprat.

According to Boeck, the Danish naturalist, the food of the Mackerel during the *Summer* months consists of minute crustaceans, which frequently give a distinct colour to the sea.

The mackerel feed also in these seas on the swimming larvæ of tape worms.

They also devour large quantities of the embryos of a small spiral shell, (Rissoa) which in its adult state is found in great abundance upon sea weed. Similar food has been detected by Mr. Whiteaves in the Gulf of St. Lawrence ([1])

b. IN AMERICAN WATERS.

The Britt, or "eye-bait" of the Canadian and American fishermen was formerly stated by Dr. Storer to be the fry of the small herring (*Clupea minima*), it is now supposed to be the fry of the common sea herring. It appears to be, generally, the first food upon which the mackerel feed when approaching the Atlantic coasts in Spring from their Winter haunts confronting the coast line where they first show themselves. The fry of the sea herring, either from Spring spawning schools or Autumn spawning schools appears to be enormously abundant some distance seawards in May and June, but varying in size from an inch to four inches in length, according to the age of the fry, whether hatched in the Spring or in the preceding Fall.

James de Kay in the "Zoology of the State of New York," also describes the "Britt" as "*Clupea minima.*" He states that the fish has a length of from one to four inches.

The length of the head is one-fourth the length of the body and the diameter of the eye is equal to one-sixth the length of the head, or one twenty-fourth part the length of the body. Perhaps from the largely developed eye, the "Britt" is styled by the American and NovaScotian fishermen the mackerel "eyebait."([2])

But the movements of the mackerel like those of the cod, and indeed of most species of fish, are determined at different seasons of the year by the geographical position of its food, and the first important kind of food which appears to lure the mackerel inshore after spawning in the Gulf of St. Lawrence, is the Launce or Sand Eel.

The relation of the Launce or Sand Eel (*Ammodytes Americanus*) to the mackerel, is very much greater than appears at the first blush, and resembles the relation of the herring to the cod, in general, and, in particular, the relation of the so-called Norwegian "Sull Cod" or Launce Cod, to this wide-spread and important bait-fish. The approach of the Launce to the coast in Spring is most probably the cause why the so-called Spring cod fishing

---

1. Report on a second deep sea dredging expedition to the Gulf of St. Lawrence—1872.

2. Rev. J. Ambrose—On St. Margaret's Bay fishing grounds—N. S. Institute of Natural Science, 1866-7.

suddenly ceases on many banks and shoals, commencing again at different localities two and three weeks later.

The cod leave the banks and shoals to meet and to follow the Launce as they approach the coast. In the same manner they meet and follow the Caplin, guided no doubt by the peculiar odor developed by each species at the approach of the spawning season.

But it is the habit of the Sand Eel of burying itself in the sand between tides, or in submerged sand beaches, that leads the mackerel so close inshore.

The Sand Launce, as its name implies, often seeks during the early summer, widespreading and soft sandy beaches, and where these are abundant and other conditions favorable, it lingers for months on the same part of the coast. Dr. Fortin states in his report for 1856, that between Seven Islands and Mingan the Launce appears in the Spring and remains until the Fall.

The fact of this fish burying itself in the sand to the depth of five or six inches during the ebb tides, is one reason why mackerel, and many other fish, are caught inshore during the flood-tide. They come in to feed on the emerging Sand Launce, as well as upon the hosts of other and lower forms of life whose burrowing habits between tides are similar to those of the Sand Launce.

Perley states that it is very abundant on the north shore of New Brunswick.(1) Here there are, as on the north shore of Prince Edward Island, very extensive sandy flats suited to the peculiar habits of this fish. Dr. Carpenter describes the Sand Launce of the British seas as burrowing in the sand to a depth of six or seven inches during the time that it is left dry by the ebb tide.

But it is not the mackerel alone among surface feeders which pursue the Sand Launce with eagerness, it is also a favorite food of the herring.

Prof. Huxley in his 'Natural History of the Herring' embodied in the 'Report of the Royal Commission on the operation of the acts relating to trawling for Herring on the coast of Scotland' states that "the food of the Herring consists of crustacea varying in size from microscopic dimensions to those of a shrimp, and of small fish, particularly Sand Eels, while in the Matie (fat) condition they feed voraciously and not unfrequently their stomachs are found immensely distended with crustacea and Sand Eels in more or less digested conditions." Again, "any circumstances which increase or decrease the quantity of crustacea and Sand Eels, for example, must influence in a direct ratio the chances of existence of a multitude of Herring, etc."

The Sand Launce is essentiallya cold water fish. Dr. Theodore Gill gives the range of the American species from Newfoundland to Cape Hatteras, but it is not included in the Report for 1871–72, except doubtfully in one case, as having been found in the stomachs of fishes taken off the New England coast and south of New England, and examined by the officers of the United States Commission of Fish and Fisheries.

The list includes thirty different species of fish whose stomachs were examined, including the mackerel and the herring, and all the important food fishes. But the only reference to what may have been the launce is described as a long slender fish(Ammodytes) found in the stomach of the common skate.

---

(1) It is found everywhere on the coast of New Brunswick and Nova Scotia chiefly on beaches under stones. — Perley — Descriptive Catalogue of the Fishes of New Brunswick and Nova Scotia.

On the coasts of Newfoundland, on the Grand Banks and throughout the entire Gulf of St. Lawrence the launce is exceedingly abundant.

The launce is found in spring, or early summer in some seas, in the neighborhood of banks and shoals remote from land, as is also the sprat in Europe and the "brit," "eyebait," or small herring in America. Prof. Sars has given a detailed description of the manner in which the approach of vast schools of young herring to the Norwegian shore in summer, not only attract the large cod and many other fish from the deep sea towards the shore, but also draw the yearling and two year old cod *from* the shore to meet the incoming schools.

There can be little doubt that a similar indraught and outdraught of mackerel and other fish occur in our waters when the launce leave the deep sea to approach the land, or when they return to the deep sea again. Unlike many of the shrimps and larval forms on which the mackerel feed, which are drifted too and fro by winds and currents, the launce is independent of the wind, but it is only in certain favourable localities frequented by this fish, that the burying process between tide-marks from which it derives its name, can be easily effected, hence these resorts are not only valuable as bait grounds, but generally noted mackerel grounds, such as Seven Islands and some parts of Bay Chaleurs and part of the Gulf coast of New Brunswick.

This bait-fish approaches the sandy beaches fringing the shores of the Gulf in the early summer months to spawn, and here the mackerel are found pursuing them while engaged in depositing their comparatively large reddish coloured ova on the sands between high and low water. Hence during flood tide and in the launce season, mackerel are commonly taken close inshore on these coasts, in pursuit of the launce, and the best catches are said to be made during the period of high tide for the following reason :—In dull, cloudy weather the launce buries itself in the sand left bare by the ebbing tides, but in bright, hot weather it rarely seeks the shelter of the sands except near low water mark, probably because the heat of the sun would be oppressive. The breadth of sandy ground in which the launce buries itself for the brief period between high and low water marks is thus dependent upon the clearness of the sky.

A continuance of cloudy weather is conducive to this kind of close inshore fishery, whereas a bright sky and a day with a drying wind, leads the launce to select the narrow bands of sandy beach near the margin of ebb tide, which always remains moist. In cloudy weather with a moist wind the area in which the launce bury themselves and emerge during the incoming tide is thus very much greater than in bright, hot weather, and it is not unfrequently found by experience, that the mackerel catch in such localities, is much greater in cloudy weather than in bright weather, because the bait ground is then far more extensive close inshore.

As the summer advances and the launce retire to deep water, the mackerel feed upon the free-swimming and floating embryonic forms of crustaceans ; among the latter the zoea of different forms of crabs, are the most common. Adult shrimps of many species form also a large portion of their food, and the infinite numbers of these forms of life which exist in the sea, from the coast line to a thousand miles from land, may be inferred from the fact, that together with fish, they form the great staple food of seals in northern seas.

Dr. Robert Brown states that during the sealing season in Spitzbergen seas he has taken out of the stomachs of seals various species of *Gammarus*, (*G. sabini ; G. loricatus: G. pinguis;*

G. dentatus; G. mutatus, &c.) collectively known to whalers under the name "mountebank shrimps," deriving the designation from their peculiar agility in water. [1.]

These small crustaceans are found in countless numbers on the great outlying banks off the North American Coast, and in the Labrador seas they are also in great profusion

It is of especial importance to notice that very many, if not all of these free swimming creatures in the sea, from invisible microscopic forms to the largest shrimp, sink to different zones of water or rise to the surface with variations in temperature, and changes in the direction and force of the wind. In fine weather *where* the food is *at the surface*, the mackerel, the herring, and other surface feeders swim open mouthed against the wind. Dr. Brown states that the great Right while and most of the whale species feed in a similar manner. The Right whale feeding, swims leisurely at the rate of about 4 miles an hour. Mackerel when feeding, come often by millions, like a swiftly moving ripple on the water, with eager staring eyes and mouths distended to entrap the floating prey. Many of the free swimming Pteropeda are active only during the night-time, sinking during the day to a certain zone of depth.

The effect of currents and tides, assisted by winds, is to drive these free swimming forms towards the different shores and into land locked or sheltered Bays. On the shores of the open sea, a continued land breeze drives them far out to sea, and the fish following them will be lost to view. Off the coast of the United States the mackerel ground is not unfrequently found near the summer limit of the Gulf stream, where wide spreading eddies prevail, caused by the meeting of the great Labrador current flowing in an opposite direction, or the surging up of the Arctic underflow. In these vast eddies the temperature is greatly reduced by the mixing of almost ice-cold water from beneath with a warm over-lying stratum.

It is here too that the free swimming mackerel food will congregate, sometimes at the surface, at other times at different depths, dependant upon the temperature of the mixed waters. In the vicinity of the south edge of the Grand Bank of Newfoundland, the line of contact between the Arctic and the Gulf streams is sometimes very marked by the local currents, which "boil and form strong eddies." (2) The line of contact of the two great cold and warm currents is continually changing for hundreds of miles with the varying seasons, and under the influence of winds, hence also the changes in geographical position and in the depth or zone of the the open sea mackerel grounds.

Inshore, the floating and free-swimming food is drifted too and fro by winds and tides, and great accumulations are sometimes thrown up upon the beaches in windrows after storms. This floating and swimming-food gathers in eddies, either near the coast line or at the junction of opposing tidal waves or currents. Hence, along sheltered and embayed coasts, confronting the open sea, in the vicinity of Banks, where great tidal currents and eddies are formed, or in the Gulf and Estuary of the St. Lawrence, where two opposite and wholly different tides, dragging along the coast-line, approach to meet, there will be the mackerel ground of the fishermen, but not necessarily *at the surface*.

In Professor Verrill's Report on the "*Vertebrated Animals of Vineyard Sound*" it is stated that the stomachs of Mackerel taken July 18th twenty miles south of No Man's Land, contained

---

(1) "On the Seals of Greenland."—Dr. R. Brown.

(2) Sailing Directions.

shrimps, *Thysanopoda, sp*: larval Crabs in the *Zoea* and *Megalops*—stages of development, young of hermit crabs, *Platyonichus ocellatus*, young of two undetermined *Macroura*, numerous small Copepod Crustaceans, and numerous shells of a *Pteropod, Spirialis Gouldii*."

The winged Pteropods, noticed at the close of this paper, very probably form an important part of Mackerel food, as they sink and rise with changes in the temperature of the zone or sheet of water in which they are feeding. The use of the thermometer may become of great practical importance in determining the zone of depth in which the fish are pursuing their free-swimming food. This instrument is now largely used by the Dutch in their herring fishery.

III.—THE APPEARANCE OF MACKEREL IN THE GULF OF ST. LAWRENCE. (1.)

The mean temperature of the season governs the time of the appearance of mackerel at the surface in different parts of the Gulf, and in this respect it follows the same law which guides the movements of all kinds of fish and marine life in these waters.

That the mackerel spends the winter months in a torpid condition near to the locality where the schools first show themselves on the coast has already been adverted to. (See page 70–80 Part I.) The "scale," or film over the eye, often noticed by fishermen on the Atlantic coasts of the United States, Nova Scotia, Cape Breton, in the Gulf of St. Lawrence, and on the Newfoundland coast, with the alleged resulting partial blindness of the fish on its first arrival, coupled with the fact already noticed that it is taken in the winter from muddy bottoms, is strongly suggestive of a winter habit of torpid hybernation, possessing greater or less duration according to the marine climate of the region where the fish is found.

The following curious notice of the habits of the mackerel occurs in Shaw's "General Zoology or Systematic Natural History," published in 1803. The four disputed points in relation to the natural history of this fish are there asserted, namely its local habits, its torpidity during hybernation, the film over the eye and the fact of its being partly imbedded in the soft mud or sand during its winter sleep.

"This long migration of the Mackerel, as well as of the Herring, seems at present to be greatly called in question; and it is thought more probable that the shoals which appear in such abundance round the more temperate European coasts, in reality reside during the winter at no very great distance; immersing themselves in the soft bottom, and remaining in a state of torpidity from which they are awakened by the warmth of the returning Spring, and gradually recover their former activity. At their first appearance their eyes are observed to appear remarkably dim, as if covered with a kind of film, which passes off as the season advances, when they appear in their full perfection of color and vigour." *

James de Kay notices in his "Zoology of the State of New York," the film covering the eye of the Mackerel when first it appears in the Spring of the year. He considers it to be a nictitating membrane, or third eyelid, similar to the nictitating membrane

---

(1) Mackerel fishing with the hook commenced in the Province of Nova Scotia about the year 1821, and was prosecuted with great success from some of the harbors in the Bay of Fundy. (2) About the year 1847, mackerel were very abundant in the vicinity of Sable Island, and the Fisheries Committee of the House of Assembly urged the granting of a bounty to all vessels engaged in the deep sea Mackerel Fishery, which was not adopted by the House.

The export of mackerel from the Port of Halifax during the years 1839 to 1846 inclusive, show that considerable attention was given to this Fishery on the coasts of Nova Scotia thirty years ago. (3)

YEAR.	NO. OF BARRELS.
1839	19,127
1840	25,010
1841	35,917
1842	54,118
1843	71,854
1844	50,698
1845	38,230
1846	82,645

1. Journal and Proceedings of the House of Assembly of the Province of Nova Scotia, 1857. Appendix No. 75.

2. Ibid.

3. Inspected.

* Of this Count de Cepede adduces the testimony of an eye-witness; viz., Mons. Pleville le Peley, who, about the Coasts of Hudson's Bay observed

found in birds, in some reptiles, and amphibians. But de Kay makes a distinction between the Spring Mackerel and the Fall Mackerel. He does not notice a nictitating membrane on the so-called Fall Mackerel, which is now known to be of the same species as the so-called Spring Mackerel. In seas which are not ice-encumbered, the winter torpidity may be of very short duration ; in ice-encumbered seas it may extend over several months.

In this particular the Mackerel resembles the Sturgeon of the Caspian Sea, whose torpidity during winter is well-known, and this winter sleep is not confined to these fish but is probably much more general than is commonly supposed. Some fishermen assert that the Mackerel caught late in the Fall, and even early in the Spring, are covered with slime, but this requires confirmation. The skin which forms over the eye is probably designed to protect that organ from the attacks of the numerous parasitical crustaceans and leaches which infest the external portions of the bodies of fish and are also found internally, as in the gills of Codfish. According to Carpenter the Lernea is not unfrequently found upon the eyes as well as in the gills of fish.

The Sturgeon of Rainy River and of the Lake of the Woods is covered in the early Spring with a thick mucus or slime, which appears to serve as a protective covering against too rapid respiration and consumption of the substance of its own body, during a long period of torpidity. The Tautog on the coasts of the United States is stated not only to be extremely sensitive to cold, but at the approach of the time of hybernation the vent becomes sealed and the fish is thus prepared for a minimum consumption of its own fat during its winter sleep.

The subjoined notice of the torpidity of the Tautog and the Scup, by Capt. Atwood, will be found on page 212 of the U. S. Commissioner of Fish and Fisheries Report for 1871–72. (1.)

---

the mud at the bottom of the small clear hollows, encrusted with ice round those coasts, entirely bristled over by the tails of mackerel imbedded in it nearly three parts of their length.

(1) In the American Angler's Guide, page 178, in the article on Tautog or Black Fish, it is remarked: "The Black Fish abounds in the vicinity of Long Island, and is a stationary inhabitant of the salt water."

"He may be kept for a long time in ponds or cars, and even fatted there. When the cold of winter benumbs him, he refuses to eat any more, and a membrane is observed to form over the vent and close it."

"He begins to regain appetite with the return of warmth in the spring." (179.)

Now we know that Tautog hybernate among rocks near the coast and in our rivers, and it has been stated by Mr. L. Tallman or Mr. Daniel Church that some years ago, after a very cold snap, not only many Tautog were washed ashore frozen stiff, but afterward quantities were also found dead among rocks off the coast.

If, during the winter, they don't feed as stated above, and this membrane closes them up, the conclusion must be that they remain in a state of torpor or sleep during cold weather.

Now it happens that the Scup, when first taken by traps, are in a state of torpor: they neither eat nor have any passage. It is probably sealed up like the Tautog, and nothing in the shape of food is to be found within them. Some say they are blind, and they seem hardly able or willing to move."

The inference, then, is, that the Scup have also been hybernating within a short distance from the coast, in the same state as the Tautog. This would account for the stray Scup mentioned by Mr. Southwick as having been occasionally found in March. A warm day wakes him up, and he visits the shore for a day or so, and then returns. To my mind, this is a more reasonable way of accounting for his presence than to assume that he has been left behind. If these facts are as stated, it is to be presumed that Scup are a local fish, and do not leave their localities any more than Tautog, about the propriety of the classification of which as a local fish there is no question."

(2). The following brief description of the winter sleep of the Sturgeon by Alexandef Schultz, in his account of the Fisheries and Seal-hunting in the White Sea, the Arctic Ocean and the Caspian, is both instructive and suggestive:—

" A very peculiar phenomenon in the Ural is the winter sleep of fish, espe-

The writer was informed by one of the officers of the Hudson Bay Company, that salmon trout on the North Eastern Coast of Labrador lie packed in large numbers close together throughout the greater portion of the winter, in deep holes, in the rivers flowing into the sea on that coast. But whether they are in a torpid condition with a temporary physical alteration in their form, does not appear to be as yet known.

The Mackerel regularly appear at the Magdalen Islands in the Gulf of St. Lawrence about one month after the first arrival of the herring. The time as far as observed during 1861 to 1866 inclusive, 1871 and 1873 to 1876 inclusive, varied from the 30th May to the 12th June.

The following table shows the dates of the first appearance of the Herring and the Mackerel at Pleasant Bay during the years named. The authorities are to be found in the official reports of officers engaged in the protection of the Fisheries, in Capt. Fortin's Reports, and in other published documents relating to the Canadian Fisheries in the Annual Sessional papers.

In Captain Fortin's Report for 1853, Herring are stated to have arrived about the 1st of May of that year, and the Mackerel Fishing to have been nearly finished on the 7th June.[1.]

TABLE SHOWING THE PERIOD AND THE YEARLY DIFFERENCES IN NUMBER OF DAYS BETWEEN THE FIRST APPEARANCE OF THE HERRING AND THE MACKEREL AT THE MAGDALEN ISLANDS, FROM 1857 TO 1876.

YEAR.	1st Appearance of the Herring.	1st Appearance of the Mackerel.	Difference in days.	
1857	May 7th	June 1st	23	
1859	April 29th	....	......	
1860	" 28th	June 1st	32	
1861	May 1st	....	......	
1862	" 2nd	June 4th	32	
1863	" 17th	" 12th	25	
1864	" 1st	" 6th	35	
1865	April 27th	May 30th	32	
1866	" 25th	" 29th	33	
1867	May 7th	June 2nd	26	
1868	....	....	......	
1869	....	....	......	
1870	April 15th	....	......	
1871	May 8th	May 31st	23	
1872	" 3rd	June 20th	......	Mackerel three weeks later than usual—much ice. [2.]
1873	April 27th	June 5th	38	
1874	May 2nd	" 7th	35	
1875	" 6th	" 8th	32	
1876	" 5th	" 6th	31	

"On the 31st May I went inside Amherst Harbor and boarded twelve vessels engaged in mackerel fishing." Report of Capt. L. H. LaChance, commanding the Marine Police Schooner "Stella Maria." Dec. 1871. Sess. Papers 1872, page 158.

The Mackerel must have been in the vicinity of the Magdalens during the last week in May, in 1871, and fishermen were then taking Mackerel simultaneously far south and far north, or in Martha's Vineyard, south of Cape Cod, in latitude 41° 20', and Amherst Harbor, Magdalen Islands, in latitude 47° 20', or six degrees of latitude apart.

cially of the Sturgeon. From the end of June, different kind of Sturgeon, as well as scaly fish, come to the Ural for the second time.

"For some time they can be seen swimming and playing in the stream, but as soon as the water grows cold this vivacity disappears; they seek the deep

1. MSS. in French—not printed.

2. Canadian Sessional Papers. Reports of the Fishery Officers.

It will be seen from the table that generally when the Herring were early the Mackerel were also early, and when the Herring appeared late, the Mackerel also were late.

In 1872 the Herring came in on the 3rd of May, but owing to the prevalence of ice, the Mackerel were three weeks later than usual inshore. With this exception the greatest difference between the recorded times of the appearance of these fish inshore was thirty-one days or about one month.

In all instances the large Mackerel are generally full of spawn when they are first seen in the Spring, and the young fry are observed a few weeks later in many parts of the Gulf.

It will be observed that in the year 1871 the Mackerel were first taken at the Magdalen Islands on the 31st of May, and in 1872 they were three weeks behind their usual time. A similar difference in point of time in the first appearance of this fish on the coast of Massachusetts occurred during those years. On that coast the following differences are recorded:

WAQUOIT, MASSACHUSETTS.(1.)

1871	April 25th.
1872	May 10th.

Difference in time—15 days.

MAGDALEN ISLANDS.

1871	May 31st.
1872	June 20th.

Difference in time—21 days.

At the Waquoit Weir the earliest Mackerel would probably be taken in 1871. At Amherst Harbor the Mackerel vessels were actually engaged in fishing, (See L. H. LaChance—Report of the Marine Police Schooner "Stella Maria," 1871.), so that the fish must have been present in small numbers perhaps some days before the fishing began, and we may conclude that the difference in time between the arrival of the schools at the two places in 1871 and 1872 was very nearly the same, and due solely to local variation in marine climate.

Referring now to the consideration of the difference in the temperature of the waters through which the Mackerel would have to pass if they made the remarkable migrations from New Jersey or Massachusetts waters to the Magdalens in the month of May(2.) it must be borne in mind that these supposed migrations involve a journey from warm coastal waters to cold seas, and as the mackerel are known to spawn not only in Massachu-

---

places ('yatoves') in which the bed of the river abounds, and hide there as soon as the bed of the river is frozen. In their state of torpor these fish secrete a viscous matter, which forms a thin layer over their whole body. The fishermen call this the 'cloak' of the fish. This torpor or sleep of the fish is caused by severe cold and want of air under the water, and is therefore a consequence of the excessive weakening of the respiration.

"The fish eat nothing during this state, for nothing is found in their stomachs but viscous matter, spoken of above. The great Sturgeon alone (*Accepenser huso*) seems to take food during his winter sleep, for some have been caught having scaly fish in their stomach.

"The deep places or 'yotoves' of the Ural are from 7 to 8 saques (49 to 50 feet) deep, and the fish there pile themselves upon each other in thick layers.

"According to the accounts of experienced fishermen, Sturgeon there associate only with Sturgeon, and scaly fish with their own kind—never intermingling. The Sinitse (*Abramis Ballerics*) is the only scaly fish which has been found among the Sturgeon.

"Watchmen posted near the 'yatoves,' every one of which has its own name, notice exactly in what quantities the fish seek refuge there, and of which kind the fishing will be most productive. These watchmen develop a most astonishing sagacity in this respect."

(1) Report of U. S. Commissioner of Fish and Fisheries, 1871-72.

(2) While the mean recorded date of the appearance of the Mackerel at the Magdalen Islands is the 3rd of June, according to the preceeding table, they were taken there on the 30th May in 1865, on the 29th May in 1866, and on the 31st May in 1871.

setts Bay, but also about Prince Edward Island, the Magdalens, in the Bay of Chaleur, and in the Bay of Notre Dame, Newfoundland, it follows, if the alleged migrations have any foundation in fact, that the same schools of this fish spawn during some seasons in the comparatively warm coastal waters of Massachusetts, in other seasons in the ice cold waters of the Gulf, and become an exception to the general rule governing fish life, namely, that fish return, as near as possible, to the place of their birth to exercise the functions of re-production.(3)

The area within the sixty fathom line of soundings in the Gulf acquires a higher temperature than the deeper portion of the Gulf in the latter part of June and during July and August. It possesses a more southern fauna, but it is cut off from the Atlantic by the Arctic outflow, which is the cause of the great southerly bend of the Isothermal lines on this part of the American coast, through which the fish would have to pass during their supposed northward migration.

According to resident Newfoundland fishermen young Mackerel have been seen in great numbers in the Bay of Notre Dame during the months of September and October, about three inches in length.

They appear on the coasts there generally about the 20th July, and during the period when Mackerel were common on the north-east coast, Green Bay, at the extremity of the Bay of Notre Dame was a noted place for swarms of Mackerel fry.

---

(3) Vide page xxxviii. Report of the U. S. Commissioner of Fish and Fisheries.

IV.—RELATION OF THE SUPPOSED MIGRATORY MOVEMENTS OF MACKEREL TO ISOTHERMAL LINES.

It is alleged that the American fishermen follow the Mackerel from the southern waters of Virginia all along the coast of the United States to the Gulf of St. Lawrence, and according to the same reasoning they might follow them through the Straits of Belle Isle to White Bay, on the North East Coast of Newfoundland, where they have been taken in abundance.

Similarly it is alleged that in the fall of the year they follow the schools from the Gulf past Cape Breton Island to Virginia waters again.

It is worth while carefully to consider what this extraordinary migration involves. It presupposes the movements of bodies of the same great schools of mackerel, which are alleged to pass Massachusetts Bay from the waters of the coasts of Virginia and New Jersey, not only through from ten to twelve degrees of latitude, but it assumes that they are able to cross in the early summer, and frequently before spawning, numerous isothermal lines in descending order, and chiefly during May, for they appear at the Magdalen Islands at the end of that month. If they came, as is here affirmed they do come, from their winter homes near to their spawning grounds, they would continue in the same isothermal zone, or pass from a lower into a higher coastal or surface temperature, and not from a high into a much lower temperature, which would be the case if they migrated, as alleged, from the south towards the north so early in the season. The influence of the Labrador current in pushing the isothermals to the south is so marked, that it forms a great exception to the general distribution of temperature throughout the world, and influences, in a corresponding degree, marine life near the shores on which it presses. The general southerly and northerly movements of the isothermals in winter and summer on the American coast, may be inferred from the following abstract of Dr. Petermann's resumé of observations published in the Mittheilungen for 1870, in the article entitled "Der Golfstrom," &c. An inspection of the colored chart illustrating Dr. Petermann's paper, will convey at a glance an idea of the sudden plunging from high to low zones of temperature which would be involved if the alleged movements of the mackerel in the months of May and June were based on actual facts.

According to the subjoined table of Marine Isothermals for July, a school of fish moving rapidly from Delaware Bay to the Straits of Belle Isle, would pass in July from a mean temperature of 68° to a mean temperature of 45° 5', a difference of more than 22° Fahrenheit. This temperature refers to the surface of the sea, but the difference between the temperatures at different depths near the coast line would very probably be maintained and in some places, as over Banks and, shoals exceeded.

GENERAL TABLE OF JULY MARINE ISOTHERMALS ON THE NORTH AMERICAN COAST, BETWEEN DELAWARE BAY AND THE GULF OF ST. LAWRENCE.

JULY, 1870.

REAUMUR DEGREES	FAHRENHEIT DEGR'S.	ISOTHERMAL TOUCHES COAST LINE.
16	68.	Delaware Bay.
14	63.5	Long Island.
12	59.	Boston.
10	54.5	Cape Sable, Nova Scotia.
8	50.	Cape Race.
6	45.5	Straits of Belle Isle.

GENERAL TABLE OF JANUARY MARINE ISOTHERMALS ON THE NORTH AMERICAN COAST, BETWEEN DELAWARE BAY AND THE GULF OF ST. LAWRENCE.

REAUMUR DEGREES.	FAHRENHEIT DEGR'S.	ISOTHERMAL TOUCHES COAST LINE.
6	45.5	South side Delaware Bay.
4	41.	North side " "
2	36.5	Nantucket Island.
0	32.	Cape Cod.
—6	18.6	South Pt. Pr. Ed. Island.
—8	14.	North Pt. " "

Mackerel are known to spawn about Block Island and in Massachusetts Bay near the close of the month of May, also on the Bradelle Banks, and the Magdalens early in June, and on the North East Coast of Newfoundland towards the end of that month.

It is scarcely to be supposed that schools of the same species of fish would one year cross numerous isothermal lines and spawn a month or five weeks later six hundred or a thousand miles off in the Gulf of St. Lawrence, or on the North East Coast of Newfoundland. It is much more rational to suppose that these are many local schools seeking their old spawning grounds, and returning to the place of their birth from their winter quarters, with the gradual increase of temperature, and that the difference in the times or periods of the spawning of the different schools is altogether dependent upon local marine climate.

If it were the case that the same schools of mackerel spawned one year in Massachusetts Bay, and another year on the Bradelle Banks in the Gulf of St. Lawrence, the conditions of life of the young fish in relation to temperature would be very diverse. The water on the Banks and shoals in the Gulf of St. Lawrence is frequently intensely cold, and is often during summer even near to the freezing point, as has been observed by Dr. Kelly and others; whereas in Massachusetts Bay and on the coast of New England, it becomes very warm during the early summer months, and so continues for a long period. It is, however, easy to comprehend how different schools of the same species of fish may become acclimated to the different conditions of their existence, as, for instance, the schools of herring in Fortune Bay, Newfoundland, and the schools on the coasts of Maine; the Cod off Massachusetts shores and in the Straits of Belle Isle; the Cod in British Seas, where salt water ice is very rarely seen, and the

Cod on the Labrador, where there is salt water ice for six or seven months in the year. These different schools of fish are born and live in very different marine climates. With the approach of warm weather the Cod on the shores of the United States, especially south of Cape Cod, retire to the shelter of the deep underflow of the Arctic Current, or to where it surges upwards along the summer edge of the Gulf Stream.

The southern schools of mackerel probably also find here a suitable summer feeding ground, seeking in the colder strata of water the temperature suited to their habits.

V.—MOVEMENTS OF THE MACKEREL COMPARED WITH THE MOVEMENTS OF OTHER FISH.

When successive appearances of Mackerel at different points of the coast are tabulated, the apparent movements afford some grounds for the popular belief in the migrations of these fish, but they are susceptible of a strictly philosophical explanation, in which temperature asserts its claim as a ruling cause. When the condition of the fish is recorded at the time, and their spawning habits considered, the falacy of the popular belief becomes apparent. The following table affords a synoptical view of the facts recorded, with authorities given in the foot notes.

TABLE SHOWING THE GENERAL DATES OF APPEARANCE OF THE MACKEREL, SHAD AND ALEWIFE OR GASPEREAU ON THE COASTS OF THE UNITED STATES AND BRITISH AMERICA.

LOCALITY.	MACKEREL.	SHAD. (1)	ALEWIFE (2).
South Carolina.........	——	January.	——
Virginia and Rhode Island...........	Middle of April.	February.	March.
New York and New Jersey..........	20th April.	End of March.	End of Mar.
Massachusetts.......	25th April to 10th May.	First week in April.	——
Nova Scotia.........	10th to 20th May.	May.	May.
Cape Breton..........	25th May.	——	——
Magdalen Islands.... Gulf of St. Lawrence	2nd June.	——	——
Miramichi.......... Gulf of St. Lawrence	First week in June.	End of May.	End of May.

(1) Charles Lanman et *Altera* in Report of the U. S. Commissioner of Fish and Fisheries. Also Perley; Fisheries of New Brunswick.

(2) Ibid; Perley; Dr. Storer; Fisheries of Massachusetts.

The first appearances of the Alewife and the Scup on the coast of Massachusetts resemble closely the relative times of appearance of the Herring and the Mackerel at the Magdalen Islands.

During the years 1859 to 1871 inclusive, the earliest and latest appearance of these fish at Waquoit Weir was as follows

Alewives, { Earliest....March 24th, 1871. / Latest......April 7th, 1869. } Difference 14 days.

Scup... { Earliest..April 25th, 1871. / Latest....May 10th, 1862 & 68. } Difference 15 days.

Difference in the annual periods or dates of their appearance about one month.

With regard to the fish, whose movements were formerly supposed to be made simultaneously over the same ground with those of the Mackerel, the United States Commissioner of Fish and Fisheries says: " We now, however, have much reason to think that in the case of Herring, the Shad, the Alewife, and the Salmon, the journey is simply from the mouths of the rivers by the nearest deep gully or trough to the outer sea, and that the appearance of the fish in the mouths of rivers along the coast at successive intervals from early Spring in the South to near midsummer in the north, is simply due to their taking up their line of march at successive epochs from the open sea to the river they had left during a previous season, induced by the stimulus of a definite temperature, which of course would be successively attained at later and later dates as the distance northward increased."[1.]

The effect of temperature on the local movements of the Mackerel may be recognized in the process employed by fishermen to "raise" Mackerel by toll-bait, and luring them seawards. The Mackerel follow the bait for some distance from shore, where suddenly they cease to bite and disappear. They probably find long exposure to the warm temperature of the surface waters unsuited to their habits, and sink to a cooler zone.

Hence the reason why a "Mackerel breeze," mixing the heated surface water with the cooler understratum, is favorable to prolonged mackerel fishing with bait. The mixing produced by agitation cools the surface and permits the fish to feed for a lengthened period.

Temperature in the case of the mackerel as with the shad, alewife, salmon, caplin, and launce, in fact both with anadromous as well as deep sea fishes, appears to be the sole guide in determining their movements in the spring and on the approach of winter.

In 1872, Mr. Whitcher prepared a full resumé of the views of different European Naturalists "On the supposed Migration of the Mackerel," which is published at the close of the Report of the Minister of Marine and Fisheries for that year.

In these recorded views the supposed migrations are entirely set on one side.

---

1. Page xxx., Report of the U. S. Commissioner of Fish and Fisheries, 1871-72.

VI.—INTERPRETATION OF THE MOVEMENTS OF THE MACKEREL.

What then is the proper interpretation of the movements of the mackerel from its first appearance in the Spring to its disappearance in the fall ? These movements vary with the geographical position of local schools of this fish. On the coasts of the United States and Nova Scotia, its annual movements resemble in all particulars those of the same species in European seas where the schools have a free and unobstructed ocean in which to seek their prey.

In the spring, at the end of April and May, the Atlantic schools of this fish which have wintered off the coasts approach the land in separate bodies, full of spawn and poor, coming direct from winter homes where they have remained in a torpid condition, partially buried in sand or mud. After spawning, the different schools feed for a short time on the fry of fish, and as the temperature rises they go out to sea in search of free swimming crustaceans and larval forms of food according as they are distributed by wind and tide.

They pursue this food against the current or tide. They often feed during the night because at that period great numbers of free swimming larval forms approach the surface. This is one reason why mackerel schools are frequently missed by fishermen, and areas supposed to be deserted, may really abound with this fish, which would be discovered by sink-net fishing. The currents are constantly changing with the seasons under the influence of temperature and prevailing winds, hence the course or direction and depth of the food is constantly changing also.

Sometimes it is carried far off from the land, at other times towards it, and the mackerel schools following the food move first in one direction, then in another, and range from close in-shore to fifty miles and more seawards, and often, doubtless, at a considerable depth below the surface.

The general direction of these movements, when plotted on paper, would be a series of irregular circles or elongated ellipses, the range of each school or group of schools being opposite and often adjacent to that part of the coast where they spawn.

As the Fall approaches, owing to the diminution in the supply of their floating food out at sea, they come more inland.

All the free swimming larval forms of most species of Shrimps, Crabs, Lobsters, Sea Urchins. Starfish, Sea Worms, &c., &c., have disappeared in the open sea, after passing through their final transformation. But near the shore there are great numbers of other forms of life, which are developed later in the year. Coming in shore to feed on these on the Atlantic Coast, the Mackerel are found by American fishermen later and later on their return voyage to the south-west, which gives rise to the impression that they are following the schools, when they are only meeting with fresh schools approaching the shore from their feeding grounds. Similar movements occur on the Atlantic coast of Nova Scotia and Cape Breton. As winter approaches, beginning at Cape Breton in November, the different schools retire to their winter homes off the coast in deep water, later and later from North to South.

In the Gulf of St. Lawrence, where land is, as it were on all sides, the local schools come from their winter haunts to the banks and beaches of the Magdalens, of Prince Edward Island, in the Bay Chaleur, &c., &c., to spawn about the first week in June. They retire after spawning to deep water, and meet the incoming Sand Launce. They follow the Sand Launce in shore or on to banks, and for some weeks feed on these fish. When the Sand Launce again retires to deep water, the season of the small crustaceans has arrived, and these by tidal action, already described, and winds, are concentrated near the coast lines of Prince Edward Island, New Brunswick, the North and South shore of the Estuary and Gulf of St. Lawrence, and the shores of Cape Breton. On all these coasts the effect of the single and confluent tides dragging along the coast line and retarded by it, is to produce eddies, where the free swimming food concentrates. The course or direction of the different schools during the summer is thus dependent upon winds and tides, and their movements would, if correctly plotted, resemble long narrow ellipses adjacent to the coast, which are doubtles many times repeated.

At the approach of winter the different schools seek their winter quarters opposite and near to the places where they spawned in the preceding spring, as is the case of the schools on the Atlantic coasts. In these particulars their movements resemble those of different species of fish which feed and move in great schools in directions outlined by circles or ellipses throughout the period during which they are at the surface.

Sars has shown that this form of movement is taken by the Herring on the Norwegian coasts. (1)

The Mackerel are pursued by Cod and Hake, and these fish gather where offal is thrown over from vessels on which the Mackerel are cleaned. As a natural consequence the Mackerel avoid the sea areas where their enemies are congregated, and fishermen attribute the desertion of the mackerel-ground directly to the throwing of offal overboard. Cod, and probably Hake follow up the scent of offal or food of any description carried by currents with remarkable facility, as may be witnessed during the process of jigging for cod in calm and clear waters. On looking over the side of the boat, with a man engaged in jigging at the bow or stern, as soon as a fish is wounded merely by the jigger and blood flows from the wound, the creature may be seen to dart here and there in pain. The neighboring fish of the Cod tribe are attracted by the scent and follow the blood "tracks' against the current, hunting their wounded comrade to the death. A fish coming across the stream of scent, immediately follows it up, and it is thus that fish offal or bait thrown overboard in the open sea, or some distance from shore, gathers the fish on the course of the current. In harbors and confined or landlocked bays, where there is no constant strong current to carry off the results of decomposition, and where the sea-scavengers are not sufficiently numerous to consume it, the effect cannot fail to be extremely prejudicial to young fry and to fish spawn.

---

(1) See chart by Dr. G. O. Sars, in his Report for 1874.

VII.—CAUSES OF THE ALLEGED ANNUAL VARIATIONS IN THE NUMBER OF MACKEREL OBSERVED.

It is well known that the spawn of the Herring is deposited at the bottom, and owing to the glutinous secretion binding the eggs one or the other, it adheres firmly to everything which may happen to touch it, and masses of eggs are found to be tightly glued together. But it has been conclusively established by Professor Sars that the mackerel spawn, like that of the cod, floats, and the spawn is developed at the surface of the sea, being drifted to and fro by currents and winds, and wholly unlike the spawn of the Herring, Sculpin, Smelt, Caplin, etc., is at the mercy of the ever varying currents of the ocean.

The taking of Mackerel on banks and shoals, dropping their spawn, must be accepted that the fish are ready to spawn at the place where they are then caught. The transparent floating spawn being very difficult to recognize and indeed rarely to be seen, except looked for and caught in tow-nets at the surface of the water.

But Mackerel *fry* are found near the land, in detached sea areas all the way from the shores of Massachusetts to the shores of North-east Newfoundland.

While the Cod spawn on the North American coast during every month of the year wherever the temperature of the water is sufficiently low and ice does not interfere, and the Herring spawn in like manner during Spring and Fall, when the *bottom* waters have acquired a certain temperature, the Mackerel spawns, as a general rule, in the Spring of the year, and large schools appear to be established only where the Arctic current exercises its influence either as a distinct surface current, or where it is brought to the surface by banks or shoals, and thus secures the requisite coldness in the waters for the floating spawn.

The floating spawn may be drifted by winds or tides many miles from the place where it is shed, and the birth place of the fish will be that portion of the sea area where the young fry first issue from the egg, but not the spawning ground of the mother fish. In ordinary seasons the swing of the tides, apart from local currents, brings back twice every day the drifting surface matter, whatever it may be, near to the place from which it set out; but winds may greatly alter the course and distance to which floating ova would be drifted. Hence, except in the case of secluded bays like the Bay of Chaleurs, Pleasant Bay or Massachusetts Bay, the geographical position of Mackerel fry is in a great measure dependent upon the winds which may have prevailed. A storm near the end of May or early in June on the coasts of the United States, may drive floating spawn far out to sea, even into the heated waters of the Gulf Stream, and it has yet to be shown that Mackerel spawn could survive the sudden and extreme change of temperature this would involve; or a continuance of southerly winds may drive the spawn on to the shore and destroy it. This occurs frequently with the spawn of those fish which are deposited near the shore, as in the case of the Caplin and Herring. The small size of the Mackerel spawn would cause it to be unobserved, and it would be more distributed than the spawn of the Herring and the Caplin. The United States Signal Service charts show the course of storms and winds during the spawning season, which would produce these results.

The relation of cod spawn to rain has been referred to elsewhere (Part 1, page xii.). Reasoning from analogy, which in so many instances must be for the present our only guide, the effect of rain or of a rainy month on mackerel spawn, would be equally prejudicial, by causing it to sink below the surface and be removed from those conditions of light and oxygen which are essential to the development of the embryo.

On the other hand, the spawn might be driven in an easterly direction, or in a westerly direction, and be hatched so memiles off the coast in great abundance. These new schools might attain great magnitude in three or four years, being unobserved, and might so remain for several years, pursuing their circular feeding movements until noticed by the fishermen. The same contingencies occur in the Gulf of St. Lawrence, and similar distribution arising from winds or tides drifting the spawn far from the spot where it was shed, often lead to the establishment of new schools of fish in different localities.

This feature in the natural history of the mackerel has already been noticed with regard to the Bay of Fundy schools. (Page 84, Part I.).

The occurrence of mackerel in great abundance on the north east coast of Newfoundland, and their subsequent disappearance may be explained in a similar manner, and may be attributed to unfavorable meteorological conditions, which would drive the floating spawn on shore, or far out to sea. There are, however other probable reasons for the observed annual variations in the schools which which will now be noticed.

In the foregoing paragraphs it is assumed that the fluctuations in the numbers of Mackerel observed by fishermen, correctly interpret a phenomenon which appears to be generally recognized.

But while it is right to receive the statement that very large fluctuations in the numbers seen, usually occur, it is wrong to infer that because the schools are not visible, proof is afforded that they do not exist. There are strong reasons for believing that during many seasons the schools escape the notice of fishermen on account of their finding their food in a lower and colder stratum of water, and more rarely coming to the surface than during other seasons, It will now be shown how a cold stratum is produced, and that as a necessary result of the mode of its formation, it varies each year and during every month of the year in vertical position and thickness, and that it is constantly brought to or near the surface on banks and shoals within certain geographical limits. These variations in depth of suitable feeding zones throw light upon the alleged inconsistancy of the appearance of the Mackerel, and its selection of coastal waters in some sea-areas and offshore waters in other areas, and variations in both during different seasons.

In European seas the depth at which the fishermen look for cod varies with the season of the year, and is a point towards which much attention is paid in Norway and England. On the Dogger Bank, the smacks fish at the following depths during the months named :—(1)

December............	12 to 15	fathoms	waters.
January..............	14 to 18	"	"
February............	18 to 22	"	"
March...............	10 to 12	"	"

The fish are caught with long lines (trawls) *at the bottom* during these months. From July to September hand lines are used on the Dogger Bank, the fish being found four or five fathoms *from the bottom*. The peculiarity in the habits of the Cod at different seasons of the year, can not be too constantly or forcibly impressed upon British American fishermen, especially in those waters where both summer and winter fishing is practicable.

(1.) Sea Fisheries Commission—Minutes of evidence, 1864.

VIII.—ON TEMPERATE STRATA, AND THEIR INFLUENCE ON THE HABITS OF FISH.

The cause of the existence of cold strata lying between warmer strata in the Gulf of St. Lawrence, noticed at length in pages 97-99, Part I., is to be traced to the remarkable properties of salt-water ice formed during our winters within the limits of the Arctic or Labrador current.

The relation which these bear to fish movements in their search for food is very intimate, but scarcely so curious and instructive as the establishment, after ages of trial, of favorable areas for the development of floating spawn and the growth of large local schools of fish. There must be a reason why the cod come year after year and century after century during the winter season to the vicinity of the once dreaded Maelstrom, among the numerous Lofoten Islands, which form one boundary of the Great West Fiord of Norway. Similarly, there must be a reason why the same species of fish come around Belle Isle in such vast numbers every year; also why the Mackerel congregate to spawn on Bradelle and Orphan Banks, in many other parts of the Gulf, and especially on Georges shoals and about Block Island, in the open Atlantic. These are all exceptionally cold sea areas, where an Arctic current exists in full force or where cold strata of sea water are brought to the surface by shoals obstructing the current.

The sea has been so generally regarded as possessing such an equable climate and uniform character, that until recently, the dependence of fish life and fish movements upon external influences, operating beyond the limits, or at the surface of the waters in which the creatures live, has been treated as of secondary importance.

This has arisen in great part from the temperate character of those European seas, where investigations have been chiefly carried on, (1) But in North American marine climates, where extreme temperatures occur under peculiar circumstances, the study of the physics of the sea becomes of the first importance. It leads to unlooked for results in relation to fish life, and may influence largely and favorably the industry of the fishermen.

No one investigating the habits of fishes in the waters off the British Isles, could form any conception of the effect of vast fields of salt-water ice upon their movements, because salt-water ice never prevails there to any noteworthy extent.

" Dutch Scientists were the first to devote more attention to temperature, by making a series of observations, with the view of ascertaining during what degrees of temperature the herring fishery is most prosperous. They found that more fish were caught at a temperature of from 53.6 to 57.2 Fah (12° to 14° Celsius) than at any other time. The Dutch herring boats are therefore always supplied with a thermometer, which enables them to place *the net at a proper depth.* Professor Munter discovered also that the higher the temperature of the water the deeper the Herring keep during the spawning time, for which reason nets on the coast of Pomerania are set deeper in summer than in spring." (1.)

---

(1) According to Mr. Buchan, the sea around Scotland constitutes a part of the Gulf Stream. "On the Temperature of the Sea on the coast of Scotland." By Alexander Buchan, Secretary Scottish Meteorological Society, 1865.

1. "The Norwegian Herring Fisheries." Ky A. I. Boeck and A. Feddersen. Translated from the Danish by O. Jacobson.

The influence of the Gulf Stream in raising the temperature upon the Western coast of Europe, when compared with the influence of the Arctic current in lowering the temperature upon the Eastern coast of North America, is seen to occasion effects on both land and marine climates of the most diverse character. Professor Mohn estimates the thermic anomaly for January, arising from the influence of the Atlantic ocean to be as follows :—

	Farenheit.
In the interior of Norway	10°.8
In the interior of Scotland	25°.4
In the northwest of Iceland	32°.4
In the Lofoten	41°.4

The effect of the Arctic current on the other hand is to lower the temperature of seas and of the interior of British America, and to occasion the formation of an immense quantity of salt-water ice, which forms when the surface of the sea has attained a temperature of 28 degrees, or four degrees below the freezing point of fresh water.

The habits of animals vary with the climatal conditions to which they are subjected. If susceptible of considerable power of acclimatization the change is very great, as is shown by the extraordinary variations in the spawning seasons of the Cod and Herring on the North American coast. Hence it becomes important to know at the outset the nature of the differences which obtain in those North American and European seas, which are the seat of the Great Fisheries, in order to understand the apparent anomalies which exist.

TEMPERATURE OF THE SEA ON THE COASTS OF SCOTLAND.

The results of numerous observations carried on for six years on the coast of Scotland [1] show that the mean minimum temperature of the sea six feet below the surface on the west coast, was 39 degrees Fahrenheit. The mean minimum on the east coast was 35.5 degrees. The mean temperature at the depth of six feet at several stations for the months December, January, February and March is shown in the subjoined table.

West Coast.	Dec.	Jan.	Feb.	Mar.	East Coast.	Dec.	Jan.	Feb.	Mar
	Deg.	Deg.	Deg.	Deg.		Deg.	Deg.	Deg.	Deg.
Sandwick	46.8	45.0	43.7	43.2	Westhaven	43.2	41.2	40.5	42.3
Stornoway	46.0	44.6	44.1	44.1	N. Berwick	43.2	41.4	40.5	41.2
Harris	46.4	44.6	43.5	43.5	Dunbar	43.9	41.4	40.3	41.0
Oban	47.1	45.0	43.7	43.0					

The mean winter temperatures of the SURFACE of the sea at the same stations are as follows : —

WEST COAST.

Sandwick	46.0 °
Stornoway	44.8 °
Harris	44.8 °
Oban	44.6 °

EAST COAST.

Westhaven	42.1 °
North Berwick	41.5 °
Dunbar	41.2 °

1. " On the Temperature of the Sea on the Coast of Scotland," by Alexander Buchan, Esq., Secretary of the Scottish Meteorological Society.

On the Coast of Norway.

Prior to the year 1875, it was thought that the water of the Great West Fiord, which is the seat of the time-honoured Lofoten cod-fisheries, had a uniform summer temperature of about 44 degrees, even to a depth of 320 fathoms. (1.) Recent investigation have established that a cold zone exists at variable depths, which in June, 1877, was ascertained to be at 60 fathoms from the surface, the thermometer showing there a temperature of 38 °.8, while at 140 fathoms, the temperature was 41 degrees, The temperature of the Gulf of St. Lawrence was found by Dr. Kelly to be generally 35 degrees below 100 fathoms.

The cod spawn in the Great West Fiord of Norway chiefly during the month of February, and as the spawn floats at or near the surface, according to the specific gravity of the surface water, it is the temperature of the superficial stratum which has to be considered in relation to the development of the spawn, whether of the cod, the mackerel, or of any other fish whose spawn floats.

The following table shows the temperature of the surface of the sea in 1868 and 1869, at different stations on the coast of Norway, between latitude 57.59 and latitude 71.05. The West Fiord (Lofoten Isles) lies between lat. 67.40 and 68.50, between the stations Villa and Andennes.(2.)

	1868.			1869.		
Locality.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.
Lindnesnes	37.2	39.9	39.2	39.9	40.1	37.8
Lister	36.3	41.0	41.2	38.7	40.6	39.0
Torungen	32.2	37.2	37.6	37.0	39.5	34.9
Udsire..........	40.6	40.3	40.6	43.0	......	......
Ona............	......	......	......	32.3	41.5	38.8
Villa	34.0	36.0	36.7	37.0	36.0	35.4
Andennes	31.3	31.3	34.0	37.6	35.1	34.5
Fruholen	36.0	35.1	35.6	39.6	37.8	38.1

The mean temperature of the surface of the sea in February and part of March at the great spawning area of the cod near the Lofoten Isles, Norway, appears to be between 33 degrees and 38 degrees Fahrenheit, or, in general terms, below 40 degrees.

1. " The water of the West Fiord had, in the Summer of 1868, when it was examined by the steamer *Hansteen*, at depths from 100 to 200 fathoms, an even temperature of 44 °.6, while outside of the Lofotes the observations of the corvette *Nornen*, in July, 1871, showed at, a depth of 35 fathoms, 44 °.6; and at 215 fathoms, 39 °.2. At about the same time I found on the bottom of of Bodo Harbour, at the depth of 9 fathoms, a temperature of 41 °.7. In the innermost branch of the Hardanger Fjord, Professor Sexe found, August 23rd, 1871, the temperature 43. °.7 at a depth of from 100 to 200 fathoms. The steamer *Hansteen* observed, south-west of Lindesnes and Lister, from June to August, 1871, at depths of 150 fathoms, 44 °.6, and at 250 fathoms 42 °.8, which is but a small decrease downward compared with the Faroe Shetland Channel, where the temperature decreases at the same depths, from 42 °.8 to 33 °.8. The Norwegian Fjords are evidently protected against the cold water of the Arctic Sea by the banks; otherwise the temperature of the water of the Fjords would be considerable lower, and Norway would not posssss its happy mixture of land and sea climate."—[*Result of the observations of the Deep-sea temperatures in the sea between Greenland, Northern Europe, and Spitzbergen, by Professer H. Mohn, Director of the Norwegian Meteorological Institute at Christiania.*]

2. *Observations of the temperature of the sea on the coast of Norway, by the Norwegian Meteorological Institute.* Villa is in lat. 64.33 North ; Andennes in lat. 69.19 N.

In the Baltic Sea.

The mean winter temperature of the surface water in the Baltic Sea, in the vicinity of Revel, approaches to that of the Gulf of St. Lawrence and the Grand Banks of Newfoundland.

	Dec.	Jan.	Feb.	Mar.	April.
Revel [1.]	34.3	30 9	31.1	31.6	31.6
Kiel [2.]	40 6	32.0	32.0	34 9	41.5
Grand Banks of Newfoundland[3.]	32	30	31	32	34

On the Grand Banks.

The mean temperature of the surface of the sea on the Grand Banks of Newfoundland, will vary from year to year according to the greater or less abundance of ice ; its observed temperature is as subjoined. [4.]

January	30
February	31
March	32
April	34
May	34
June	40
July	45
August	50
September	52
October	47
November	44
December	32

When the mean temperature of the surface of the sea on the Grand Banks of Newfoundland is not more than six or eight degrees above the freezing point, the increasing warmth of the coastal waters of the United States, conjointly with the progressive invasion of the Gulf Stream all south of and around the shores of Cape Cod, has already driven the cold water fish from the fishing banks, and their places are supplied by Southern forms.

Near the Straits of Belle Isle.

The surface temperature of the sea during Summer about the Atlantic entrance to the Straits of Belle Isle, is given on Dr. Petermann's temperature maps of the North Atlantic, as lying between 39 and 40 degrees. The authority for these temperatures are the observations taken on board the Montreal ocean steamers, during their passage from Montreal to Liverpool and return. Generally it may be stated that the temperature in American waters best suited to the development of the spawn of the cod and the mackerel, and probably of many other fish, lies between 37 ° and 43 degrees. That being about the limits of temperature of the surface in American waters where the cod is most abundant and most constant in its appearance as a spawning fish. Such localities are the Straits of Belle Isle in August, the Grand Banks in June, the coast of Nova Scotia in the latter part of May and towards the end of September, the Georges Banks in the latter part of February and beginning of March. The mackerel appear to be limited to Spring months, and find suitable spawning areas whenever the water acquires a surface temperature of from 37 to 43 degrees in the Spring.

1. Dove.
2. Messrs. Meyer and Mobius (1863-1864.)
3. Nicholas Whitley, C. E.
4. Ibid.

Temperature Zones in Norwegian Waters.

Temperature of the sea at different depths in the West Fiord, Norway (the seat of the Lofoten Cod Fisheries) during July, August and September. (1)

Date.	Depth in Fathoms.	Temperature of Depth.	Temperature of Surface
July 16........	60	45.5	50
" 18........	65	45.3	50.4
" 27........	82	45.3	50.4
" 29........	85	45.0	57.2
Aug. 7........	94	43.5	55.8
" 20........	146	45.0	54.3
July 28........	150	45.0	57.2
August 5......	160	44.6	54.3
September 12..	180	45.3	51.4
August 22.....	221	44.6	54.7
" 4.....	240	44.6	53.6
July 7........	320	45.7	51.4

Temperature of the West Fiord in June 1877. (2.)

Surface ....45.7 °
At 60 fathoms (cold zone)..........................38.8
" 140 " 41.0

Particular attention was directed in Part I., pages 99 and 100, to Admiral Bayfield's and Dr. Kelly's determinations of temperature strata in the Gulf of St. Lawrence, during the Admiralty Survey of the Gulf in 1831 to 1836. These results, so long remaining in obscurity, acquire special interest since the discovery of similar temperature strata on the coast of Norway by the Norwegian Expeditions, under the Scientific direction of Professor G. O. Sars, and the Sweedish Expedition in the Baltic, under the direction of Professor F. L. Ekman. These observations, with the exception of Prof. Ekman's, the details of which have not yet been published, with those made in the Arctic Seas so far back as 1810 and 1811 by Dr. Scoresby, are tabulated below. The cold zones are indicated by large figures, and, as will be seen presently, these zones have not only a direct bearing upon fish life generally in certain seas, but they appear to exercise a very important influence upon sub-surface currents, and thus direct and in a measure govern the movements of fish in pursuit of their free swimming food, or their minute organic food, whether belonging to the animal or vegetable world.

1. Professor Mohn. Journal of the Steamer *Hansteen*.
2. Norwegian Expedition of 1877 (vide "Nature," 1877.)

COMPARATIVE TABLE, SHOWING THE COLD AND WARM ZONES IN THE GULF OF ST. LAWRENCE, THE NORWEGIAN FIORDS AND THE ARCTIC SEA.

	GULF OF ST. LAWRENCE.			NORWAY	ARCTIC SEAS.		
	Dr. Kelly.—Off Anticosti.	Dr. Kelly.—Off Point De Monts.	Dr. Kelly.—Off Point De Monts.	Norwegian Expedition: West Fiord.	Scoresby Lat. 76.16.	Scoresby Lat. 76.31.	Scoresby.
Temperature.	10th August, 1831.	19th June, 1832.	17th June, 1830.	June, 1877	10th April, 1810.	10th April, 1811.	20th May, 1814.
Surface.	54.	43.	51.	45.7	28.8	30.	29.
5 fath.			42.5				
10 "	46.	**37.5**	38.0				31.
20 "		39.				31.0	
30 "	**34.5**		**32.5**				
40 "						35.0	33.8
50 "	34.	**33.**	33.		**31.8**		
60 "				**38.8**		**34.0**	34.5
70 "							
80 "			34.				
90 "							
100 "	37.	36.				34.7	36.
110 "			35.				
120 "					33.8		
140 "				41.			
150 "			35.				

Some of Scoresby's temperatures were taken at an odd number of fathoms in depth. Thus the temperature at 60 fathoms in the last column was taken at a depth of 342 feet or 57 fathoms, but it is introduced in the table as representing 60 fathoms, or three fathoms deeper, for the sake of comparison. A difference of three fathoms at that depth, probably produced no appreciable difference in temperature. The increase of temperature with the depth in Scoresby's observations may be explained by the influence of the Gulf Stream. The cold zone, at a depth of from 30 to 50 fathoms, is most marked in the Gulf of St. Lawrence. (See Diagram. Also temperature of the sea at different depths—Part I. page 97.)

The Baltic is a closed sea like the Gulf of St. Lawrence, and is subject also to great extremes of cold Salt water ice forms in abundance in its northern portions, and, as a necessary consequence, there is produced the alternating zones of cold and warm water similar to those found to exist in the Gulf of St. Lawrence thirty years ago by Dr. Kelly. The subjoined notice of the recent discovery of temperature zones by the Swedish expedition is very interesting, as showing in certain parts of Europe the existence of conditions similar to those which obtain where the cold of the Labrador current prevails. (1.)

1. Hydrographic Survey of the Baltic." (1) The plan of this survey, which is said to be the most complete that has yet been made for its special objects, the determination of the salinity and temperature, was drawn up and carried out by Prof. F. L. Ekman. New instruments for taking samples of sea water at different depths were employed, and as the temperature of the water did not undergo any perceptible alteration during the time required for getting it to the surface, for every sample that was obtained, the temperature of the depth from which it was raised was ascertained simultaneously, without any great loss of time The survey shows the Baltic and the Gulf of Bothnia to consist of three strata, differing greatly in temperature, and often very sharply defined, viz., an upper stratum, which is warmed during the summer by the heat of the sun to a pretty high temperature, a lower, in which the cold of winter still prevailed to a great extent, and under the latter still another of a somewhat higher temperature than the intermediate stratum, the third stratum being of great thickness where the depth was considerable. In the Gulf of Bothnia, as in Skagerack and Kattegat, on the other hand, the temperature diminished steadily in proportion to the depth, as is commonly the case in the ocean. The uppermost summer warm stratum of water was found to be of variable thickness at different places in the Baltic; at some it was scarcely perceptible at the period of observation. This and other peculiarities will probably be explained in the course of the working out of the observations which is now proceeding.

1. Nature, Sept. 27, 1877.

EFFECT OF TEMPERATURE STRATA OR CURRENTS.

Fishermen frequently complain of the effect of deep-seated and powerful under currents, of which no sign is visible at the surface. The depth of the under current and its direction is constantly varying on the Atlantic Coast of Nova Scotia with the months of the year. Similar changing and powerful under currents were noticed by Admiral Bayfield in the estuary of the St. Lawrence, where it is upwards of five and twenty miles broad and more than 100 fathoms deep. At one observation the line with weight attached would remain perpendicular to the bottom ; at another, below three fathoms at flood tide, it would be drawn out strongly up the estuary, and still more strongly at greater depths, shewing that during flood tide the thin surface stratum of water, to the depth of three fathoms, was slipping over the under current flowing in an opposite direction. This may be attributed to the confined character of the tidal current in the estuary, but in the open Atlantic off the coast of Nova Scotia no such limitation exists, and yet the fishermen, fishing in sixty fathoms, not unfrequently find that their fishing leads will not take the bottom, although there is little appearance of a surface current. The cold under currents move with considerable velocity in one direction, while the upper warm surface stratum is slowly drifting on an opposite or different course.

There are frequently observed high in the atmosphere, where aerial currents prevail, cloud strata at different altitudes, which are seen to move in opposite directions, or towards points of the compass far removed from one another.

The inference is strong that diverse ocean currents in a given vertical depth must seriously influence the movements of certain species of fish, such as the Herring and Mackerel following their food. The vertical position of the food, when not at the surface, will be determined by the temperature of the zone best suited to its habits, and the direction it is carried will be dependent upon the course taken by the under current.

XI.—INFLUENCE OF THE DIFFERENT FORMS OF ICE.

In discussing the relation of fish to temperature (Chapter V. Part I.) allusion was made to the prominence with which the Arctic or Labrador Current is necessarily invested in connection with the marine climate and fish life on the coasts of North America, but the influence of this great current, and particularly of the temperature zones it embraces, are modified by the different forms and properties of ice, which are either the consequences of its extreme low temperature, or are gathered and conveyed by it from remote sources. Field ice and salt water anchor ice, are produced throughout the greater portion of the entire length of the Arctic current, all the way from the Spitzbergen Seas to the coasts of Labrador and Newfoundland. Berg ice being formed on the land from rain, snow, and the condensation of aqueous vapor, is freshwater ice, and its effects on the seas of British North America are widely different from those produced by salt-water ice.

Both of these forms of ice, however, are essential to the production of those cold strata in the Gulf of St. Lawrence which exercise such a beneficial influence upon the development and permanency of the cold water commercial fishes. They are the instruments also for preserving the cold zones on the Atlantic seaboard, which afford a refuge to the cold-water fish during the summer invasion of the heated surface waters of the Gulf Stream, and are thus invested with peculiar interest in relation to the fisheries.

BERG ICE—FRESH WATER ICE.

The mean temperature of the surface of the sea on the Grand Banks of Newfoundland is 30 degrees Fah. during the month of January, and 31 degrees during the month of February. [1] It rises to 32 degrees in March and 34 degrees in April; the width of the cold current being 400 miles.

Berg ice, which is fresh water ice, melts at a temperature of 32 deg. Fah.; and while melting, it diminishes the salinity of surrounding waters, which thus becoming lighter than the substratum of pure sea water, float with a temperature of about 32 deg., until mixed by winds with the underlying stratum.

But a berg which has been floating for many months in sea water during its long journey from Hudson's Straits or Baffin's Bay, must have acquired by the time it arrives off the coast of Newfoundland a stratified external temperature just above or just below the freezing point of fresh water, throughout every portion which has remained immersed, whatever may be the temperature of the mass exposed to varying atmospheric conditions. Its temperature at different depths below the surface will be that of the stratum of water at that depth, so that if the water at the surface is at 32, and at 20 fathoms 34, and at 50 fathoms 33, and at 80 fathoms 31, those portions of the Berg in contact with the different strata of ice will be eithe

1. "On the Surface Temperature of the North Atlantic, in reference to Ocean Currents"—by Nicholas Whitley, C. E. (Proceedings of the Royal Geo. Soc.) The vast difference between the Marine climate in Winter off the coast of Newfoundland and in the North Sea is strikingly shown by the thermometer. Mr. Whitley states that the mean temperature of the North Sea in January, 1868, between Hull and Hamburg was 43 degrees; "in the same month on the American coast the sea is very cold, seldom rising above the freezing point (32°) and often from two to four degrees below it." * * * "On the eastern side of the cold current and in close proximity to it, there is a bed of very warm water having a mean temperature in January of 57°, being 27° warmer than that on the Grand Banks, over a width of about 200 miles. This appears to be a strong eddy of the Gulf Stream, curving northward, and holding the Arctic current in its warm embrace."

melting or remain solid, according as the water is above or below 32.

That a large body of submerged ice, such as the portion of an iceberg below the surface, extending downward in many instances over a thousand feet, or 170 fathoms, would, in stratified layers, acquire externally the temperature of the medium in which it was floating, up to the melting point, is apparent from the following observations of Mr. Koldeway on the temperature of ice formed at the surface of the sea.[1.]

No. I.

Thickness of ice formed	31 inches
Temperature of air	—12°.3 Fah
" of ice at surface	—6°.7 "
" " at 8 inches deep	—0°.8 "
" " at 12 " "	5°.9 "
" " at 18 " "	13°.3 "
" " at 24 " "	22°.5 "
Temperature of water at 3¼ inches lower	28°.0 "

No. II.

Thickness of ice	36.5 inches
Temperature of air	—2°.9 Fah.
" of ice at surface	0°.1 "
" " at 7½ inches	7°.0 "
" " at 13 "	12°.3 "
" " at 18.5 "	16°.5 "
" " at 23 "	19°.9 "
" " at 27.5 "	21°.4 "
" " at 30.0 "	23°.9 "
Nemperature of water 3½ inches lower	28°.2 "

In these illustrations the sea is a warm body on one side of a sheet of ice, the air an extremely cold body on the other side. If the temperature of the air rose to that of the sea, the temperature of the sheet of ice throughout would gradually become the same as that of the media between which it was placed. But a reference to Scoresby's table of temperature zones in the Arctic seas (page 29) shows the presence there of zones of water warmer than the freezing point of fresh water, or than that of the melting point of an iceberg, which is 32 degrees Fahrenheit. The icebergs which begin to drift past the Northeast Atlantic coast of Newfoundland in February, must materially assist in raising the temperature of the surface of the sea, for a constant stream of water of 32 degrees, will be rising to the surface by its inferior salinity, from those portions of the berg which are floating in zones having a higher temperature than the freezing point of fresh water. The berg is instrumental in bringing this warmth to the surface, and elevating the mean temperature of the surface of the sea in winter, which on the Grand Banks is from one to two degrees below 32 deg. during the months of January and February. During the Spring and early Summer months the bergs will have the effect of diminishing the temperature of the surface of the sea. This influence is very different to that of salt water floe ice, which, as will now be shown, is always raining down heavy brines with a temperature two and three degrees below that of the freezing point of fresh water.

1. Second German Expedition to the Arctic Seas.

FLOE ICE—SALT-WATER ICE.

Field Ice or Floe Ice is salt-water ice, which melts at a temperature varying from 28° to 31°, according to its salinity, because sea-water in freezing rejects a portion of its salt, and, after the ice is formed, its upper layers are continually losing salt by drainage or efflorescence, and require a higher temperature to melt them than those constantly bathed in sea-water. Whenever the lower portions melt in contact with warmer currents, the most saline portions being the coldest, must necessarily melt first, and the temperature of the surrounding sea is not only kept down to 30°, 29° or 28° in the vicinity of the floe and pan ice, but the heavy saline water sinks, and carries its cold down to a stratum which has the same specific gravity. Here it remains, if beyond the reach of tides, and forms a cold zone or stratum at variable depths below the surface of the sea, or descends to the bottom. [1.]

While the presence of salt-water ice generally implies a reduction in the temperature of the surface of the ocean to 29° or 28° it does not convey an idea of the degree of cold which occurs in the temperature of the whole, or a great part of the water, before salt-water ice can be formed in shallow seas.

The greatest density of sea water being attained at 27°5 to 25°40, Fah., every particle of water at the surface, which approaches that temperature in the winter months, descends, either to the bottom, or, as is no doubt more generally the case, to a depth where the specific gravity of the water is the same as that of the descending particle.

It is replaced by one of higher temperature, but which rapidly radiates heat when the air is colder than itself, and sinks in its turn.

SALT WATER ANCHOR ICE.

One might suppose, at the first consideration of the subject, that the process just described goes on until, in shallow and sheltered places, the mass of water becomes cooled to its freezing point from the bottom upwards, and at or about 28° degrees congeals, if agitated, or at 26° if undisturbed, also that congelation begins first at the bottom. But now steps in another condition, namely, that of specific gravity. Sea water, as it occurs in great bodies such as the Gulf of St. Lawrence, varies in its specific gravity, that is to say, in the amount of salt a definite portion contains. It has been already shown (page 99 Part I.) that different zones of water in the Gulf possess not only different temperatures but different specific gravities, and where there are no disturbing causes to mix the strata, the freezing of the surface may go on with warmer strata lying at some depth below, whose position is maintained by their greater specific gravity. Hence a salt water ice-cold, or a frozen stratum, may rest on a comparatively warm stratum. It is thus that specific gravity, or its equivalent, salinity, exercises a controlling influence. But where the conditions are such that during the prevalence of low temperatures the surface sea-water, becoming cooled to 28°, sinks to the bottom and accumulates there, rapid motion and points of contact are alone necessary to produce congelation. Ice spiculæ, with tabular crystals, are formed, and the production of Anchor ice sets in.

This occurs on the southern Labrador and on Newfoundland coasts. It is also noticed in the northern portion of the Baltic

---

1. For an account of some properties of salt-water ice, see "On Saline Matter in Ice," by Dr. Rae. Also various notices on this subject published in the '*Arctic Manual and Instructions*, 1875; pages 635-54.' Also Dr. Carpenter's recent papers published in the Proceedings of the Royal Society;—Mr. Buchanan's 'Challenger Observations,' &c.

sea, and is of constant occurrence on the northern Labrador, and very probably in many parts of the Gulf of St. Lawrence. Mr. Samuel Robertson, who resided many years near to the entrance of the Strait of Belle Isle, thus describes the effect of Anchor Ice on seal nets and on the bottom of the sea. (1)

"I have seen a net, sixty feet deep, every mesh incased with ice like a rush light; hawsers, chains, and other larger matters, with a proportionably greater crust. When this happens, if this net is not taken up immediately, it is lost; for it soon floats like a cork—although ever so heavily sunk—and then forms a solid block of ice. I have known the bottom, at a depth of sixty or seventy feet, frozen, and resembling a limestone flat: and all the anchors of a seal fishery, whose flukes were fixed in the sand so firmly that no purchase could draw them out. I have seen, on another occasion, when the fluke of an anchor was partially buried, when drawn out, the palm brought up a piece of frozen sand, as angular as a stone, and nearly as hard as a piece of Bristol sandstone."

The Swedish Icthyologist, Axel V. Ljungman, states that "because a temperature of 3° Celsins has no destructive effect it cannot be maintained that a still lower temperature *with its consequent formation of bottom ice* will not prove injurious."(2.)

The Specific Gravity of Sea Water.

The increasing specific gravity of sea water with the depth is an element of such great importance in regard to the temperature of different zones, both in winter and summer, that it demands careful consideration. In order to estimate its value, the specific gravity of any body of sea-water must always be referred to a definite temperature. When H. M. S. *Challenger* visited Halifax in May, 1873, Mr. Buchanan found the specific gravity of the Gulf Stream on the 1st of May to be 1.02675, and its temperature 23°9 c (75 Fah). The next day the temperature of the water was 13°3 c (55 Fah), a difference of 20 degrees Fah. The specific gravity of the water, however, was only 1.02538, a difference of 0.0137, apparently in favor of the greater specific gravity of the Gulf Stream. But, as Mr. Buchanan states, (3.) "if the results be reduced to their values at the respective temperatures of the different waters, we have the specific gravity of the Gulf Stream water, 1.02445, and of the Labrador current water, 1.02584; so that the fall of temperature very much more than counterbalances the want of salt in the water."

---

1. "*Notes on the Coast of Labrador,*" Transactions of the Literary and Historical Society of Quebec, January, 1841.

2. Report on the Herring Fisheries on the coast of Swoden.

Much valuable information on the manner in which fresh-water Anchor Ice is formed, will be found in the following notices of this phenomenon:

1. "On the formation of ice at the bottom of the water," by M. Engelhardt, Director of the Forges at Neiderbroon. This article was translated for the Smithsonian Institution from the "Annales de Chimie et de Physique,' Paris, 1866, and is published in the Smithsonian Report for 1866. M. Engelhardt quotes in this article the arguments and opinions of numerous scientific men of reputation, among whom are Nollet, Desmarest, the Abbe Brauthona, Hugi, Fargeaud, Arago, Gay Lussac, and Plieninger.

2. T. C. Keefer, C. E., Canadian Journal, 1862.

3. A letter addressed to Professor Tyndall, by Mr. G. W. Thompson, and communicated by Professor Tyndal to "Nature," published March 31st, 1870. The removal and transportation of pebbles by anchor ice is described.

4. "Recent Glacial and Aqueous Action in Canada," by the Rev. Wm. Bleasdell, Proc. Geol. Soc. London, June, 1876.

5. "The Earth." *Reclus.*

6. Poggendorf's *Annalen.*

Notices of the transporting power of Anchor Ice are embodied in the papers above referred to.

(3) Preliminary Report to Professor Wyville Thompson: "On work done on board H. M. S. Challenger, by J. W. Buchanan, Chemist and Physicist to the Expedition. Proceedings of the Royal Society, March 16th, 1876."

X.—ILLUSTRATIONS OF THE EFFECT OF EXTREME LOW TEMPERATURES UPON THE MOVEMENTS OF FISH.

The different properties which have been enumerated of salt water ice and of sea-water at low and variable temperatures, combine in giving rise to alternating cold and warm zones, especially in confined seas. They occasion, too, the constant zone of cold which is found at variable depths, and has been described as a record of winter cold. When regular tidal currents bring the cold water near to the surface over banks and shoals, or mix it with warm surface waters on a shelving coast-line, and reduce the temperature of the whole mass, they point to causes which must greatly influence the winter and spring movements of fish and explain some of the fluctuations which occur in the annual take on the Grand Bank, and elsewhere. They serve to elucidate the fluctuating moves ments of Mackerel during the fishing seasons, the variations in the spawning of Herring in the spring and fall, together with the changeable approach of different kinds of fish to the coast at different times in different seasons and localities, as illustrated in succeeding paragraphs. Beyond the ordinary accumulation of fat, and in some cases, probably, of mucus or "slime," there is no visible increase of the external covering in any of our fishes on the approach of winter, or during that season, and the fat is required for respiration, or to nourish the embryo spawn.

Fish which do not become torpid, or feed on the bottom in winter, descend or rise, as the case may be, to different zones or strata in the sea, according to their temperature, and where they find the food suited to their habits.

Each zone of the ocean is characterized by its peculiar life, and these zones of life rise and sink with changes in the temperature. "Everywhere," says Mr. J. Murray, "we have found life abundant on the surface and substratum waters of the ocean. If living creatures are small in number on the surface the tow-net will usually yield many forms if dragged at a depth of 100 fathoms or more. We have not met with any really barren regions. (1.)

Extremes of low water temperatures are not unfavorable to fishing operations either in relation to the Herring or the Cod, or, as far as known, to the Mackerel. But they affect different kinds of fish in a different manner, and this is a subject which is deserving of the closest attention.

The returns afforded by the Dominion and Newfoundland Statistics of the catch and exports of sea fish show, that as a general rule severe winters, or severe weather in April, are favorable to the fisheries. The conclusion which may be drawn is, that severe weather tends to bring the fish from deep sea feeding-grounds to inshore shallower waters, where many schools find abundant, but perhaps, different kind of food in some respects from that upon which they are accustomed to feed. The immense area of the feeding grounds is, however, indicated by this influx shorewards during severe seasons, and would seem to direct inquiry as to the whereabouts of the sea areas which support such a vast multitude of fish in ordinary seasons. The following years were noted as exceptionally cold during the winter or early spring; yet in all cases the yield was considerably above the average: 1842, 1849, 1859, 1862, 1863, 1874.

The fishing season in the early part of the year 1874 was the coldest known in the Dominion or Newfoundland records, yet

---

(1) Mr. J. Murray on surface organisms examined on board H. M. S "Challenger."—Proceedings of the Royal Society, No. 170.

the catch exceeded that of any other year before or since, and reached the enormous value of more than twenty millions of dollars worth of the cold water sea fish.

The observations of the Danish Naturalist Boeck on this subject in relation to the Herring are of great interest:—

"During his stay on the west coast of Norway, Boeck constantly noticed the temperature, and noted down a large number of observations during different years. In his report for 1862 he showed the influence of cold on the Herring fishery. In that year he examined the temperature at different depths. The weather had been calm, but a severe cold had prevailed for some time, by which the temperature of the sea, at a depth of 10 fathoms, had been brought as low as 1½° (35° 37 Fah.) or 2° Reaumur (36° 50 Fah.), while at a depth of 30 fathoms it was 3° R. (38° 75 Fah.) to 4° R. (41° 00 Fah.).

"He noticed that same year, while present at the rich Herring fisheries near Rövœr and Skaareholmene, that some fishing implements, which were placed at a depth of about 10 fathoms below the surface, and were held there by means of buoys, caught but few fish; while others, placed at the bottom, in a depth of from 50 to 60 fathoms, caught a very large number. Seine-fishing was also very unproductive during that year, although the schools of Herring came in in enormous numbers. The same was the case in 1864, and similar observations might be quoted indefinitely. If we examine these accounts we find frequent references to the fact that the cold prevented the Herring from approaching.

Thus it was extraordinarily cold in 1855, likewise in 1860; and in 1853 the cold was so severe that the bays and inlets on the outer coast were frozen over, which happens but very rarely, and presupposes a long period of low temperature. The cold was so severe that the fishermen were obliged, after emptying their nets, to lay them in the water to prevent their freezing quite stiff, and in order that they might have them ready for use again in the evening. The Herring fishery was, notwithstanding this, successful, although the Herring, for quite a long time, remained out in the deep sea and would not approach the coast. A great many instances might be quoted from observations made in former years and collected by Boeck. It will suffice to mention a few years, such as 1825, 1826, 1828, 1829, 1836, 1840, 1841, and 1844. In several of these years the cold was so severe that nearly all the bays were covered with ice, and in some years even the Bay of Bergen was so much obstructed that all communication was interrupted. Still the fisheries were good, and in some years unusually so, although the sea had grown cool at a far greater depth and to a greater degree than during the preceding year; for then the cold was not particularly severe, and the temperature, according to the observations of the government inspector, was 1° (34.25 Fah.) at a depth of 10 fathoms.

Boeck thinks, therefore, that the failure of the fisheries the year before cannot at all be ascribed to cold. He found that in calm weather the Herring seldom approaches the coast, except in small numbers when chased by the Haddock, while the chief fishery always commences when a southwesterly or northwesterly wind has stirred up the sea and mingled the lower and warmer water with the upper and colder. Of this, Boeck gives many examples, partly from his own observations and partly from those of the Government inspector. It is important to keep this in mind whenever the influence of the cold is spoken of." (1)

1. "Norwegian Herring Fisheries," by A. J. Boeck and A. Feddersen, embodied in the Report of the U. S. Commissioner of Fish and Fisheries for 1873-4 and 1874-5, page 101.

Among the numerous illustrations which might be presented showing the effect of the extremes of temperature in British American Waters on the movements of Fish, the following may be outlined.

a.—As Affecting the Cod.

The year 1874 was distinguished by the extraordinary catch of Cod on the Newfoundland and Labrador Coasts, as well as, in some instances, of the poorness of the livers of the fish. The schools came in great numbers towards land in places where they had not been numerous for years before, and the aggregate catch of the entire season exceeded one million seven hundred thousand quintals in Newfoundland waters, exclusive of the French Fisheries.(1.) The Cod were abundant on the Grand Banks as well as on the coasts of the Island and on the Labrador, but in many cases their livers were poor and thin and the flesh of the fish had a watery taste.

The mean temperature of April, 1873, was 23.66 degrees Fah. at Rama on the North-eastern Labrador: it fell to a mean for that month in 1874, of 11.66 or 12 degrees less, and 16 degrees less than in 1876. Such differences for a week would scarcely produce appreciable results, but continued throughout an entire month, and prolonged into May, they had the effect of creating an extraordinary quantity of salt-water or floe ice, much of which carried its temperature of 28 to 30 degrees, according to its salinity, on to the North-east coast of Newfoundland and the Grand Banks, and lowered the temperature of the sea there.

During the year 1874, icebergs were very numerous and early coming down Davis Strait. Bergs were seen in the latitude of Cape Race (46°39) in February, and subsequently were noticed as far south as lat. 42° drifting to the north-east in the heated waters of the Gulf Stream. A few of these bergs were supposed to be three miles in length, and on two occasions steamers passed through or around ice-fields 100 miles in length. It is also alleged that another was stopped five hours by field-ice so far south as the 49th parallel.(2)

On the Grand Banks the French caught in 1874 eighteen million kilogrammes of dry and green fish, or 341,927 quintals, against 14,800,000 kilos, or 273,927 quintals in 1875, and 13,-800,000 kilos, or 256,252 quintals, in 1876. But on the Grand Banks, as well as elsewhere, the oil yielded by the livers was very small in quantity, being 140 tons for 1874, 101 for 1875, and 181 for 1876.

The yield of Cod roes was also small, and stood thus: for 1874, 900 barrels; 1875, 1,301 barrels; 1876, 1,370 barrels.

It can scarcely be doubted that the cause of this enormous catch, conjointly with the poor quality of the fish, arose from a scarcity of food, resulting from the remarkable inclemency of the month of April, and the vast abundance of salt water or Floe Ice.

The Cod were compelled to abandon their accustomed feeding grounds by the scarcity of their food, which the severity of the season had driven into prolonged shelter at an unusual season, according to the different habits of the fishes, crustaceans or mollusks forming the food. (3)

---

1. The total French and English catch this year exceeded 2,300,000 quintals.

(2) Capt. W. W. Kiddle—*Nature*, Aug. 13th, 1874.

(3) In his interesting work on "Deep Sea Fishing," Mr. Holdsworth gives a valuable illustration of the effect of extreme winter cold on fish in the German Ocean:—

"The great Silver Pit was first worked over during a very severe winter about 1843. The Well Bank and Botany Gut had been explored and discovered to be very productive grounds; and between them and the Dogger and bear-

The following tables, beginning with Rama on the north-east coast of Labrador, in latitude 60°, will serve to show the very low temperature of April during 1874, and its wide distribution over the Gulf of St. Lawrence.

NORTH EAST COAST OF LABRADOR.

No. I.

Station of Rama, (situated near the 60th degree of latitude). The years 1872 to June, 1873, are from Professor Gautier's Paper on the "Meteorological Observations on the Coast of Labrador," Geneva, 1875. From August, 1874, to July, 1876, from 'Nature,' September, 1877.

	Centigrade.					Fahrenheit.				
	1872.	1873.	1874.	1875.	1876.	1872.	1873.	1874.	1875.	1876.
January.......		-20.2	-17.2	-17.8	-20.5		—4.36	1.04	—0.04	—4.90
February......		-16.6	-17.7	-19 6	-19.1		2.12	0.14	—3.28	—2.38
March		-17.4	-14.1	-17.9	-14.8		0.68	6.62	—0.22	5.34
April...........		**-4.8**	**-11.3**	**—8.1**	**-2.3**		**23.36**	**11.66**	**17.42**	**27.86**
May............		1 7	—0.1	—3-7	1.7		35.06	31.82	25.64	35.06
June...........		5.1	3.1	4,2	3.5		41.18	37.58	39.56	38.30
July...........	8.5			5.2	6.5	47.35			41.56	43.70
August.........	9.9	9.3	7.7	7.0		49.82	48.74	45.86	44.60	
September....	6.9	4.0	4.9	2.3		44.42	39.20	40.82	36.14	
October........	0 5	0.3	—0.7	—2 0		32.90	31.46	30.74	28.40	
November...	-5.0	-5.9	—6.5	—6.1		23.00	21.46	20.30	21.02	
December.....	-16.2	-16.5	-15.2	-15.4		2.84	2.30	4.64	4.28	

The temperatures of the month of April are printed in large type, and a glance at the figures showing the temperature of April in 1874 will suffice to establish the extreme coldness of that month when compared with the same month in 1873, 1875 and 1876. A similar remarkable lowness of temperature for April, 1874, will be observed to run through all the subsequent tables showing the monthly means of temperature at Hopedale on the Labrador, Fogo and St. John's on the Newfoundland Coast, and at various stations on the Gulf of St. Lawrence.

ing nearly true east from Flamborough Head, the Admiralty chart showed a bed of deeper soundings, ranging in some parts of it from 30 to 40 fathoms, the whole extending for about 60 miles east and west, and from 6 to 10 miles wide. This patch was marked the "Outer Silver Pit," and on trying it with the trawl in the deeper parts at the western end and near the middle, soles were found during that very cold season in almost incredible numbers; the nets were hauled up bristling with fish trying to escape through the meshes, and such catches were made as the most experienced fishermen had never dreamed of.

"The discovery soon got wind, and a migration of trawlers from Ramsgate and Brixham took place; but although with the breaking up of the cold weather, this extraordinary congregation of soles became dispersed, more attention was henceforth directed to the North Sea fishing generally; and in subsequent years the Silver Pit has again been found very productive whenever the winter has been very severe, or, as the trawlers call it, in 'pit seasons.'"

No. II.

HOPEDALE (Lat. 55 ° 35').

The mean of three observations per day, with a Centigrade Thermometer reduced to Fahrenheit scale, from 1869 to 1874, inclusive. (1)

	Antigrade.					Fahrenheit.				
	1870.	1871.	1872.	1873.	1874.	1870.	1871.	1872.	1873.	1874.
January....	−22.2	−24.0	−16.4	−20.7	−18.5	−7.06	−11.20	2.48	− 5.26	− 1.30
February...	−15.7	−15.9	−15.1	−17.1	−17.5	3.74	3.38	4.82	1.22	0.50
March.....	−10.6	−11.9	−12.1	−15.0	−12.0	12.92	10.58	10.22	5.00	10.40
April.......	− 3.4	− 4.9	− 0.1	− 4.2	− 8.8	25.88	23.18	31.82	24.44	14.16
May.......	0.8	0.1	1.5	0.7	0.3	33.44	32.18	34.70	33.20	32.54
June.......	5.5	5.3	6.6	6.8	4.6	41.90	41.54	43.88	44.24	40.28
July.......	8.8	12.1	9.6	9.3	13.0	47.84	53.78	49 28	48.74	53.60
August....	9.0	12.3	10.4	12.1		48.20	54.14	50.72	54.32	
September.	5 1	6.4	7.5	5.8		41.18	43.52	45 50	42.44	
October....	− 1.1	0.1	3.2	2.2		30.02	35.18	37 76	35.96	
November.	− 3.9	− 2.1	− 4.2	− 7.0		24.98	28.22	24.44	19 40	
December..	−11.4	−18.7	−16.0	−17.0		11.48	− 1.66	3.20	− 0.22	

In these tables for Hopedale, it will be seen upon inspection that the temperature of April, 1873, was greatly below the mean of the four preceeding years, and is thus represented :—

	1870.	1871.	1872.	1873.	1874.
Temperature of April..	25.88	23.18	31.82	24.44	**14.16**

No. III.

NORTH-EAST COAST OF NEWFOUNDLAND.

FOGO. (2)

	1873.	1874.
January........	......	23.5
February......	18.1	15.0
March..........	27.4	26.0
April..........	**36.4**	**28.1**
May..........	39.4	40.4
June..........	54.8	47.8
July..........	61.8	60.6
August........	64.3	61.0
September.....	55.3	56.8
October........	47.6	52.9
November......	......	38.1
December......	27.0	30.0

No. IV.

NORTH-EAST COAST OF NEWFOUNDLAND.

ST. JOHN'S. (3)

	1872.	1873.	1874.	1875.	1876.
January.......	24.6	23.9	28.3	19.4	18.7
February......	23.2	24.3	20.6	18.2	19.7
March	27.5	30.1	28.6	20.9	26.9
April..........	**35.6**	**33.6**	**30.7**	**31.6**	**35.3**
May..........	43.8	43.1	42.0	39.8	42.1
June..........	52.6	52.0	47.4	55.9	58.7
July..........	59.3	61.6	59.9	57.6	61.5
August........	57.9	61.4	60.9	60.6	63.7
September.....	57.0	55.5	54.8	53.6	49.7
October........	50.3	48.7	49.7	45.1	43.4
November......	37.1	39.4	37.6	31.0	35.5
December......	29.0	29.2	31.5	23.5	27.2

(1) Taken from Professor Gautier's "*Seconde Notice sur les Observations Meterologiques faites sur la Cote du Labrador.*" Par des Missionnaires Moraves Geneva, 1875.

(2) From "The Reports of the Meteorological, Meguetic and other Observatories, of the Dominion of Canada, for the year ending 31st December, 1873-4."

(3) From "Reports of the Meteorological, Magnetic and other Observatories of the Dominion of Canada, for the years ending 31st December, 1872-73-74-75-76."

If available and reliable records exist of the temperature of the month of April at St. John's, Newfoundland, for thirty or forty years past, it might be shown that the greater or less abundance of fish, other things being equal, on the southern and eastern part of the coast, was synchronous with the occurrence of unusual or extreme cold in the month of April, and thus lead to useful practical knowledge capable of wide application to the fisheries during other months of the year, as will be shown further on.

No. V.

MEANS FOR THE GULF OF ST. LAWRENCE AND ATLANTIC COAST.

Mean temperature for the month of April from 1873 to 1876, inclusive, at Bathurst and Dalhousie in New Brunswick, Charlottetown in Prince Edward Island, and Guysborough, Sydney, and Halifax in Nova Scotia.

	Bathurst.	Dalhousie.	Charlottetown.	Guysborough.	Sydney.	Halifax.	Mean.
1873......	36.6		35.4	35.2	34.4	38.1	35.54
1874......	**31.4**	**27.7**	**31.2**	**30.6**	**30.6**	**33.4**	**30.81**
1875......	31.9	32.1	32.1		31.6	34.9	32.5
1876......	33.3	33.3	35.0		34.4	36.3	34.46

At each station, it will be observed, the mean temperature of the month of April was lower in 1874 than during any of the other years in the table. From Rama, on the Labrador, to Halifax, on the Atlantic, seventeen degrees of latitude farther to the south, the April cold prevailed.

It is remarkable, however, that while the catch of Cod on the Newfoundland and Labrador coast was enormous in 1874, the catch in Dominion waters throughout the Gulf of St. Lawrence was considerably less than during the previous year, the aggregate for the Dominion being 100,000 quintals less in 1874 than in 1873. It might be inferred from this comparison, if the returns are contemporaneous, that the extreme cold which drove the Cod, in its search after food, inshore on the Newfoundland coast, compelled the schools to go into deep water, remote from the customary fishing grounds, in the Gulf of St. Lawrence.

b.—AS AFFECTING THE HERRING.

In 1875 and 1876 great apprehension existed in Newfoundland that the Fall Herring Fishery would fail on the Gulf Coast of the Island. Herring did not make their appearance at the usual period in the Bay of Islands and Bonne Bay, and in one instance they rushed into the Humber estuary and out again in a manner never before observed.

Subsequently it was ascertained that the Herring were off the Coast, but at a greater depth than usual, and their vertical movements were erratic; now high, now low, in great variations of depth.

Although the temperature of the air is not necessarily an indication of the temperature of the sea, yet when the mean temperature of the air for an entire month descends some de-

(1) From "Reports of the Meterological, Magnetic and other observations in the Dominion of Canada."

grees below its ordinary depression, the sea will be affected in a corresponding degree.

The months of September and October, when the Herring begin to approach the Gulf Coast of Newfoundland, and prepare to enter the sheltered Bays, were unusually cold in 1875 and 1876. The mean recorded temperature of these months at Bay St. George in 1874-75-76 stands thus:[1]

	September.	October.
1874	64.0	58.5
1875	55.0	47.0
1876	53.8	46.9

Sept.		Difference from 1874.	Oct.	Difference from 1874.
1874	64.0		58.5	
1875	55.0	9.0	47.0	11.5
1876	53.8	10.2	46.9	11.6

Subjoined is the entire table for three years at Bay St. George, showing monthly mean temperatures:

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1874..	25.4	16.4	27.7	29.5	42.1	51.7	67.0	70.9	64.0	58.5	41.4	31.7	43.8
1875...	15.3	13.1	15.1		41.0	55.0	62.2	63.6	55.0	47.0	34.0	23.1	
1876..	19.7	22.1	31.8	38.0	45.7	59.4	62.2	63.7	53.8	46.9	41.6	32.2	43.05

The interpretation of the movements of the Herring on the Gulf Coast of Newfoundland becomes greatly simplified by the now known fact that warm and cold strata exist in the Gulf, and it can scarcely be doubted that the erratic movements of these fish were caused by their search for the zone most suited to their habits at this season, whether as regards temperature or microscopic food. The unusual cold of September and October had depressed the zone in which their food lay. Hence the reason why the Herring were found lying unusually deep.

The great differences between the autumnal air temperatures of 1874 compared with those of 1875 and 1876 suggest the necessity for ascertaining the temperature of the sea at different depths in those localities where the Herring are accustomed to winter in American waters. Very probably such a close relationship between the vertical movements of the Herring, and the temperature of the zones of depth at which they are to be found, would be proved to exist, that a valuable guide would be obtained through the instrumentality of the thermometer, by which fishermen might learn the depth at which it would be advisable to set their nets. A rule once established for St. George would also be applicable to many other localities where Herring winter. By this means a permanency and stability would be given to the Herring fishery which it could not be made to possess by any empirical method.

c.—As Affecting the Mackerel.

The Mackerel, like the Herring and the Cod, seeks cold water for its spawning grounds wherever the Labrador current exercises its influence. Between Block Island and No Man's Land, where the spawning grounds on the United States Coast south of Cape Cod are alleged to exist, a thin wedge of the Labrador current stretches far into Long Island Sound.[2]

In Massachusetts Bay, where a Mackerel spawning ground also

1 Reports of the Meteorological, Magnetic and other Observatories in the Dominion of Canada, 1874-76.

2 Professor Verrill quoted in Part I.

exists, as also in the vicinity of Stellwagen Banks, the temperature when observed by Dr. Packard in September, ranged from 41½ to 45 degrees, and the fauna resembled the cold water species on each side of Jeffrey's ledge. On George's Shoals the marine life is said by Verrill to be the same as that found in the deeper muddy parts of the Gulf of St. Lawrence, and indicates a temperature not above 40 degrees, and probably considerably lower. (Para. 92, Part I.) Bradelle Bank, according to Mr. Whiteaves, presents the phenomenon of a small stony patch, tenanted by an assemblage of Marine animals which usually inhabit very cold water, and are almost entirely surrounded by another series, which are for the most part prevalent where the bottom is warmer and more affected by surface conditions of temperature.[1.]

Wherever the areas are situated where young Mackerel are found in the Summer, we find near at hand a cold water zone, either existing as a part of the Labrador Current at the surface, or brought up from greater depths by banks and shoals. On the coast of Prince Edward Island, and in the Gulf generally, the cold water lies frequently near the shore, because the diurnal tides mix the strata warmed during the daytime with the cold underlying strata. In the estuary of the St. Lawrence Dr. Kelly found the surface temperature 57 degrees Fah. on the 9th July, but three feet below the surface it was 44 degrees, having in that short vertical space sunk 13 degrees; at 24 feet it was 40 degrees, or 17 degrees below the surface temperature.

The coastal waters of Massachusetts rapidly acquire an elevated temperature in June, when the waters of the Gulf of St. Lawrence are often still ice-cold. In April, May and June, the Cod and Haddock resort in large numbers to the banks and reefs off Stonington, Watch Hill, No Man's Land, and other similar places, but are quite unknown there later in the Summer.[2.]

Local winds and tidal currents bring the waters of the Gulf Stream on to this coast and displace the cold waters, even at

---

1. "The Orphan Bank, which is situated off the entrance to the Bay des Chaleurs, is a stony patch, as are most of the inshore fishing banks, many of which are not indicated or defined on the charts. The masses of rock are usually large pieces of reddish sandstone (often perforated by two species of boring bivalves, the *Saxicava rugosa* and *Zirphæa crispata*) with a small proportion of pieces of Laurentian gneiss, &c. Animal life is profusely abundant here, which is undoubtedly the reason why cod, mackerel, etc., frequent this and similar banks in such enormous numbers. Soft bodied organisms of various kinds give a special facies to this particular one. These are encrusting sponges; tunicates, of many genera and species, some of unusual size; an *Actinia (Metridium)*: the common northern *Alcyonium (rubiforme)*: *Alcyonidium gelatinosum*; hydrozoa and polyzoa, in great profusion, &c., &c. Among the harder forms are an abundance of the commoner echinoderms, with a few scarce species; large calcareous polyzoa; and a large number of fine crustacea. Shells are tolerably numerous, thought not nearly so much so as on the Bradelle Bank, and annelids were relatively scarce.

"The Bradelle Bank is also a stony patch, but the pieces of rock are usually small, and there is a greater admixture of gravel, sand and mud on this bank than upon the Orphan. Soft-bodied animals appear to be scarce upon the former, and shells occur in unusual abundance. The assemblage of hydrozoa, echinoderms, polyzoa, and crustacea, is much the same on both banks, though a few peculiar species were found on each. The rarer forms found at these two places will be catalogued in the second part of this report. While the animal life of the shores of Cape Breton (except in deep water), of those of the Magdalen group and of Prince Edward Island, as well as that of the whole of Northumberland Strait up to the southern entrance to the Baie des Chaleurs, is of an Acadian or southern type, the fauna of the Orphan and Bradelle Banks has a decidedly Arctic or northern character. The Bradelle Bank, in particular, presents the phenomenon of a small patch, tenanted by an assemblage of marine animals which usually inhabit very cold water, and almost entirely surrounded by another series, which are for the most part prevalent where the bottom is warmer and more affected by surface conditions of temperature."—*Report of G. J. F. Whiteaves, F. G. S.*, 1873.

2. Prof. Verrill, Page 485, Report of the U. S. Commissioner of Fish and and Fisheries, 1871-72.

the distance of twenty or thirty miles from the shore in summer. [1]

In the Gulf of St. Lawrence the temperature of the surface in summer rarely reaches, as far as observed, the temperarure of the bottom of the sea off No Man's Land, or 59½ to 61½ degrees in 11 and 18 fathoms respectively. [2]

Dr. Kelly records the following surface temperature in various parts of the Gulf, and generally within view of the land:—

Date.		Position.	Temp. of Surface.
1832.	19th June.	Off Point de Monts.	43°
1831.	9th July.	Do. do.	57°
"	10th Aug.	Off Anticosti.	54°
1832.	2nd Sept.	Mingan Harbor.	53°
"	28th June.	Estuary of St. Lawrence.	48°
"	14th August.	Off Kegashka.	53°
"	15th "	In Kegashka Harbor.	48°
"	18th "	" "	38°
"	28th "	" "	55°
"	30th "	" "	52°
"	31st "	Off Mingan,	51°
"	1st Sept.	Mingan Harbor.	39°
"	10th Oct.	Near Cape Gaspe.	41°
"	" "	Off " "	43°
1831.	Oct. 11th.	Near Mount Louis.	41°
"	" "	7 miles off.	47°
	" 12th,	Bay of Seven Islands.	46°
	" 13th,	" "	42°
	" 14th,	" "	39°

In the harbors of the Gulf Coast, and even at a considerable distance off the land, the temperature of the surface is greatly affected by winds. A warm dry wind off the land diminishes the temperature of the surface by evaporation.

Tidal currents have a powerful effect on the temperature of the surface over shoals near the shore, by bringing the cold water to the surface. On the 27th June, 1832, Dr Kelley observed the temperature of the surface water over a shoal ledge which runs out a considerable distance from Mingan Harbor to be only 33 degrees; on the previous day the water in the Estuary of the St. Lawrence being 47 or 48 degrees.

In these differences of surface temperatures, and the causes which give rise to them, we discover the reason why the Mackerel retire, as the summer advances, from the warm coastal waters of the United States out to sea, where they find a stratum of water of the requisite temperature for their free swimming food. In the Gulf of St. Lawrence this requisite temperature is best attained where cold substratum waters are mixed with warmer coastal waters by the tidal waves, the food being at the same time brought inshore by these currents as already described. Here it lingers, partly on account of a suitable temperature being attained, and partly because the efflux and reflux of the tides occasion a constant circular or elliptical movement of the water. Hence while the offshore waters on the Coast of the United States alone possess the requisite degree of coolness in summer for the Mackerel food, the inshore waters of the Gulf acquire the degree of warmth best suited to the habits of these free swimming creatures, which continues until late in the fall. The question of inshore and offshore Mackerel fishing grounds thus becomes, in a great measure, reduced to the different conditions of marine climate which prevail where the Labrador Current is the controlling agent, or where the Gulf Stream asserts its power and influence during the summer season.

---

1. Prof. Verrill, page 485, report of the U. S. Commissioner of Fish and Fisheries 1871–72.

2. Ibid, page 484.

3. Ibid, 486.

XI.—RECENT SCIENTIFIC INQUIRIES INTO THE SEA FISHERIES.

The extent and character of the scientific investigations which have been authorized by different European governments in relation to the sea-fisheries, is of great interest to the fishing industry of North America. The subject has never been a popular one at the outset, and until comparatively recent times, so opposed have fishermen been to scientific inquiries, from the suspicion that they were the forerunners of restrictive and burdensome legislative enactments, that when the late Axel Boeck commenced his investigations into the causes of the decline of the Norwegian Herring-fisheries, the zoologist Van der Hooven attempted to dissuade him from occupying himself with these studies on the ground that they would be productive neither of profit or honor. (1)

So also Axel V. Ljungman when pursuing his inquiries into the Swedish Herring-fisheries for the Swedish government, met with similar discouragement from similar unfounded prejudices. In his report he states: "I need scarcely say that the distrust and opposition with which the investigations were met, not only by nearly the whole population engaged in fishing, but even by those from whom assistance might reasonably have been expected, exercised a depressing influence, and will continue to do so in the future, though not, perhaps, to so great an extent." (2)

There was often great reason in former times for the objection urged by fishermen against goverment supervision and control, for in the absence of a correct knowledge of the habits of fish and of marine physics, enactments of a very prejudicial and hurtful character were instituted, which weighed heavily upon the industry of the fishermen, without producing any beneficial results. Gradually, however, as the fishing population began to understand the scope and object of scientific inquiries, opposition became transferred into co-operation, and the term "Telegraph Herring" has for some time been a popular acknowledgement of the advantages accruing from the application of Science to fishing industries in Norway.

The Dutch Herring fishermen have been supplied with thermometers for their guidance as to the depth at which they should set their nets since 1858, and the gradual increase of exports, being exclusively the products of the Dutch Herring Fishery, afford a striking illustration of the advantage of scientific enquiry. The steady increase of this industry is well shown in the following tables of export for ten years. (1.)

DUTCH HERRINGS EXPORTED.

	Barrels.
1866	13,023
1867	15,098
1868	22,152
1869	15,921
1870	39,435
1871	48,437
1872	46,839
1873	58,388
1874	68,306
1875	68,142

1. 'The Norwegian Herring Fisheries,' by A. I. Boeck and A. Fedderson.

2. Preliminary Report for 1873-74 on the Herring and the Herring Fisheries on the west Coast of Sweden. See Report of U. S. Commissioner of Fisheries for 1874-75.

3 Consular Reports—Netherlands, 1877.

The Scottish Meteorological Society have recently supplied fishermen with thermometers for ascertaining the temperature of the sea at different depths most suited to the habits of the Herring, and the results already attained give promise of many great benefits likely to flow from the proper application of this most useful instrument, as a means for detecting the zone in which the Herrings are feeding, reposing, or moving.

These remarks apply also to the Cod, and one of the first steps taken by the Lofoten fishermen is to ascertain the depth at which the Cod are swimming before they set their nets or cast their buoyed lines. The information thus gained by fishermen respecting the depths at which fish swim at, different seasons of the year, and during the spawning seasons, if they belong to any one of the class whose spawn floats, is practically most valuable. It is from this cause alone that the Norwegian and Dutch fishermen practice methods of fishing with great success in different zones of water, which are entirely unknown in British America.

The Swedish Government are now taking active measures to examine minutely into the condition of their sea fisheries in the Baltic. Already the results are striking and suggestive and among the most interesting may be noticed the discovery of three zones in the Baltic of different temperatures, namely: a warm upper zone, a cold intermediate zone and a warm underlying zone. These zones assimilate in their general features as regards temperature and salinity to the zones which have been described as existing in the Gulf of St. Lawrence. (See Diagram).

The principles upon which the useful application of the thermometer in fishing operations are based, are of a complex character and appear to be inseparably associated with temperature strata in the ocean, which vary in vertical depth and in thickness during each season, and each month of the year. These have at all times a particular relation to the habits of innumerable organic forms which constitute, directly or indirectly the food of fish.

Since the publication of the results obtained by Dr. Carpenter, Dr. J. Gwyn Jeffreys, and Sir Wyville Thomson, in the dredging cruises of H. M. S. S. "Porcupine," and "Lightning;" since the renowned "Challenger" expedition; the various Norwegian and Swedish Explorations; and the United States Commission of Enquiry into the Deep Sea Fisheries, the amazing vastness of the field which has been opened to view has become dimly apparent.

Scoresby's excellent observations were made at a time when they were neither appreciated or understood in their bearings, and few private individuals have given much practical attention to the large field of enquiry which is comprehended under the term 'Ocean Physics.' In his exhaustive work on "The Gulf Stream," Dr. Petermann enumerates the names of nearly all observers who have treated of the temperature of the sea and the causes which affect and govern the distribution of that temperature. Among private observers, to whom science is indebted in this branch of enquiry, Dr. Petermann singles out Lord Dufferin, the present Governor-General of the Dominion of Canada, stating that "the observations of Lord Dufferin, in themselves, offer so numerous data that they permit the construction of isothermal curves for the northern sea from 50° to 80° latitude or from the coasts of the German Sea to Spitzbergen, Iceland, Jan Mayen and Bear Island." These papers on the Gulf Stream have been translated from the German for the United States Coast Survey and the paragraphs relating to Lord Dufferin's observations are in part as follows:—

"Although only a pleasure trip, yet of eminent value to the knowledge of the entire Northern Sea, from the parallel of the German Coast to the latitude of 80° N. is Lord Dufferin's cruise to Iceland and Spitzbergen in a sailing yacht of 85 tons in 1856-57.

The principal dates of this cruise are: Sailing from Stornoway in the Hebrides, June 13; Reickiavik, June 20; the northwestern Cape of Iceland, July 9; Jan Mayen, July 13; Hammerfest, July 20; Bear Island, July 31; Spitzbergen (English Bay), August 6; Drontheim, August 26th; Bergen, August 31st; Copenhagen, Sept. 10th; Christiansand, Sept. 19th; arrived in England, Sept. 25th. During these three and a half months Lord Dufferin kept an excellent journal of observations of the temperature of the sea and of the air, and of the weather, for each two hours day and night—twelve times from noon to noon. Their great value lies principally in the direction of the cruise, from Scotland around Iceland, to Jan Mayen, and thence to Hammerfest. To this day there is no other cruise, and no other connected series of observations existing on that line. The lowest temperature of the sea during this trip was observed 70 miles west of Bear Island (30°); the highest (North of the Arctic Circle) between the 18th and 19th of July, in 70½ N. latitude and 15° longitude East of Greenwich, about 8 nautical miles off the Scandinavian coast, (54°). Further Southward, in the German Sea, from Bergen to Copenhagen, and from there to England, between the 3rd and the 25th of September, temperatures of from 51.6 to 68.4 degrees are noted; generally, however, they were found to be between 54.4 and 59.32 degrees."

"The observations of Lord Dufferin, in themselves, offer so numerous data that they permit the construction of isothermal curves for the Northern Sea, from 50 to 80 degrees latitude, or from the Coast of the German Sea up to Spitzbergen, Iceland, Jan Mayen, and Bear Island. Among other facts they demonstrate that an arm of the Gulf Stream extends along the entire West and North Coast of Iceland, and that the cold Polar Stream penetrates at Bear Island far to the Westward.[1]

The practical bearing of new and unexpected relations which have been in part established between the life of the great deep, and the every varying depths at which that life is sustained, is illustrated in the growing conviction that a correct knowledge of the great Sea Fisheries can only be obtained by means of their study from a scientific point of view, and based upon a knowledge of the physics of the sea.

The great differences which exist between the marine climates of the northern portion of the European and American Continents have been pointed out, with the resulting variations in the habits of fish. (See Part I.) Hence it arises that the deductions applicable in Europe, are not available in many cases on American coasts where the Arctic current reigns supreme, and where the great fisheries, which have yielded their treasure for three hundred years, still remain in the aggregate unimpaired, although by some alledged to show unmistakable signs of local decrease.

The quantity of human food annually supplied without any artificial aid, by a small area of the sea, is enormously great when compared with an equal area of the richest land, although cultivated and enriched by all the resources of capital and skill.

Year after year fishermen resort to the same submarine bank, and if the weather is favourable, procure nearly the same weight of food. For the last fifty years the waters surrounding Newfoundland have yielded to the British, French and American fishermen an average of one hundred thousand tons of dried codfish, and between 6000 and 7000 tons of oil, or equal to about 250,000 tons of fresh fish. The British Commissioners appointed

---

1 Papers on the Eastern and Northern Extensions of the Gulf Stream—From the German of Dr. A. Petermann, Dr. W. Von Freeden, and Dr. A. Mühry. Translated in the United States Hydrographic Office, in charge of Captain R. H. Wyman, U. S. N.

to inquire into the sea-fisheries of the United Kingdom in 1863, drew especial attention to this subject in their exhaustive Report. The following extract from this Report is worthy of attentive consideration, as having especial application to many well known fishing grounds on British American coasts, which are still unrivalled in their continued productiveness, although there is danger of gradual decline.

"The produce of the sea around the coasts bears a far higher proportion to that of the land than is generally imagined. The most frequented fishing-grounds are much more prolific of food than the same extent of the richest land. Once in the year an acre of good land, carefully tilled, produces a ton of corn, or two or three cwt. of meat or cheese. The same area at the bottom of the sea, on the best fishing-grounds, yields a greater weight of food to the persevering fisherman every week in the year. Five vessels, belonging to the same owner, in a single night's fishing, brought in 17 tons weight of fish—an amount of wholesome food equal in weight to that of 50 cattle or 300 sheep. The ground which these vessels covered during the night's fishing could not have exceeded an area of 50 acres."

"When we consider the amount of care that has been bestowed on the improvement of agriculture, the national societies which are established for promoting it, and the scientific knowledge and engineering skill which have been enlisted in its aid, it seems strange that the sea-fisheries have hitherto attracted so little of the public attention. There are few means of enterprise that present better chances of profit than our sea-fisheries, and no object of greater utility could be named than the development of enterprise, skill, and mechanical ingenuity which might be elicited by the periodical exhibitions and publications of an influential society specially devoted to the British fisheries," (1)

Leopold Von Buch, writing in 1810, states that "while the fisheries of almost every other part of Norway have gradually being declining, that of Loffoden has maintained its fame above a thousand years, without a single instance of failure." (2) From the most recent returns, continuing up to 1875, the statement made by Von Buch 67 years ago, appears to hold good at the present time, for the Cod are found at the Loffoden as abundant as ever, although it must be stated that the means and appliances to take the fish are far more effectual than they were when the great traveller and geologist wrote an account of his journey through Norway and Lapland. Mr. Frank Buckland considers that the North Sea Fisheries shows some marked signs of diminution, and the reality may come suddenly and unexpectedly upon the British public. The decline in the United States has already been referred to in Part I., and there can be little doubt that similar results may be expected on some parts of British American Coasts.

---

(1) "Report of the Commissioners appointed to inquire into the Sea-fisheries of the United Kingdom."

(2) "Travels Through Norway and Lapland." By Leopold Von Buch. Berlin, 1810.

XII.—SYNOPSIS OF THE EXTENT AND CHARACTER OF THE BRITISH NORTH AMERICAN FISHERIES COMPARED WITH THOSE OF OTHER COUNTRIES.

European Sea Fisheries.

No. I.

THE BRITISH EUROPEAN SEA FISHERIES.

The yield and value of the British Fisheries in European Seas, take the first place among the products won from the Sea by fishing nations.

The question whether the Fisheries in British Seas are declining is one of great commercial importance, and respecting which much diversity of opinion appears to exist. During the past two years, two distinguished authorities have affirmed that with regard to some valuable species of fish the decline is decided and even alarming. In an address delivered at the Biological Section of the British Association at Glasgow in 1876, Professor Alfred Newton expressed decided opinions in support of the view that the British Fisheries were declining, and he advanced the results of the "Minutes of Evidence" taken before the Sea Fisheries Commissioners of 1863-66, in support of his views.

In a communication addressed to "Nature." (Nov. 16, 1876) Mr. Newton says:—

"Any one who has ever tried to learn the facts attending the process of extinction of animals, will soon find that premonitory symptoms of approaching extirpation may be for a long time hardly recognizable at places where the particular species concerned is most abundant. It is first cut short on its borders, and scarcity begins and is most readily perceived at its outlying localities. Hence it is exactly in accordance with what always, or almost always happens, that the smaller and least important fisheries should first show signs of decline, if such decline is going on as the above figures seem to prove. It may be years before the great trawling grounds on various parts of the coast, or the Dogger and Silver Pit show unmistakable signs of exhaustion, but where is the take of fish inshore increasing or even stationary? [1.]

Mr. Frank Buckland embodies in his recent report on the "Fisheries of Norfolk," [1.] many important proofs of the decrease of some species of fish, especially those which are taken by net trawling, such as soles, turbots, brills and plaice. This decrease has taken place within the last few years, and does not militate against the conclusion arrived at by the Sea Fisheries Commission in 1863–6, that *then* no material decrease in general was to be discerned. A great increase has taken place during the past ten years in net trawling vessels, and the effect is now notably visible in the size of the fish taken. The Dutch vessels are stated to do great injury on account of their net trawling operations near to the shores.[2] The Germans protect their coast, and will not allow any trawling vessels to fish inside of nine

---

1. Prof. Alfred Newton, of Cambridge, England—Letter on Sea Fisheries, published in "Nature," Nov. 16, 1876.

2. Report on the Fisheries of Norfolk, especially Crabs, Lobsters, Herrings and the Broads, by Frank Buckland, Inspector of Salmon Fisheries.—Blue Book, 1875.

fathoms of water. They have a gunboat constantly watching the smacks to see this is strictly carried out.[1] There is no net trawling carried on in Dominion or Newfoundland waters.

The estimate of James Caird, Esq., one of Her Majesty's Commissioners appointed to enquire into the Sea Fisheries of the United Kingdom in 1863, is as follows:—

Estimated weight and value of sea-fish annually caught in the British Seas:—

120,000	tons of	White Fish [1] @ £20	per ton.....	£2,400,000
250,000	"	Herrings @ £15	"	3,750,000
20,000	"	Mackerel @ £15	"	300,000
20,000	"	Sprats @ £7 10s.	"	150,000
3,000	"	Pilchards @ £16 10s.	"	50,000
12,000	"	Oysters @ £20 10s.	"	250,000
20,000	"	other Shell Fish @ £5	"	100,000
			Total....	£7,000,000

Estimated value of River Fish, consisting of Salmon, Trout, Eels. etc.:—

England	£ 30,000
Ireland	330,000
Scotland	200,000
	£560,000

No. II.

NORWEGIAN FISHERIES.

The Norwegian Fisheries are pursued with great skill and with special regard to their preservation. Government inspectors are always on the great fishing grounds to see that regulations are respected. Nets are sunk at different depths to find the zone at which the fish are lying. The thermometer is also used, and advantage taken, under the supervision of Government, of every artifice designed to promote the efficiency of the apparatus used to take fish, and the permanency of the fisheries. In no country have long continued scientific observations been pursued to such an extent as in Norwegian waters, and the present success of Norwegians in maintaining their high position as a fishing and maritime people, is largely due to the care and interest taken by Government in whatever pertains to the industry of the fisherman.

Statistics of the Norwegian Cod Fishery.

NUMBER OF COD TAKEN.[1]

	Loffoden.	Finmark.	Romsdal.	Total Catch.
1861	20,000,000	5,000,000	3,500,000	28,500,000
1862	11,500,000	8,000,000	6,000,000	25,500,000
1863	17,500,000	3,000,000	4,000,000	24,500,000
1864	10,000,000	11,500,000	5,500,000	27,000,000
1865	19,000,000	9,000,000	9,500,000	37,500,000
1866	21,000,000	15,000,000	3,900,000	39,900,000
1867	16,000,000	14,000,000	4,000,000	34,000,000
1868	....	12,455,000	....	....
1869	20,700,000	9,476,000	5,000,000	35,176,000
1870	23,000,000	11,500,000	....	34,500,000
1871	19,000,000	15,000,000	2,700,000	36,700,000
1872	18,000,000	16,250,000	....	34,250,000
1873	18,000,000	16,500,000	....	34,500,000
1874	16,000,000	17,500,000	....	33,500,000
1875[2]	23,000,000	19,750,000	....	42,750,000

2. Page 19.

1. 'White Fish' include Cod, Haddock, Hake, Ling, Pollock, Soles, Turbot, Plaice Brill, Halibut, Hake, Whiting.

1. Reports of H. M. Consul at Christiania—from 1866 to 1876.

2. The total catch for 1870, and from 1872 to 1875 inclusive, does not include the catch of Romsdal.

LIVER AND ROES.

	Yield in Liver.	Yield in Roes.
1869	19,000 barrels	17,000 barrels
1870	30,000 "	20,000 "
1871	22,000 "	16,000 "
1872	24,000 "	22,000 "
1873	50,000 "	18,000 "
1874	40,000 "	15,000 "
1875	52,000 "	28,000 "

COMPARISON BETWEEN NORWEGIAN AND NEWFOUNDLAND EXPORTS DURING AVERAGE GOOD YEARS.

The years 1855, 1856 and 1857 were unusually productive in Norway.

The Newfoundland Exports, as compared with the Norwegian Exports during the same years, stands thus :—

	NEWFOUNDLAND. Quintals.	NORWAY. Quintals.
1855	1,107,388	890,943
1856	1,268,334	944,836
1857	1,392,322	969,127

Difference between the Newfoundland and Norwegian Exports in favor of Newfoundland:—

	Quintals.
1855	216,445
1856	323,498
1857	423,195

The NORWEGIAN catch of 1873 exceeded the average of the previous ten years, according to the Report of H. M. Consul for that year.

The results of the total catch were thus estimated in Official Returns :—

Cod Fisheries	609,249	£ stg.
Cod Roes	80,564	"
Liver Oil	165,804	"
Total value of Cod-fisheries	855,617	£ stg.

Compared with the NEWFOUNDLAND Exports of 1873, the relative values stand thus :—

Newfoundland Valuation of the Exports of the Products of the Cod alone, during 1873 :

Dried Codfish	$4,929,136
Core "	2,284
Cod Oil	553,560
Refined Oil	64,200
Cod Roes	2,572
Total	$5,551,752

Norwegian valuation of the Product of the Cod Fisheries alone, in 1873	$4,166,854
Difference	$1,384,898

Excess of value of Newfoundland *Exports* of Codfish and Codfish Products over the value of Norwegian *Catch* in 1873......$1,384,898

A considerable proportion of the total amount of fish exported from Norway under the English name 'Codfish,' consists of Pollock, Haddock and Ling.

Consul-General Crowe states in his report on the Norwegian Fisheries for 1873, that the ten thousand tons of 200,000 quintals bartered to the Russians on the northern coasts of Norway, largely consists of Halibut and Pollock, or Coal Fish. When these species of fish are deducted, the difference between the annual catch in Newfoundland by British fishermen of the Codfish proper, stands out in its true light. But this difference, great as it is, fails to convey a correct appreciation of the immense annual catch in Newfoundland waters. To the Newfoundland exports of Cod and its products, such as cod oil and roes, tongue and sounds, there must be added the French catch and the American catch, which together may be assumed equal to the Newfoundland total catch, during an average of years.

TABLE showing the total value in dollars of the Fisheries of Norway in 1873, including Seal, etc., Fishery:

Cod Fisheries	$2,967,042
Cod Roes	392,346
Liver Oil	807,465
Herring Fisheries	1,248,400
Mackerel do	201,676
Salmon do	41,127
Lobster do	148,096
Total	$5,806,152
Result of Shark, Walrus and Seal fishing, combined	443,067
Total value [1]	$6,250,219
Total value of the Newfoundland exports of fish and fish products in 1873, including Seal Fishing	$8,138,965
Excess of value of Newfoundland exports over value of Norwegian catch in 1873	$1,888,746

THE NORWEGIAN SPRING HERRING FISHERY.

The cause of the decline of the Spring Herring Fishery on the coasts of Norway is still partly shrouded in mystery. Professor Sars holds out expectations that the Herring have not really left their accustomed haunts at particular seasons, but are to be found a little farther out to sea, and in deeper water. Be this as it may, the decline is very great, as shown in the following tables, and brings with it a great and widespread suffering among the fishing population.

Average Export of Norwegian Spring Herring during periods of ten years, from 1816 to 1869.

1816 to 1826	192,905	barrels.
1826 to 1836	431,615	"
1836 to 1846	508,844	"
1846 to 1856	585,523	"
1856 to 1866	609,271	"
1866 to 1869	511,782	"

From 1866 to 1869 the mean is for four years only, after 1869 the Spring Herring Fishery began to decline, as shown in the subjoined table.

Spring Herring Fishery since 1870—Catch.

1870	160,000	barrels.
1871	83,000	"
1872		
1873	65,000	"
1874	275,000	"
1875	Failure.	

1. From the Report of H. M. Consul at Christiania for 1873.

Norwegian Lobster Trade.

TABLE showing the number of Lobsters exported from Norway from 1865 to 1875, inclusive:

	Number of Lobsters Exported.
1865	1,956,000
1866	1,850,000
1867	1,582,000
1868	1,572,000
1869	1,088,000
1870	1,207,000
1871	1,045,000
1872	1,016,000
1873	912,285
1874	
1875	400,000 [1.]

Comparative Table shewing the Catch and Value of the Mackerel Fishery of Norway and the Dominion of Canada.

	Norway.		Canada.	
	Yield—Cwt.	Value.	Yield—Bbls.	Value.
1868	47,000	$ 92,744		
1869	61,000	107,032	53,011	$ 530,110
1870	64,700	131,334	92,213	1,097,234
1871	71,800	194,152	240,426	2,404,260
1872	70,100	159,302	119,859	1,578,026
1873	65,446	141,704	160,617	1,597,138
	No. of Fish taken.			
1874	2,800,000	123,552	161,763	1,578,806
1875	3,500,000	156,827 [1.]	123,960	1,239,600 [3.]

No. III.

Russian Fisheries.

According to the Report on the Fisheries of Russia, by C. Danilewsky, President of the Commission, the following estimate supplies a tolerably correct idea of the vast extent of the Fishing Industry in the Russian Empire:—

European Fisheries—

	Value in £ Sterling.
In the Baltic	218,758
" White Sea and Arctic Ocean	175,000
" Black Sea	105,000
Total value of Russian Fisheries in Europe	498,758

Asiatic Fisheries—

Caspian Sea, with the Volga, Ural, &c.	1,837,500
Sea of Azov	700,000
Total value of Russian Fisheries in Asia	2,237,500

---

1. From the Reports of H. M. S. Consul at Christiania.
2. Report of H. M. Consul at Christiania.
3. Statistical Memorandum on Canadian Fisheries, compiled by J. C. Tache, Deputy Minister of Agriculture, Ottawa, June, 1876.

No. IV.

SEA FISHERIES OF THE NETHERLANDS FOR THE YEAR 1876.

Sea Fisheries.	Quantity.	Estimated Value.
Salt Herring	11,702,814	
Smoked Herring	3,094,158	
Fresh Sea Fish	6,906,048	
Salt Cod	595,432	
Shrimps	463,297	
Dried, Salted, or Smoked Fish of all other kinds	3,776,993	
Oysters and Lobsters	531,565	
Mussels	9,374,695	
Salt Ling (Stock Fish)	1,455,708	
Anchovies	1,355,064	
Total	39,255,774	
Equal to Tons	38,637	£335,878

£335,878——$1,635,725.86

STATEMENT OF THE NUMBER OF VESSELS, BOATS AND MEN EMPLOYED IN THE FISHERIES OF THE NETHERLANDS.

Fisheries. [1.]	Total No. of Vessels or Boats.	Total No. of Men Employed.	Average Crew per Vessel.
Great Fishery	114	1,678	14 to 15 men
North Sea Fishery	410	2,965	7 to 8 "
Zuider Zee Fishery	1,282	3,269	2 to 3 "
Friesland and Groningen Fishery	183	524	2 to 3 "
Zealand Fishery	472	1,026	2 to 3 "
Grand Total	2,461	9,462	3 to 4 each

DUTCH HERRING FISHERY (NETHERLANDS).

"The following returns show the remarkable extent to which the export of salt herring from Holland to foreign countries has increased within the last few years, this return applying, I should state, exclusively to the produce of the Dutch Herring Fishery itself, and leaving aside the herrings imported from foreign countries and re-exported from Holland:—"

	Total Exported—Barrels.
1866	13,023
1867	15,098
1868	22,152
1869	15,921
1870	39,435
1871	48,437
1872	46,839
1873	58,388
1874	68,306
1875	68,142 [2.]

The quantity of salt herring, properly so called, produced by the North Sea Fisheries of South Holland in 1875 were—

	Barrels.
Scheveningen	32,344
Kalwijk	9,033
Novidwijk	1,110
Total	42,487

1. Report by Mr. Fenton on the Sea Fisheries of the Netherlands—Consular Trade Reports, 1877.

2. Report by Mr. Fenton on the Sea Fisheries of the Netherlands.—Trade Reports, 1877.

This number of barrels contained in the aggregate 36,976,350 herrings; adding 20,000,000 fish cured as red herrings, the total number of herrings taken by the whole fleet of South Holland boats engaged in the North Sea Coast Fishery in 1875 would be about 57,000,000. In 1874 the total number was estimated at about 64,750,000, and in 1873, at about 87,250,000.[1]

No. V.

DANISH FISHERIES.

I.—Exports from the Faroe Islands—[2]

1874	37,569	quintals of	Klip Fish.[3]
"	1,312	"	Tor Fish.
"	1,285	"	Fresh Fish.

II.—Exports from Iceland—

1875	90,000	"	Klip Fish.
"	2,500	"	Tor Fish.

III.—Denmark Proper—

Estimated total value of the fisheries of all descriptions of Denmark Proper amounts to about £150,000.

IV.—Danish Greenland—

1874 .... 71,350 lbs.[4] Dried Cod Fish.

Nearly the whole of the Cod Fish was imported from Sukkertoppen.

No. VI.

FRENCH FISHERIES.

(For details of French Fisheries see page 107, Part I; also pages 165 and 166, Part I.)

VALUE OF THE SEA FISHERIES OF FRANCE.

1870	$11,975,460.[5]
1871	13,978,457.
1872	12,333,333.[6]
1873	10,500,000.
1874	12,166,666.[7]

1. Report by Mr. Fenton on the Sea Fisheries of the Netherlands—Trade Reports, 1877.
2. The Fisheries of Denmark, the Faroe Islands, and Iceland.—*Geographical Mag. Oct.* 1876.
3. Klip Fish—Cod, dried in air, but not salted. Tor Fish—Cod, salted, pressed and dried. 100 lbs. to a quintal.
4. The Danish pound is 1.1 English pounds.
5. Revue Maritime et Coloniale, December, 1872.
6. Revue Maritime et Coloniale, March 1874.
7. Revue Maritime et Coloniale, 1876.

NORTH AMERICAN SEA FISHERIES.

I.

DOMINION OF CANADA.

The details of the catch of Herrings and Mackerel by each maritime Province of the Dominion for a large number of years are given in Part I. The following table represents the general total catch.

TABLES AND ESTIMATE BY J. C. TACHE, ESQ.[1]

The quantities caught *so far* as they are *returned*, by the Fisheries' Report, are in their aggregate, for the Atlantic Provinces of the Dominion, shown in the following table :

TABLE I.

Years.	Cod, Haddock, Hake & Pollock, Quintals.	Herring in Barrels.	Mackerel in Barrels.	Average Prices indicated by the Fisheries' Returns.		
				Cod.	Herrings.	Mackerel.
				$	$	$
1869	531,387	307,478	53,011	3 00	3 00	10 00
1870	582,731	248,839	92,213	3 90	4 07	11 90
1871	700,926	380,600	240,426	3 00	3 00	10 00
1872	997,598	324,877	119,859	4 00	3 90	14 00
1873	1,033,602	349,666	160,617	4 15	3 90	9 95
1874	936,885	326,476	161,793	4 40	4 15	9 76
1875	882,094	340,382	123,960	4 35	4 15	10 00

"The existence of complete statistics of the fish catch of one year, gathered through the regular process of a carefully taken census (1870), renders these annual reports available for deductions, which being, furthermore, as a whole borne out by the Trade Reports, and such broad means of comparison as are furnished by the previous censuses, cannot fail to bring a very near approximation to exactness.

The following table is the result of calculations, made on such bases, and is confidently given as expressing the quantities of the catch of each of the years therein mentioned. The quantities in this table refer to the Provinces of Nova Scotia, New Brunswick, Prince Edward Island, and to the Province of Quebec from the gulf up the river St. Lawrence, as far as Pointe de Monts and Cap Chatte: in other words it gives the result of the yearly catch of the Cod, Herring and Mackerel in the fishing fields concerned in the Treaty of Washington :—

TABLE II.

Year.	Quintals of Cod, Haddock, Hake and Pollock.	Barrels of Herrings.	Barrels of Mackerel.
1869	730,928	505,195	54,022
1870	801,553*	408,850*	93,972*
1871	964,131	625,337	245,012
1872	1,372,207	533,783	122,145
1873	1,405,804	557,979	163,681
1874	1,278,499	534,307	164,879
1875	1,193,579	555,371	126,324

The figures marked by an asterisk are the figures given by the Censuses of 1870-71, of the Dominion and of Prince Edward Island, less the quantities of fish caught West of a line drawn from Pointe de Monts to Cap Chatte.

1. J. C. Tache, Deputy of Minister of Agriculture.

" It is to be remarked that the returns of the Fisheries' Department previous to the year 1873, do not contain the fish catch of Prince Edward Island ; and that the quantities included in the returns for 1873, 1874 and 1875, on account of Prince Edward Island, have been deducted for Cod and Herring, Mackerel not being caught in any quantity west of Cap Chatte."

DOMINION FISHERIES FOR 1876

Species.	Aggregate Value.	Aggregate Value.
Cod Fish	$4,123,100	$
" Oil	59,135	
" Tongues and Sound	12,352	
Haddock	906,121	
Pollock	168,021	
Hake	256,312	
Ling	5,745	
Tom Cod	11,000	
Total of Cod Fish Tribe		5,576,786
Herring	1,780,338	
Alewife or Gaspereau	96,250	
Shad	98,820	
Total of Herring Tribe		1,874,408
Mackerel		997,681
Lobsters		795,082
Salmon		312,002
Smelts		171,017
Trout		10,271
Fish Oil		298,524
Other Fish and Miscellaneous Products		315,380
Total value of Sea Fisheries		$10,314,119
Oysters		119,449
Porpoise Skins and Oil		8,532
Seal Skins and Oil		40,952
Whale Oil		4,809
Inland Fisheries		555,042
Total value of Dominion Atlantic Sea Coast and Inland Fisheries for 1876		(1.) $11,042,893

II.

NEWFOUNDLAND.

As early as 1517, about fifty French, Spanish and Portuguese vessels were engaged on the Bank Cod Fishery of Newfoundland, and in 1578, or 300 years ago, the British Fishery Fleet numbered fifteen vessels, while that of other countries had increased to a very great degree. France had at that period 150, Spain 100, and Portugal 50 ships, employed in the Newfoundland Fisheries, making a total of 315 ships recorded as engaged in that pursuit, In 1615 the British Fishing Fleet amounted to 250 vessels, and the total number of French, Biscayan and Portuguese ships, employed at the same date reached four hundred. [2] In 1615 Capt. John Smith addressed a letter to Lord Bacon, then Chancellor of England, in which he states that the " Hollanders raise yearly by fishing from Newfoundland at least £400,000."

1. Compiled from the Reports of the Commissioner of Fisheries of the Dominion of Canada for 1876.

2. Lex Mercatoria—McGregor, quoted by Bouchette.

These few historical facts show how long and how perseveringly the Cod Fishery has been pursued in Newfoundland and Labrador waters, and point in an unmistakeable manner to the unfailing resources of these cold water seas, where the Labrador Branch of the Great Arctic Outflow reigns supreme, and is the natural home of so many species of Cold Water Fish.

The statistical data given in the Appendix to Part I. supply a general view of the progress of the French and British Fisheries in Newfoundland waters to the commencement of the present century. The following tables exhibit the exports of the Newfoundland Cod Fishery from 1804 to 1876, as prosecuted by the inhabitants of Newfoundland, which are wholly distinct from the French Newfoundland Cod Fisheries, or the fisheries pursued in those waters by the fishermen of the United States.

The annexed column, showing the number of quintals of Dried Cod Fish required to produce a ton of Cod-liver Oil, exhibits remarkable variations in the annual yield of this important product, and points to climatal conditions which affect the supply of food. It is not unreasonable to suppose that future investigations may offer a clue to the whereabouts of the great body of fish during particular seasons, and in what depth of water they find their food during certain months of the year. It has been shown that owing to the exceptional character of the month of April, 1874, enormous numbers of fish came inshore during that year, evidently driven shorewards in search of food. But the question arises, where do these fish feed in ordinary seasons? There can not be a doubt that there are numerous banks off the coast of Newfoundland as yet entirely unknown to the fishermen. A notable illustration of this fact is the bank discovered during the soundings for the Atlantic Cable, about a degree and a half due East of Catalina Head, on which one sounding showed 59 fathoms, but near at hand the depth may be considerably less.

Corrected Table, Showing the Exports of Quintals of Cod from Newfoundland during the years 1804 to 1816, inclusive, and from 1820 to 1876.

Year.(1)	No. of Quintals.
1804.	661,277
1805.	625,519
1806.	772,809
1807.	674,810
1808.	576,132
1809.	810,219
1810.	884,474
1811.	923,540
1812,	711,059
1813.	891,360
1814.	947,762
1815.	1,086,266
1816.	1,046,625

1. Thomas Luck—Office for Trade, Whitehall, 24th June, 1817.

Year. (1)	Exports—Quintals of Fish.	Tons of Cod Oil—Crude and Refined	No. of Quintals to a Ton of Oil.	
1820	901,159			
1822	881,476			
1823	864,741			
1825	973,464			
1826	963,942			
1829	924,237			
1832	619,177			
1833	683,536			
1834	674,988			
1835	712,588			
1836	860,354			
1837				
1838	724,515			
1839	8[illegible]5,377			
1840	915,795			Mild winter.
1841	1,009,725			
1842	1,007,980			Mild winter; spring very severe
1843	932,202			
1844	852,162			
1845	1,000,233			
1846	879,005			
1847	837,973			
1848	920,366			
1849	1,175,167			Severe winter.
1850	1,009,182			
1851	1,017,152	3,492	299	
1852	972,991	3,912	248	
1853	922,718	3,875	238	
1854	774,117	3,409	227	
1855	1,107,388	4,058	272	
1856	1,268,334	4,207	301	
1857	1,392,322	4,944	261	
1858	1,038,089	5,295	196	
1859	1,105,793	4,354	254	Very severe win.
1860	1,138,544	4,565	249	
1861	1,238,373	3,318	370	
1862	1,269,837	3,878	326	" "
1863	999,086	2,939	339	" "
1864	1,016,234	2,211	459	
1865	997,114	3,235	308	
1866	930,447	3,249	256	
1867	1,066,215	4,455	239	
1868	1,169,948	3,296	354	
1869	1,204,086	4,084	256	
1870	1,213,737	4,035	300	
1871	1,328,726	5,551	239	
1872	1,221,156	4,354	278	
1873	1,369,205	4,275	320	
1874	1,609,724	3,161	509	April very severe
1875	1,136,235	3,079	368	
1876	1,364,068			

1. N. B. The data from 1820 to 1856 are from Pedley's History of Newfoundland, subsequently from official statements.

STATEMENT.

Quantity and Value in Pounds Currency of Fish and Seal Exports from Newfoundland and Labrador, for the year 1874.

Fish, Dried Cod..	1609724 Qtls.	at £ 0	19	0	£1529237	16	0
Fish, Green " ..	904 "	0	7	6	339	0	0
Seal Skins.......	398366 num.	0	6	6	129468	19	0
Seal Oil.........	4358 Tuns	35	0	0	152530	0	0
Cod Oil.........	2939 "	40	0	0	117560	0	0
Whale Oil.......	62 "	35	0	0	2170	0	0
Refined Oil......	222 "	p. gl. 0	4	6	12787	4	0
Other Oil........	26 "	32	0	0	832	0	0
Blubber..........	81 "	4	0	0	324	0	0
Salmon..........	7883 Tierces	0	75	0	29561	5	0
Herrings frozen..	8300 Barrels	0	5	0	2075	0	0
Herrings Pickled..	189956 "	0	15	0	142467	0	0
Trout..........	2234 "	0	40	0	4468	0	0
Mackerel.........	47 "	0	40	0	94	0	0
Cod Roes........	1186 "	0	15	0	889	10	0
Haddock..........	18 Qtls.	0	17	6	15	15	0
Halibut.........	1449 "	0	10	0	724	10	0
Turbot...........	13 Barrels	0	20	0	13	0	0
Sounds & Tongues	276 Pkgs.	0	5	0	69	0	0
Salmon preserved in tins.........	36562 Lbs.	0	0	8	1218	14	8
Lobsters........	25814 "	0	0	6	645	7	0
Other articles not enumerated, bait &c., sold to the French.........	....	....			15000	0	0
					£2142490	0	8
					Or $8569960 00		

TABLE I.

Showing the Amount of Fish Exported from Newfoundland from 1851 to 1863.

		1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859	1860.	1861.	1862.	1863.
Codfish Dried.....	Quintals..	1017152	972901	922718	774117	1107388	1268314	1392322	1038089	1105793	1138544	1238373	1260837	909089
" Core fish.....	"	420	810	2440		1078	6040	1142	986	885	3402	372	420	505
" Fresh frozen.	"													
" Oil, crude....	Tuns.....	3415	3785	3505	3200	3706	3999	4822	4968	4301	4575	3318¼	2758½	2897
" Liver Oil, refi.	"	77	127	370	209	262	208	122	327	424	426	205¾	354	224
" Roes.........	Barrels....												118	346
" Sounds&Ton.	Pkgs.....	314	1039	620	1023	390	1346	209	480	699	723	1122	1077	602
Haddock..........	Quintals..												1135	
Halibut...........	"			12	71		30	18	22	54	29	10	58	190
Herring...........	Barrels..	36259	42715	55140	36152	32012	82294	49780	82155	69910	63711	78191	34704	68576
" smoked in bxs.	Boxes....													254
" frozen fresh....	arrels..													
" Oil...........	Tuns.....							1	1	1¼	3	3	1	17
Turbot............	Quintals..				7	2		8						
" Smoked....	"													
Lobsters..........	Lbs......							87 (2)	8 (2)	8 (2)				
Salmon...........	Tierces....	4035	3409	3355	3753	3050	2973	2805	2726	3716	3908	3085	5435	6528
" preserv'd in tins	Lbs......							165	109	29			14	8
Trout..............	Barrels.	34	80	64	78	19	6	129	21	31	750	77	549	43
Caplin.............	Pkgs.....	544	577	1146	674	353	402	217	239	206	88	191	79	495
Mackerel..........	Barrels...			50	21	61	12	33	134	7	4		217	23
Dogfish Oil........	Tuns....								7	8¼	7	8	19	11
Whale Oil.........	"								11	29	19	13	17	22
" Bone.......	Cwt.....	105	39	10		113		2						
Blubber and Dregs.	Tuns.....	420	358	286			414	333	290	386	73	122	202	147
Seal Oil...........	"	6938	7334	8137	5567	3760	5009	7165	6177	5565	4673	5288½	3433	4166
" Skins.........	Number..	511630	534378	521783	398870		361317	493113	507624	329185	344202	375282	268024	287151

1. Tuns. 2. Cases.

TABLE II.

Showing the amount of Fish Exported from Newfoundland from 1864 to 1876.

		1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876
Codfish, dried....................	Quintals	1016234	997114	930447	1066215	1169948	1204086	1213737	1328726	1221156	1360205	1600724	1136235	1364068
" Core Fish..............	"	408	6				2355	1942	640	730	1523	904	730	959
" Fresh frozen....	"									358				
" Oil, crude..............	Tuns	2312	2816	3011	4183	3071	4528	3834	5238	4133	3954	2930	2000	2372
" Liver Oil, Refined........	"	172	419	238	272	225	333	419	313	221	321	222	89	112¾
" Roes.....................	Barrels	8	1590	342	763	1092	964	1265	1039	910	858	1186	221	715
" Sounds and Tongues.....	Packages	455	924	485	816	500	1559	452	190	124	279	276	164	119
Haddock..........................	Quintals	1024	668	457	1685	837	1719	28	630	12	1798	18	144	535
Ling..............................	"	24												
Halibut...........................	"	608	951	1424	1317	749	664	337	450	429	1848	1449	330	332
Herring...........................	Barrels	40833	64946	203782	149776	187163	179440	146689	187439	140873	122608	183956	192639	291751
" frozen fresh...............	"	682	30							6898	10550	8300	14450	
" Smoked	"									14	200†			200
" Oil........................	Tuns	1½	61½	11¼		34	30	2	20	50	78	20	20	19
Turbot............................	Quintals		15	5380*		32			20	5		13	15	
" Smoked..................	"												8	
Lobsters..........................	Lbs.	20										25814	144723	6046
Salmon............................	Tierces	3115	3570	4319	5340	6503	9214	6551	3977	5049	7711	7883	8101	7448
" preserved in tins..........	Lbs.	23	990									30562	50120	50288
Trout.............................	Barrels	729	324	305	1137		1525	1330	454	2169	1552	2234	1458	967
Caplin............................	Packages	405	534		75	915				147	135	51	57	398
Mackerel..........................	Barrels	158	17		17	9		1019	1374	604	47	47		1
Dogfish Oil.......................	Tuns	15	30		11		11	6	7	8	6	6	5	
Whale Oil.........................	"	24	92	48	64	75	21		9	38	57	62	37	24
" Bone.......................	Cwts		104	250		1						17	57	
Blubber and Dregs................	Tuns	297	255	104		86	198	210	79	104	143	81	92	72
Seal Oil..........................	"	1629	3267	4813	5142	4855	5580	6369	8504	4228	6835	4358	4971	4696
Seal Skins........................	Number	125950	242471	311265	359672	333316	343021	355428	537004	278372	403531	398908	346921	341811

* Number of Turbot.
† Barrels.

TABLE showing the Gradual Progress of the Value of the Products of the Newfoundland Fisheries during each Group of Five Years, from 1852 to 1876, inclusive.

Average Value of Exports.	Group of Five Years.
1852 to 1856...........	$5,166,129
1857 to 1862...........	6,132,392
1862 to 1866...........	6,080,445
1867 to 1871...........	7,011,407
1872 to 1876...........	7,847,661

No. III.

PRODUCE OF UNITED STATES SEA FISHERIES. [1.]

Year.	Value.
1870........................	$ 5,313,967
1871........................	11,482,410
1872........................	9,526,647
1873........................	8,348,185
1874........................	9,522,553
1875........................	10,747,579
1876........................	9,756,683

1. United States Official Returns.

DETAILS OF UNITED STATES SEA FISHERIES.—COLD WATER FISH.

Estimate for 1876.[2.]

	SPECIES.		Aggregate Value.
Cod Fish Tribe.	Cod, (fresh) New York.......	$ 325000	
	" " Gloucester, Boston, &c.......	800000	
	" Cured................	3698915	
	" Roes...............	1625	
	Tom Cod..................	5500	
	Total of Cod Fish Tribe...	....	$4831040
Mackerel Tribe.	Mackerel, (fresh)............	701040	
	" cured............	1674222	
	Total of Mackerel Tribe...	....	2375262
Flat Fish Tribe.	Flounders and Flat Fish.....	109620	
	Halibut (fresh)............	1172205	
	" " New York.....	125000	
	" (cured) Gloucester, &c., flitches..........	236010	
	" Fins...............	12750	
	" Napes...........	.275	
	Total of Flat Fish Tribe..	....	1546240
Herring Tribe.	Sea Shad....................	235637	
	Alewife.....................	55387	
	Herring....................	48144	
	" (cured)............	457833	
	Total of Herring Tribe....	....	799001
	Smelts............................	....	50000
	Eels...............................	....	37500
	Salmon...........................	....	8020
	Total value of Cold Water Sea Fisheries	....	$9756683

2. Compiled from Tables by George Browne Goode Esq., for Professor Spencer F. Baird, U. S. Commissioner of Fish and Fisheries, 1877.

UNITED STATES SEA FISHERIES.—WARM WATER FISH NOT FOUND IN BRITISH AMERICAN WATERS IN COMMERCIAL ABUNDANCE.

Estimate for 1876. [1]

Species of Fish.	Aggregate of Value.
Tautog	$ 70,788
Spanish Mackerel	28,875
Bonito	143,000
Pompano	4,000
Swordfish	165,000
Butterfish, Whiting, White Perch	3,000
Sea Robins	2,250
Squeteague	138,208
Kingfish	2,000
Spot and Croaker	5,625
Sheepshead	13,125
Scup	504,400
Sea Bass	74,812
Striped Bass	21,560
Bluefish	424,080
Menhaden	1,657,790
Cunner[2]	10,000
Sturgeon	5,625
	$ 3,274,138
Cold water fish	9,756,683
Total	$13,030,821

Product of American Fisheries other than whale, received into the Customs Districts of the United States during the fiscal year ended June 30th, 1874: [3]

Articles.	Quantity.	Value.
Codfish—cured	850,732 cwt.	$3,694,483
Mackerel—cured	418,627 "	2,822,766
Herring—cured	114,552 "	199,209
Other fish—cured	71,663 "	202,620
Oysters	11,050 bush.	8,620
Other shell-fish	....	372,950
Fresh fish, not shell-fish	31,777,666 pounds.	1,108,169
Oils, other than whale	1,405,745 gallons.	699,121
Teeth	47,741 pounds.	12,083
Skins	15,966 No.	99,617
Manure	23,398 Tons.	224,335
All other products		78,676
Total value	....	$9,522,553

1. Compiled from Tables prepared by George Brown Goode, Esq., for Professor Spencer F. Baird, U. S. Commissioner of Fish and Fisheries
2. The Cunner or Blue Perch occurs as far north as Newfoundland.
3. Annual Report of the Chief of the Bureau of Statistics, Commerce and Navigation, 1874.

Produce of American Fisheries, other than whale, received into the Custom Districts of the United States during the fiscal year ended June 30, 1875. (1)

Articles.	Quantity.	Value.
Codfish—cured. ...., ...	756,543 cwt.	$3,664,496
Mackerel—cured.	527,633 "	2,655,623
Herring—cured	124,215 "	265,463
Other fish—cured........	1,125,654 "	337,971
Oysters. .... , ...	21,870 bush.	16,725
Other shell-fish	....	308,519
Fresh fish, not shell-fish	39,726,788 pounds.	1,665,201
Oils, other than whale..	1,009,054 gallons.	459,227
Teeth	58,941 pounds.	28,517
Skins....................	24,645 No.	164,523
Manure	44,458 Tons.	783,299
All other products.......................	....	397,965
Total value.........	....	$10,747,579

Comparative Table showing the Product of the United States, Dominion and Newfoundland Cold Water Sea Fisheries from 1870 to 1876.

VALUE IN DOLLARS.

YEAR.	United States.	Dominion of Canada.	Newfoundland.
1870........	5,313,967	7,000,000	7,260,298
1871........	11,482,410	8,000,000	8,086,081
1872........	9,526,647	9,570,116	6,954,528
1873........	8,348,185	10,754,088	8,133,965
1874........	9,522,553	11,681,886	8,511,710
1875........	10,747,579	10,347,886	7,845,328
1876........	9,756,683 (2)	11,019,451	7,687,877

Product of the United States and of British American Cold Water Fisheries Compared.

YEAR.	United States.	British North America.	Difference.
1870........	5,313,967	14,260,298	8,947,331
1871........	11,482,410	16,086,081	4,603,671
1872........	9,526,647	16,524,644	6,997,997
1873........	8,348,185	18,793,953	10,445,768
1874........	9,522,553	20,193,596	10,671,043
1875........	10,747,579	18,193,214	7,445,635
1876........	9,756,683	18,707,328	8,959,645

From this table it is evident that the mean annual yield of the Sea Fisheries of the United States,—the greater portion of the catch being made in waters off British American coast lines,—is not much more than half of the combined catch of the Dominion and Newfoundland.

1. Annual Report of the Chief of the Bureau of Statistics, Commerce and Navigation, 1875 Page 819.
2. Cold Water Fish. (See page 62.)

No. IV.

Table showing the Average Exports or Catch of Codfish and the Cod Tribe, during groups of five years, from 1846 to 1875, by Scotland, Norway, Newfoundland, Canada and France.

YEARS.	SCOTLAND.		NORWAY.	NEWFOUNDLAND.	CANADA.	FRANCE.
	Total quantity of Cod, Ling and Hake Cured.	Total quantity of Cod, Ling and Hake Exported.	Cod, Ling, Hake, Pollock, Haddock Exported.	Codfish Exported.	Codfish Catch.	
	Cwt.	Cwt.	Quintals.	Quintals.	Quintals.	
1846 to 1850......	90,486	25,832	537,450	980.336		Average aggregate of the entire French catch on the Grand Banks, the Coasts of Newfoundland and the Gulf of St. Lawrence, about 500,000 quintals each year.
1851 to 1855......	104,780	21,499	605,737	953,858		
1856 to 1860......	108,968	32,847	666,076	1,220,154		
1861 to 1865......	108,658	41,011	751,382	1,056,551		
1866 to 1870......	126,032	50,925		1,130,176 (1)		
1871 to 1875......	151,375	64,159		1,333,009	785,426	

1. Mean of the years 1867-69-70.

No. V.

Table showing the Average Catch or Exports of Herring during groups of five years, from 1846 to 1875; by Scotland, Norway, the Netherlands, Newfoundland, and Canada.

YEARS.	SCOTLAND.		NORWAY.		NETHERLANDS.	NEWFOUNDLAND.	CANADA.
	Cured.	Exported.	Spring Herring–Catch.	Spring & other Herring Exported	Exported.	Exported.	Catch.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1846 to 1850,..........	625,854	274,110	....	618,590	....	13,185	
1851 to 1855,..........	650,804	338,864	....	565,051	....	39,100	
1856 to 1860,..........	599,921	340,985	476,000	600,288	....	59,570	
1861 to 1865,..........	683,392	402,038	662,200	785,413	....	57,462	
1866 to 1870,..........	728,694	423,881	....	865,326	21,126	173,370	
1871 to 1875,..........	892,421	611,305	....	....	58,022	106,140	344,400

SUMMARY.

		Total value in Dollars.
I.	British European Sea Fisheries	$34,090,000
II.	British American Sea Fisheries[1]	20,193,596
III.	United States[2]	13,030,821
IV.	France[3]	12,166,666
V.	Norway[4]	6,250,219
VI.	Russia, (European Sea Fisheries)	2,425,156
	" (Asiatic Fisheries	10,896,625
VII.	Netherlands	1,635,725

1. 1874.
2. The Oyster Shell Fish Industry of the United States exceeds $25,-000,000.
3. 1874.
4. 1874.

APPENDIX.

No. 1.

"I have spoken of the discolored portions of the Arctic Sea as abounding in animal life, and this life was nowhere so abundant as in those dark spaces which, as I have already demonstrated, owe this hue to the *Diatomaceæ* in question.

These animals are principally species of *Beroidæ* and other *Steganophthalmous Medusæ; Entomostraca*, consisting chiefly of *Arpacticus Kronii*. A *chelifer* and *Cetochilus Arcticus* and *Septentrionalis*, and Pleropodous Mollusca—the chief of which is the well-known *Clio borealis*, though I think it proper to remark that this species does not contribute to the whale's food nearly so much as we have been taught to suppose. The discolored sea is sometimes perfectly thick with swarms of these animals, and then it is that the whaler's heart gets glad as visions of "size whales" and "oil money" rise up before him, for it is on these minute animals that the most gigantic of all known beings solely subsists. What, however, was my admiration (it was scarcely surprise) to find, on examining microscopically, the alimentary canals of these animals, that the contents consisted entirely of the *Diatomaceæ* which give the sable hue to portions of the northern sea in which these animals are principally found! It thus appears that in the strange cycle of "Nature" the "whale's food" is dependent on the Diatom, so that in reality the great things of the sea depend for their existence upon the small things thereof! I subsequently found (though the observation is not new) that the alimentary canals of most of the smaller *Mollusca, Echinodermata*, etc.. were also full of those *Diatomaceæ*. I also made an observation which is confirmatory of what I have advanced regarding the probability of these minute organisms giving off *en masse* a certain degree of heat, though in the individuals inappreciable to the most delicate of our instruments. On the evening of the 4th of June this present year (1867), in latitude 67° 26 N., the sea was so full of animal (and *Diatomaceous*) life that in a few minutes upwards of a pint measure of *Entomostraca, Medusæ* and *Pteropoda* would fill the towing net. The temperature of the sea was then, by the most delicate instruments, found to be 32°.5 Fahr., and next morning (June 5th) though the air had exactly the same temperature, no ice at hand, and the ship maintained almost the same position as on the night previous, yet the surface temperature of the sea had sunk to 27°.5 Fahr., and was clear of life, so much so that in the space of half an hour the towing net did not capture a single *Entomostracon, Medusa* or *Pteropod*. I also found that this swarm of life ebbed and flowed with the tide, and that the whalers used to remark that whales along shore were most frequently caught at the flow of the tide, coming in with the banks of whales' food. This mass of minute life also ascends to the surface more in the calm Arctic nights when the sun gets near the horizon during the long summer day.

In 1861 I was personally acquainted with the death of thirty individuals of the "Right Whalebone Whale" (*Balæna mysticetus L.*) and of this number fully three-fourths were killed between ten o'clock, p. m., and six o'clock, a. m., having come on the "whaling grounds" at that period (from amongst the ice where they had been taking their *siesta*), to feed upon the animals which were then swarming on the surface, and these again feeding on the *Diatomaceæ* found most abundantly at that time in the same situations. I would, however, have you to guard against the supposition, enunciated fully enough in some compilations, that the "whale's food" migrates, and that the curious wanderings of the whale north, and again west and south, is due to its "pursuing its living;" such is not the case. The "whale's food" is found all over the wandering ground of the *Mysticete*, and in all probability the animal goes north in the summer in pursuance of an instinct implanted in it to keep in the vicinity of the floating ice-fields (now melted away in southern latitudes), and again it goes west for the same purpose, and finally goes south at the approach of winter—but where, no man knows.

There are some other streaks of discoloured water in the Arctic Sea known to the whalers by various, not very euphonious names, but these are merely local or accidental, and are also wholly due to *Diatomaceæ*, and with this notice may be passed over as of little importance. I cannot, however, close this paper without remarking how curiously the observations I have recorded afford illustrations of representative species in different and widely separated regions.

In the Arctic Ocean the *Balæna mysticetus* is the great subject of chase, and in the Antarctic and Southern Seas the hardy whalemen pursue a closely allied species *Balæna Australis*. The northern whale feeds upon *Clio borealis* and *Cetocheilus septentrionalis*; the southern whale feeds upon their representative species *Clio Australis* and *Cetochilus Australis*, which streak with crimson the Southern Ocean for many a league. The northern sea is dyed dark with a Diatom on which the *Clio* and *Cetochilus* live, and the warm waters of the Red Sea are stained crimson with another Alga: and I doubt not that, if the southern seas were examined as carefully as the northern have been, it would be found that the southern "whales' food" lives also on the Diatoms staining the waters of the Austral Ocean.

I do not claim any very high credit for the facts narrated in the foregoing papers, either general or specific, for really it is to the exertions of the sailor-savant, William Scoresby, that the first light which has led to the solution of the question is due, though the state of science in his day would not admit of his seeing more clearly into the dark waters of that frozen sea he knew and loved so well. At the same I believe that I am justified in concluding that we have now arrived at the following conclusions from perfectly sound data, viz.: [1]

1st. That the discoloration of the Arctic Sea is due not to animal life but to *Diatomaceæ*.

2nd. That these *Diatomaceæ* from the brown staining matter of the "rotten ice" of northern navigators.

3rd. That these *Diatomaceæ* form the food of the *Pteropoda, Medusæ* and *Entromostraca*, on which the *Balæna mysticetus* subsists.

---

1. Dr. Robert Brown "On the Nature of the Discolouration of the Arctic Seas."—Transactions of the Botanical Society of Edinburgh; 1875.

No. 2.

NOTES ON THE NORTHERN LABRADOR FISHING GROUNDS.

(Revised by the Author.)[1]

The Fishing Grounds on the Atlantic Coast of the Labrador as far north as Sandwich Bay, have been occupied to a greater or less extent for one hundred and twenty years. Those extending from Sandwich Bay to Cape Harrison or Webeck, have also been visited by fishing craft for a generation or more; but north of Aillik, about 40 miles from Cape Harrison, the coast has only been frequented by Newfoundland cod fishing craft, during the last fifteen years. A Quebec and a London house have possessed detached salmon fishing Stations as far north as Ukkasiksalik or Freestone Point, (lat. 55°.53, long. 60°.50) for about 30 years, but these have all passed into the hands of the Hudson Bay Company. Until the recent publication of Staff Commander Maxwell's Surveys, [2] our knowledge of the Labrador coast has been chiefly derived from the Moravian Missionaries, and the surveys of certain harbors far removed from one another, by the officers of Her Majesty's vessels.

A glance at Commander Maxwell's chart, when compared with any document published previous to 1876, shows how little is known respecting the geographical outlines of this extended coast line, which, from its amazing fish wealth, promises to become a very important commercial adjunct to Newfoundland.

The leading characteristics of the coast north-west of Aillik are as follows:—

1st. The shore line is deeply serrated by a constant succession of profound and narrow fiords stretching from 30 to 50 miles into the interior.

2nd. It is fringed with a vast multitude of Islands, forming a continuous archipelago from Cape Aillik to Cape Mugford, averaging 20 miles in depth from the mouth of the fiords seawards.

3rd. Outside of the Islands and about 15 miles seawards from them, are numerous banks and shoals, which form the summer feeding grounds of large cod, while outside of the shoals, there appears to be a second range of banks and slopes, which are probably their winter feeding-grounds.

4th. The island-studded area forms an immense cod-fishing ground, which covers between Cape Harrison (Webeck) and Cape Mugford, a boat fishing ground, exclusive of the shoals and banks outside, nearly as large as the combined area of the English and French boat fishing ground on the coasts of Newfoundland. [3]

For the sake of distinction, I have styled the area under review, "The Northern Labrador Fishing Grounds," beginning at Cape Harrison (Webeck) and, for the present at least, terminating at Cape Mugford.

AREA OF THE NORTHERN LABRADOR BOAT FISHERY.

The following table shows approximately the area of the boat fishing-grounds about the Island of Newfoundland, and the northern and southern divisions of the Labrador. From this table it will be seen that the area of the northern Labrador fishing grounds alone, exclusive of the Banks, amounts to about five-sixths of the entire area of the British and French boat fishery on the coast of Newfoundland. The area of the inner range of banks cannot be even approximately stated.

Comparative Table of Newfoundland Fishing Ground Area.

	Area of Fishing Ground. Geo. Square Miles.
Northern Labrador Boat Fishery—Cape Harrison to Cape Mugford, 260 miles, averaging 20 miles deep among Islands	5200
Newfoundland Boat Fishery—French Shore—Cape St. John via Cape Bauld to Cape Ray, 696 miles, by 3 miles deep—Shore Fishery	2088
South Shore of Newfoundland Boat Fishery—Cape Race to Cape Bonavista, 294 miles, 3 miles deep—Shore Fishery	882
North East Shore of Newfoundland Boat Fishery—Cape Bonavista to Cape St. John, 225 miles, 3 miles deep—Shore Fishery	675
North East Shore of Newfoundland Boat Fishery—among the islands in Bonavista Bay and Bay of Notre Dame, 120 miles, 7 miles deep	840
Area of British Newfoundland Boat Fishery	4116
Area of French Newfoundland Boat Fishery	2088
Total area of Newfoundland Boat Fishery	6204
Area of Northern Labrador Boat Fishery—Cape Harrison to Cape Mugford	5200
Area of Southern Labrador Boat Fishery—Cape Harrison to Blanc Sablon, estimated five miles deep	1900
Total area of Labrador Boat Fishery	7100

---

1. The following letter accompanied the Paper.

St. John's, Newfoundland, *8th November*, 1876.

Sir,—I have the honor to submit for the information of His Excellency, the enclosed "Notes on the Northern Labrador Fishing Grounds."

Since the sketch Charts illustrating these Notes were sent to you in September last, I have had the opportunity of seeing and studying Commander Maxwell's Chart of the Labrador from Sandwich Bay to Nain, published during the past summer. This most valuable and timely addition to our knowledge of the Labrador Coast will serve to illustrate the accompanying Notes respecting its Fisheries, and form to a certain extent the basis of future enquiry into the resources of these Northern Seas.

I am convinced that investigations extended over another season, and having the study of the Fisheries as far as Cape Mugford or Cape Chudleigh in view, would lead to the acquisition of information of great value to the commercial interests of Newfoundland, if pursued in a scientific manner, and the deductions compared with the results of similar enquiries on the Coasts of the United States, the Dominion, and Northern Europe.

I have the honor to be,
Your obedient servant,

The Hon. F. B. T. Carter, M. E. C., Attorney-General. HENRY Y. HIND.

2. Coast of Labrador—Sandwich Bay to Nain, including Hamilton Inlet. By Staff Commander W. F. Maxwell, R. N. Published at the Admiralty, 10th July, 1876.

3. Capt. Chimmo, R. N., states that in 1867 he was informed of the existence of Banks with fish, 50 miles east of Cape Harrison (Webeck).

PHYSICAL OUTLINES OF THE COAST.

As in Norway, so on the Labrador, the whole coast, from the Straits of Belle Isle to Hebron, is deeply cut by profound Fiords penetrating the land from 30 to 70 miles. These Fiords have been mapped as far as Hamilton Inlet by the officers of Her Majesty's vessels, but beyond that point no surveys have been made and published, with the exception of those before mentioned. As an illustration of one of the unsurveyed Fiords, I append a sketch plan made this summer of Kypokok Bay, the next Bay north of Aillik. It is fifty-three miles deep, estimated from Aillik Head, and has an average breadth of three miles. Opposite the Hudson Bay Co.'s Post, 35 miles from Aillik Head, the water is more than fifty fathoms deep, although not above a mile across. This Bay or Fiord has been excavated by glaciers, like all the other Fiords on this coast, and the innumerable Islands off the coast are rocky eminences which have escaped the general glacial denudation. But the glaciers of Labrador have probably left even more valuable records, in the form of moraines, of their early existence here, than deep Fiords or innumerable Islands. These are the shoals or banks which lie some fifteen miles outside of the Islands, and on which ice-bergs strand in long lines and in groups. I have styled them the Inner Range of Banks, to distinguish them from a supposed Outer Range in deeper water, where large ice-bergs sometimes take the ground. The inner banks, as far as they are known, are stated by fishermen to have from twenty to forty fathoms of water on them Commander Maxwell's soundings between Cape Harrison and Gull Island near Hopedale, and just outside of the Island Zone, rarely show depths greater than 40 fathoms. In one instance only, in a distance of about 110 nautical miles, is a depth of 59 fathoms recorded.

ABSENCE OF ISLANDS ON THE SOUTHERN LABRADOR.

The Admiralty Chart portrays a very important conformation of the Labrador Coast line, from St. Lewis Sound to Spotted Island. The trend of the Coast line between the Battle Islands, South of St. Lewis Sound, and Spotted Island, Domino Run, a distance of 65 miles, is due North, and with very few exceptions there are no islands off the Coast throughout this distance, excluding the group close in shore between Spotted Island and Stoney Island. As soon as the Coast line begins to turn North-westerly, Islands become numerous, and continually increase in number as far as Cape Mugford, and even towards Cape Chudleigh. Between Cape Harrison and Cape Mugford the Island zone may be estimated as having a depth of twenty miles from the mouth of the Fiords seawards. The cause of the general absence of Islands South of Spotted Island and Stoney Island can probably be traced to the never ceasing action of Northern ice, driven on the Coast line where it suddenly makes its southerly bend, by the influence of the rotation of the earth upon the Arctic Current.[1] This current sweeps past the Labrador with a speed of from 1½ to 2 knots an hour, and a westerly pressure, due to the earth's rotation, which may be estimated at about eleven inches. That is to say, the mean level of the sea on the coast of Labrador is supposed to be about eleven inches above the level it would assume if uninfluenced by the earth's rotation.[2] As soon as the ice-ladened current reaches Spotted Island it is in part relieved from this pressure by the trend of the Coast from South-east to due South, hence the current changes its course southerly and on to the land. But the effect of this sudden change in the direction of the current near the shore is to throw the ice-bergs on to the coast from Spotted Island to Cape St. Lewis, where they may be seen stranded each year in great numbers. The Islands which doubtless once existed here, have been removed by constant abrasion, acting uninteruptedly for ages, and with the Islands the moraines lying seawards. We may thus trace the cause of the vast difference between the distribution of stranded ice-bergs South of Spotted Island and North-west of it. In one case they are stranded near the coast line, wearing it away and deepening the water near it, assisted by the undertow; in the other case they are stranded some fifteen miles from the Island fringe, and continually adding to the Banks the debris they may bring, in the form of mud streaks, from the glaciers which gave them birth in the far North and North-east. It is more than probable that this distribution of ice-bergs has a very important bearing upon the food and feeding ground of the Cod, which justifies me in referring here with so much detail to the action of glacial ice.

RELATION OF THE CODFISH TO STRANDED ICEBERGS.

Upon what forms of life do the cod feed on the Northern Labrador coast, where the summers are so short, the caplin, the herring, the squid, and even launce comparatively scarce, and where ice-bergs continually abound? The answer may be expressed, speaking generally, in one word—crustaceans. These are infinite in number, from the minute sea-lice of the fishermen to a large crustacean resembling a prawn; crabs are very numerous, as well as mollusks. Although the caplin is said not to appear on the coast in large schools above the latitude of Nain, the herring is not reported to be numerous beyond Ukkasiksalik, the squid is stated not to be found beyond Domino Run, and the launce is considered to be the only known Southern Labrador fish which visits the northern coasts in great numbers, yet crabs, shrimps, prawns and "herring bait" with medusæ occur in vast profusion, and form, with mollusks, the chief food of the cod. The officers in charge of the Hudson Bay Co.'s Post at Ukkasiksalik informed me that at the more northern Hudson Bay posts, if seals were left in the fall of the year for a single night in the nets, the head was sure to be cleaned to the bone by prawns. He also stated that in the northern waters opposite Hebron, Lampson and Nachwack, the cod feed on a small fish bearing a resemblance to the ordinary tommy-cod, but that crustaceans were their chief food The connection existing between ice and the food of the cod is not apparent at the first blush, but when it is borne in mind that infusorial forms and diatomaceæ abound in sea-water in the immediate vicinity of arctic ice, and on these minute organisms larger forms of life find sustenance, which again become the food of crustaceans and different species of fish, upon which the cod are nourished, the chain is complete, and the relation of stranded ice-bergs to fish life on the Labrador becomes apparent. It has been shown by the labors of the United States Fishery Commission, that the cod, which once existed to a large extent on the New England coast, has been starved out by the destruction of its food, and valuable fisheries ruined, but not beyond the power of restoration, if the remedial measures suggested are faithfully carried out and sufficient time allowed. But on the Labrador, particularly the northern portion, through the unfailing advent of Arctic ice, a perennial supply of food is indirectly supplied to the cod, forbidding the idea of starvation on these coasts.[3]

THE INNER RANGE OF BANKS.

The foundation of the inner range of banks consists, very probably, as already stated, of glacial moraines. In their present state they may reasonably be assumed to be formed in great part of remodelled debris brought down by the same glaciers which excavated the deep fiords.

The absence of deposits of sand in the form of modern beaches on every part of the Labrador Coast visited this

1. See a paper by the Author, published in Vol. VIII. of "*The Canadian Naturalist*," entitled "Notes on some Geological Features of the North-eastern Coast of Labrador," April 6th, 1877.
2. See Colding "On the Laws of Currents in Ordinary Conduits, and in the Sea."—*Nature, Dec.* 1871.
3. See a paper by the author entitled, "Notes on the Influence of Anchor Ice in Relation to Fish Offal and the Newfoundland Fisheries." Part I. and Part II. St. John's, Newfld, 1877.

season, except one, was very marked. The exceptional area observed lies between Sandwich Bay and Hamilton Inlet, Cape Porcupine being the centre. It is protected from the northern swell of the ocean by the Indian Harbor Islands and promontory, Here large deposits of sand are seen covering many square miles in area. The reason why sandy beaches are not in general found on this coast, notwithstanding that enormous quantities of rock are annually ground up by coast ice, and ice pans driven on the shore, arises from the undertow carrying the sand seawards and depositing it on the shoals or banks outside of the Islands.

It may be advisable here to advert to a popular error which assumes that the depth of water in which an ice-berg grounds is indicated by the height of the berg above the level of the sea. It is commonly stated that while there is one-ninth above, there will be eight-ninths of the berg below the sea level. This is approximately true only with regard to volume or mass of the berg, not with regard to height and depth. A berg may show an elevation of one hundred feet above water, and yet its depth below may not exceed double that amount, but its volume or mass will be about eight times the mass it shows on the surface. Hence, while icebergs ground in thirty and forty fathoms of water, they may expose a front of one hundred or one hundred and fifty feet in altitude, the broad, massive base supporting a mass about one-ninth of its volume above the sea level.

MOVEMENTS OF THE COD ON THE LABRADOR.

The following tables show the periods of first arrival and last catch of Cod on the Newfoundland and Labrador Coasts. In framing these tables I have been careful to eliminate extreme seasons, for the Cod have been known to approach the shore during an exceptionally early season, a fortnight or three weeks sooner than during the average of years. Early and late springs occur in the movements of fish just as irregularly as in the movements of migratory birds or in the leafing and flowering of plants. The Salmon and the Cod generally come within a week of one another, and the Eskimo of Ukkasiksalik have a tradition that the Salmon may always be looked for on the day of the first spring tide after the 16th July. In 1875, a very late season, Codfish were not taken before the 7th August; this year they came in on the 20th July, and this accords with the experience on other parts of the coast.

An impression prevails among fishermen that the Caplin are "moving north," and that the Cod are following them. This opinion is not shared by the missionaries who have occupied the coast for a century. They have known the Caplin as far north as Nain for many years. On the Admiralty Chart of Port Manvers (lat. 57, long. 62.7) thirty miles north of Nain, constructed by Capt. Manby in 1808 and published in 1871, Caplin Bay is the name given to an anchorage at Port Manvers, from which it is manifest that Caplin were seen there sixty-eight years ago, or half a century before the fishermen passed Aillik Bay, or even Cape Harrison, nearly 200 miles to the south-east. The Caplin, however, is not known to the officers of the H. B. Company's Post, or to the missionaries, beyond Cape Mugford.

Elsewhere it is shown that the Caplin is an inhabitant of seas very much farther to the north than those washing the Coast of Labrador. It is abundant on the South Greenland Coast, and visits the Northern Coasts of Norway in incalculable numbers.

TABLE showing the approximate mean date of arrival of Cod, mean date of departure, and mean length of the Fishing Season for Cod, in North-eastern Newfoundland, Southern and Northern Labrador:

Lat.	Locality.	Mean Date of Arrival.	Mean Date of Close of Fisheries.	Mean Length of Fishing Season.
	NEWFOUNDLAND,—			
47.30	Conception Bay,..............	1st June,	20th Nov.	
48.20	Bonavista Bay,..............	10th "	10th "	
48.30	Notre Dame Bay..............	20th "	10th "	
50.	Cape St. John to Par. Point,....	20th "	1st "	143 days.
49·30	White Bay,..............	10th "	1st "	
51.	Cape Rouge Harbor..............	10th "	1st "	
51.30	Cape Bauld to Cape Onion,......	20th "	20th October	
	Over four degrees of Latitude.			
	SOUTHERN LABRADOR,—			
52.0	Chateau Bay,..............	20th June,	1st October	
53.24	Batteaux,..............	12th July,	10th "	87 days.
54.26	Indian Harbour,..............	15th "	1st "	
54.56	Cape Harrison,..............	18th "	1st "	
	Over three degrees of Latitude.			
	NORTHERN LABRADOR,—			
55.14	Aillik,..............	20th July,	1st October	
54.57	Kypokok,..............	20th "	1st "	
55.27	Hopedale,..............	20th "	1st "	
53.30	Double Island Harbor,.........	22nd "	1st "	
55.52	Ukkasiksalik,..............	28th "	1st "	61 days.
56.33	Nain,..............	28th "	1st "	
57.30	Okak..............	28th "	1st "	
58.30	Hebron..............	15th Aug.	25th Sept.	
58.46	Lampson,..............	15th "	15th "	
	Over three and a half degrees of Latitude.			

From this Table, imperfect as it is, we may deduce the following law: "Over an area extending northerly from Conception Bay for seven hundred miles, the cod approach the shore about one week later for every degree of latitude we advance to the north."

These tables show also that for a period of about forty days the cod-fishery goes on simultaneously during August and September, throughout the length of a coast line extending from latitude 47° to latitude 58°.30, or more than seven hundred statute miles in one continuous line. Hence it appears that the migrations of the schools of this fish are morely from deep water winter feeding grounds to the nearest coast spawning grounds, and from the coast to the nearest deep water feeding grounds again.*. The coast migrations during the summer months appear to be of equally limited extent, and schools of cod frequenting any particular coast, may be said to be INDIGENOUS to it.

On the Labrador, especially in well-known deep bays, such as Hamilton Inlet, the coast movements of the fish appear to be very regular and determined to a large degree by the tidal currents. The caplin generally precede the Cod by a few days, and these fish are known to approach the coast and enter sandy coves for the purpose of spawning. The same meteorological influence which guides the movements of the cod affects also the periods of spawning of the caplin. I saw numerous schools of this fish spawning in Trinity Bay on the 27th June, a month later they spawn in Kypokok Bay, and still later further to the north.

PRESENT STATUS OF THE NORTHERN LABRADOR FISHERY.

About four hundred fishing craft, from eighteen to ninety tons burden, are supposed to have passed Cape Harrison this season. [1] Taking the average of the entire fleet, they carried each eight men, three fishing boats and one shore boat. Out of the 3200 hands, we may assume that 2400 were actually engaged in fishing. The estimated catch was 60 quintals per man, or in the aggregate 144.000 quintals. This work was accomplished in an average aggregate of twenty-four fishing days, and to a large extent with the jigger, [2] that is, without the use of bait. The average weight of the fish is about 3 lbs fresh. Allowing 130 fish to the quintal the number taken would be about eighteen millions, the number wounded and lost about four and a half millions, although some fishermen consider that one fish out of three is wounded by the jigger and lost when the fish are very numerous.

During the gale of the 11th and 12th of September there lay next to us in Indian Harbor, off Hamilton Inlet, a small craft of 30 tons burden, just arrived from off Nain. She had been fishing about the Islands near the Missionary Station in lat. 56.40, about 600 miles north west of St. John's, and in three weeks had taken three hundred quintals. Her complement consisted of six men and two fishing boats. She arrived, like all the fishing fleet this year, too late to take advantage of the season. The cod had "struck in" many days before she commenced fishing. [3] Had she arrived a fortnight earlier, she might easily have taken 80 quintals to the man in place of 50, but she had *used all her salt*, and the crew were satisfied with the result. Her fishing days were eighteen in number, excluding Sundays, which are always observed by fishermen on this coast.

Another craft, also lying alongside, and hailing from Notre Dame Bay, was of 60 tons burden, her complement 12 men and 4 boats. She reached the islands off Hopedale (lat. 55 27) on the 22nd July, fished for six weeks and took 700 quintals of fish or about 60 quintals per man. She takes her green fish direct to Notre Dame Bay to make there. No fish are made or cured on this shore, as yet, north of Long Island Tickle, some twenty-five miles north-west of Cape Harrison.

Hitherto on the Northern Labrador coast, the jigger, as already stated, has been almost exclusively used; it is only lately that launce have been tried as bait, and with marked success. But it is well known that only the smaller sized cod come into shallow water, the larger fish remaining to feed on the banks outside and in deeper water. Very few attempts have been made to fish on the Labrador Banks, but when tried, I have been assured by trustworthy persons that large fish have always been taken with bait.

Larger boats than those used about the islands are required for this kind of fishing; indeed a totally different organization and equipment will be necessary for the Northern Labrador Bank Fishery, which appears destined to become, under proper encouragement and management, the FISHERY OF THE FUTURE.

THE CLIMATE.

Experience, now extended over twelve years, shows that the seasons are sufficiently late and long to permit Newfoundland fishermen to come from their homes after spring fishing is over there, and their garden work attended to. They may arrive on the Northern Labrador Fishing Grounds from the tenth to the twentieth of July, or even later if they go north beyond Nain. They may return in general by the tenth to the twentieth of September to Southern Labrador rooms, or even to their homes, with full fares of green fish.

The extremities of many of the deep Fiords from Cape Harrison to Ukkasiksalik or Freestone Point, a distance in an air line of 120 miles, contain timber fit for spars, for the construction of "fore-and-afters" and for all ordinary building purposes. The climate there, namely, *at the bottom* of many of these deep Fiords, permits of the cultivation of potatoes and other garden vegetables. Between Aillik and Ukkasiksalik, there are at present about sixty resident settlers in the deep Fiords, most of whom have been in the service of the Hudson Bay Co. or the fishing firms already named, and some of them are married to Eskimo women.

There are several other points of great interest in regard to the Northern Labrador which are worthy of notice, but the details would swell this paper to dimensions far exceeding those of a brief descriptive outline sketch of a comparatively new field for that kind of enterprise and industry in which Newfoundland is so distinguished, and from which she annually derives so much wealth.

The expansion and preservation of her fishing grounds for the use of her own people, appears to claim, however, thoughtful and liberal consideration, and not only from those who may profit by the Industry, but from those also who may be able to assist in lessening the difficulties with which it is beset, in ameliorating the hardships inseparable from its pursuit, and in aiding the development of the resources of the vast area it may yet be made to occupy.

St. John's, November 8th, 1876.

HENRY Y. HIND.

---

* This law regulating the movements of several species of fish has long since been recogni ed in other countries.

1. Capt. Chimmo in 1867 was informed that 200 sail had that year passed Cape Harrison or Webeck going North.

2. Bait was used in Stag Bay, but north of Aillik almost all the fish were taken with the jigger. The launce is stated to have been used to a small extent, as well as IMPORTED bait. The "jigger" is an implement made of lead or tin in the shape of a fish, with a cod hook soldered to it. It is rapidly drawn up and down about a yard from the bottom. No bait is used. The principle is the same as the use of a "spoon" in trowlling.

3. In 1867, a year of great catch on the Labrador, the cod and caplin "struck in" at Icy Tickle, Indian Harbor, on the 10t June, many days before the fishing fleet arrived.

INDEX.

Page.

Atwood, Captain, On the Torpidity of the Tautog in Winter.......... 11

Boeck, His Observations on the Herring.......... 36
" His Inquiries—how received by fishermen.......... 44
Bradelle Bank (footnote).......... 42
Buchan, Alexander, On the Temperature of the Sea on the Coasts of Scotland.......... 25
Buchanan, Mr., On the Specific Gravity of Sea Water 34
Buckland, Mr. F., On the decline of certain British Sea Fisheries.......... 47, 48
Bayfield, Admiral—His Description of the Prince Edward Island Double Tides.......... 2
Brown, Dr. Robert, Description of the Shrimps taken from the Stomachs of Seals.......... 7
Britt, Description of.......... 5

Caird, James, His estimate of the annual value of the British Sea Fisheries.......... 49
Carpenter, Dr., Notice of the Sand Launce.......... 6
" " Notice of the Lernea.......... 11
Codfish follow up the scent of blood against the current.......... 21
" Spawning periods of.......... 22
" Depths at which they are taken.......... 23
Cold Zones, Comparative table of.......... 29
Currents, Affected by temperature strata.......... 30
Dutch Herring Fisheries, Improvement of.......... 44
Dufferin, Lord, His observations on the temperature of the surface of the sea.......... 45

Ekman, Prof. F. L., His discovery of temperature zones in the Baltic Sea.......... 28

Fish—How affected by temperature.......... 35
The Mackerel.......... 12, 16, 18
The Herring.......... 40
The Cod.......... 37
The Tautog.......... 11
The Scup.......... 11
The Sturgeon.......... 11
The Salmon Trout.......... 12
The Sole.......... 37
On the Grand Banks of Newfoundland.......... 37

Fisheries, European Sea.......... 48
" North American Sea.......... 55
" Supposed decline of British.......... 48
" Comparison between Norwegian and Newfoundland.......... 50, 52
" Statistics of different nations.
British European.......... 48
Norwegian.......... 49
Russian.......... 52
Netherlands.......... 53
Danish.......... 54
French.......... 54
Dominion of Canada.......... 55
Newfoundland.......... 56
United States.......... 61

General Tables of Fisheries of different nations.......... 64, 65
General Summary.......... 66
Gill, Dr. Theodore, On the range of the Sand Launce.......... 6
Gulf Stream, Effects of.......... 25
Hake, Congregate to feed on offal.......... 21
Herring, Time of its appearance at the Magdalen Islands.......... 12
" Movements affected by currents.......... 30
" Its relations to temperature.......... 36

Page.

Herring, As affected by low temperatures on the Newfoundland Coast.......... 40
" Exports of Dutch.......... 44
Huxley, Prof., Notice of the Sand Launce.......... 6

Ice, Influence of the different forms of.......... 31
Berg-ice—how affected by temperature zones.......... 31
" " Elevates the temperature of the surface of the sea in winter.......... 31
" Salt water, temperature of different parts of a sheet of.......... 32, 33
" " " How formed.......... 43
" " " Produces cold zones in the sea.......... 33
" " " Anchor ice.......... 33
" " " " "..........
Isothermal lines, The relation of the Mackerel to.......... 15
Jeffreys, Dr. J. Gwyn.......... 45

Kay, James de, His description of "Britt".......... 5
" " His description of the film over the eyes of the Mackerel.......... 10
Kelly, Dr., On Temperature Zones in the Gulf of St. Lawrence.......... 28
" His Table of the Temperature of the Surface of the Sea in the Gulf of St. Lawrence.......... 43

Lernea.......... 11
Launce, or Sand Eel.......... 5
" Habits of.......... 6
" Spawning Habits of.......... 7
" How affected by weather.......... 7
Ljungman, Axel V., His enquiries, how received by Fishermen.......... 44
Loffoden, Cod Fisheries, Statistics of.......... 49

Mackerel, How they feed.......... 4
" Food of.......... 5
" " in European Seas.......... 5
" " in American Seas.......... 5, 6, 7
" Appearance of, in the Gulf of St. Lawrence 10
" Torpidity of in Winter.......... 10
" Early Fishing for in Nova Scotian waters.. 10
" When they appear at the Magdalen Islands 12
" In Bay of Notre Dame, Newfoundland.......... 14
" Migratory Movements of.......... 15
" Relation of their movements to Isothermal lines.......... 15
" Time of Spawning.......... 16
" Movements of, compared with the movements of other fish.......... 18
" Interpretation of the Movements of.......... 20
" Causes of alleged variation in the numbers of.......... 22
" Spawning Periods of.......... 22
" Eggs of, affected by storms.......... 22
" Movements of, affected by currents.......... 30
" " as affected by temperature.......... 41, 43
" Where the young are found.......... 42

Newton, Mr., On the decline of the British Sea Fisheries.......... 48
Norway, Scientific enquiries in, relating to the Sea Fisheries.......... 44
Norwegian Sea Fisheries.......... 49

Orphan Bank (footnote).......... 42

Petermann, Dr., His Table of Isothermals in the North Atlantic.......... 15

Page.

Perley, On the Sand Launce........ 6
Prince Edward Island, Cause of the wearing away of the North Shore of........ 3
Pteropods as food for Mackerel........ 9

Sea-water, Specific Gravity of........ 34
Scientific inquiries in relation to the sea fisheries...... 44

Table of the Appearances of the Herring and Mackerel at the Magdalen Islands........ 12
" of Marine Isothermals........ 16
" of the Appearance of Mackerel, Shad and Alewives at different points........ 18
" of the temperature of the sea on the coasts of Scotland........ 25
" of the temperature of the sea on the coast of Norway........ 26
" of the temperature of the sea on the Grand Banks of Newfoundland........ 27
" of mean temperature at Rama........ 38
" " " Hopedale........ 39
" " " Fogo........ 39
" " " St. John........ 39
" " " on coasts of the Gulf of St. Lawrence........ 40
" " " at Bay St. George........ 41
Temperature of the sixty fathom area in the Gulf of St. Lawrence........ 14
" Effect of, on the local movements of Mackerel........ 18
" of the sea on the coasts of Scotland........ 25
" " on the coasts of Norway....... 26
" " in the Baltic Sea........ 27
" " on the Grand Banks........ 27
" " near the Straits of Belle Isle.. 27
" of coastal waters in Massachusetts Bay.. 42
" of the surface of the sea in the Gulf of St. Lawrence........ 43
Temperature Strata, Cause of the existence of, in the ocean........ 24

Page.

Temperature Strata, Importance of a knowledge of.... 24
" " Effect of, on Currents........ 30
" " Table of........ 29
Temperature zones in Norwegian waters........ 28
" " in the Gulf of St. Lawrence........ 28
" " in the Arctic Sea........ 29
" at which Cod and Mackerel spawn in American seas........ 27
" of waters in which bergs float........ 31
" of a sheet of salt water ice........ 32
" How it affects the Herring........ 36, 40
" How it affects the Cod........ 37
" How it affects the Mackerel........ 41
" Extraordinary cold of April, 1874........ 37
Tide, Prince Edward Island, Double........ 1
" Eddy Flood, in Estuary of St. Lawrence........ 3
Tides, influence of on Fish food........ 1
" of different ages........ 2
" meet........ 2
" Effect of, in concentrating fish food........ 3, 8
" on Cape Breton coast........ 4
Tidal currents, Effect of on Temperature of the sea... 43
Torpidity of Mackerel........ 10
" of Tautog........ 11
" of Scup........ 11
" of Sturgeon........ 11
" of Salmon Trout........ 12

Scoresby, Dr., His Temperature zones........ 29
Shaw, Dr., His notice of the habits of the Mackerel... 10
Storer, Dr., His description of Britt........ 5
Sturgeon, of the Caspian Sea........ 11
" of Rainy River........ 11

Verrill, Prof., List of Marine Animals found in the Stomachs of Mackerel........ 8
Whitcher, Mr., His paper on the supposed migration of the Mackerel........ 19
Zones of life in the ocean........ 35

ERRATA.

Page.

12—13 lines from bottom, for "Stella Maria," read "Stella Maris."
13—29 lines from top, for "Stella Maria," read "Stella Maris."
18—9 lines from top, for "falacy," read "fallacy."
18—18 lines from bottom, for "appearance," read "appearances;" and for "was," read "were."
21—6 lines from top, for "shore," read "shores."
22—6 lines from top, for "eggs one or the other," read "eggs one to the other."
24—top line (heading), for "TEMPERATE," read "TEMPERATURE."
25—13 lines from top, for "temperature of Seas," read "temperature of the Seas."
27—14 lines from bottom, for "37° and 43 degrees," read "37° and 43°, that."
30—top line (heading), for "Effect of Temperature Strata or Currents," read "Effect of Temperature Strata on Currents."
31—14 lines from bottom, for "Strata of Ice," read "Strata of Water."
34—20 lines from top, for "Celsins," read "Celsius."
35—9 lines from top, for "when regular tidal," read "when regular or tidal."
39—6 lines from top, for "antigrade," read "centigrade."
45—22 lines from bottom, for "or," read "nor."
47—10 lines from bottom, for "shows," read "show."
61—7 lines from top, for "1862," read "1863."