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Article abstract

L'histoire de l'exploration des eaux côtières de la péninsule Québec-Labrador remonte très loin dans le temps, mais c'est vraiment l'Année polaire internationale de 1882 qui marqua les débuts des premières recherches sérieuses. Les progrès les plus considérables des recherches océanographiques ont cependant été réalisés depuis la II^e guerre mondiale, grâce surtout aux travaux entrepris dans l'Arctique oriental par le *Bureau des recherches sur les pêcheries.*

L'auteur s'étend d'abord sur l'océanographie physique de la région ; il étudie successivement la bathymétrie, la répartition et les caractères des principales masses d'eau, les courants, les glaces et les marées. Suit une analyse de la biologie marine, qui souligne en particulier l'importance d'un facteur : l'absence de brassage vertical des eaux. La répartition de la faune marine indique que si les régions dominées par les eaux arctiques sont riches en mammifères, celles où l'influence atlantique est forte sont de beaucoup les plus poissonneuses. L'auteur insiste sur l'importance des ressources biologiques de la mer dans l'économie alimentaire des Esquimaux.

De même qu'il existe des preuves d'oscillations climatiques à courte période, on peut aussi conclure à un réchauffement des eaux depuis le début du siècle, bien que cette tendance soit moins évidente depuis quelques années.

THE SEA WATERS SURROUNDING THE QUÉBEC-LABRADOR PENINSULA

by

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The shores of the Québec-Labrador Peninsula are washed by sea water from the Arctic and Atlantic Oceans, and by fresh water from the land ; the latter being comparatively insignificant except in Hudson Bay and the Gulf of St. Lawrence. This coastal water is part of a current system of considerable scale, involving the two outflows from the Arctic Sea through the Canadian Arctic Islands and in the East Greenland Current, and the North Atlantic Drift. The pattern of this circulation is shown in outline in Figure 1. The Arctic water, that is to say the water from the upper 200 metres of the Arctic Sea, is very cold, below 0°C., and of low salinity, between 32 and 34 ‰. The Atlantic Drift water, represented for our present purposes by the Irminger Current or Labrador Sea water, is warmer, with a maximum of about 10°C. in summer at the surface, and of salinity above 34 ‰. These two water types, together with admixture from land drainage, combine to produce the distribution shown in Figure 2, a temperature-salinity diagram constructed from observations at 50 metres depth and below, omitting the topmost layers in which seasonal and local variations are great. The surface waters are described below in the regional sections.

History

The exploration of the waters of our Peninsula can be said to have begun, no doubt, with the travels of Indians and Eskimos, especially the latter, being a maritime people. The first non-indigenous visit recorded is that of Leif Ericsson, who crossed the Labrador Sea from Greenland in the year 1000 A. D., and very probably sighted, and perhaps landed on, the Labrador coast. Indeed, the sea-going nature of the Norsemen could give us justification to suppose that Leif Ericsson was not the first to land in our area. In 1500, two Portuguese, Caspar and Miguel Cortoreal, almost reached the Québec-Labrador shores when they investigated the Newfoundland fishing banks, three years after John Cabot. Jacques Cartier of St. Malo, the first European, by all common account, to enter the Gulf of St. Lawrence, in 1534, had already visited the Canadian eastern shores ten years before that, with Verrazano. By the end of his second St. Lawrence voyage, in 1535, he had visited the Magdalen Islands, the Baie des Chaleurs, Anticosti, and had penetrated to the present location of Québec City and almost to Montréal. He had established that the Gulf of St. Lawrence was not the Northwest Passage.

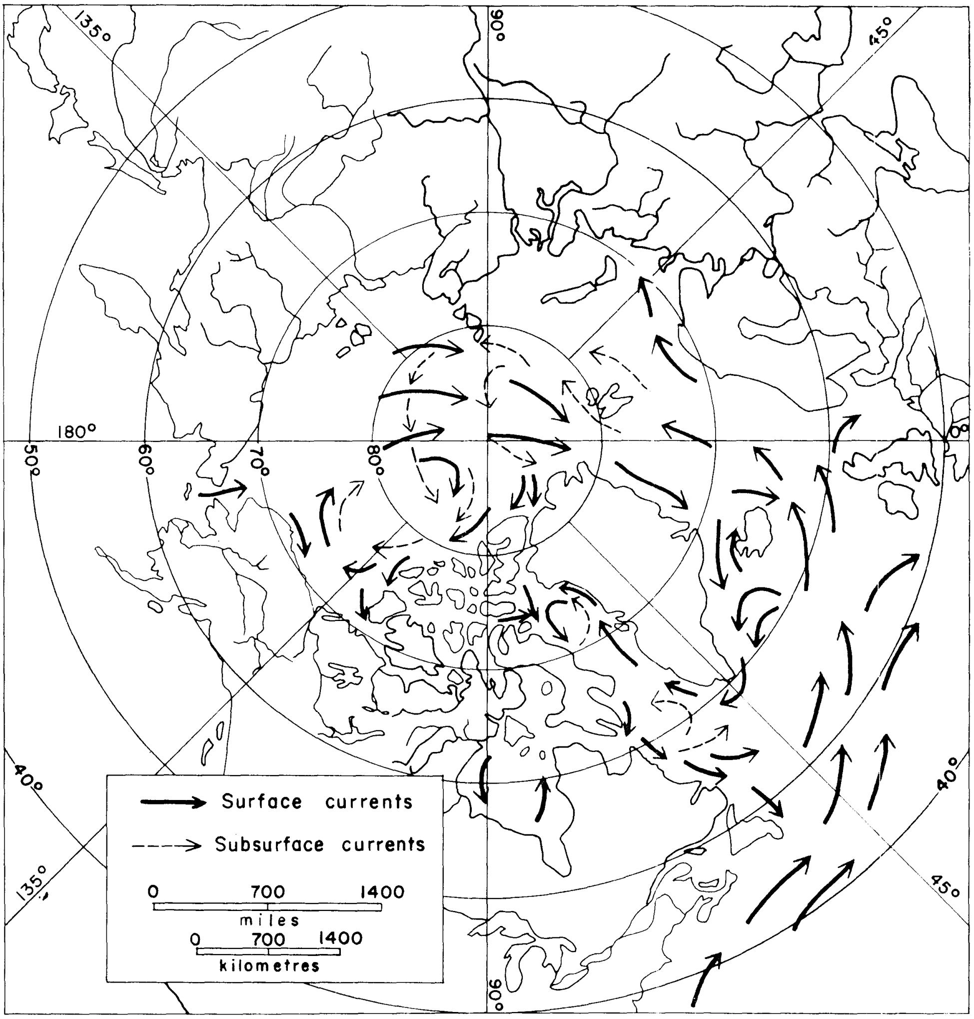

Figure 1 General circulation of Northern Atlantic and Arctic Waters.

Farther north, it was not until the year 1576 that the earlier exploits of the Norsemen were matched ; Martin Frobisher sailed up the Labrador Sea in three voyages, 1576, 1577 and 1578. A decade later, in 1585, 1586 and 1587, John Davis came by the same route, to southwest Greenland and southeast Baffin Island. The first to enter Hudson Strait, the northern boundary of the Province of Québec, was Captain Weymouth in the *Discovery* (1602), followed by Knight in 1606 and by Henry Hudson in 1610, that unhappy and disastrous voyage. Other voyages into Hudson Bay followed, some successfully in search of trade and others unsuccessfully in search of a passage to Asia, but it was not until after the Napoleonic wars that maritime exploration in our area began to take on a recognizably modern or scientific appearance. The great 1818

Arctic expedition under Parry sailed east and north of the Labrador Peninsula, but Parry tried a more southerly route in 1821, in the *Fury* and *Hecla*, sailing into Hudson Bay. Subsurface temperatures were measured for the first time on the 1818 expedition.

There followed several marine expeditions to areas farther north, including the Franklin exploit of 1845-47. Of the forty expeditions sent out in the following decade to find Franklin, thirty-four were marine, and some of them added to oceanographic knowledge of the Québec Peninsula. It was not until well into the second half of the nineteenth century, however, that really serious work began in our area.

In 1860-61, Leopold McClintock and G. C. Wallich began soundings in the Labrador Sea, between Labrador and West Greenland, in the *H.M.S. Bulldog*. This was followed in 1868 by the *H.M.S. Gannet*, Captain Chimmo. In 1875, Captain Carpenter in the *Valorous* made three oceanographic stations in the Labrador Sea, including temperature measurements at intervals from the surface to the bottom (Carpenter, 1877).

1882 was the year of the first International Polar Year Expeditions, forerunners of IGY. The U.S. Army, besides sending Greely to Ellesmere Island, sent L. M. Turner to Fort Chimo, at the head of Ungava Bay, to make general scientific observations including meteorological and oceanographical, the latter consisting of tidal and ice observations. Two years later, in 1884, the first Canadian Government eastern arctic expedition was launched, under Lieutenant Gordon in the *Neptune*, whose program included the measurement of surface temperatures and the recording of ice and tides in Hudson Strait. The next year and the year after, the *Alert* continued this work, again in Hudson Strait. In 1889 the Danish vessel *Fylla*, on her third Greenland cruise, extended investigations into the Labrador Sea on the Canadian side. The work of this ship established the existence of the Baffin or Canadian Current, flowing down the east coast of Baffin Island, which is continued as the Labrador Current, and had demonstrated the mixture of the Atlantic and East Greenland Arctic water to form the West Greenland Current. Much later, Smith, Soule and Mosby (1937), of the U.S. Coastguard Expeditions, paid tribute to the accuracy and significance of the *Fylla* results. Another Danish expedition in the *Ingolf*, with the scientific program under Dr. Martin Knudsen, elaborated and extended the work of the *Fylla*, particularly (for present purposes) in the Labrador Sea. This was in 1895 and 1896.

The Canadian Government Ship *Diana*, under Captain Wakeham (whose name is now remembered in Wakeham Bay), made a voyage into Hudson Strait and Hudson Bay in 1897, reporting on ice conditions, tides, and depths. In 1900 an expedition from Brown and Harvard Universities worked at Nachvek, Labrador, and brought back some information on temperatures and depths. Three years later came the famous cruise of the *Neptune*, Canadian expedition led by A. P. Low, which included Hudson Strait and Hudson Bay in its coverage. The main objectives were not oceanographic, however. Captain Bernier, an equally redoubtable explorer, sailed the *Arctic* on three expeditions in 1906, 1908 and 1910 ; although he was concerned mainly with the more distant north, he added to our knowledge of marine conditions along the Labrador coast.

The first hydrographic section to be made across the Labrador Current was the work of the *Scotia* expedition under D. J. Matthews, at the latitude of Hamilton Inlet, in 1913. The next year the *Burleigh* sailed into Hudson Bay on fisheries investigations, and, more important, 1914 was the first year of the work of the International Ice Patrol, which has been maintained ever since by the United States Coast Guard, with interruptions during two world wars. The knowledge of the Labrador Sea and the coastal waters of Labrador that has grown from these Coast Guard expeditions is a veritable memorial to the value of hard, routine, continued scientific work at sea, year after year in the same area. Individual expeditions of this program are mentioned in particular below, but it is the maintenance of the effort that is the truly valuable thing.

By this time the Canadian Government had turned its attention to the Gulf of St. Lawrence, the waters immediately to the south of the Québec-Labrador Peninsula. Efforts had been made at the end of the last century to begin oceanographic work, both biological and physical, on the eastern Canadian shores including the Gulf, but it was not until the *Michæl Sars* expedition of 1910, under Dr. Johan Hjort and Sir John Murray, that the benefits to be gained from marine research were brought home to Government. The Department of the Naval Service supplied the funds to bring Dr. Hjort to Canada and to float the Canadian Fisheries Expedition of 1914-15. It is from the report of that expedition (Hjort, 1919) that scientific work in the Gulf of St. Lawrence is to be dated.

The Cheticamp expedition in 1917, and the Miramichi expedition in 1918, worked in the Gulf, and in 1923 the Biological Board (now the Fisheries Research Board) sent an expedition in the *Arleaux* and *Prince,* under Dr. A. G. Huntsman, to the Strait of Belle Isle, which established the water exchange in that area (Huntsman, 1924). The Norwegian vessel *Michæl Sars*, which had made preliminary investigations on the Newfoundland Banks in 1910, was sent by the Norwegian Government to Davis Strait in 1924, between Greenland and Baffin Island, making observations which contributed much to our understanding of the Labrador Current. Knowledge of the Labrador Current was given greater precision by the work of Dr. Iselin (Iselin, 1927, 1932) in the schooner *Chance*, particularly in northern Labrador.

The year 1928 saw two important expeditions in the Labrador Sea and farther north : the U.S. Coastguard Expedition in the *Marion* and the Danish *Godthaab* Expedition (Smith, Soule and Mosby, 1937, and Riis-Carstensen, 1931). Both expeditions together can well claim the basic foundation of scientific research in the Eastern Arctic waters of Canada. It is a witness to our landlubber attitude to polar exploration that neither expedition is mentioned at all in contemporary histories of arctic exploration. The U.S. Coastguard made later expeditions to the same general area in 1931, 1933, 1934, and 1938, and, as already mentioned, has continued routine observations of inestimable value.

The Canadian vessel *Acadia* worked in Hudson Strait and Hudson Bay in 1929, 1930 and 1931; these were the first Canadian expeditions to extend their oceanographic investigations below the surface, and they were the heralds of Canadian work in the Eastern Arctic which has gained momentum steadily. In 1930 the trawler *Loubyrne*, with the scientific work in the charge of Dr. H. B. Hachey, was sent to Hudson Bay, and produced the first physical oceanographic results from that most important Canadian sea. Quoting from Dunbar (1951): « . . . the cruise was hurried, so that Hachey did not have the opportunity to make as complete a survey as he would no doubt have liked. The sections had to be made along the line of route, and hence in Hudson Strait they were made parallel to the currents instead of across them. Nevertheless, the results (Hachey, 1931*a*, 1931*b*) are very important, supplying as they do the only information we now have for purposes of comparison with later work. »

In 1931, 1932 and 1933, the Newfoundland Government *Cape Agulhas* made a series of hydrographic stations in the area of the Strait of Belle Isle and southern Labrador. The Forbes Labrador expeditions of 1931 and 1932 made a coastal survey, largely from the air, producing sailing directions and maps which are even today unrivalled for accuracy; and in 1932 also, the *H.M.S. Challenger* began work on the Labrador coast, which included sections out from Cape Harrigan in central Labrador. In the two following years the *Challenger* work was restricted to coastal survey and soundings between Indian Harbour and Cape Chidley.

In 1938, to quote from Hachey (1961), « the Biological Station of Laval University, which had been located for several years at Trois-Pistoles, was moved to Grande-Rivière, Québec, to initiate studies in the marine biology of the northern part of the Gulf of St. Lawrence. The activities of this Biological Station continued over a period of years, finally being incorporated into the Marine Biological Station which is now operated at Grande-Rivière by the Department of Fisheries of the Province of Québec. » At about the same time (1937-39) the Finland Labrador Expeditions made important studies on the Labrador coast, and the final report (Tanner, 1947) included an excellent description of the waters of the Labrador coast compiled from various sources.

Oceanographic research came to a virtual standstill during the war, but developed enormously after it. In 1947 the Fisheries Research Board began operations in the Canadian Eastern Arctic, under M. J. Dunbar ; the Arctic Unit of the Board was set up in 1955, with Dr. H. D. Fisher in charge. These organizations have added greatly to our knowledge of the biological and physical oceanography of the northern waters of Canada, including, as relevant to the present paper, the waters west and north of the Québec-Labrador Peninsula (Hudson Bay, Hudson Strait and Ungava Bay). Ungava Bay was given special attention in the seasons of 1947, '48, '49 and '50 ; and the Arctic research vessel *Calanus*, built in 1948, worked in Hudson Strait and Hudson Bay in 1951, '53, '54 and in 1958-61. Larger Fisheries Research Board ships, such as the *Investigator II* and the *A. T. Cameron* made annual cruises which included the Labrador coast. The Hydrographic Service became very active in charting work over the whole of our area. In 1948 the Royal Canadian Navy sent three ships, *Haida*, *Nootka* and *Magnificent* up the Labrador coast, into Hudson Strait and Hudson

Bay. The *Blue Dolphin*, Captain David Nutt, made several cruises in Labrador waters from 1948 onward, under the auspices of the Arctic Institute of North America (Nutt, 1953 ; Nutt & Coachman, 1956).

The *H. M. C. S. Labrador*, Captain O. C. S. Robertson, sailed the Northwest Passage in 1954, and from 1955 onward has been occupied in oceanographic work in the north. In recent years much work has been done in the Gulf of St. Lawrence by the Atlantic Oceanographic Group of the Fisheries Research Board, and by the Grande-Rivière Station of the Province of Québec.

Bathymetry

The Québec-Labrador Peninsula is not afraid of getting its feet wet. On all its four sides the shores are bold, dropping off rapidly to shelf depths, and the shelf itself is narrow. Even on the Hudson Bay side, Hudson Bay being only a little over 200 metres deep, the eastern shores are considerably steeper than on the west side. James Bay is everywhere shallow, only a small part of it being greater than 50 metres deep ; but in southeast Hudson Bay the 100-metre contour lies close in to shore (Grainger, 1960). Most of Hudson Strait, forming the northern boundary of the Peninsula, is over 400 metres in depth, and here the coast is particularly bold, often forming sheer cliffs into the sea. Ungava Bay is shallower, seldom reaching 300 metres, and bottoms less than 50 metres deep constitute a large proportion of the inshore area (Dunbar, 1958). The Labrador coast is a fjord region ; the 100-metre contour lies a few miles off shore but the coast is indented by inlets many of which are well over 100 metres, with shallow sills at their mouths characteristic of fjords. As a result of the *Blue Dolphin* work of several seasons on this coast, Nutt (1953) lists the following sill and inside depths :

Table* 1 *Sill and inside depths (in meters)

	Sill depth	*Inside depth*
Lake Melville	29	50
Kaipokok Inlet	34	220
Nain Bay area	25	110
Hebron Fjord	55	255
Kangalaksiorvik (Seven Islands Bay)	27	105

The mountains of Labrador, especially in the northern part, are high, the highest peaks of the Torngats reaching to over 5,000 feet (Forbes, 1938). The shores are correspondingly steep, and the coastal landscape has a strength and beauty rivalled only by other fjord coasts such as those of Baffin Island and Greenland.

Most of the Strait of Belle Isle, between Labrador and Newfoundland, is between 50 and 100 metres in depth ; the shallowness and narrowness of this strait is important in determining the hydrographic pattern in the north-eastern Gulf of St. Lawrence. The bathymetry of the Gulf itself is discussed in various publications (e.g. Lauzier and Trites, 1958 ; Huntsman, Bailey and Hachey, 1954 ; Hjort, 1919). The Laurentian Channel, which extends from the continental shelf south of Newfoundland, through the Gulf and almost to the mouth of the Saguenay River, is over 200 metres deep ; most of it is over 400 metres and there are places deeper than 500 metres. The Esquiman Channel, which joins the main channel and extends northeastward between the North Shore and the west coast of Newfoundland, is between 200 and 300 metres deep.

Water Masses and Currents

As mentioned briefly above, there is in the waters surrounding the Québec-Labrador Peninsula a pattern of balance between three main water types: Arctic, Atlantic and coastal, the latter being influenced by drainage from the land. Water from the Arctic Sea enters the system from two main sources: through the Arctic islands of Canada and down the east coast of Greenland. The first source forms the bulk of the Baffin Island current and enters also through Fury and Hecla Strait into Foxe Basin, from which cold water flows into Hudson Bay. The Baffin Island Current, by the time it reaches the eastern end of Hudson Strait, is not unmixed Arctic water ; it carries also an undetermined proportion of West Greenland water (and also drainage from the land), and the West Greenland water contains water from the Irminger Current and the Labrador Sea, both Atlantic in origin. On reaching Hudson Strait, the Baffin Island Current divides, most of it continuing southward to form part of the Labrador Current, and a branch pushing westward into Hudson Strait. This latter branch flows westward, holding to the Baffin Island coast ; most of it appears to peel off to the left and join the dominant eastward flow along the Québec coast, which is the outflow from Hudson Bay (Campbell, 1958), but there is evidence that some of it, carrying Atlantic water, penetrates into the southeast part of Foxe Basin. This evidence is both physical and biological, the latter being perhaps the more persuasive. Grainger (1961) showed that the plankton of this area contained a proportion of the Copepod *Calanus finmarchicus*, as well as the dominant *C. glacialis*. The former is an Atlantic form, the latter Arctic, and the proportions of the mixtures of the two are interpreted as reflecting the proportions of mixture of the two water types. Interestingly enough, *Calanus finmarchicus* has so far been shown to penetrate only into the extreme northern part of Hudson Bay ; the physical demonstration of Atlantic water in Hudson Bay is still controversial.

The circulation in Hudson Bay is cyclonic (anticlockwise), and thus the water flows northward along the western shores of the Peninsula. When the eastward-flowing current along the north coast, in Hudson Strait, reaches Ungava Bay, some of it turns south into Ungava Bay, rounding the southern end of Akpatok Island. For more detailed discussion of the Ungava Bay circulation, see Campbell (1958) and Dunbar (1958).

The eastern end of Hudson Strait is thus a crossroads or key region in the Eastern Arctic. Through its limits there are both westward and eastward currents, carrying water from Hudson Bay, Foxe Basin, the Arctic sea, Baffin Bay, East and West Greenland and the Labrador Sea. It is thus an important region in which to keep routine observations going every few years, if not every year, in order to follow as closely as possible annual variations in relative proportions and volume transport, and also trends and changes in longer terms.

The great Labrador Current sweeps, majestic and ice-laden, down the Labrador coast. Iselin (1927) described it as « a cold water stream which flows southward over the continental shelf inside the comparatively motionless homogeneous mass of North Atlantic water » (Bailey and Hachey, 1949). The mouth of this great stream is on the Grand Banks of Newfoundland, and its surface velocity can be as high as 20 km. per day. It draws its waters from Baffin Bay, Hudson Bay, Foxe Basin, West Greenland and the Labrador Sea, and there is therefore a large proportion of Arctic water in it. On reaching the Strait of Belle Isle some of it turns to the southeast through the strait, but the actual volume transport here seems not to have been computed. The definitive, and very important, study of the Strait of Belle Isle, another key region, is that of Huntsman, Bailey and Hachey (1954), who measured current velocities between 0.5 and 1.2 knots. The currents vary considerably seasonally and with the state of the tide, and the authors concluded that the water movements through the strait could be summarized as *a*) a progressive inward movement of water of Arctic and subarctic origin on the north, *b*) a progressive outward movement of Gulf water on the south side, and *c*) a dominant outward flow of Gulf water. Bailey (1958) added a rider to this analysis by showing that the dominant flow could be in either direction, east or west, according to the state of a number of causative factors, the most important of which was probably the wind system in the whole area.

Studying the temperature-salinity relations of the waters of Belle Isle and adjacent areas (Esquiman Channel and the Labrador Current) in summer, Huntsman, Bailey and Hachey (1954) distinguished no less than seven water types, as follows :

1. Gulf of St. Lawrence surface water ; temperatures higher than 11.0°C. and salinity approximately 30.5‰. Found in the upper 25 metres in the western part of the Strait and in the Gulf ;

2. Arctic water ; characteristics approximately −1.6°C. and 33.3‰ ;

3. Labrador Sea water modified by West Greenland water ; temperatures and salinities generally greater than 3.5°C. and 34.5‰ ;

4. Labrador coastal water influenced by land drainage ; 5.0°C. and 27.2‰, found at the surface ;

5. Less modified Labrador coastal water ; temperatures between 4.5 and 6.5°C., salinities between 30.5 and 31.5‰, and comprising the greater portion of the surface waters on the northern side of the Strait and near Belle Isle itself ;

6. Labrador Current surface water with temperatures from 5.0 to 6.0°C. and salinities from 32.5 to 33.1‰, found across the Labrador Current ;

7. Labrador Sea water found in the greater depths of the Labrador Current, temperature 0.5°C. and salinities between 33.8 and 34.1‰.

It is probable that most of the Labrador Current water which enters the Gulf of St. Lawrence, where it is known as « Arctic » water, does so not through the Strait of Belle Isle but through Cabot Strait, by rounding the east and south of Newfoundland. There is some evidence, again from Huntsman *et al.*

(1954), that in Esquiman Channel the Arctic water of direct Labrador origin, *via* Belle Isle, can be distinguished from the Arctic water of « Cabot characteristics », and that the former (−1.7°C., 33.2‰), is found on the north side in Esquiman Channel, the latter (−1.6, 32.7) on the south side. However that may be, the presence of Arctic water in the Gulf of St. Lawrence has been recognized at least since the time of the Fisheries Expedition of 1951 (Hjort *et al.*, 1919). It forms part, but apparently not all, of a cold intermediate layer in the Gulf which varies in thickness seasonally and locally. Lauzier and Bailey (1957), for convenience, define this water as being lower in temperature than 0°C. ; so defined it has an upper depth of from about 30 to 90 metres, varying considerably locally, a lower depth of from 70 to 140 metres, and a thickness of up to 100 metres in the spring and about 30-60 metres in the autumn. These figures are based on measurements made in 1947 and 1948 ; considerable annual variation is to be expected. It appears, for instance, from a comparison of the studies of Lauzier and Bailey (1957), Huntsman *et al.* (1954) and Bjerkan (1919), that in 1923 the intermediate layer was colder than in 1914-15 or 1947-48. There is still a great deal of work to be done on the physical oceanography of the Gulf.

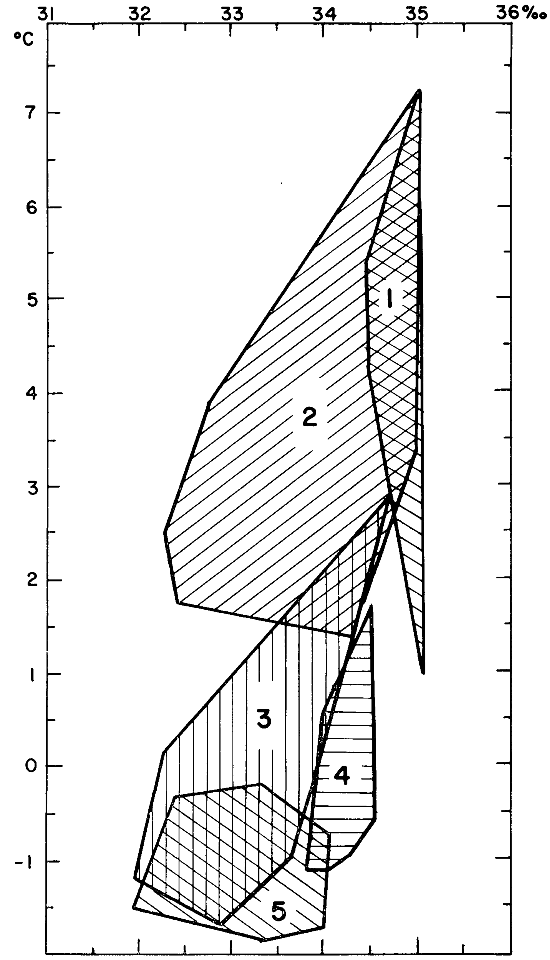

Figure 2 Temperature-Salinity diagram showing water masses in the Canadian Eastern Arctic. Water from surface to 49 metres is omitted. 1. Labrador Sea. 2. West Greenland, Disko Bay to Cape Farewell. 3. Labrador Current. 4. Deep Baffin Bay water, 300 metres to bottom. 5. Arctic Water, found in upper 200-250 metres in the Arctic archipelago, Canadian current and Hudson Bay and Strait.

From analysis of T-S relationships, Lauzier and Bailey conclude that at least one third of the intermediate layer is formed *in situ* within the Gulf, by mixing with upper water and cooling, and that since the intermediate layer reduces significantly during the season, communication with the outside is not maintained.

These authors also consider that the outside source is a surface one. To quote from their 1957 paper : « The data have shown that the layer in the Gulf had decreased in volume, with the progress of the seasons, and that its temperature and salinity had increased. In other words, the cold intermediate water had been expended either by mixing or movement or both, faster that it was replenished from May to November. It therefore follows that if water from an outside source contributes to the cold-water layer of the Gulf of St. Lawrence, this water enters the Gulf through Cabot and Belle Isle Straits, probably during the winter months as a surface layer, and is modified by horizontal mixing to yield a salinity lower than its original source, namely the Labrador Current ». The origin of the intermediate cold layer is also discussed by Tremblay and Lauzier (1940), based on measurements made on board the *Laval S.M.E.* out of the St. Lawrence Biological Station in 1936 and 1938.

The deep water of the Gulf, which fills the Laurentian and Esquiman Channels below the intermediate layer, is characterized by temperatures between 3 and 6°C., and salinities usually above 34‰. Precise definition is in fact impossible ; the data show gradation between the layers. It is probably formed « by the mixing of the cold-water layer outside the Gulf of St. Lawrence (−1.3°C., 32.95‰) with the water system found in the very deep Central Atlantic waters which upwells against the continental slopes » (Lauzier and Bailey 1957). Lauzier and Trites (1958) have detected a significant rise in the temperature of this water in the last three decades, from about 4°C. to 6°C., something which is decidedly food for thought.

The surface layer in the Gulf has been described by Lauzier, Trites and Hachey (1957). It is a mixed layer, strongly influenced by land drainage, and seasonally highly oscillatory, as would be expected. The southern part of the Gulf, in the Gaspé Current, is the warmer, and does not concern us here. The surface waters of the North Shore, in May, vary spatially from about 6°C. west of Anticosti Island, to 2−3°C. in the northeast. In August, temperatures of from 4 to 12°C. may be expected. There appear to be zones of upwelling along the shore, making prediction of surface temperature difficult. It can at least be said safely that none of the waters surrounding our Peninsula are warm, at any time of year, in human terms. Holiday resorts, except for the hardiest of hunters and fishermen, are not likely to develop.

Surface temperatures and salinities on the western, northern and eastern shores of the Peninsula are at the freezing point for most of the year, naturally. Readings of −1.5°C. to −1.7°C. are the rule. During the short summer season, however, there is a considerable range. Hudson Bay, being considerably estuarine, and therefore vertically very stable in summer, warms up to levels of 9 and 10°C. in the southern part. James Bay can reach 14°C. In Hudson Strait and Ungava Bay summer temperatures range from 2 to 6°C., and may be a degree or two higher on the Labrador coast ; always allowing for local calm weather conditions which may produce higher temperatures for short periods, especially in the fjords. Below this immediate surface layer, however, in all

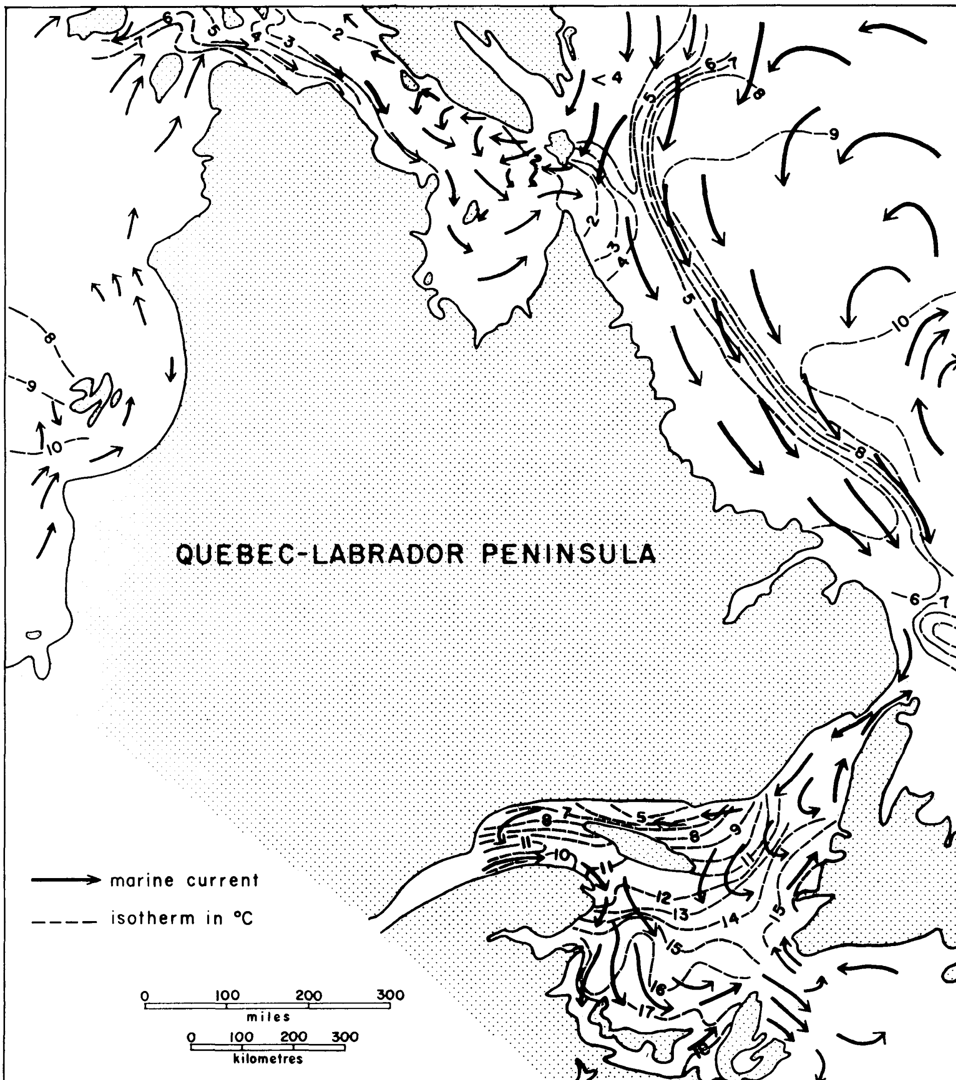

Figure 3 Waters surrounding the Québec-Labrador Peninsula, showing surface temperatures in summer (August). Compiled from various sources.

three areas, the temperatures fall rapidly ; negative values are common even at 50 metres, and the bottom water of Hudson Bay is unexpectedly (perhaps as yet inexplicably) low, approaching -2°C. (see Dunbar 1951). Surface salinities in Hudson Strait, in summer, range from 30 to 32‰, with local patches of lower values close to shore. Surface water in Hudson Bay may be somewhat lower, owing to the great area of land which drains into the bay, values of 23 or 24‰ being not uncommon. James Bay goes lower still, down to 15‰. Again, these low values apply to the uppermost water only.

Ice Conditions

The study of sea ice has become a highly specialized affair, and this paper is not intended to cover it. All the waters surrounding the Québec-Labrador Peninsula are covered with ice in winter, except where small-scale local conditions of water movement keep the surface open, or at times when off-shore winds cause the establishment of in-shore leads. Ice thickness probably varies between four and seven feet towards the end of winter, except where rafting of the ice occurs. The Pilot of Arctic Canada, Volume one, describes the ice of Hudson Strait as unconsolidated pack, in motion all winter ; this is true also of the Labrador coast and the Gulf of St. Lawrence. In Hudson Bay the ice is more consolidated, but may be in motion for part of the winter. In summer, ice disappears completely from the Gulf, but sea ice may always be met with in Hudson Bay and Hudson Strait, although in low concentration, depending on the year and on local events. On the Labrador coast glacier ice, in the form of icebergs, « bergy-bits » and « brash ice » occurs at any time of year ; this glacier ice comes mainly from the northwest coast of Greenland.

The open season, when navigation is possible without special aids, extends from about July to October or November in Hudson Bay, Hudson Strait and the Labrador coast, and some two to three months longer along the north shore of the St. Lawrence. There is considerable variation from year to year. In Ungava Bay there are special local conditions, in that the eastern part of the bay usually opens in the second or third week of June, sometimes earlier, so that boat travel is possible at that time between Fort Chimo and Port Burwell. Exit from the bay, however, or entry into it, is not possible by sea until Hudson Strait itself opens, about the middle of July.

Tides

Tidal ranges on the Peninsula vary from quite small to the largest recorded in the world. At Seven Islands, normal spring tides in March and September are of the order of 10 feet, neap tides about five feet. Springs at Harrington have been recorded as high as 8.7 feet, but normally run about six. From the Strait of Belle Isle northward along the Labrador Coast, ranges vary between 4 and 7½ feet. Hudson Strait presents an effective bottle-neck to the tidal wave, with the result that the tides in the Strait itself are high, those in Hudson Bay smaller. The *Atlantic Coast Tide and Current Tables* (1958) give the following ranges for selected stations :

Table 2 ***Tidal ranges for selected stations (in feet)***

	Max. springs	*Min. neaps*
Port Burwell	22½	8
Koksoak River entrance	45	11½
Leaf Basin	54½	17
Payne Bay	38	12
Diana Bay	34	12
Wakeham Bay	30	8¾
Digges Harbour	12	3¾
Port Harrison	*ca.* 2½	*ca.* 2
Fort George (James Bay)	*ca.* 6½	*ca.* 5¼

The tidal range at Leaf Basin, Ungava Bay, can in fact approach 60 feet, and is the highest known.

Biological Production

The basic production level in the living part of all ecosystems is, of course, that of the plant material, upon which all other life depends ; hence the quantity of living substance produced in any given situation is a function of the factors which determine plant growth and multiplication. Those factors are : light, suitable temperature conditions, and inorganic nutrients. There is good evidence that temperature is not a limiting factor anywhere ; plant life in the several temperature zones of the world is adapted to the prevailing conditions, and in the sea the temperature range, both seasonally and in space, is not large. The seasonal oscillation of light conditions in the middle and high latitudes, coupled with the persistence of sea ice in the spring, limits the period in each year during which plant growth is possible, but during the growing period as such, light is not limiting. The decisive factor is the supply of nutrients, the phosphates, nitrates, silicates, etc., required by the phytoplankton.

These inorganic nutrients are produced by the breakdown of larger-molecule organic material derived from dead plants and animals, so that there is a circular relation between plant nutrients and the total life produced, and the total capital of nutrient material available in any region can only grow slowly by additions from outside the system. A recently-formed lake, for example, in northern Canada, gradually increases its nutrient capital and thus its productivity as time goes on, by the supply of nutrient salts to the lake from the leaching out of the surrounding territory. For this reason alone, high latitude, recently glaciated areas cannot be expected to show high productivity. Secondly, the nutrient salts in the sea are formed not only from organic detritus suspended in the upper layers, by bacterial action, but also, and in colder waters probably predominantly, in the lower waters below the euphotic zone and at the bottom. These products of mineralization therefore build up their concentration well below the levels at which plant growth is possible at any time of year, and before they can return into the trophic cycle must be transported upwards to the sunlit upper zone. This factor of upward physical transport of nutrients is the important one in determining the productivity of the waters of the world, and it applies most significantly to the waters discussed here. It is a matter of the stability or instability of the density-structure. The more stable the system, the greater the resistance to the vertical exchange of water, and the lower the productivity will be.

The Arctic Sea, or Central Arctic Basin, being ice covered, is a highly stable region. The freezing of sea water involves the gradual elimination of salt, which forms dense water beneath the ice, and sinks, with a net loss of salt to the upper layers. The melting of the ice in spring and summer thus dilutes the surface layers, setting up a stable density profile. In certain areas adjacent to the Arctic Sea itself, such as the great fjord systems of Greenland and the glacier-carrying parts of the Canadian Arctic Islands, this process is increased in intensity by the melting of glaciers and icebergs. Such a pattern tends to reduce the production of living substance in the sea, and in consequence the Arctic Sea is conspicuously low in productivity (in contradiction to the unsupported but reiterated claims of those emotionally committed to a productive Arctic).

Coming farther south, the pattern changes in several important aspects. The climate deteriorates, entering the low pressure areas, the Atlantic influence enters the system, and the temperature rises somewhat. Temperature, as noted above, probably has little effect upon the overall productivity, but it does appear to affect specifically the fish populations, as opposed to the mammals and the invertebrates, as is described below. Stormy weather causes mixing of the upper layers, thus reducing the density stability, and the Atlantic intrusion and admixture has the same effect in overcoming the dilution of the surface layer. One area which appears to be decisively affected by storm turbulence is Hudson Bay. For several seasons the *Calanus*, one of the vessels of the Arctic Unit of the Fisheries Research Board of Canada, has worked in Hudson Bay, including the taking of vertical plankton hauls with the Hensen net for quantitative purposes. The results have not yet been fully worked out, but it is already clear that Hudson Bay is considerably more productive, in terms of planktonic life, than its Arctic nature, heavy ice cover and extensive land drainage would lead one to suppose. The surface layer is very stable in summer, but the region is stormy and the water fairly shallow, which must allow for vertical mixing in the late summer and fall.

Hachey (1931*b*), from preliminary observations and considering in particular the very low bottom temperatures, suggested that Hudson Bay below about 50 metres might be dynamically dead. Later, working on the *Haida* 1948 material, Bailey and Hachey (1951) found that this was not the case, which was confirmed by Dunbar (1958). It was also inferred as a possibility, from the high summer stability of the water, that winter vertical exchange in Hudson Bay might be inhibited, and that this might be related to the supposed low productivity of the bay. (This low productivity was deduced from the lack of commercially exploitable fishes ; it is now known, as mentioned above, that the plankton production is not greatly different from that of neighbouring bodies of water). The evidence available at present, however, does not support such a winter inhibition. The table given on the opposite page summarizes the measurements made in South Bay, Southampton Island, from April to June 1955, by Dr. A. W. Mansfield, quoted from Dunbar (1958).

The implication of these data is plain : « The marked similarity in temperatures, salinities and densities from the surface to 50 m., up to the middle of June, is quite plain and leaves no doubt that there is vertical exchange during the winter. Comparison of the density values at 50 m. with those at 100 and 200 m. in summer shows that there is no reason to suppose that the vertical exchange fails to reach the bottom of Hudson Bay. The reduction in salinity and very slight rise in temperature at the surface on June 18 indicates that melting of the ice had begun to take effect by that time » (Dunbar, 1958).

Table* 3 *Data from winter and early spring stations in South Bay, Southampton Island, 1955

Date	*Location*	*Depth* m	*Temperature* °C.	*Salinity* ‰	*Density* σt
April 3	63°45′N.	1	−2.20	32.75	26.38
	83°02′W.	10	−1.72	33.19	26.70
		25	−1.75	33.19	26.72
		50	−1.72	33.28	26.80
April 28	63°40′N.	1	−1.57	32.94	26.52
	82°40′W.	10	−1.65	32.94	26.53
		25	−1.73	32.97	26.55
		50	−1.79	33.12	26.67
May 17	63°50′N.	1	−1.62	32.94	26.52
	83°25′W.	10	−1.62	32.94	26.52
		25	−1.77	33.12	26.67
		50	−1.79	33.49	27.05
May 27	63°43′N.	1	−1.42	33.03	26.59
	83°37′W.	10	−1.43	33.06	26.61
		25	−1.64	33.06	26.62
		40	−1.75	33.08	26.64
June 7	63°46′N.	1	−1.60	32.45	26.12
	83°30′W.	10	−1.60	32.54	26.21
		25	−1.47	32.54	26.20
		50	−1.81	33.21	26.75
June 18	63°47′N.	1	−1.33	30.91	24.88
	83°25′W.	10	−1.20	32.50	26.15
		25	−1.60	32.72	26.34
		50	−1.78	33.08	26.64

Stability of the upper water in spring and summer becomes progressively reduced along Hudson Strait, from west to east, and this lower stability tends to be maintained along the Labrador coast. This is apparently the effect both of atmospherically induced turbulence and of Atlantic admixture. At the present state of our knowledge on this point it is not possible to make very positive statements ; in fact the stability conditions in our waters offer a highly promising field of study. It is quite clear, however, that the productivity of the Labrador coastal waters, and of Hudson Strait and Ungava Bay, is not as high as that of the West Greenland region on the other side of the Labrador Sea, where the summer standing crop of plankton, and the fishery resources, are very considerable and of great economic importance. The West Greenland Current in Southwest Greenland carries a large proportion of Atlantic water from the Irminger Current, which has the effect of decreasing surface stability, keeping the surface ice-free during the winter and thus allowing for greater winter vertical exchange, and raising the mean temperature to levels which favour the development of fish populations.

Plankton studies, especially quantitative studies, in the northern Gulf of St. Lawrence, have not yet been carried out sufficiently to make generalizations possible. A very promising start was made by Huntsman (1919), on the 1914-15 Fisheries Expedition, in the Gulf as a whole, but it has not yet been followed up.

Following the production up to higher trophic levels, we are at once struck by the antithesis between the mammals and the fishes in the waters of the Québec-Labrador Peninsula. The regions dominated by Arctic water are rich in mammals, those in which the Atlantic influence is strong offer the best fisheries. The reason for this is by no means clear, but in the opinion of the present author it must be closely related to the history of the Pleistocene period ; a matter of the difference in time required, by homotherms and large poikilotherms, to adapt to a large and wide-reaching climatic change. At all events, the facts are obvious : the number of species of fish living in pure Arctic water is quite small, probable less than 50 (Dunbar, 1963), and few of them have developed really large numbers, which is contrary to the generally accepted rule that Arctic faunas are poor in species but rich in individuals. The Arctic Sea, the waters between the Arctic islands, including Baffin Bay and Hudson Bay, are poor in fishes, and there is little hope of significant economic fish resources in them. On the other hand, whales and seals abound, and the temptation offered by their abundance has led, through the uncontrolled activities of commerce, to the threatening of the survival of some of them, notably the Right Whale and the Fur Seal. In subarctic waters, in which there is an Atlantic (or Pacific) admixture, the place of the sea mammals is taken over very largely by the fishes, as witness the fishery resources of West Greenland, southern Labrador, Newfoundland and the Gulf of St. Lawrence.

The Atlantic Cod (*Gadus morhua*) is a dominant species in the Gulf of St. Lawrence and on the Labrador coast. It enters Ungava Bay after the spawning period, in August, but does not normally penetrate farther than a little south of Port Burwell ; it is not known in Hudson Strait west of Resolution Island, and it is absent from Hudson Bay. It stands as the most northerly of the important economic fishes ; farther south in range, the mackerel, herring, Atlantic halibut, various other flatfishes, redfish, hake, etc., are important in the waters under consideration here. They cannot be treated individually in the space available, nor is it the purpose of the present paper to do so. The more northerly, or more nearly Arctic fishes include the Greenland Cod (*Gadus ogac*), the Greenland or Arctic Halibut (*Reinhardtius hippoglossoides*), the Capelin (*Mallotus villosus*), the Greenland Shark (*Somniosus microcephalus*) and the Arctic Char (*Salvelinus alpinus*), the latter being marine only during a few weeks in the year. The Arctic Halibut is known from the northern tip of the Labrador, in the Chidley and Burwell area ; the Greenland Shark from that region and also at Cape Hope's Advance, farther into Hudson Strait. The Greenland Cod is common throughout the area east, north and west of the Peninsula, and farther north, and the Arctic Char is a subarctic and high arctic species which extends north to Ellesmere Island. The Atlantic Salmon (*Salmo salar*) and the Speckled Trout (*Salvelinus fontinalis*) occur as far north as Ungava Bay, the former west to Leaf River only, the latter into the streams of Hudson Bay. For detailed discussion of the fishes of the northern part of the Peninsula see

Dunbar and Hildebrand (1952), and for Hudson Bay, Vladykov (1933). The subject of fish and fisheries is too big for full treatment here, and in fact the whole matter of the distribution of the marine fauna can only be treated superficially.

When Jacques Cartier passed Sable Island in 1534, he reported seeing walrus in large numbers. The nearest walrus to Sable Island today are normally to be seen in Ungava Bay, a thousand miles to the north. Walrus were once common in the Gulf of St. Lawrence. The causes of the restriction in distribution are probably to be found in the hunting activities of Europeans, that is to say of white men in North America. Walrus today are nevertheless still a significant resource for the Eskimos of Hudson Strait and Hudson Bay ; their present status has been investigated by Mansfield (1958), and there is now good hope that their numbers will be maintained. The commonest sea mammals of the Gulf today are the Harbour Seal (*Phoca vitulina*), the Harp Seal (*Phoca groenlandica*) during its breeding period in the early part of the year, the Blackfish or Pilot Whale (*Globicephala melæna*), the Finner Whale or Common Rorqual (*Balænoptera physalus*) and the Beluga or White Whale (*Delphinapterus leucas*). All these are subarctic or boreal species with the exception of the last, the Beluga, which is a decidedly Arctic form. The Beluga has been given special study in the Gulf of St. Lawrence by Vladykov (1944). Its presence in the Gulf may safely be ascribed to the Arctic water in the Gulf, but its abundance there is nonetheless surprising ; it is otherwise so distinctly Arctic in its distribution, extending also to some extent into the subarctic. Quite possibly it is to be considered an Arctic relict in the Gulf of St. Lawrence ; this is suggested also by its occurrence in the Sea of Okhotsk and its sporadic appearance on the Labrador coast and in the Baltic Sea.

The sea mammals of the northern seas of Québec-Labrador are more specifically Arctic, with the exception of the cosmopolitan Sperm Whale (*Physeter catodon*), which extends up the Labrador coast and even into Hudson Strait, but is seldom if ever seen in Hudson Bay. The little Ringed Seal (*Phoca hispida*) is rare in the Gulf of St. Lawrence, but becomes increasingly common northward up the Labrador. It is in fact a creature of the ice, and its distribution is in close association with ice. The Bearded Seal or Squareflipper (*Erignathus barbatus*), the largest of the Arctic seals, is more sparsely distributed (McLaren, 1958), being found, within our area, in Hudson Strait, Ungava Bay and Hudson Bay, and in northern Labrador. The Harp Seal, a migrant species, is found along the Labrador coast and in northeast Ungava Bay, but is not known to enter Hudson Bay. The Right Whale, or Bowhead (*Balæna mysticetus*), once thought to be extinct, now appears to be recovering, and is occasionally seen in Hudson Strait and Hudson Bay, as well as farther north. Finally, the Beluga, already mentioned, is of fairly general occurrence in Hudson Strait and Hudson Bay, and the Killer Whale (*Orcinus orca*), the terror of the seas, is seen sporadically in our area. Other whales are casual members of the fauna.

A good general description of the fauna of the northeastern Gulf of St. Lawrence and the Strait of Belle Isle is given by Huntsman *et al.* (1954).

Several Arctic indicator species are recognized in the Gulf fauna, both planktonic and nektonic. The polar cod (*Boreogadus saida*) and the Greenland cod are both found in the fauna, the latter in some numbers. The Greenland cod cannot be considered an Arctic indicator as such, being common in subarctic regions ; but the polar cod is generally considered to be so. Certainly Arctic indicators are found in the plankton : the Ctenophores *Mertensia ovum* and *Beroë cucumis* are carried by the Labrador Current water into the Esquiman Channel, and the same is true of the Calanoid *Acartia longiremis* and the Arctic pelagic Amphipods *Pseudalibrotus glacialis* and *Parathemisto libellula.* The detailed distribution of such indicators within the Gulf, horizontal as well as vertical, has not yet been examined.

Analogous to the presence of Arctic species in the Gulf, but of different significance, is the finding of warmer water forms in southern Hudson Bay, left there as relicts of a past warmer climate, probably at the « climatic maximum » of some 6,000 years ago, and able to survive in Hudson Bay owing to the warming of the surface waters in summer. The Hudson Bay fauna is not yet fully explored but several of these Atlantic relicts have come to light, the two best known being the Capelin, *Mallotus villosus,* and the Copepod *Acartia clausi.* The Capelin is very common in the southern half of Hudson Bay, rare in the northern part ; and it is not known in the western part of Hudson Strait. It is a subarctic-boreal species, extending up the Labrador coast but becoming sparse in northern Labrador, common in Newfoundland, the Gulf of St. Lawrence and southwest Greenland. There have been records of its appearance in Ungava Bay in some numbers, recorded below. There is thus a gap in its distribution between eastern Hudson Strait and southern Hudson Bay.

The distribution of *Acartia clausi* (Jespersen, 1934) is even more intriguing. Present in southern Hudson Bay, it is absent in northern Hudson Bay, Hudson Strait, the waters of Labrador and West Greenland ; it appears again, in the main area of its distribution, from Newfoundland and southwards, and across to northwest Europe. It is thus a fully boreal, as opposed to Arctic or subarctic species.

The availability of local food resources in the sea, in the northern part of the Peninsula, is a matter of great importance to the economy and general well-being of the Eskimo population, and considerable study has been given this problem in recent years, particularly by the Fisheries Research Board of Canada, the Department of Northern Affairs and National Resources, and the Government of Québec. It will be apparent from the account given above that the resources, except for the cod fishery of the Labrador coast which is exploited not primarily by the Eskimos at all, are not abundant. North and west of the Labrador, valuable economic fisheries disappear, so that the most has to be made of small resources, and those resources have to be conserved. Some years ago the present writer (Dunbar, 1952) studied the Eskimo situation in Ungava Bay and advocated the development of fish and seal resources at Port Burwell, and the stimulation of internal trade within the area. Such a policy is now developing, under the Department of Northern Affairs, and indeed looks very promising.

The population of Port Burwell, which is the richest part of Ungava Bay, has risen very considerably, cod and Arctic char are being caught and preserved, and the migration of the Harp Seal is being rationally exploited.

Port Burwell is probably the only place within our northern area where this could be done. Other possibilities exist there ; the Greenland Halibut is known in the region of Cape Chidley and exploratory fishing in deep water is planned, and a market might be developed for the Greenland Shark. West of Ungava Bay, the only significant marine food resources are in the mammals and the birds, at least until such time as methods are developed for the direct use of the plankton.

Climatic change

No discussion of the waters surrounding the Québec-Labrador Peninsula would be complete without some reference to the interesting and very important matter of the oscillations or fluctuations of climate, especially in view of the fact that one of the regions most sensitive to change — the eastern entrance to Hudson Strait — lies within our area. Changes in marine climate are manifested in changes in the proportions of the several water types, especially Arctic and Atlantic, in any given place, and in changes in the heat carried by the water masses. Such changes occur seasonally as a normal process, but there are fluctuations also in longer periods.

The literature of recent climatic change is now large, and many symposia have been held on the subject. In West Greenland, where the balance between the East Greenland and the Irminger water is decisive, the warming of the water year by year was first made apparent by the arrival of Atlantic cod, an event of great economic importance to the country. From the second decade of this century, about 1915, the marine and atmospheric climate of that region began to grow warmer, and the process has been recorded in a now classic paper by Jensen (1939). The order of temperature rise is large, about 2°C. in the core of the West Greenland Current in southwest Greenland. By the mid 1930's the peak of this process appears to have been reached ; since that time there have been signs of a return to cooler conditions, although no established trend has yet been demonstrated.

A similar warming trend was recorded in the Gulf of St. Lawrence, in the waters of Newfoundland, and in the northeast Atlantic. For reviews of the subject see Dunbar (1946, 1955) and symposia published by the Conseil Permanent (Conseil, 1949) and the International Commission for the Northwest Atlantic Fisheries (ICNAF, 1953). Whether the trend at present is upward or downward is still a matter of controversy ; perhaps no present trend is discernible at all. In the longer term (centuries rather than decades) there is evidence from the sediments of the sea floor that the climate is cooling (Wiseman, 1954) ; that, in fact, we are still living in the Pleistocene.

There have been warmer periods, of shorter duration that the present one, in the past century or so. Cod fishing was possible in West Greenland, for instance, in the 1820's and again in the 1840's (Jensen, 1939), and the decade of

1880 seems also to have been warmer, both in West Greenland and in at least part of our home waters. The West Greenland peak at that time seems to have been much less high than the present warming, but there is evidence that Ungava Bay experienced an increase in marine temperatures in the 1880's greater than anything that has happened there since, with the possible exception of the year 1959 (see below). From 1882 to 1884 Lucien Turner, on a commission from the United States Corps of Signals, worked at Fort Chimo. Much of his work during that time has not been published, and there do not appear to have been any observations of sea temperatures, but his manuscript report on the fishes collected[1] records that the Atlantic Cod was moving northward at that time « even to far north of Cape Chidley », and that the Capelin was also moving northward year by year and into Ungava Bay. On the subject of the Capelin he writes : « Within Hudson Strait they had not been detected until several years ago when a few were seen in the neighbouring waters of George's River. In the spring of 1884 they were observed in great numbers in that vicinity. On the 8th of August 1884 a school of several thousand individuals appeared four miles within the mouth of the Koksoak River. As many as were desired for specimens were secured by the hand as they swam near the shore . . . This is the first instance known either to whites or natives of the appearance of the Capelin in the southern portion of Ungava Bay. »

The Capelin is a subarctic-boreal fish, as already described ; its centre of distribution has moved northward in West Greenland during the past forty years following the climatic warming. It is a very conspicuous species owing to its habit of swarming in very large numbers close in to shore during the breeding season. During four seasons of field work in Ungava Bay from 1947 to 1950, the *Calanus* expeditions, using dredges, trawls, handlines and stramin plankton nets, took only two young specimens of the Capelin, and none was found in the stomachs of seals or cod. The temperatures measured in Ungava Bay were somewhat low for the normal Capelin range, being never above 5.8°C. at the surface nor above 2.5°C. at 10 metres.

On this evidence alone it must be supposed that the marine climate of Ungava Bay in 1884 was milder than in succeeding years. Since the *Calanus* expeditions in Ungava Bay, however, the Capelin has been recorded there in some numbers, indicating warmer conditions. In 1954, Tuck and Squires (1955) reported Capelin to be fairly common in the stomachs of Brünnich's Murre (*Uria lomvia lomvia*) on Akpatok Island. They were all young specimens, and there is no information on precisely where they were eaten. The Murre is a fast flier and can use distant feeding grounds. The second recent record of the Capelin, however, is in no doubt and is of the same order as that of Lucien Turner. In 1959 Roger Le Jeune (Le Jeune, 1959), in examining the resources of Arctic Char in the George River, reported that that year was abnormal in Ungava Bay in two ways. It was a very heavy ice year, the pressure of ice being such that it was impossible to reach George River or Port Burwell by sea

[1] The author is indebted to the Smithsonian Institution for the loan of Mr. Turner's manuscript on the fishes, and of his capelin specimens.

before the beginning of August, whereas both ports can usually be entered in the second half of June, from inside the bay ; secondly, there appeared large quantities of Capelin and of Atlantic Cod in the interior of Ungava Bay, the former as far as the Koksoak River and the latter to the George River. In 1959 the Capelin formed a most important item in the diet of the Arctic Char, which turned from their normal crustacean food to the Capelin, with the result that the colour of their flesh changed from pink to white.

Unfortunately sea temperatures were not measured either in 1884 or in 1959, but the presence of Capelin in Ungava Bay in the numbers reported by Turner and by Le Jeune, and the penetration of Atlantic Cod to George River, can probably be explained only by a change in the marine climate, an increase in the Atlantic element in the water entering the bay. It is interesting that 1884, like 1959, is also reported as one of very heavy ice conditions in Ungava Bay, by Turner.

Such fluctuations of marine conditions round the Québec-Labrador Peninsula are of great interest, and the establishment of some sort of pattern in them would be a considerable achievement. To do this we need routine measurements, year after year, and we also need measurements in winter. During most of the year our northern waters are ice-covered, and even in the Gulf of St. Lawrence the summer season is not long. To restrict our observations to the summer is therefore to take a very small sample of the annual process. This applies as well to the living processes in the water as to the physical and chemical. We have still, I believe, to make an asset out of our long winter, rather than a handicap.

RÉSUMÉ

L'histoire de l'exploration des eaux côtières de la péninsule Québec-Labrador remonte très loin dans le temps, mais c'est vraiment l'Année polaire internationale de 1882 qui marqua les débuts des premières recherches sérieuses. Les progrès les plus considérables des recherches océanographiques ont cependant été réalisés depuis la IIe guerre mondiale, grâce surtout aux travaux entrepris dans l'Arctique oriental par le Bureau des recherches sur les pêcheries.

L'auteur s'étend d'abord sur l'océanographie physique de la région ; il étudie successivement la bathymétrie, la répartition et les caractères des principales masses d'eau, les courants, les glaces et les marées. Suit une analyse de la biologie marine, qui souligne en particulier l'importance d'un facteur : l'absence de brassage vertical des eaux. La répartition de la faune marine indique que si les régions dominées par les eaux arctiques sont riches en mammifères, celles où l'influence atlantique est forte sont de beaucoup les plus poissonneuses. L'auteur insiste sur l'importance des ressources biologiques de la mer dans l'économie alimentaire des Esquimaux.

De même qu'il existe des preuves d'oscillations climatiques à courte période, on peut aussi conclure à un réchauffement des eaux depuis le début du siècle, bien que cette tendance soit moins évidente depuis quelques années.

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