BIOLOGICAL BOARD OF CANADA
UNDER THE CONTROL OF
THE MINISTER OF MARINE AND FISHERIES

BULLETIN No. XIII

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BY
A. G. HUNTSMAN
Director, Atlantic Biological Station

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INTRODUCTORY

On our Atlantic coast the severity of winter is not infrequently shown in a widespread blocking of harbours and of the coastal steamship routes. Whence comes all this ice? How much of it is formed locally and how much comes from the Arctic regions via the Labrador current? Although knowledge of these things is still quite limited, data that are available make it possible to form a fairly clear picture of the main course of events in this connection. The ice has an effect on the waters into which it is carried far greater than the mere addition of so much fresh water from its melting. In view of its great importance in determining the character of the fisheries, we hope that more attention will be paid to it, so that the full details of its origin and fate may be worked out.

It may at first thought seem surprising that ice definitely of arctic origin should have to be reckoned with along our Atlantic coast. It is true, however, that from both the Arctic and Antarctic regions mountains of ice, or icebergs, are regularly carried by the ocean currents for a distance of 1,500 miles or more toward the tropics. The ice-laden current in each case hugs the eastern coast of America, either north or south as the case may be. In the North Atlantic the icebergs or their fragments occasionally reach almost as far south as the latitude of Florida, southwestward nearly to Cape Hatteras, southeastward beyond the Azores halfway to Gibraltar, and eastward nearly to the British Isles. Consequently, it is not surprising that Arctic ice should exercise an important influence in our waters.

COURSE OF THE ICEBERGS

The icebergs enter our waters from the north from Davis strait. While most of them pass south with the Labrador current, a few enter Hudson strait and pass along its northern shore for a greater or less distance before turning south into the outgoing current along the southern shore. Occasionally they reach the western end of the strait before turning, or they may even pass into Hudson bay, and move southward to James bay, but this is unusual.

In the Labrador current they pass southward to the eastern coast of Newfoundland and the northern part of the Grand Bank. The vast majority of them pass southward along the eastern side of the Grand Bank and off the tail of the Bank meet the "Gulf stream" and are rapidly melted and turned eastward.

At three points along the course that we have traced some of the bergs leave the main stream. At the Strait of Belle Isle in summer and autumn the bergs pass inwards along the north shore, and not infrequently reach westward along the Quebec shore of the gulf almost to Cape Whittle before being melted or turned southward

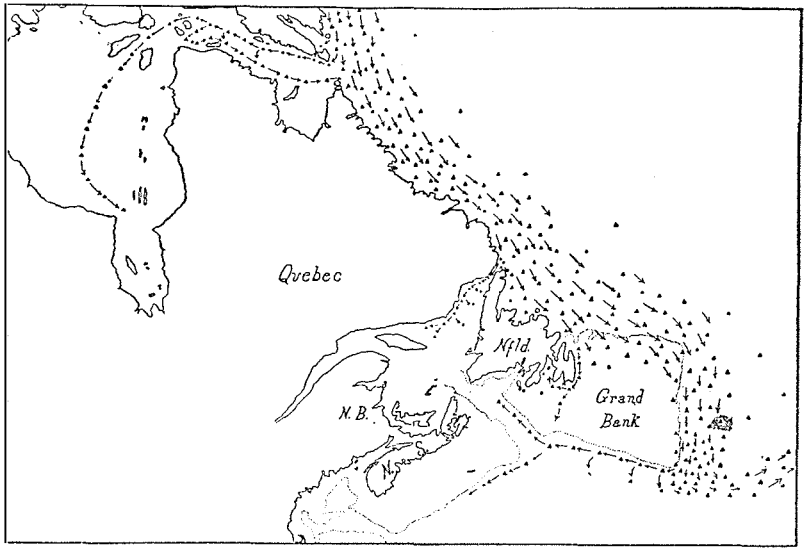

FIGURE 1.—Routes taken by the icebergs from Davis strait.

toward the Newfoundland coast. They have even been known to pass beyond Cape Whittle almost to Anticosti island.

Where the main stream leaves the Newfoundland coast to pass eastward north of the Grand Bank, some of the icebergs deviate from it and take a course southwestward in the deep water between the Grand Bank and Newfoundland. They pass westward around Cape Race to enter St. Mary and Placentia bays on the south coast. They rarely, if ever, reach as far westward as the French island of St. Pierre. Whether any of these move southwestward and south-

ward across or between the fishing banks to reach the deep water is not at all certain.

Around the tail of the Grand Bank, where the icebergs congregate and melt, and where the *Titanic* sank, there is more or less of a westerly movement of the water nearest the bank, and some of the bergs are thus carried some distance toward Nova Scotia. Usually they do not proceed far before being caught in the Gulf stream and forced back east. Occasionally they reach westward to the mouth of the deep channel leading between the banks toward Cabot strait, and may even go up this channel on the east side to a point abreast of St. Pierre or beyond. Others on rare occasions continue southwestward outside the fishing banks to the offing of Sable island, or even much farther. In the accompanying chart (figure 1) we have shown the various courses taken by the icebergs.

COURSE OF THE FIELD ICE

The icebergs are so peculiar, and retain their characteristics so nearly to the point of their disappearance, that no one can doubt the evidence they afford of the carrying of Arctic conditions far into our waters. Field ice, on the other hand, is not so distinctive. It is formed in many localities, and that from the Arctic regions, though for the most part peculiar, is subject to such alterations (loss by melting and additions by freezing) that it rapidly becomes unrecognizable. As it is so much thinner than the icebergs, it quickly disappears under the influence of the heat of summer, and at the beginning of autumn is to be found only near its source in the Arctic. In winter, however, it has its opportunity and presses farther and farther south. Not being as deep in the water as the icebergs, it is more under the influence of the winds and superficial currents, and is readily carried throughout the shoal waters along the coast. For this reason it is certain to have a more extensive southward distribution close to the coast than have the icebergs. The temperature of the open ocean even at the end of winter is so high as to melt the northern field ice quickly; but in the shallow coastal water, that is not kept warm by a current from the south, it is finally, as winter progresses, able to survive (and even grow) to the southward well down the coast of Nova Scotia.

This Arctic field ice is from two chief sources. With or pre-

ceding the icebergs it comes south from Davis strait and takes the same routes as they, part passing into and around Hudson strait, but the main mass progressing directly southward with the Labrador current. It appears at the mouth of Hudson strait in late October or November. Even before its arrival ice may be starting south from another source,—Fox channel. This latter ice may have been lingering at the inner end of Hudson strait just clear of the entrance to Hudson bay all summer. Sometimes before the first of October it is able to extend eastward through the strait and reach Cape Chidley by the beginning of November. Here it joins or is joined by the ice from Davis strait, and both pass southwards in the comparatively rapid current along the coast of Labrador. By December the strait of Belle Isle is reached, and in January the northern part of the Grand Bank. The courses taken by this stream of field ice are similar to those that have been described for the icebergs. Large quantities are carried down the eastern side of the Grand Bank and disappear before or after reaching the meeting place with the Gulf stream off the tail of the Bank. It is doubtful whether any appreciable amount works westward from this point.

There is a stream of ice passing close to the Newfoundland coast inside the Grand Bank to and around Cape Race. This ice blocks up the harbours on the south coast of Newfoundland nearly or even at times quite to St. Pierre, and spreads southward and southwestward to some extent over the neighbouring banks. It is doubtful if much of this passes beyond the banks into the deep water, seeing that a clear passage is regularly to be found in the mouth of the deep channel leading toward Cabot strait.

A very large amount of field ice undoubtedly passes from the Labrador current through the strait of Belle Isle into the gulf. The extent to which this may occur is shown by the fact that in June, 1897, after the gulf had become free of ice and was warming up rapidly, favourable winds brought so much ice through the strait of Belle Isle that fishing was interfered with on the Quebec shore as far as Mekattina. If that can happen in summer, how very much more extensive must it be in winter, when the winds are favourable to such a movement for a much longer period, and when there is little heat to stop the advance of the mass of ice. This explains the otherwise anomalous fact that the gulf of St. Lawrence is in winter regularly filled with ice from shore to shore, even though

it is comparatively open to the Atlantic and its waters quite salt, whereas the Great lakes in the same latitude, containing fresh water that is much more easily frozen, and Hudson bay, which is considerably farther north, remain comparatively free from ice, except near shore. For these reasons we believe that the ice fields of the Gulf of St. Lawrence come directly from the Labrador current through the strait of Belle Isle, or, when formed locally, are indirectly due to ice coming in through the strait of Belle Isle, which ice has in melting cooled the water of the gulf to such a point that the latter is able to freeze and form field ice. Although the final picture is due to (1) ice from the rivers, (2) ice formed locally in the gulf, and (3) field ice from the Arctic, it is necessary to insist that without the latter the picture would be radically different and the Gulf of St. Lawrence would be open to navigation throughout the winter.

The ice coming into the gulf through the Strait of Belle Isle spreads along the Quebec shore for a variable distance before passing southward toward the Newfoundland coast and filling the northeastern portion. The progress of the ice varies from year to year, but gradually the channel north of Anticosti is filled, then that south of Anticosti, and westward up the estuary of the St. Lawrence as well as southward into the lower gulf and southeastward to the outgoing current through Cabot strait past Cape North. Not infrequently the last part to remain open or the part to open up from time to time is along the path of the comparatively warm current flowing into the gulf through Cabot strait on the northeast side around Cape Ray, giving a stretch of open water up the Newfoundland coast perhaps as far as the Bay of Islands.

The ice fields leave the gulf more or less constantly past St. Paul island and Cape North. On emerging from Cabot strait they take a variable course, usually southeast or south, towards Sable island, covering more or less perfectly the banks north of that island. In this region melting is rather rapid at all times, but, if the mass of ice is extensive enough and the winds favourable, it will spread in a circular fashion eastward and northward toward Newfoundland. Some of it will also circle in an opposite direction, moving southward and westward outside Sable island, and a part of this is certain to make the circuit of Sable island. It tends, however, to be caught up into the "Gulf Stream" and carried eastward, rapidly melting.

If the mass north of Sable island be very large, or if easterly to northerly winds prevail, a considerable body of ice will move from the offing of Cape Breton southwestward along the Nova Scotian coast. Before reaching Cape Sable this ice tends to swing off shore and circle back toward Sable island, or move out beyond the banks to be dissipated in the margin of the "Gulf Stream." A small amount may continue past Cape Sable for a short distance into the Gulf of Maine.

In figure 2 the general course taken by the ice south of Belle

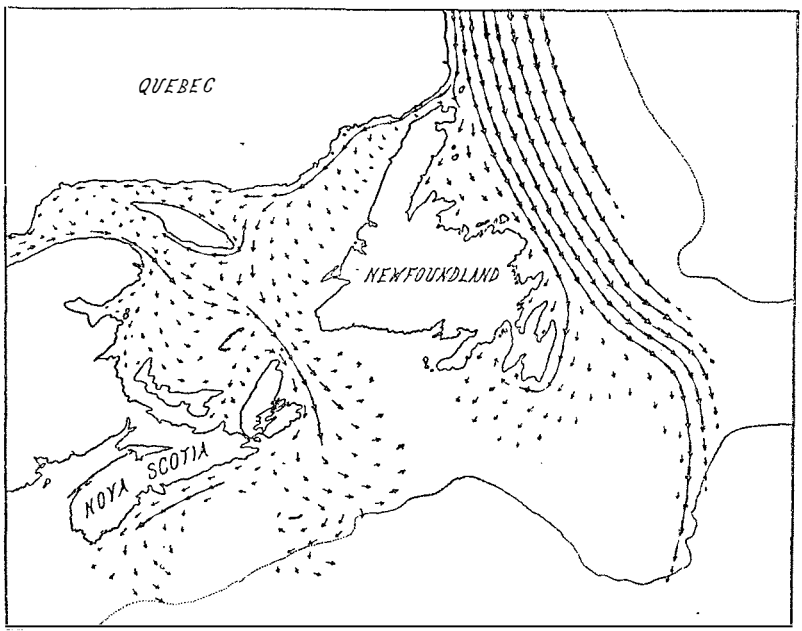

FIGURE 2.—Principal routes taken by the field ice from the north.

Isle is shown. In figure 3 the reported extent of the field ice and the observations of icebergs for the last week of February of 1923 are indicated.

The advance part of the field ice, whether at Belle Isle in December, or from Nova Scotia to the tail of the Grand Bank in February, consists of loose ice, comparatively small and thin cakes. This is the natural result of the melting, to which the foremost part

of the field ice is subject, giving superficially a cold water, which readily freezes in frosty weather, and then breaks up into cakes. Only after the main body of the water has been cooled practically to its freezing point is the heavy Arctic ice able to retain its characteristics even to a moderate degree.

GENERAL CONSIDERATIONS

During the winter the icebergs are for the most part confined to the outer portion of the Labrador current, and become progressively more and more rare going towards the coast. For this reason

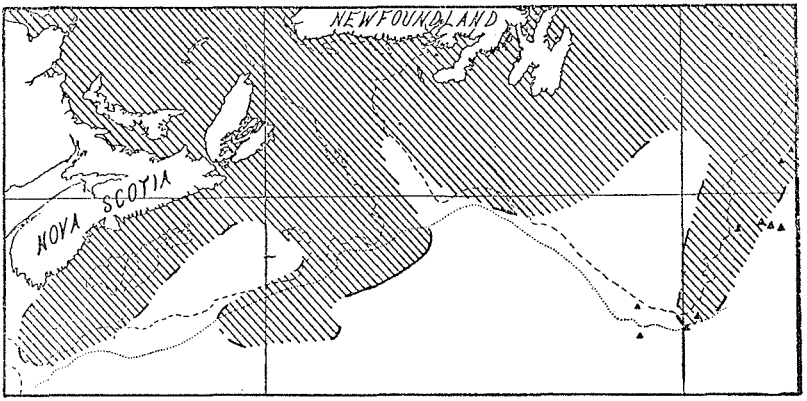

FIGURE 3.—Extent of ice and location of icebergs during last week of February, 1923. Definite borders indicate actual observations.

they are a negligible element in the gulf and south of Newfoundland. The steamers meet them as usual eastward of the Grand Bank.

With the coming of spring and summer the field ice disappears in the reverse order from south to north; but the icebergs remain and have now room to move close to the coast, appearing in the strait of Belle Isle and in the vicinity of Cape Race.

The course taken by the ice in winter can be traced even in midsummer by its effect on the water below. In July or even later at a depth of from 25 to 50 fathoms water cold enough to freeze fresh water can be found throughout the Gulf of St. Lawrence, around Newfoundland, over the banks north of Sable island, and

even along the coast of Nova Scotia (see figure 4). For this reason Arctic animals are able to live throughout this area.

We are aware that the account that we have given of the movements of the ice is in a number of details at variance with the generally accepted views as to the courses of the currents along our shores. It is in agreement, nevertheless, with a large and varied body of facts in addition to those of the distribution and progress of the ice, such as the magnificent series of current measurements

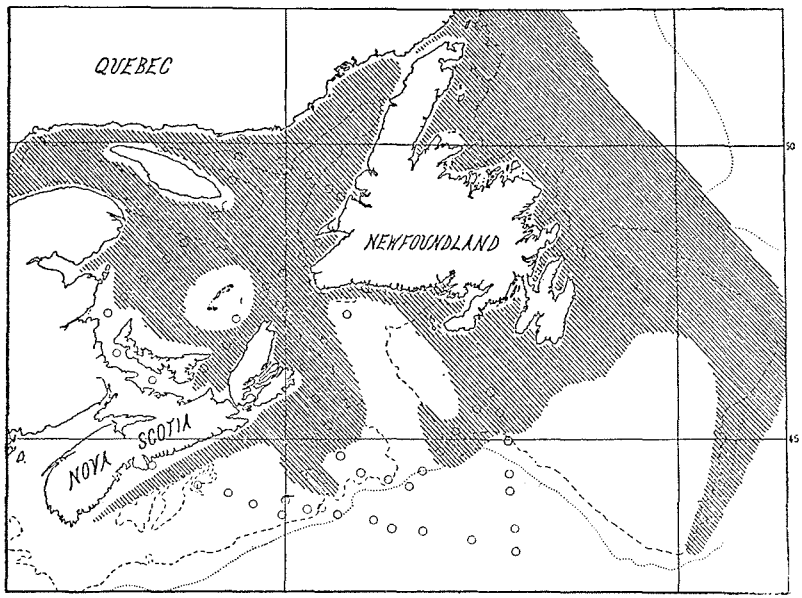

FIGURE 4.—Ice-cold water in June. Circles show stations of 1915.

of Dr. W. Bell Dawson, the distribution of the brackish water from the St. Lawrence, the distribution of the bottom animals, the movements and distribution of the floating animals and of the fishes, the results of drift bottle experiments, the temperatures of the water in the different regions, and the character of each of the many factors that determine the currents,—configuration of the bottom, inflow of fresh water, direction and strength of the winds, changes in barometric pressure, and tidal movements.

A consideration of all the available facts has led to the following

conclusions. Winter and summer alike the Labrador current does *not* as such flow westward past St. Pierre toward the Gulf of St. Lawrence, nor southwestward to the coast of Nova Scotia, but is limited by the St. Pierre, Green, and Grand Banks, and mixes with the warmer ocean water to the south over, between, and to a slight extent on the southern side of these banks. The water that moves southwestward between the "Gulf Stream" and the banks is not Labrador current, but a mixture of "Gulf Stream" and Labrador current and decidedly and constantly different from both. The superficial part of the Labrador current enters the gulf along the north side of the Strait of Belle Isle during summer in a somewhat modified form, but in winter with little alteration. This water makes the circuit of the gulf, and finally passes mixed with other water out of Cabot strait, much in the manner described by Admiral Bayfield nearly a century ago.

BLOCKING BELLE ISLE STRAIT

It has been maintained that the amount of movement in through the Strait of Belle Isle is not at all significant, but the facts have forced the belief that we receive through it an enormous amount of cold water and ice, as many have believed. If this were an unmixed evil, the proposed blocking of the strait would be worth consideration. Such a radical step would produce evil as well as good results. The greater part of the cold enters in the form of ice. A moderate course would be to stop the ice, but not to interfere with the flow of the water through the strait. Whether such an engineering feat as the bridging of the strait with a string of pontoons, held together with steel cables strong enough to hold back the ice until it jammed, will ever be feasible, is a question. If it were successfully accomplished, a marked change would come over the gulf. It would be open for navigation during the winter. The north shore would become habitable and develop much more valuable fisheries. The favourable fishing conditions of the outer banks would extend into the gulf and transform it, and the lobster and mackerel fisheries of the Magdalen shallows would remain much as they are. This would be the result of the absence of the ice-cold water between 25 and 50 fathoms in depth, that is now left all along the trail of the Arctic ice.

MUCH YET TO BE DONE

In such a brief account as this it has been necessary to omit all mention of the very many points in which our knowledge of the movements of the northern ice is deficient, and to which attention should be directed in future investigations. There can be no question as to the correctness of this account in the main; but in detail changes will doubtless be necessary. The movements of the ice are so variable, largely depending upon the vagaries of the wind. The advancing ice may closely hug the shore, or may swing off out of sight for a time; it may halt, or even retreat somewhat, but sooner or later it presses on and takes the course that has been indicated. We hope that the realization of the great importance of this subject for all maritime enterprise will be an incentive to the publication of all observations that may assist in settling the doubtful points. Does the field ice ever come west around the tail of the Grand Bank? To what extent do icebergs and field ice of the region of Cape Race move southwest beyond the banks? Does the field ice that comes out of Cabot strait ever reach the St. Pierre bank and Fortune bay? What is the usual course of this ice outside of Cape Breton? To what extent does ice from the north invade the Magdalen shallows and Northumberland strait? To what extent does the northern ice usually enter the estuary of the St. Lawrence, and does most of it enter north or south of Anticosti island? How much ice passes westward through the Strait of Belle Isle during the winter? The last question is a crucial one for determining how important the Arctic ice is in lowering the temperature of our waters. In the summer Dr. Dawson has found the current flowing westward through the strait for fairly long periods, with velocities averaging as high as two knots for several days. Usually, however, the summer flow is eastward, corresponding with the southwesterly winds. If there were an inflow with a velocity of one knot for the three winter months, enough ice could be carried in to cover half of the Gulf of St. Lawrence. If this melted it would lower the temperature of ten times its mass of water more than 14°, and it would still retain the full cooling power of the same mass of ice-cold water. So powerfully might winter be reinforced by an inflow through the Strait of Belle Isle of ice alone, not counting the much more voluminous cold water!