THE *CALANUS* EXPEDITIONS IN THE CANADIAN ARCTIC, 1947 TO 1955*

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THE recently reorganized Arctic Unit of the Fisheries Research Board of Canada, with headquarters at McGill University in Montreal, is a development of the Eastern Arctic Investigations that began in 1947. The *Calanus*, a diesel ketch of 43 tons, was built in Nova Scotia in 1948 (Dunbar, 1949); her name has been taken to cover all the field work of the series, including the seasons of 1947 and 1948 before the *Calanus* was used, and the work of individual members of the staff not attached to the ship.

The work done on the *Calanus* expeditions consists of the collection of material for the study of the abundance, distribution, and breeding cycles of sea mammals, fishes, plankton, and benthos. The emphasis has varied from season to season according to the particular nature of the region of operation and in relation to the needs of development and improvement of Eskimo economy. More time has been spent on mammals, especially walrus, ringed seal and beluga from 1953 to 1955. Collections of plankton and benthos were only qualitative in the first years. Quantitative work on both was begun in Frobisher Bay in 1951, and since 1954 efforts have been made to attack the problem of the rate of production of organic material in these cold arctic and subarctic waters. Physical oceanographic observations, including hydrographic sections, have been made on all expeditions. Oxygen concentrations have been measured since the start of operations, and phosphates since 1951.

The results so far available, whether published or not, are summarized below, following a brief account of the area of work, personnel, and logistics of each year's expedition. Station lists for all years to 1954 incl. have been published (Dunbar and Grainger, 1952; Grainger 1954b; Grainger and Dunbar, 1956).

1947. A reconnaissance of Ungava Bay was carried out by the author, assisted by H. Hildebrand, then a graduate student at McGill. Students have been employed as summer assistants every year, and the training of young men in northern work has been an important part of the programme. The party worked the coastal waters of the bay from Payne Bay to Koksoak River in a 30-foot "trap-boat" during the first half of the summer. In the second half work was done in the eastern part of the bay, from Koksoak River to Port Burwell in a 40-foot native-owned Peterhead boat.

*This paper does not mention arctic and subarctic work of the Fisheries Research Board before 1947. The northern work began in 1944 in northwestern lakes and rivers. (*See* F. R. B. Bulletin No. LXXII.)

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1948. Hildebrand worked on two lakes in the vicinity of Fort Chimo in March and April to obtain information on freshwater conditions in the winter.

Hildebrand and Ph. Orkin accompanied an Eskimo hunting party during late June and early July to work on ringed seal (*Phoca hispida*) and bearded seal or squareflipper (*Erignathus barbatus*). The second half of the summer was spent in the vicinity of Port Burwell, the work there being concerned mainly with the Atlantic cod (*Gadus callarias*).

E. H. Grainger was attached to a commercial fishing venture as observer, in order to begin a study of the arctic char (*Salvelinus alpinus*) at the head of Frobisher Bay. The *Calanus* was built during this summer and was sailed north to Fort Chimo by Ernest Ritchie, with W. E. Wilson (engineer), Kingsley Morisson, and Constable Hayley of the marine section of the R.C.M.P. Hayley replaced Dunbar, who was invalided ashore at Halifax. The boat was beached at Chimo, using cradle and winch.

1949. This was the first season in which the *Calanus* was used in field work. The ship's company consisted of Dunbar, Grainger, Wilson, T. Creery, E. Reid, and two Chimo Eskimo. The boat was launched on June 16 and entered Mission Cove harbour at Burwell on June 29. The eastern half of Ungava Bay is always clear of ice before the western. Hydrographic sections were made across the bay, using Akpatok Island as the hub. The Button Islands were visited and a considerable part of the season was spent at Port Burwell.

1950. The work in Ungava Bay was continued, with emphasis on experimental fishing, especially for Greenland shark (*Somniosus microcephalus*). Some time was spent in the vicinity of Cape Hope's Advance and Diana Bay (which had been visited also in the previous year), and a section was made across Hudson Strait from Wakeham Bay to Big Island. Work at Burwell and in the Button Island group was continued. On another project, J. Wright accompanied the same commercial fishing venture that Grainger had joined in 1948, working on the arctic char in Frobisher Bay and on the Atlantic cod at Resolution Island (Acadia Cove). A. H. Lawrie accompanied the U.S. Navy Resupply Mission to the far northern stations as observer for the Fisheries Research Board. The *Calanus* was again beached at Chimo for the winter, as in the two previous years.

1951. With Dunbar, Lewis, I. McLaren, W. E. Wilson and T. E. Wilson on board, the *Calanus* spent a few weeks in the eastern part of Ungava Bay, paying special attention to the little fiord of Adlorilik. She then crossed Hudson Strait to Lake Harbour and arrived at the Frobisher R.C.A.F. base on August 1. The month of August was spent entirely within Frobisher Bay, carrying out an elaborate series of sounding runs, dredging, trawling, and plankton hauling. The ship was beached at the Frobisher air base.

Grainger spent the season at the Sylvia Grinnell River in Frobisher Bay, making an intensive study of the arctic char. Lawrie took part in the *Cancolim II* expedition into the Beaufort Sea in the western Arctic as marine biologist for the Board. This was the first extension of the field of operations into the West.

1952. Grainger, McLaren, W. F. Black, T. E. Wilson, and an Eskimo pilot took the *Calanus* into Cumberland Sound. The working season was cut short by mechanical trouble and the party had to return to Frobisher for temporary repairs, after which the ship was taken at reduced speed to Churchill for repairs and wintering. J. Martin and S. McCall joined the ship's company for that trip. Some of the roughest weather of any of the expeditions was encountered on this voyage together with further mechanical trouble and Grainger's party did exceedingly well to bring the crippled *Calanus* safely into Churchill harbour.

McCall and A. Dawson had been working during the summer on Ogac Lake on the southwest shore of Frobisher Bay, in which exists an isolated population of Atlantic cod (see page 184). This work was supported by the Carnegie Arctic Fund of McGill University, but the results will be incorporated in due course into the *Calanus* expedition series.

1953. For the work in Hudson Bay, which is a very large inland sea, a professional skipper was engaged for the first time. This post was filled in 1953 by R. Collyer. Grainger was again in charge of the scientific work and assisted by McLaren, Black and Dawson. The field work covered northern Hudson Bay and the western end of Hudson Strait, and a beginning was made in the study of the northern Hudson Bay herd of walrus (*Odobenus rosmarus*) that is to be found in summer first at Walrus Island, then at Bencas Island and the northern end of Coats Island, and still later at Seahorse Point, Southampton Island.

1954. Captain H. Norden Andersen took over as skipper, with Wilson still as engineer. The scientific party consisted of Dunbar, Grainger, and J. A. Thomson. The field work was very largely on the walrus at Walrus Island, Bencas Island, and Coats Island. Grainger spent several weeks at Coats Island with two Eskimo tagging walrus and collecting material. Thomson left in August and the remainder of the party sailed the ship to Montreal, where she was given her first refit. She was fitted with a new magnetic compass, a Sperry gyrocompass, a new and more powerful radio, a new auxiliary engine, and a set of hydraulic winches from Scandinavia (main trawl winch, hydrographic winch, and anchor windlass). All hatches were renewed and rearrangements made in the space below decks.

McLaren spent the period from March to October in the Cape Dorset area of Baffin Island, making a thorough study of the ringed seal. Dr. F. Neave, of the Nanaimo, B.C., Station of the Fisheries Research Board, accompanied an ice-breaker and supply mission in the Beaufort Sea, to make a reconnaissance of fisheries research needs in that region.

1955. The *Calanus* left Montreal at the end of June with Andersen, Grainger, McLaren, Black, and Wilson on board; Dawson served as supernumerary as far as Battle Harbour, Labrador. The ship was greatly delayed by unusual ice conditions on the Labrador coast; this provided opportunities for some interesting work on plankton production, and on cod at Nain. The late arrival at Coral Harbour made it necessary to abandon the work planned for the southeastern part of Hudson Bay. The party was joined at Coral

Harbour by A. Mansfield, who had been working from there on walrus since late March, on a grant from the McGill Carnegie fund. The work of 1954 at Coats Island was continued. Wilson left early in September, and Mansfield continued his work on walrus by accompanying an Eskimo hunting party to Seahorse Point and returned to Montreal in October. The remaining four took the ship through Roes Welcome Sound and Frozen Strait to Igloolik, where she was frozen-in in October. Black and McLaren left a little later for Montreal, leaving Andersen and Grainger as wintering party on board. A winter station was established through the ice in some 50 metres of water in Foxe Basin for the observation of the winter regime in plankton and benthos, and work began at the same time on walrus and ringed seal; northern Foxe Basin is one of the few places where walrus are known to winter.

D. Sergeant spent the summer studying the beluga (*Delphinapterus leucas*) in the area of Churchill, where a commercial company has a license for the limited exploitation of the beluga. Material from 200 whales was collected with the aid of a whaleboat. The *Calanus* group now has two powered whaleboats in commission, one at Coral Harbour, the other at Churchill.

J. G. Hunter, attached to the Nanaimo Station, joined the group in 1955 in order to begin work on the fishes of the coast of Beaufort Sea from Herschel Island to Baillie Island, studying the fully marine, as well as the anadromous species. The chief purpose of this work is to establish the biotic potential of these fishes, with a view to a rational development of native fisheries.

The author was in charge of these investigations from 1947 to 1955 on a part-time basis. They have now grown so large that full-time control is essential. In 1954–55 the group was reorganized and the staff considerably enlarged. Dunbar remains as consultant and adviser, and the present full-time staff is as follows:

Dr. H. D. Fisher (in charge)	Mr. A. W. Mansfield
Dr. E. H. Grainger	Miss B. M. Barry
Dr. D. E. Sergeant	Captain H. N. Andersen
Mr. J. G. Hunter	Miss L. McMullen
Mr. A. S. Bursa	Miss J. Thompson
Mr. I. A. McLaren	Mr. T. E. Wilson

Captain Andersen, who has had five years' experience with schooners on the west coast of Greenland, is skipper of the *Calanus* and general technical assistant. Miss L. McMullen is secretary and general assistant to Dr. Fisher.

Summary of results

Physical oceanography

The map Fig. 1 shows the hydrographic sections made up to 1954, and the waters covered in the field work. Sections in Ungava Bay show a flow of water into the bay from the northwest, across its central part south of Akpatok Island, and out in the northeast, this last flow being pressed against the Labrador side. Akpatok Island sits on a shelf extending eastward from the island (which is of Palaeozoic limestone, in contrast to all the rest of the

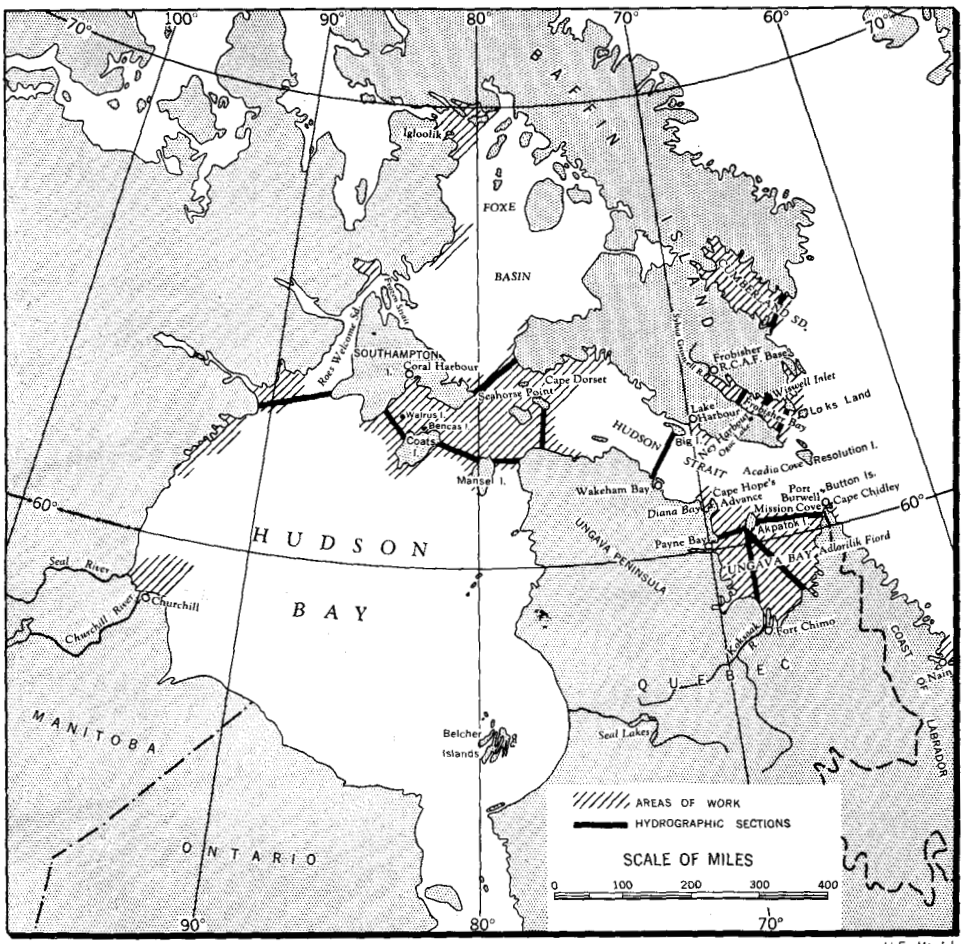

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Fig. 1. Hydrographic sections and working areas of the *Calanus* expeditions.

Ungava Bay rocks), and there is a trench with depths of over 200 metres surrounding this formation. No good trawling bottom was found in the bay; the bottom is exceedingly uneven and apparently boulder-strewn. The water is of low temperature and of low salinity, but the upward trend of these two parameters that is commonly encountered at depths below 200 metres probably indicates the entry of Atlantic (West Greenland) water into Ungava Bay at these depths. The upper water of the bay shows great dilution by land drainage, and Atlantic influence is not demonstrable from hydrographic data; admixture of Atlantic water is, however, strongly suggested by the plankton, which is subarctic rather than arctic (for the criteria used to delimit the two marine regions see the paper on the Ungava amphipods (Dunbar, 1954)), by the amphipod fauna, and by the presence of two fishes, namely the Atlantic cod in the northeast part of the bay, and the Atlantic salmon (*Salmo salar*) in the rivers of the eastern and southern shores, as far west as the Koksoak.

Mixing of the waters of Ungava Bay and also of Hudson Strait and Frobisher Bay appears to be facilitated by the establishment of density inversions, probably for short periods of time only. Density inversions, which are not yet fully accepted as respectable by the oceanographic world, began to appear in the *Calanus* results from 1949 onward, and there is evidence that they are associated with strong tidal currents and large tidal intervals (Dunbar, 1955).

Exceptional hydrographic conditions were found in Adlorilik, a small fiord on the eastern side of Ungava Bay. This is an inlet that is well over 100 metres deep and that has a very shallow sill at the entrance. In contrast to the usual conditions in such fiords in the North, as in Victoria Bay on the shore of Frobisher Bay or in fiords in Greenland, where the deep water inside the fiords is much colder than the water at similar depths outside the fiords, the deep water of Adlorilik was found to be very much warmer than the corresponding water outside (3°C. at 80 metres inside compared with 1.2°C. outside). Possibly this is a wind effect.

From the sounding runs made in Frobisher Bay in 1951 an interesting pattern was brought to light, the two main features of which are (1) a deep trough along the southwest side of the bay, extending from a fairly low threshold at the mouth (about 275 metres) to the islands that separate the outer and inner bays; this trough is often deeper than 550 metres, and sometimes deeper than 640 metres, which is beyond the limit of the sounder scale of the *Calanus*; (2) a shelving bank in the northeast half of the outer bay extending from the level of Wiswell Inlet to at least as far as Loks Land. This bank, now known as the "Calanus Shelf", slopes gently from very shallow depths near the shore to some 130 metres before meeting the deep trough already described. Bottom temperatures over this shelf were of the order of -0.5°C. in 50 metres in August 1951, and trawling over the shelf as a whole gave very poor results.

Fishes

The collection of fishes from Ungava Bay has already been published (Dunbar and Hildebrand, 1952), and only features of the fish fauna that are of zoogeographical interest are referred to below. Special attention has been given to the Atlantic cod of the Port Burwell area and to the arctic char of Frobisher Bay. These two species, together with the Greenland shark, and perhaps the Greenland halibut (*Reinhardtius hippoglossoides*) form the small group of fishes which offers possibilities of development in the interests of the Eskimo economy in restricted localities of the Eastern Arctic. The shark is easily caught wherever seals are abundant along the eastern shores of this region, at least from Cape Chidley and Burwell to northern Baffin Island; it does not appear to be common in Hudson Strait or in Frobisher Bay.

The Atlantic cod arrives at Burwell in late July or early August and leaves again in September-October. During that short period, however, large numbers are present, and it can be taken at the rate of about 20 fish per

man-hour. Long-lining was not successful at Burwell, perhaps owing to the shortage of good bait. Burwell is the only region in the whole of the Canadian Eastern Arctic, except the Labrador coast, that offers a cod fishery. The fish are small and the rate of growth is slow, a 60-cm. specimen being 12-13 years old. The possibility of developing a fishery in Ungava Bay has been discussed elsewhere (Dunbar, 1952).

A study of the biology of the arctic char, as regards its breeding cycle, growth rate, and sea-life, has been published by Grainger (Grainger, 1953), who has shown that the char of the Sylvia Grinnell River, at the head of Frobisher Bay, can reach an age of more than 24 years and a length of approximately 70 cm. The first migration to the sea occurs probably during the fifth to seventh summer, and the sea-life each year lasts from late June to late July or early September. The females reach sexual maturity at a length of about 54 cm. and an age of about 12 years. Egg counts of maturing fish averaged 3,590, and apparently only one third of the females over 12 years breed in any one year. From these results, and without yet knowing the mortality of the young in fresh water, it was concluded that the char population of a single stream could be seriously damaged by intensive fishing, especially on a commercial scale. At the same time it became clear that many char streams were not touched at all by the Eskimo, and that almost no effort was made to preserve the fish caught. The key to the development of this important resource lies, therefore, in providing greater mobility of the Eskimo and in encouraging the preservation of the char for winter use by smoking, salting, or freezing.

Ogac Lake, a small lake on the southwest shore of Frobisher Bay, has long been known to contain cod. The *Calanus* expedition of 1951 found that these are *Gadus callarias* and that they live completely isolated from the main marine population of cod. Atlantic cod are not known from Frobisher Bay itself, or from anywhere north of Resolution Island in the Canadian Eastern Arctic. The cod of Ogac Lake live in a layer of water of about 26.00‰ salinity or less and of temperatures of the order of 7-8°C., which is far above the temperature of the water in the adjacent fiord (Ney Harbour). This stratum lies between fresh water at the top and stagnant salt water at the bottom. There is contact with the fiord water at spring tides, but the cod apparently do not pass over the sill out of the lake. Fish of all sizes were taken in the lake, including large individuals of over four feet in length. The vertebral count is very low (51-52), indicating development in warm water. This cod population may have invaded the lake during a past period of warmer climate, at a time when cod were normally present in Frobisher Bay in summer.

Marine mammals

Walrus The walrus herd of northern Hudson Bay frequents in summer Walrus Island, Bencas Island, Coats Island, and Seahorse Point on Southampton Island, in that order, appearing at Walrus Island in July and at Seahorse Point in late August and September. Possibly some of them go south to the Belcher Islands during that period. An estimate of the numbers in the herd

is difficult to make at this stage; the present estimate is 3,000 animals. For the groups seen a ratio of one first-year young to every ten adults and adolescents was inferred. Of 18 specimens taken in 1954 five were males and 13 females. Of the females one was first-year, one second-year, two had newly-born young, and four were pregnant.

As a preliminary experiment, 23 walrus were tagged in 1954 with a new stainless steel tag designed by the writer (Fig. 2). The tag is about 1½ inches long and is designed to pierce the very tough hide, and lodge with the head in the layer of blubber and the basal disc on the outside of the skin. In 1955, 48 animals were marked, and the tagging is to be continued on a larger scale.

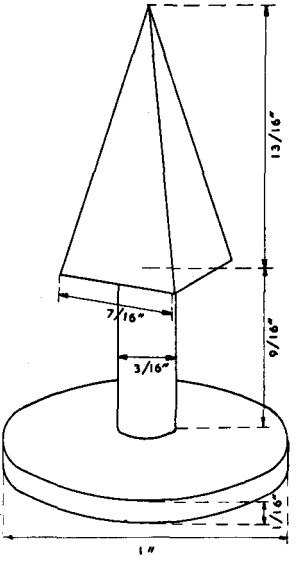

Fig. 2. *Calanus* walrus tag (stainless steel).

The walrus haul out on rocks of a certain shape that is not found everywhere in the north. Much of the shore-line is either very steep or very flat and not suitable for walrus. They prefer a sloping rocky shore that rises in terraces or otherwise unevenly to some few tens of feet above the water level. Since no significant difference was found between the benthonic food supply close to these rocks and the supply in other areas, it was concluded that an important factor in determining the walrus distribution in the summer may well be nothing more complex than the conformation of the shore. The winter distribution of this herd is still unknown; the tagging is expected to shed light on this.

Ringed seal. The *Calanus* has worked in areas rich in seal only since 1951. Intensive work on the ringed seal began at the western end of Hudson Strait in 1953. In that year, McLaren's material consisted of 44 animals. In 1954, working at Cape Dorset from March to October, he collected material from 498 specimens. Some of the results of this work, which will be published shortly, may be summarized as follows (McLaren, 1955):

The ringed seal is not a truly migratory animal and it appears that the decisive factor governing its distribution in the Arctic is the duration of the ice cover. This is formed earliest and persists longest along irregular coasts with much skerry development, and there appears to be a correlation between the pattern of the coast line and the seal distribution. By far the most important food organism, especially in offshore waters, is the pelagic amphipod *Themisto libellula*, but it is clear that the distribution of this crustacean has little to do with the distribution of the seal. In shallower inshore waters, seals feed to a large extent on decapod crustaceans, Mysids, and polar cod.

The study of the teeth of the ringed seal has shown that the fact that this species is a solitary form, and not a migratory and harem-breeding species, complicates the interpretation of the tooth-sections, since there tends to be a wide range of nutritional histories. The oldest individual, a male, was a little over 40 years old; very few were more than 20-25 years old. The male does not mature on the average until the seventh year; most of the females ovulate for the first time when about six years old, although a few may do so in their fifth year. "Testis histology reveals that the males are capable of fertilizing from late March until at least mid-April and that they are out of rut by late May and probably earlier. The females normally ovulate shortly after parturition, during lactation. Mating probably occurs shortly after the birth of the young. The young adult females may tend to be polyœstrous; older seals, possibly by fixation of the œstrous cycle through pregnancy, probably lose this tendency. . . . . The blastocyst remains unimplanted for a period of more than three months and individual embryos may implant over a period of about one month. . . . . The peak of pup production probably occurs near the beginning of April and the females may attend the young until mid-June, or later in some cases." (McLaren, 1955).

Beluga. A preliminary survey of the white whale population of western Hudson Bay was carried out by the Central Station of the Fisheries Research Board, when a license for commercial exploitation at Churchill was first granted (Doan & Douglas, 1953). Sergeant, of the Arctic Unit staff, began a thorough study in 1955 and examined 200 individuals. By aerial reconnaissance 2,700 white whales were counted on July 25; 900 in the Churchill River estuary and 1,800 near the mouth of the Seal River. By August 30 the whales had left the estuaries and were presumably on migration. A whale tag that is to be fired from a crossbow and which lodges in the blubber has been developed and will be used in 1957. Work is planned also on the beluga of the Mackenzie Delta.

Zoogeography and systematics

In the large-scale marine zoogeography of the north, the delimitation of a subarctic from an arctic marine zone has already been proposed by the author (Dunbar, 1954), and this system is used in discussing the present expedition results. The *Calanus* has worked so far on the northern fringes of the subarctic zone (Ungava Bay, Frobisher Bay, and Cumberland Sound),

and in the special region of Hudson Bay. Hudson Bay, although definitely outside the subarctic waters on the criteria used here and showing many of the characteristics of the arctic zone, nevertheless has to be placed in a category by itself on account of the high temperatures and low salinities in the upper layers in summer (up to 10°C. and down to about 23.00‰), a result of freshwater influx and very high stability, and on account of the preservation of warmer-water relicts, such as the caplin (*Mallotus villosus*) and the calanoid copepod *Acartia clausi*.

It has been established as a general rule that in the arctic zone the macronecton is dominated by mammals, with the fishes of minor importance and represented by comparatively few species, but that in the subarctic zone the macronecton is made up almost entirely of fishes, with the mammals relatively unimportant.

The northern limits of the distribution of the fishes of economic importance in the north, that is to say, of all fishes produced in large numbers, occur either close to the northern edge of the subarctic or well within it. The Greenland shark and the arctic char are the only exceptions, and the latter is an anadromous fish with a very short sea-life. The reasons for this striking distributional pattern are not clear, but they are no doubt connected with the different capabilities of homoiothermous and poikilothermous animals, and possibly with the time required for the adaptation of large poikilotherms to very cold environment.

In general faunistic and systematic studies, work in the following groups has been done, some of which has already been published: Fishes of Ungava Bay (Dunbar & Hildebrand, 1952); amphipods of Ungava Bay (Dunbar, 1954); polychaetous annelids (Grainger, 1954a); echinoderms (Grainger, 1955); cirripedes (Bousfield, 1955); priapulids, sipunculids, and pycnogonids of Ungava Bay, eastern Hudson Strait, Frobisher Bay, and Cumberland Sound; and the plankton copepods of Ungava Bay (Fontaine, 1955). Among the benthonic forms, including fishes, are many new records for the area and several for North America, and there are five new species of amphipods. The zoogeographic affinities of the fishes, annelids, echinoderms, and amphipods are as follows:

Fishes: 44 species, of which 13 are freshwater forms. Of the marine species 3 are arctic, 10 are arctic-subarctic (panarctic), 2 are subarctic, 5 are subarctic-boreal, 2 are typically boreal forms, and 8 are of wide north-to-south range from arctic to boreal. Two of the panarctic species, *Icelus spatula* and *Eumesogrammus praecisus*, are not known east of Greenland or west of the Kara Sea, and are probably of Pacific origin.

Only five of the total number are known to be circumpolar, though several others probably are.

Polychaetes: 74 species. Circumpolar or probably so, 42 species; panarctic, 15; arctic-subarctic-boreal, 49; "cosmopolitan", 9; probably of Pacific origin, not known east of the Canadian Eastern Arctic, 3. (In all, 134 species of polychaetes are now known from the Eastern Arctic, of which 8 belong to this Pacific group).

Echinoderms: 26 species. Circumpolar or probably so, 14; panarctic, 13; arctic-subarctic-boreal, 10; Pacific species known only as far east as Greenland, 2. *Amphipods*: 114 species. Circumpolar or probably so, 45; arctic, 3, perhaps 7; subarctic only, 13; panarctic, 32; panarctic-boreal or subarctic-boreal, 57; recorded also from the Japan Sea or the Sea of Okhotsk, 33; known only from the Atlantic sector, 28, of which 12 belong to the single family Stenothoidae; Pacific forms not known west of the Kara Sea or east of Greenland, 6.

In all four groups there is a certain small proportion of species that are known only from North America and Siberia, but not from the intervening European waters. These are very probably immigrants to both regions (North America and Siberia) from the Pacific by way of Bering Strait. They are thus in the same category as certain species of decapod crustaceans known from the West Greenland coast, and of certain fishes known from Hudson Bay (Vladykov, 1933). It is also interesting that Doutt (1942) found that the freshwater harbour seal (*Phoca vitulina*) from the Seal Lakes of the Ungava Peninsula showed closer affinity to the Pacific than to the Atlantic subspecies.

Plankton production and standing crop

The Ungava Bay copepod plankton (harpacticoids excluded) has been found to contain 22 species, 5 of which had not been previously recorded from the western North Atlantic (Fontaine, 1955). With one exception, the species are all panarctic in distribution; the exception is the boreal form *Pleuromamma robusta*, of which only two specimens are recorded from Ungava Bay. *Calanus finmarchicus* breeds continuously in the short summer, but apparently goes through only one generation per year. The same is true of *Pseudocalanus minutus*, but it is possible that in this species part of the population breeds a second time in the fall. *Ascartia longiremis* and *Oithona similis* spawn in July, probably producing only one generation per year.

The breeding cycles, growth rates, and metabolic rates of cold water holoplanktonic animals are matters of considerable general interest upon which much work has still to be done. Evidence has been brought forward by various workers that growth rates of certain littoral and benthonic species are not lower in cold arctic waters than those of the same or closely related species in temperate and even subtropical waters, and that the same is true of the metabolic rates measured in terms of oxygen consumption. It appears clear, however, that in the holoplanktonic species so far studied, the growth is much slower in cold water. The measurement of the metabolic rates is the next step in this particular line of research, and is planned for the immediate future in the *Calanus* series. For a general review of recent work on metabolic regulation with respect to temperature in poikilotherms see Bullock (1955). The breeding cycle in the large pelagic amphipod *Themisto libellula* is at present under study; its growth is slow, and its life cycle appears to take two years, with only one breeding period per individual. Similar work will shortly be undertaken on the Euphausiacea.

Hudson Bay is intensely stratified in the upper 50 metres in summer, so much so that there has been doubt expressed as to whether a normal vertical exchange during the winter is achieved; until a few years ago it was also thought possible that the water below 50 metres was dynamically dead and therefore might be expected to be very low in oxygen content. As regards the former possibility, hydrographic work has now been carried out in the winter, but the results are not yet available. The oxygen content of the deep water in Hudson Bay is normal, and there is therefore no reason to suspect unusually poor conditions for the production of phytoplankton or zooplankton. The standing crop of zooplankton is not much below that of Ungava Bay, judging from present results; and the phytoplankton, according to Mr. Bursa's work with the plankton (Utermöhl) microscope, maintains a standing crop in summer that is only a little below that of the western end of Hudson Strait, where the stability of the water is much less.

The standing crop of plankton has been sampled by means of (1) the two-metre stramin net hauled horizontally, (2) the Henson net with No. 6 bolting silk hauled vertically, and (3) water samples preserved in weak neutralized formalin for estimation with the Utermöhl microscope. Measurement of the rate of production of organic matter in Hudson Bay is being undertaken at present by means of the oxygen (Winkler) method. The results promise to be very interesting, for they suggest that the method may need considerable modification, and that there may be factors not yet considered, such as the possible dampening of zooplankton activity in the darkened bottle, and even the possibility of a considerable lag in the cessation of synthesis of organic matter in the dark, which complicates the interpretation of the results, and which may apply especially to the use of the method in water of very low temperature.

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