ARCTIC INSTITUTE OF NORTH AMERICA

TECHNICAL PAPER NO. 1

THE PLANKTON OF THE BEAUFORT AND CHUKCHI SEA AREAS OF THE ARCTIC AND ITS RELATION TO THE HYDROGRAPHY

By

MARTIN W. JOHNSON

PUBLISHED JULY 1956

THE ARCTIC INSTITUTE OF NORTH AMERICA

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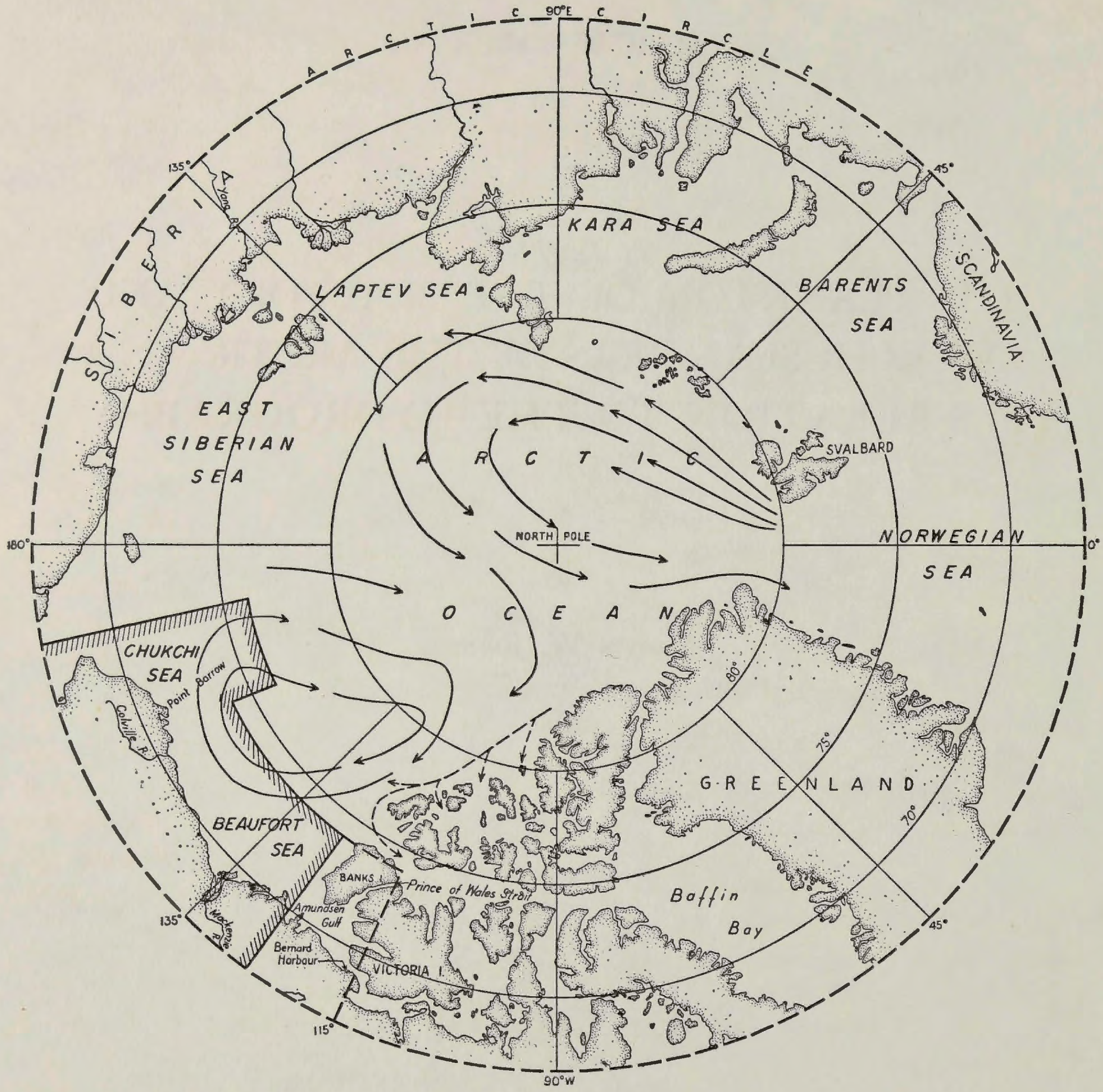

Fig. 1. Arctic regions showing area considered in this study. The water circulation in the Polar Basin is based on Worthington's (1953) modification of Nansen's picture to include the cyclonic eddy. The dashed arrows are from Dunbar (1951).

THE PLANKTON OF THE CHUKCHI AND BEAUFORT SEA AREAS OF THE ARCTIC AND ITS RELATION TO THE HYDROGRAPHY*

Martin W. Johnson†

Within the last decade there has been a great surge of interest in arctic research which has been prompted in part by a hope for greater use of the resources of the Arctic, including those associated with the sea. Even if the expectations prove greater than warranted in some instances, much research is needed to evaluate the potentialities and variabilities in the arctic marine fauna. The urgent problems and implications involved have been well discussed by Dunbar (1953) who stresses particularly the need for research in the Beaufort Sea. Marine biological research important to our knowledge of both the Chukchi and Beaufort seas has been carried out from the Arctic Research Laboratory at Point Barrow, but this has not been concerned directly with the marine plankton. Some pioneering investigations have been made of the ecology of the marine zooplankton of the Bering and Chukchi seas (Johnson, 1934, 1938, 1953). These investigations have provided information on the composition and reproduction of endemic forms and have also indicated a northward drift of characteristically Bering Sea and north Pacific copepods through the Bering Strait into the Chukchi Sea. A Russian plankton survey carried out in this area and reported upon by Stepanova (1937) has also indicated a northward drift of plankton through Bering Strait.

The present paper extends our information on the plankton much farther into the Arctic Ocean than did the earlier accounts and penetrates into hitherto unexplored waters of the Arctic (Fig. 1). It is based mainly on two extensive oceanographic surveys made by the U.S.S. *Burton Island*, a naval icebreaker, in the Chukchi and Beaufort seas during August 1950 and August and September 1951. In 1950, 73 oceanographic stations were occupied for the study of physical, chemical, and biological conditions. Plankton hauls were made at 50 widely distributed stations covering the area between 125°W. and 164°W., and from 70°N. and northward into the pack ice to nearly 74°N. These hauls consisted of vertical tows made from various depths (usually 100 to 0 metres) with a one-half-metre Nansen-type plankton net, the upper and lower parts being constructed respectively of No. 2 and No. 10 bolting silk. In 1951 a total of 56 stations were occupied for plankton samples with the one-half-metre net drawn vertically from 100 to 0 metres. The area covered was roughly the same as that for 1950 but extended into higher latitudes and

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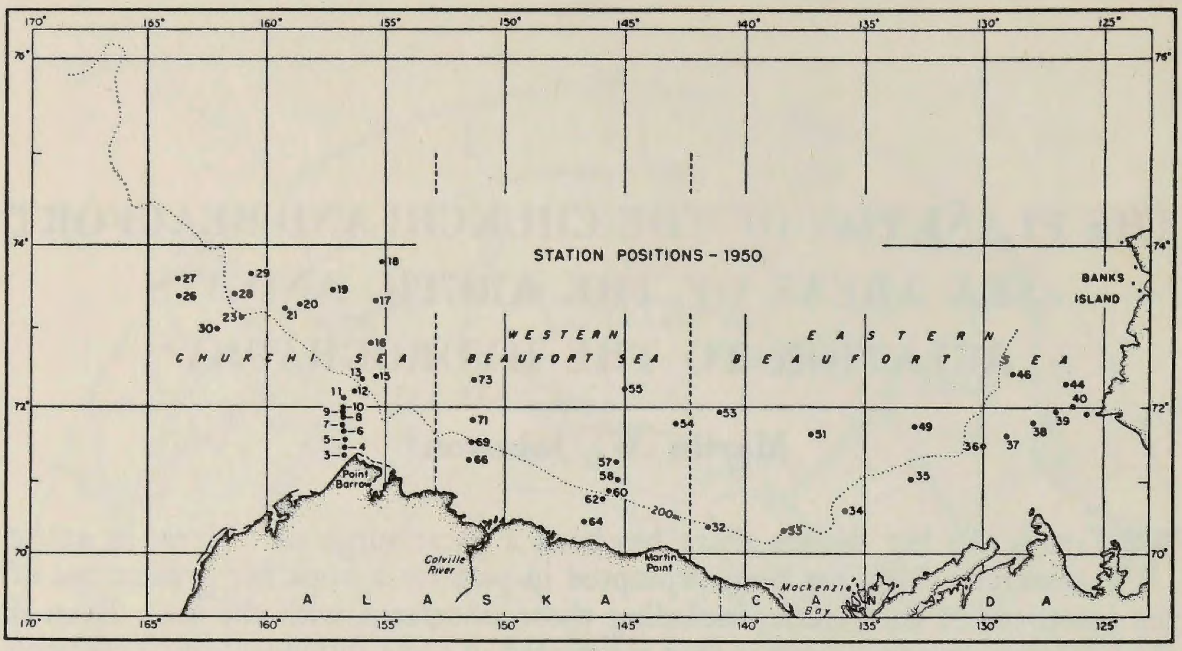

Fig. 2. U.S.S. *Burton Island* 1950 plankton station positions and approximate location of 200-metre contour (after Carsola, 1954).

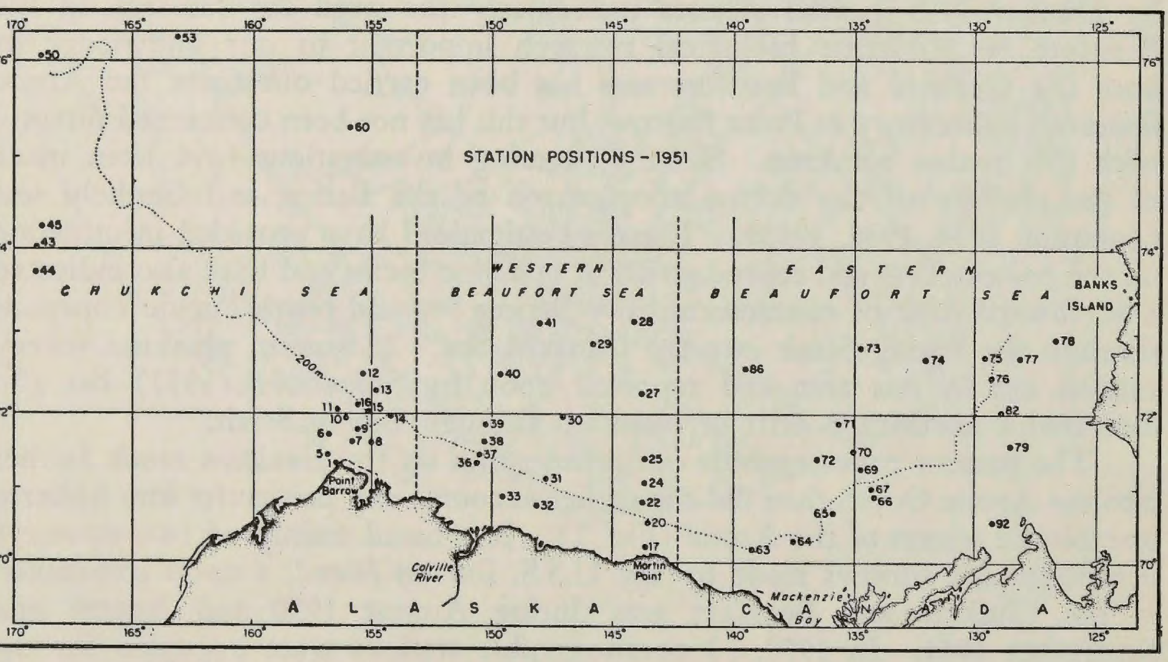

Fig. 3. U.S.S. *Burton Island* 1951 plankton station positions and approximate location of 200-metre contour (after Carsola, 1954).

5° farther to the west. The station positions are shown in Figs. 2 and 3. The depth intervals sampled are given in Tables 1 to 14. In 1953 samples were obtained at 30 stations in Amundsen Gulf and Prince of Wales Strait.

The analyses of the plankton samples given in Tables 1 to 14 are based on a complete enumeration of the less abundant organisms, and for the abundant forms on counts of an aliquot part of the sample multiplied by the appropriate factor and, when needed, standardized to 0–100-metre vertical hauls (excepting hauls in Tables 4 and 11) which is the most frequent depth interval sampled, especially in 1951. Some of the organisms not included in the tables are discussed in the text. The distribution of selected forms that show restriction in geographical range is given in Figs. 4 to 10.

From a study of the range of certain species and the relative abundance of certain pelagic species and larvae, it will be seen that during the period of the survey the area falls rather sharply into a western and an eastern section. These sections correspond to the northern Chukchi Sea and the Beaufort Sea. Biologically, the boundary between these areas appears to lie in the region off Point Barrow with a transition zone, which in 1950 extended eastward into the Beaufort Sea to the next line of stations (numbers 66 to 73), especially to stations 71 and 73. In 1951 the areas were also clearly distinct but with somewhat greater penetration of the Chukchi Sea elements obliquely into the western Beaufort Sea, including stations just to the east and southeast of Point Barrow as far as Martin Point. On this basis the whole area covered can be divided more or less clearly into three parts: Chukchi Sea, western Beaufort Sea, and eastern Beaufort Sea as indicated in Figs. 2 and 3.

In presenting the results it will be convenient to consider the fauna in two parts: 1) The copepods which constituted by far the greater bulk of the plankton and 2) The miscellaneous plankton.

This exceptional survey was made possible through the cooperation of the U.S. Navy during the exploratory cruises of the icebreaker U.S.S. *Burton Island*. I am greatly indebted to the officers and men and to the scientists aboard who, under the leadership of Dr. Clifford A. Barnes of the University of Washington and Dr. Waldo K. Lyon of the Navy Electronics Laboratory, made the net collections. Among those contributing specifically to the collecting should be mentioned especially Mr. Eugene LaFond in 1950 and Mr. Alfred A. Carsola in 1951, both of the Navy Electronics Laboratory, and Dr. Warren Wooster in 1950 and Mr. Robert Bieri in 1953, both of the Scripps Institution of Oceanography. Miss Linda Haithcock assisted in the calculations and in preparing the tables and figures.

Copepods

No attempt will be made to give in detail the known geographic range of all of the different species found during this survey. There are a number of systematic and biological reports that include this information for certain of the species dealt with. Some of these sources are mentioned elsewhere in the text, especially useful are: G. O. Sars (1900, 1903, 1918), van Breeman (1908), With (1915), Farran (1926), Rose (1933), Jespersen (1934), Wilson (1950), and Vervoort (1951). These reports, covering different parts of the world, show how very extensive is the range of several of the species that flourish best in arctic waters. In the lower latitudes these arctic species are either migrants, transported by currents from the north, or inhabitants of the deeper, colder waters, where they may live and reproduce.

Species characteristic of the Bering Sea found in the area

Several of the stations occupied in the northern Chukchi Sea and western Beaufort Sea yielded a few copepod species that thrive normally in the Bering Sea and to the south. Among those that occurred in small numbers in the more offshore waters within the Arctic Circle are especially *Eucalanus bungii* Giesbrecht (northern variety *bungii*), and *Metridia lucens* Boeck (Figs. 4–6).

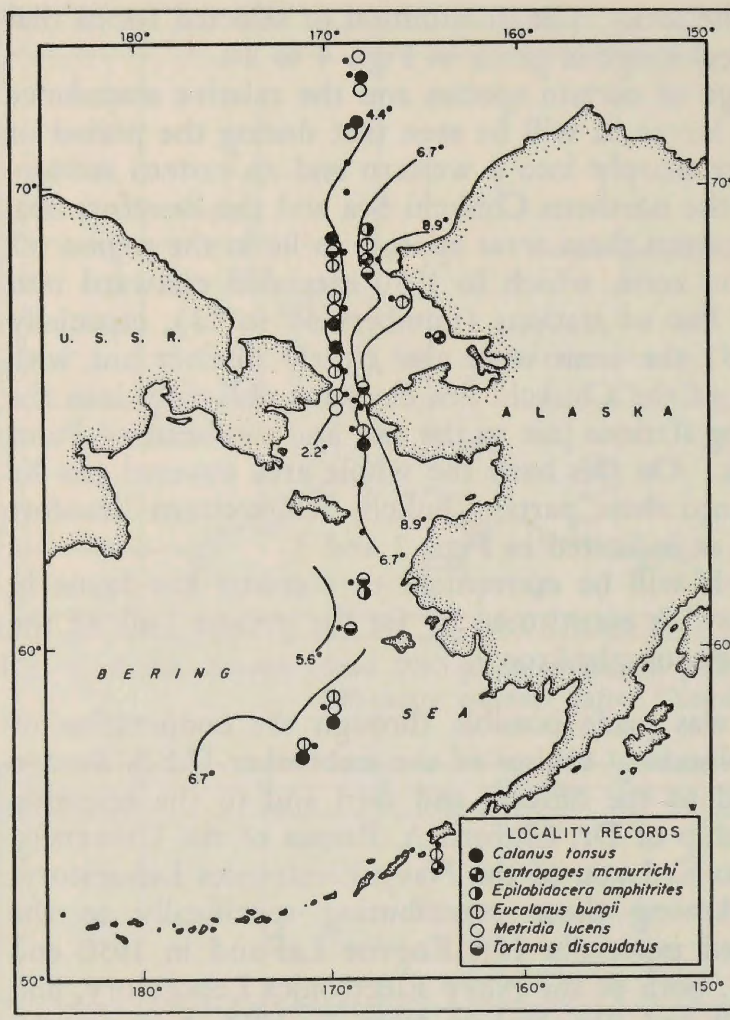

Fig. 4. Copepod distribution. Locality records U.S.S. *Nereus* 1947; surface isotherms °C from Johnson (1953).

Eucalanus bungii is a large, numerically important Pacific species that extends well down the west coast of North America as sub-species *californica*, and is also present on the Asiatic coast. *Metridia lucens* is usually less abundant along the west coast but is well represented there and elsewhere in the Pacific and in the Atlantic but is not considered arctic in its northern range. Only adult or sub-mature specimens of these two species were found as expatriate stragglers in the northern range whereas previous surveys (Johnson, 1934) have shown them, particularly *Eucalanus*, to be actively reproducing in the Bering Sea and Bering Strait. In 1951 one adult male of *Eucalanus bungii* was found at Station 20 off Martin Point far beyond its expected range.

Calanus tonsus Brady was not found as far north as were the previous two species, but it is clearly a northern extension of the more southern fauna. Each year it occurred near Point Barrow only. In 1950 a single specimen was taken at Station 5, whereas in 1951 it occurred at six stations grouped just north of Point Barrow (Figs. 5 and 6). Elsewhere the species is reported from both the Atlantic and Pacific. It is often very abundant in the Bering Sea and in the inshore and offshore waters on the west coast of Canada and the United States and is also reported from the northwest Pacific by Brodskiy (1952).

Calanus cristatus Krøyer likewise appears to be a visitor from the southern fauna. It occurred in our samples only twice. In 1950 a single Stage V

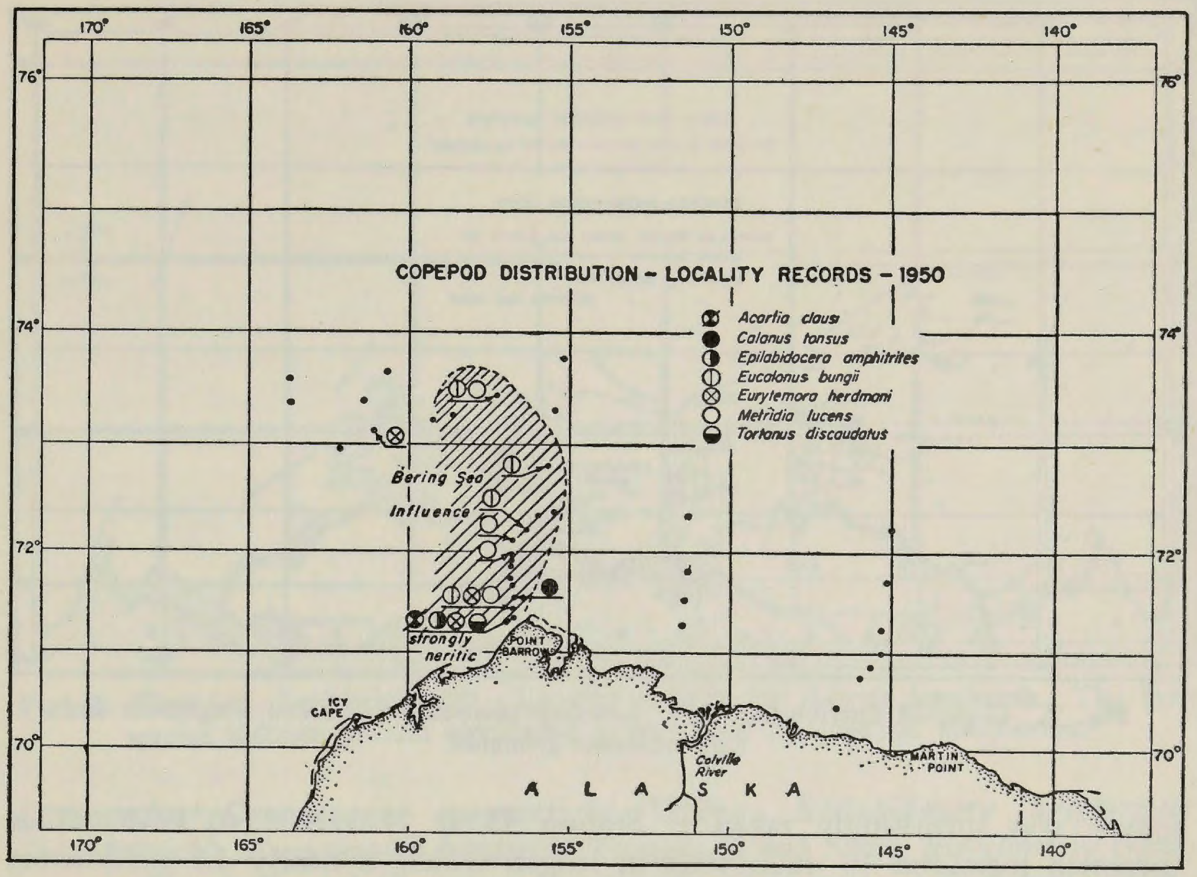

Fig. 5. Copepod distribution 1950. Locality records for seven species.

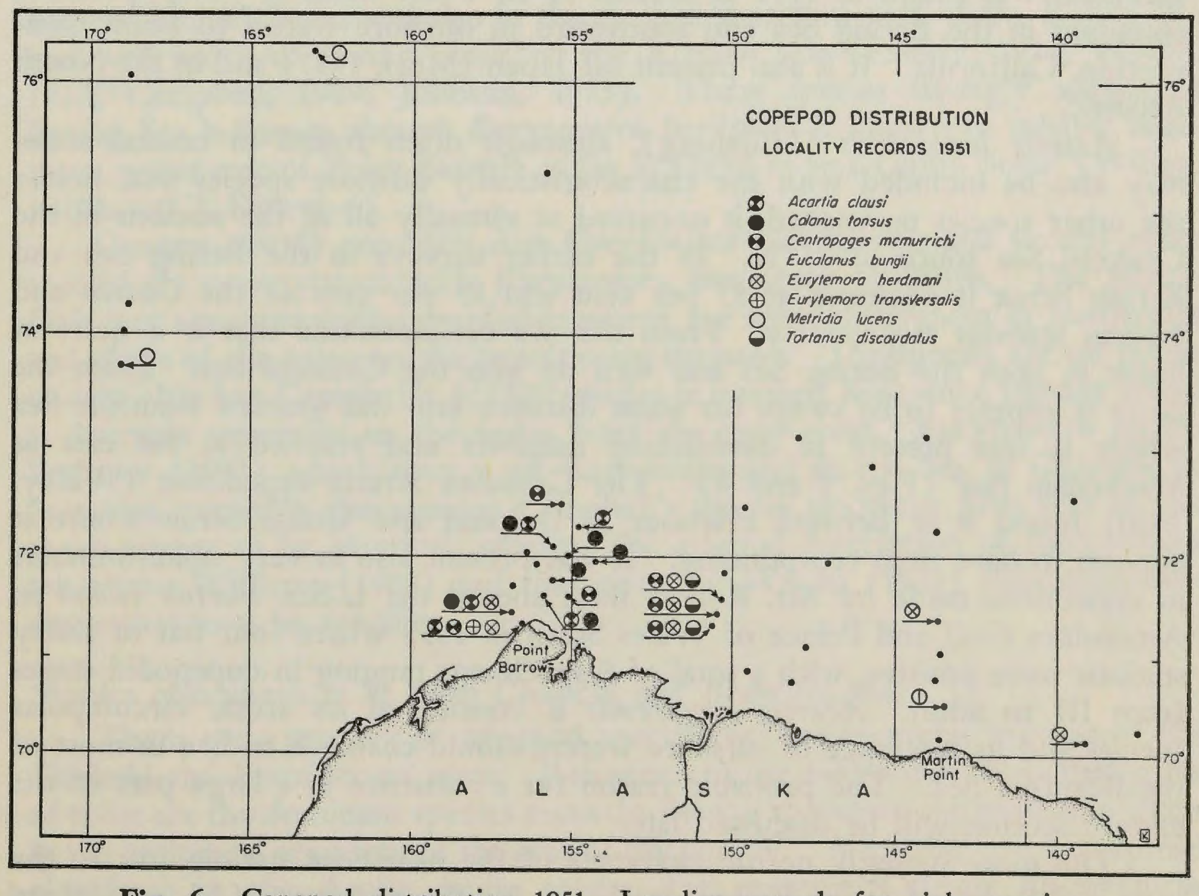

Fig. 6. Copepod distribution 1951. Locality records for eight species.

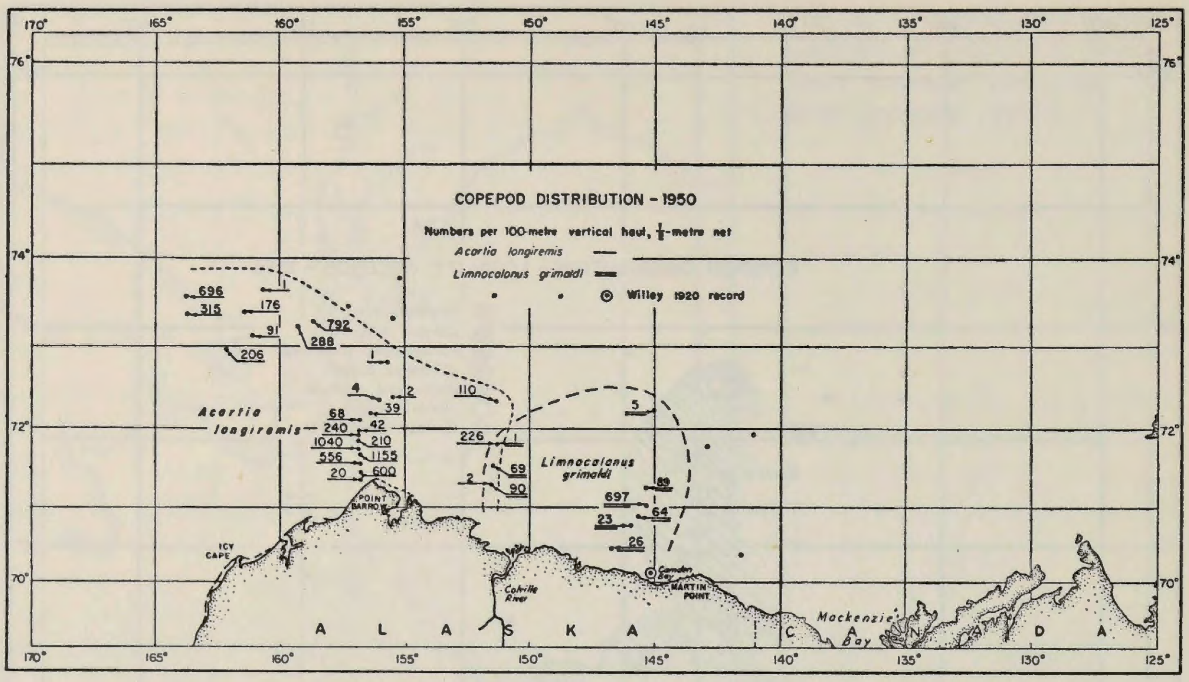

Fig. 7. Copepod distribution 1950. Locality records for *Acartia longiremis* and *Limnocalanus grimaldi.*

female was surprisingly taken at Station 53 at 71°57N., 140°59W. This specimen measured 10 millimetres in length which is nearly 1.5 millimetres longer than usually reported for this stage of the species. The second specimen was found in 1951 at Station 7, off Point Barrow. The species is abundant in the Bering Sea and southward in offshore waters to Point Conception, California. It is also present off Japan (Mori, 1937) and in the North Atlantic.

Acartia longiremis (Lilljeborg), although often found in coastal areas, may also be included with the characteristically offshore species but, unlike the other species mentioned, it occurred at virtually all of the stations in the Chukchi Sea south of 75°N. In the earlier surveys in the Bering Sea and Bering Strait it occurred at 55 per cent and 85 per cent of the *Chelan* and *Nereus* stations respectively. From this we can conclude that it is quite at home in both the Bering Sea and well up into the Chukchi Sea. From the latter it appears to be swept for some distance into the western Beaufort Sea where it was present in diminishing numbers and reached as far east as Mackenzie Bay (Figs. 7 and 8). The Canadian Arctic expedition (Willey, 1920) found it at Bernard Harbour in Dolphin and Union Strait where it appears to have been reproducing. It was present also in very small numbers in collections made by Mr. Robert Bieri aboard the U.S.S. *Burton Island* in Amundsen Gulf and Prince of Wales Strait in 1953 where four out of thirty stations were positive, with a total of 8 specimens ranging in copepodid stages from III to adult. *Acartia longiremis* is considered an arctic circumpolar species and its tolerance of offshore waters should enable it to live in most of the Beaufort Sea. The probable reason for its absence in a large part of the eastern section will be discussed later.

The more strongly neritic character of the nearshore stations just to the west and north of Point Barrow is shown by the presence of *Acartia clausi*

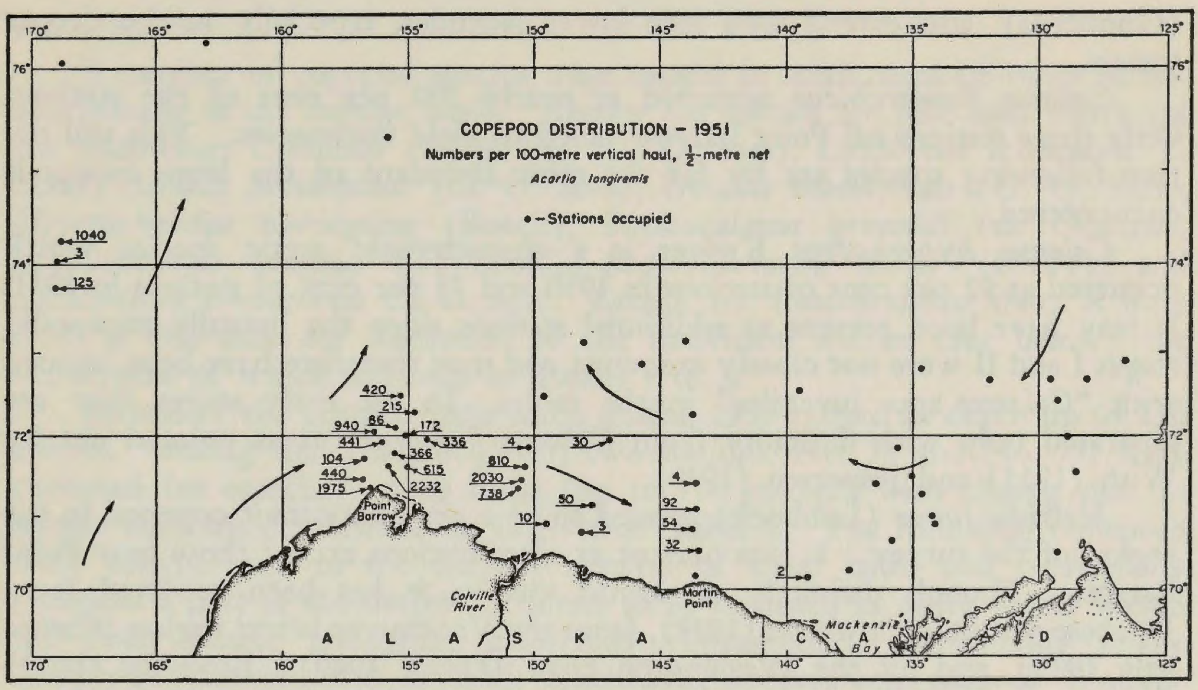

Fig. 8. Copepod distribution 1951. Locality records for *Acartia longiremis*. The long arrows indicate general circulation as suggested by copepod distribution.

Giesbrecht, *Centropages mcmurrichi* Willey, *Epilabidocera amphitrites* (McMurrich), *Eurytemora herdmani* Thompson and Scott, *Eurytemora transversalis* Campbell, and *Tortanus discaudatus* (Thompson and Scott). Most of these species are at times abundant in the coastal waters of western Canada and the United States and also in the shallower eastern part of the Bering Sea and well north of Bering Strait on the Alaskan side (Esterly, 1924; Willey, 1920; Campbell, 1929; Johnson, 1953). These species strongly suggest a Bering Sea influence though *Eurytemora herdmani* is known to inhabit near-shore water east of Point Barrow as far as Dolphin and Union Strait (Willey, 1920). (Cf. Figs. 4–6).

Gurney (1933) considers that *Eurytemora transversalis* and several other species are synonymous with *Eurytemora americana* Williams. The female fifth feet are quite indistinguishable except for some differences in the length and shape of the spine on the penultimate segment. The species are no doubt closely akin but Campbell's (1930) species is retained here since further study is desirable especially on the males from the type areas. *Eurytemora kieferi* Smirnov (1931) which occurs off Kamchatka and in the Sea of Okhotsk is, however, probably the same as Campbell's species since the fifth feet of the males appear to be identical, whereas the original description of *Eurytemora americana* Williams (1906) and that given by Wilson (1932) indicate differences that may be specific.

Species characteristic of both Chukchi and Beaufort seas

There are a number of copepod species that are common to most of the Chukchi and Beaufort sea areas. Reference to the tables will show that some of these are the dominant species numerically and therefore the most important in the biological economy of the area of this survey. A number are widespread elsewhere in the Arctic while others, for example *Calanus finmarchicus*

(Gunnerus), also extend well into lower latitudes, especially in the deeper waters.

Calanus finmarchicus occurred at nearly 100 per cent of the stations. Only three stations off Point Barrow failed to yield the species. This and the two following species are by far the most abundant of the large copepods encountered.

Calanus hyperboreus Krøyer is a characteristic arctic species which occurred at 92 per cent of stations in 1950 and 73 per cent of stations in 1951. It may have been present at additional stations since the juvenile copepodid stages I and II were not closely examined and may therefore have been lumped with "*Calanus* spp. juveniles" in the tables. In the early stages they are separated only with difficulty from *Calanus finmarchicus* as pointed out by With (1915) and Jespersen (1939).

Metridia longa (Lubbock) proved to be a very important copepod in the region of the survey. It was present at most stations except those near Point Barrow. Though definitely an arctic species, it has been reported from Japanese waters (Marukawa, 1928), from the Vancouver Island region (Campbell, 1929), and off the Washington coast (Davis, 1949). Brodskiy (1952) does not report it from the northwest Pacific nor have I seen the species in many collections from the north Pacific.

Pseudocalanus minutus (Krøyer) was found at all but six stations in 1950 and four stations in 1951, and was certainly the most generally abundant of the microcalanids. Sars (1900) established a second species *Pseudocalanus major* to receive a form larger than *Pseudocalanus minutus*. In the present survey some large forms were also present but no attempt was made to distinguish the two in the analysis of the catches. With (1915) made a careful analysis of the two species and *Pseudocalanus gracilis* G. O. Sars but was unable to find valid distinctions. In the tables it is lumped together with *Microcalanus pygmaeus* as "microcalanids".

Microcalanus pygmaeus (G. O. Sars) was the second most abundant microcalanid, except at stations in the ice pack where it was often the most abundant. It was widely distributed in the Beaufort Sea where it occurred at all but two of the stations in 1950. In the Chukchi Sea it was absent mainly from the coastal stations off Point Barrow. It is a widespread species in the Arctic (Sars, 1900) but was not taken at any of the stations occupied by the Canadian Arctic expedition (Willey, 1920); the probable reason is that the stations were all situated too near shore. In the present survey the offshore stations were the most productive, however, it was commonly present in samples taken by the U.S.S. *Burton Island* in Amundsen Gulf and Prince of Wales Strait in 1953.

Oithona spp. and *Oncaea* spp. are among the numerically important tiny copepods. The species involved appear to be mainly *Oithona similis* Claus and *Oncaea borealis* G. O. Sars, both of which are widespread in the Arctic (Sars, 1900, 1903, 1918; Linko, 1913; Willey, 1920).

Pareuchaeta norvegica (Boeck) occurred at many stations throughout the area but at fewer stations and in diminished numbers in the Chukchi Sea, especially near Point Barrow. It was nowhere abundant but its large size and persistent presence could make it of some significance in the marine economy.

Rarer species

A number of copepod species were caught in small numbers more or less sporadically in the regular hauls. Among the species not discussed above are the following: *Chiridius obtusifrons* (G. O. Sars), *Cyclopina schneideri* T. Scott, *Gaidius brevispinus* (G. O. Sars), *Gaidius tenuispinus* (G. O. Sars), *Heterorhabdus norvegicus* (Boeck), *Limnocalanus grimaldi* (de Guerne), *Scaphocalanus magnus* (T. Scott), *Scolecithricella minor* (Brady), and *Scolecithrix brevicornis* G. O. Sars. Except for *Limnocalanus* there is little need at this time for discussion of the individual species (*see* below) the occurrence of which is shown in Tables 1 to 7.

Several of the regular hauls taken during 1950 ranged in depth up to 230 metres. During that year, however, two stations, No. 18 and No. 71, were occupied for especially deep hauls (up to 700 metres) with closing nets to sample different depth intervals as given in Table 4. The following copepods were caught only in the deepest interval of these hauls and presumably represent a part of the deepwater fauna tó be expected in many places within the Polar Basin: *Haloptilus acutifrons* (Giesbrecht), *Mormonilla minor* Giesbrecht, *Spinocalanus abyssalis* Giesbrecht, *Spinocalanus magnus* Wolfenden, and *Xanthocalanus propinquus* G. O. Sars.

Nauplii

The nauplius larvae of copepods occurred throughout the area and while quite patchy, they were often present in considerable numbers giving evidence of active copepod reproduction during the period of sampling. The average number adjusted to 0–100-metre hauls per station (including Stations 18 and 71 for 1950) for areas by years was: Chukchi Sea–2,225 (1950), 2,510 (1951); western Beaufort Sea–1,863 (1950), 1,486 (1951); eastern Beaufort Sea–849 (1950), 842 (1951). The copepod larvae occur mainly in the surface waters (Table 4).

Miscellaneous Plankton

Holoplankton

The amphipods (which will form part of a separate report) and the ostracods were scattered irregularly over most of the area. From Table 11, it appears that the ostracods prefer the deep water and, like certain copepods, may not have been adequately sampled by the shallower, regular hauls. *Conchoecia maxima* Brady and Norman was the dominant ostracod.

In 1951 *Podon* and *Evadne* (not in tables) were abundant at Station 1 and common at Station 8. A few were observed at Station 64 and at Stations 36, 37, and 38. None were counted in 1950.

The Euphausiacea were poorly represented in the catches, especially in the adult stage. The collections do, however, greatly extend the range of the species found. *Thysanoëssa inermis* (Krøyer) was found at three stations in the Chukchi Sea but not elsewhere. *Thysanoëssa raschii* (M. Sars) appears to be the main euphausiid of the area, occurring at seven stations in the Chukchi Sea and three stations in the western Beaufort Sea. *Thysanoëssa longipes* Brandt occurred but once in the Chukchi Sea. No adult euphausiids were caught in the eastern Beaufort Sea and only two furcilia stages were found at Station 63 (1951). The larval stages of euphausiids were best repre-

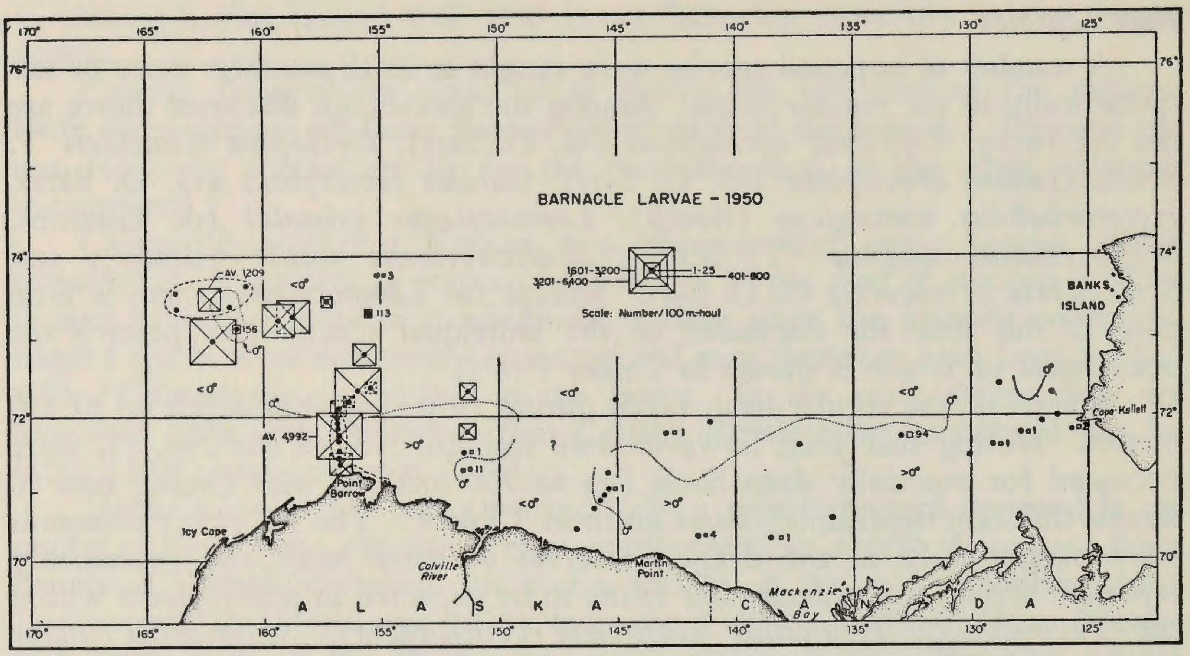

Fig. 9. Barnacle larvae 1950, total nauplii and cyprids combined. Where several station points are encircled by a dashed line, the square that has its centre nearest the centre of the station points is the average value for those stations. The dotted line shows approximate position of 0°C surface isotherm.

sented in 1951 when most stations in the Chukchi Sea and western Beaufort Sea yielded a few larvae.

The euphausiid species mentioned above are the only ones recorded by Schmitt (1919), from the Canadian Arctic expedition collections. It is of interest to note that none of these euphausiid species were reported from the collections made by the *Fram* (Sars, 1900), but *Thysanoëssa raschii* has been reported from various localities in the eastern Arctic as far north as Svalbard and *Thysanoëssa inermis* to 69°44N. (Stephensen, 1933). The *Sedov* apparently took no euphausiids whatever (Bogorov, 1946).

Chaetognaths were well represented at many of the stations in both the Chukchi and Beaufort seas. Their occurrence will be covered in a separate report.

Medusae, especially *Aglantha* were common in most of the area.

Meroplankton

The temporary planktonic stages of bottom-living animals were best represented by barnacle larvae. Both naupliar and cyprid stages were abundant in the Chukchi Sea in 1950 and in 1951, especially the latter year when they extended also in considerable numbers into the western Beaufort Sea at the more coastal stations (Figs. 9 and 10). Only scattered specimens, mostly cyprid stages, were present in the eastern Beaufort Sea, with the exception of Station 49 (1950) which appeared anomalous in yielding 94 larvae.

The summary of cyprid and naupliar stages of barnacles given in Table 15, provides some information on the biology of the area under survey. It appears that:—

1. In 1951 there seems to have been a far greater production of barnacle larvae than in 1950. The period of collecting was almost identical for both

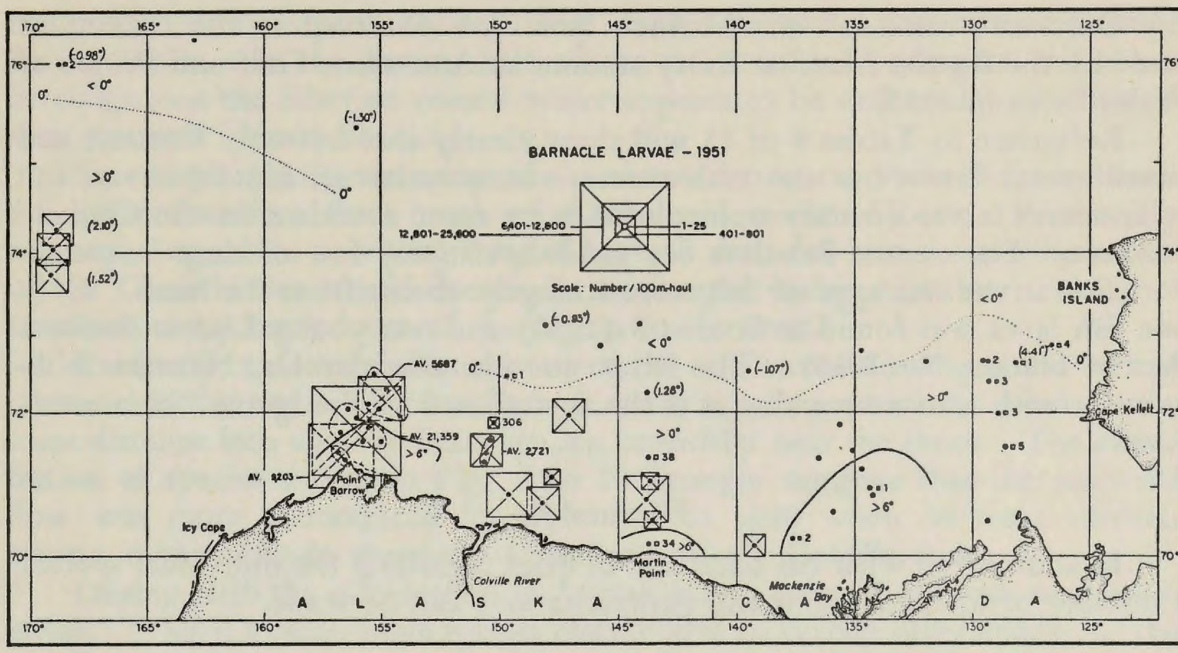

Fig. 10. Barnacle larvae 1951, total nauplii and cyprids combined. Where several station points are encircled by a dashed line, the square that has its centre nearest the centre of the station points is the average value for those stations. The dotted line shows approximate position of 0°C surface isotherm.

years for the western Beaufort Sea area and for the Chukchi Sea area, except for the six far offshore stations, 43, 44, 45, 50, 53, and 60 which were taken from 3–7 September 1951. In the eastern Beaufort Sea there is a discrepancy of nearly a month in collecting time, but in any event, the number of larvae taken in each year was very small, except for Station 63 (1951) near Mackenzie Bay.

2. It would appear that the reproductive season was somewhat more advanced when the 1951 samples were collected since the cyprid stage follows the naupliar stage in the development of barnacles. However, there may have been an early release of larvae in the far eastern Beaufort Sea in 1950 which gave rise to the significant number of cyprids found at Station 49.

Lamellibranch larvae were most abundant during the 1951 cruise. The following summary shows the average number netted per station by areas. When the number of larvae at a station was so small that it was indicated in the tables by only a plus sign (+), this is considered as one specimen in calculating the averages. This will doubtless usually err in minimizing the numbers actually present but the error cannot be very significant. In arriving at the average for the western Beaufort Sea in 1950, the larvae taken at Station 71 are included, but since only two stations in that section yielded larvae, the figure merely emphasizes their relative scarcity.

Average Number of Lamellibranch Larvae per Station

1950			*1951*		
Chukchi Sea	Western Beaufort Sea	Eastern Beaufort Sea	Chukchi Sea	Western Beaufort Sea	Eastern Beaufort Sea
160	10.4	6	3192	492	15

Only an occasional lamellibranch larva was observed in the collections made by the *Burton Island* at thirty stations in Amundsen Gulf and Prince of Wales Strait in 1953.

Reference to Tables 8 to 13 will show clearly that not only barnacle and lamellibranch larvae but also crab zoaeae, macruran larvae, annelid larvae, and echinoderm larvae (mainly ophioplutii) were most abundant in the Chukchi Sea area. The eastern Beaufort Sea yielded relatively few of these larvae.

The larvae and eggs of fish were strangely absent from the hauls. Only one fish larva was found at Station 3 (1950) and one young *Liparis koefoedi* Parr at Station 71 (1950). The latter was identified by Dr. Norman Wilimovsky with a statement that it is the first record of the species from arctic Alaska.

Discussion

In addition to what has been said in brief regarding the individual species, a number of interpretations and generalizations can be made.

Hydrographic implications

The geographic distribution of the holoplankton taken gives evidence of a northward flow of water from the Bering Sea into the Chukchi Sea. This flow appears to be detectable biologically northward to at least latitude 76°N.

Figure 4 shows the locality records for the collections taken during the U.S.S. *Nereus* 1947 cruise in the Bering and Chukchi seas. This figure, together with Figs. 5 and 6 for the 1950–1 surveys, shows the continuity of the following species with the Bering Sea fauna: *Calanus cristatus*, *Calanus tonsus*, *Eucalanus bungii*, and *Metridia lucens*. All of these probably drift into the Chukchi Sea area with little or no local reproduction to replenish the stock in the more northern reaches. The numbers occurring at the U.S.S. *Nereus* stations in 1947 and also the locality records and numbers for the 1934 U.S. Coast Guard cutter *Chelan*, are given by Johnson (1953). There are also a number of characteristically neritic copepod species that are pressed northward near the coast and to the east around Point Barrow, as indicated in the discussion under the species (*see* Figs. 5 and 6). These biological observations corroborate the hydrographic reports which also indicate a northward flow through Bering Strait during the summer (Barnes and Thompson, 1938; LaFond and Pritchard, 1952).

LaFond and Pritchard reporting on the U.S.S. *Nereus* 1947 data, state that the Bering Sea water flowing northward tends to follow the Alaskan coast but that at the northernmost stations near 72°N., 170°W. "the more saline and relatively warm water found at mid-depths seems to have originated in the Bering Sea . . ." (1952, p. 82). That this is probably the case is borne out by finding *Calanus tonsus* and *Metridia lucens* at these stations in 1947 (Fig. 4). The present report on the 1950–1 cruise gives biological evidence of Bering Sea water considerably farther to the north.

It should be pointed out also that for the summer of 1949, Saur, Tully, and LaFond (1954) obtained evidence indicating a flow of water from the northeastern Siberian coast to a point directly north of Bering Strait at the latitude of Kotzebue Sound. This flow would be expected to transport certain plankters from the Siberian coast but the contribution to the area covered by the present study is probably relatively small since the major current through Bering Strait is in the eastern half of the strait and according to the above investigations the Siberian coastal water appears to be deflected to the northwest towards Herald Shoal.

Sverdrup's (1950) summary of the circulation in the Polar Basin indicates a westward surface flow north of Alaska and eastern Siberia. Presumably subarctic organisms surviving long enough to drift far into the northern part of the Chukchi Sea would eventually be caught within this flow and either succumb or be carried out of the region to the west.

Evidently, a considerable amount of the northward-flowing water swings eastward in the region of Point Barrow, carrying elements of the plankton for some distance into western Beaufort Sea, especially near the shore. The distribution of species shown in Figs. 5 to 10 strongly suggests that the eastward flow was more pronounced in 1951 than in 1950 when its most obvious extension was only to the series of stations off the Colville River.

During 1950 the distribution of *Limnocalanus grimaldi* proved very interesting. This is a remarkable species closely akin to certain other species of the genus living in freshwater bodies that in the past may have been connected with the sea. It was encountered only in 1950 when it occurred in appreciable numbers at nine adjacent stations sampled in a restricted area of the western Beaufort Sea, between Point Barrow and Martin Point. This area lies off the mouth of the Colville River extending far off shore, as shown in Fig. 7. In 1913 the species was taken at one station by the Canadian Arctic expedition (Willey, 1920), near shore at Collinson Point in Camden Bay to the east of the Colville River. Since the species has estuarine affinities in some other parts of the world, it is not surprising to find it off the river mouth where its presence might indicate a spread of river water outward towards the north and east. But the salinity distribution does not readily support this view. The surface salinities at the stations where *Limnocalanus* occurred ranged from 28.04‰ to 31.65‰, and excepting the innermost station at each line, there is a general decrease in salinity with distance from shore. The picture may, however, be confused by offshore water formed from melting ice, as indicated by lower temperatures.

The absence of *Limnocalanus* from Stations 32, 33, 34, and 35, off the mouth of the Mackenzie River and Mackenzie Bay, is somewhat puzzling in view of the extensive distribution off the Colville River. This may suggest a westward flow of water (not sampled) from the Mackenzie along the shore to the area where the species was actually found. In support of this, at Station 32 the salinity was only 16.19‰. However, a better explanation may be that the Mackenzie discharge flowed to the east so near the shore that it was not sampled even at the innermost stations in that section.

Elsewhere in the world *Limnocalanus grimaldi* occurs in the Gulf of Bothnia, the Baltic and Kara seas, off Svalbard, in the estuary of the Yana River in Siberia, and strangely, also in the Caspian Sea where Sars (1897) considered it a relic of a glacial fauna in that area.

A freshwater species, *Limnocalanus johanseni*, was described by Marsh (1920) from freshwater collections near Collinson Point, and Comita and Edmondson (1953) found it to be the dominant copepod in a lake near Point Barrow.

During the summer months, some of the more neritic copepod species do find conditions favourable for limited reproduction. For instance, the disc-like egg cases and at least one nauplius larva of *Tortanus discaudatus* were found east of Point Barrow. This species and several others which are common to abundant along the east coast of Canada and northeastern United States may have a more or less continuous though probably intermittent distribution near shore in the arctic region, depending upon variations in climatic conditions and strength of arctic currents at the coast.

Coastal collections made by the Canadian Arctic expedition working from the west bears this out, at least eastward to Bernard Harbour, where Willey (1920) reported the following species with which we are concerned: *Acartia longiremis* and *Eurytemora herdmani.* A similar eastern extension of the range is shown for *Acartia* by the *Burton Island* collections for 1953, as mentioned above.

As a part of the biological picture, it was pointed out earlier that certain more or less neritic copepod species and the larvae of barnacles occur as an oblique extension southeastward into the Beaufort Sea. *Acartia* is similarly distributed in the regular hauls to about Mackenzie Bay, and, similarly, the extension was greater in 1951 than in the previous year. The surface temperatures as plotted by Carsola (unpublished MS.) from the 1950 and 1951 cruise data also show a more pronounced extension of warm water into western Beaufort Sea in the latter year (Fig. 11).

The distribution of *Acartia longiremis* (Figs. 7 and 8) presents an interesting problem and appears to throw some light on the general prevailing circulation of the water from the north or northeast, from the Arctic Ocean into the offshore eastern Beaufort Sea. In considering its transport and survival in the far north it is significant that the species lives in the surface layers (*see* Table 4) where it is subject to surface currents and to the variations in salinity and temperature found in the vicinity of melting ice. The species is considered arctic with a wide southern extension, and from its distribution elsewhere during this survey, one might assume, *a priori,* that as far as temperature or salinity conditions are concerned during the summer, it should thrive in the eastern Beaufort Sea as well as it does in the Chukchi Sea. In 1950 the surface temperatures at the eight most northwesterly stations in the Chukchi Sea where *Acartia longiremis* occurred ranged from 0.79°C at Station 28 to -1.35°C at Station 27 where nearly 700 specimens were taken. No *Acartia* were taken at Stations 17, 18, and 19 where temperatures were -1.46 to -1.54°C (*see* Figs. 9 and 10 for general surface temperature conditions). Salinities in the Chukchi Sea ranged from 24.35‰ to 28.77‰. In the eastern Beaufort Sea for the same year most of the area surveyed was characterized by surface temperatures above 0°C, with ranges from 0.80 to 2.38°C (temperatures to 5.31°C were noted at stations off Mackenzie Bay); surface salinities ranged from 23.24‰ to 30.80‰.

Despite these similarities in temperatures and salinities, *Acartia longiremis* was absent from both the 1950 and 1951 collections taken in the eastern Beaufort Sea. It was also absent from the most northerly stations in the Chukchi Sea and western Beaufort Sea. This pattern of distribution with its diminution in numbers to the east and disappearance in the northern Chukchi Sea suggests that the conditions in the Arctic Ocean are sufficiently inimical to *Acartia longiremis* to eliminate it from the plankton north of latitude 75°N. during the years sampled. Similarly, Sars (1900) found *Acartia longiremis* only in the

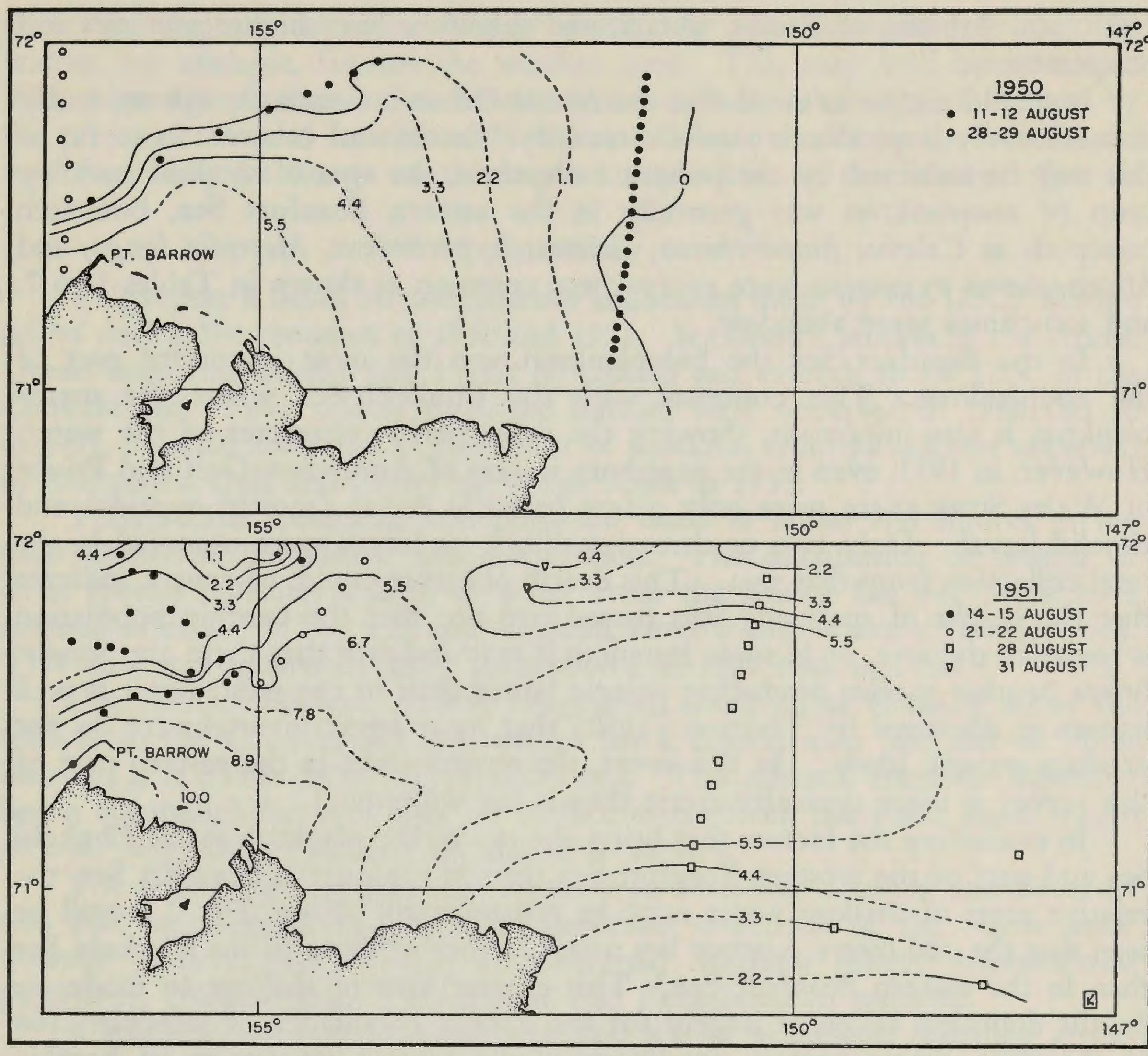

Fig. 11. Surface temperatures (°C) in the region of Point Barrow, 1950 and 1951.

first of Nansen's collections when the *Fram* was still near the Novosibirskiye Ostrova. No further specimens were found once the *Fram* had penetrated well into the Arctic Ocean. Likewise, Bogorov (1946) reports no *Acartia* from the *Sedov* drift across the Polar Basin.

Since the species apparently cannot survive in the Arctic Ocean, it is clear that a flow of water from that ocean must be barren of the species as it enters the Beaufort Sea in a great clockwise movement, swinging into the eastern portion and turning again northwestward east of Point Barrow as pictured by Dunbar (1953) and Worthington (1953). Whether or not there is a distinct eastern eddy as indicated by Worthington or a single large cyclonic flow around the perimeter of the basin as postulated by Nansen (1902) is perhaps not significant in this instance as long as the surface flow entering the Beaufort Sea is from the far north.

Thus *Acartia longiremis* is a subarctic species rather than a true arctic species if we use Dunbar's (1951) distinction between arctic and subarctic areas. According to his definition, the marine arctic is formed of those areas in which unmixed water of polar origin is found in the surface layers (200–300 metres). This water is characterized by low salinity and low temperatures, as compared with the marine subarctic in which the surface layers consist of a mixture of arctic and Atlantic or Pacific waters, and therefore have higher salinities and temperatures.

It should not be inferred that the Arctic Ocean is barren though evidently it is relatively unproductive as observed by Nansen and others. In so far as this may be reflected by the present collections, the area of smallest standing crop of zooplankton was generally in the eastern Beaufort Sea, but such copepods as *Calanus finmarchicus*, *Calanus hyperboreus*, *Metridia longa*, and *Microcalanus pygmaeus* were everywhere common as shown in Tables 1 to 7, and sometimes were abundant.

In the Beaufort Sea the holoplankton was the most important part of the zooplankton. This contrasts with the Chukchi Sea where the meroplankton is also important, showing the more neritic character of the water. However, in 1953, even in the nearshore waters of Amundsen Gulf and Prince of Wales Strait there were only a few barnacle larvae (mostly cyprids) and annelid larvae. Only two or three lamellibranch larvae were observed in the total collection from that area. This dearth of larvae could, of course, indicate that the height of spawning was passed and not that the benthic population is sparse in the area, or in some instances it may indicate that there are present fewer benthic species producing pelagic larvae than to the west, for it is well known as discussed by Thorson (1950) that most arctic invertebrates do not produce pelagic larvae. In this event, the environment in the eastern part of this survey is more typically arctic than is the western.

In evaluating the factors that bring about a richer plankton in the Chukchi Sea and part of the western Beaufort Sea than in the eastern Beaufort Sea, the relative areas of shallow water must be remembered. From Fig. 2 it will be seen that the 200-metre contour lies much farther offshore in the Chukchi Sea than in the eastern Beaufort Sea. This greater area of shallow to moderate depths doubtless accounts largely for the greater abundance of meroplankton to the west, where bottom conditions would favour production of benthic adults with planktonic larvae. The flow of water from a more favourable area must also be a significant factor. Outflow from the Mackenzie River may also suppress production of the more stenohaline species in parts of the Beaufort Sea area.

The net employed on these surveys was too coarse to sample the phytoplankton adequately but despite this, the relative amounts caught indicated that in 1950 there was obviously a burst of blooming of diatoms (mostly *Coscinodiscus* but also *Thalassiosira* and *Chaetoceros*) extending from Point Barrow to Station 30. Elsewhere that year phytoplankton was moderately sparse. In 1951 the waters just off Point Barrow were not richly populated, but there was a burst of filamentous diatoms at Stations 44 and 45 and considerable concentrations at Stations 50, 53, and 60, the farthest north sampled. In the Beaufort Sea in 1951 there was in progress a moderate burst of filamentous diatoms (and *Coscinodiscus*) from Station 17 to Station 28, and from Stations 75 to 79 there was an abundance of filamentous forms, mostly *Chaetoceros*. Among the dinoflagellates, *Ceratium* sp. was widespread, especially in the Beaufort Sea where at some stations it was abundant.

Just what these biological differences in plankton between the Chukchi and Beaufort seas mean to the production of higher marine life of direct economic importance needs further study. It may be significant that the walrus, for example, favours the western area. This may well be associated with a greater production of benthic life for food as strongly indicated by the preponderance of lamellibranch larvae. Baleen whales on the other hand may find adequate forage on the larger holoplankton in the Beaufort Sea.

Summary

This report is based on zooplankton collections made by the U.S.S. *Burton Island* during the summers of 1950 and 1951. It covers a section of the Arctic Ocean bordering Alaska and a part of Canada and extends to 76°22N. in the Chukchi Sea. Fifty widely dispersed stations were occupied in 1950 and 56 in 1951. Partial analysis was also made of plankton from 30 stations occupied in Amundsen Gulf and Prince of Wales Strait in 1953.

Thirty-three species of copepods are listed in tables and figures giving their numerical abundance and distribution. The distribution of several of these species indicates a flow of water from the Bering Sea and Strait to a latitude of about 76°N. and around Point Barrow into western Beaufort Sea. This flow was apparently more pronounced in 1951 than in 1950.

One Arctic copepod, *Acartia longiremis*, occurred at virtually all of the stations in the Chukchi Sea but, except for a coastal strip just east of Point Barrow, it is absent from the Beaufort Sea. This absence from the Beaufort Sea is accounted for by a flow of surface water from the Polar Basin where *Acartia longiremis* is apparently unable to survive.

The following copepods are common to both the Chukchi and Beaufort seas and are numerically the most important copepods of the whole area: *Calanus finmarchicus*, *Calanus hyperboreus*, *Metridia longa*, *Microcalanus pygmaeus*, *Oithona* spp., *Oncaea* spp., and *Pseudocalanus minutus*.

A study of the miscellaneous plankton was of interest in revealing a preponderance of larvae of benthic organisms especially barnacle nauplii and cyprids in the Chukchi Sea area. This is probably correlated with the greater extent there of relatively shallow water and with the direction of prevailing water currents.

Table 1. Copepods: Chukchi Sea area — 1950. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	3 0–5	4 0–58	5 0–100	6 0–100	7 0–61	8 0–72	9 0–90	10 0–109	11 0–150	12 0–230	13 0–46	15 0–122	16 0–91	17 0–107	19 0–100	20 0–100	21 0–100	23 0–145	26 0–69	27 0–137	28 0–100	29 0–91	30 0–90
Acartia clausi	78																						
Acartia longiremis	20	600	556	1155	1040	210	240	42	68	39	4	2	1			792	288	91	315	696	176	1	206
Calanus finmarchicus		840	+	110	624	630	180	375	136	39	818	228	1053	377	370	132	45	234	48	7	18	528	103
Calanus hyperboreus				112	20	200	150	175	102	43	18	48	381	75	278	2	3	52	1	12	5	6	309
Calanus tonsus			1																				
Calanus spp. juveniles			202	715	30	80	150	75	103	158	500	50	45	25	648	616	144	182	236	371	220	1232	464
Chiridius obtusifrons									1	1													
Epilabidocera amphitrites	+																						
Eucalanus bungii		1								1			1		1								
Eurytemora herdmani	100	1																2					
Gaidius tenuispinus										1													
Heterorhabdus norvegicus										59													
Metridia longa					1		2	3	305	276	273		8	75	370	20	48	26		1	2	12	4
Metridia lucens		1						2	1						1								
Oithona spp.	951	2460	1162	1485	2010	1050	360	667	271	276	1637	715	254	754	2778	1804	624	247	158	1624	1760	1496	1030
Oncaea spp.	+	300	202	385	139	420	+	489	136	315	273	1	363	75	648	352		39		186	220	264	464
Pareuchaeta norvegica								2	1	5		1		5	3		3	1		2	2	1	
Scaphocalanus magnus									1	2					2								
Tortanus discaudatus	1																						
Microcalanids*	178	7320	5657	9625	7207	9730	4260	4587	5729	1319	7911	10107	3267	4549	5834	4488	1920	1261	709	5197	2200	3080	7056
Copepod nauplii	50	360	3434	5060	2356	1470	840	959	2441	1084	10776	3770	980	415	2408	5016	576	637	867	1902	1012	2200	4686

*Includes *Microcalanus pygmaeus* and *Pseudocalanus minutus*.

Table 2. Copepods: western Beaufort Sea — 1950.
Number per haul adjusted to 0–100-metre vertical tow. (= +present).

Station Depth sampled in metres	54 0–100	55 0–100	57 0–100	58 0–100	60 0–91	62 0–61	64 0–27	66 0–46	69 0–100	73 0–100
Acartia longiremis								2		110
Calanus finmarchicus	198	78	8	82	21	30	229	51	72	183
Calanus hyperboreus	30	16	13	59	24	59	38	62	93	90
Calanus spp. juveniles		117	31		+	+	229	29	52	548
Chiridius obtusifrons							7			
Cyclopina schneideri		11								
Gaidius tenuispinus	2					2				
Heterorhabdus norvegicus	3	6			1					
Limnocalanus grimaldi		5	89	697	64	23	26	90	69	
Metridia longa	119	26	57	246	36	46	59	191	50	53
Oithona spp.	4859	2808	744	1681	3574	1650	803	2031	3090	913
Oncaea spp.	514	663	217	656	1400	512	2753	1562	1803	803
Pareuchaeta norvegica	8	10	4	8	21	10	1	11	17	8
Scolecithricella minor	4									1
Microcalanids*	1896	5811	31	492	1216	796	7800	3592	1597	3030
Copepod nauplii	672	741	496	205	2063	170	2065	547	2987	1752

*Includes *Microcalanus pygmaeus* and *Pseudocalanus minutus*.

Table 3. Copepods: eastern Beaufort Sea — 1950. Number per haul adjusted to 0–100-metre vertical tow.
(+ = present).

Station Depth sampled in metres	32 0–46	33 0–91	34 0–46	35 0–91	36 0–91	37 0–100	38 0–100	39 0–100	40 0–15	41 0–67	44 0–30	46 0–100	49 0–100	51 0–86	53 0–100
Calanus cristatus															1
Calanus finmarchicus	445	81	42	10	195	101	29	172	53	648	135	75	658	63	94
Calanus hyperboreus	295	31	205	101	221	108	15	6		15	12	52	288	51	79
Calanus spp. juveniles	267	+	441	155	390	100	161	129	13	360	13	+	+		94
Metridia longa		106	22	1	1		589	344	46	17		75	3	18	2
Oithona spp.	4722	502	8427	3698	5889	3232	3585	4601	845	2232	3986	1200	10528	3772	3055
Oncaea spp.	1693	+	824	478	819	657	749	516		648	867	638	1034	349	893
Pareuchaeta norvegica	11	5		1	3		8	4		2		3	1	10	8
Microcalanids*	1782	167	6229	1523	625	506	+	86		144	+	188	1034	443	799
Copepod nauplii	1604		733	914	1443	1263	535	387	1056	828	693	488	1833	634	329

*Includes *Microcalanus pygmaeus* and *Pseudocalanus minutus*.

Table 4. Copepods in deep tows — 1950. Not adjusted to standard tow.

Station Depth sampled in metres	18 1–110	18 190–597	71 0–50	71 145–250	71 430–700
Acartia longiremis			225	1	
Calanus finmarchicus			1062	52	10
Calanus hyperboreus	20	10	680	19	59
Chiridius obtusifrons					3
Gaidius tenuispinus				17	3
Haloptilus acutifrons		1			
Heterorhabdus compactus (?)		1			
Heterorhabdus norvegicus		1			1
Limnocalanus grimaldi					1
Metridia longa	4	162		155	223
Mormonilla minor		122			
Oithona spp.	533		5076	206	59
Oncaea spp.		243	301	155	1362
Pareuchaeta norvegica	3	1			5
Scaphocalanus magnus		2			1
Spinocalanus abyssalis		1		26	
Spinocalanus magnus		1			
Xanthocalanus propinquus		1			
Microcalanids	249	41	4286	688	459
Copepod nauplii	107	+	4399	146	118

Table 5. Copepods: Chukchi Sea area — 1951. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	1 0–36	5 0–100	6 0–63	7 0–100	8 0–50	9 0–100	10 0–60	11 0–100	12 0–100	13 0–100	14 0–100	15 0–100	16 0–100	43 0–100	44 0–100	45 0–100	50 0–100	53 0–100	60 0–100
Acartia clausi	7511	110		2						+			+						
Acartia longiremis	1975	440	104	2232	615	366	441	940	420	215	336	172	86	3	125	1040			
Calanus cristatus				1															
Calanus finmarchicus		770	413	5	82	549	840	940	1050	559	966	1505	215	1960	1000	1560	104	15	28
Calanus hyperboreus			2	4		1					2	9		784	15	1	120	35	55
Calanus tonsus		330		800		549					+	1	+						
Calanus spp. juveniles		1100	1156	2604	164	2196	525	987	1400	215	420	1505	172	315	200	+	208	31	60
Centropages mcmurrichi	977				82				1										
Chiridius sp. juveniles															1				
Eurytemora herdmani	1	+																	
Eurytemora transversalis	1																		
Metridia longa						+	105	141	210	258	126	43	+	71	1	390	156	11	
Metridia lucens															1			1	
Oithona spp.	9044	770	2311	2232	12054	1098	3790	2303	1750	731	2814	1849	430	6272	2375	4680	3588	1260	3286
Oncaea spp.			1073	248	82	366	11	376	70	86	168	215	215	2058	625	1300	1508	630	1060
Pareuchaeta norvegica			1					1		3					1	1	7	1	5
Scolecithricella minor																		5	
Microcalanids*	6255	12980	7470	12980	1968	12078	2835	6721	7000	3698	7182	6278	2795	4802	4000	6760	936	1530	2332
Copepod nauplii	10511	6380	2064	4092	1804	2196	1995	2867	1890	688	2520	903	344	1078	2125	2990	1560	630	1060

*Includes *Microcalanus pygmaeus* and *Pseudocalanus minutus*.

Table 6. Copepods: western Beaufort Sea — 1951. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	17 0–16	20 0–50	22 0–100	24 0–100	25 0–100	27 0–100	28 0–100	29 0–100	30 0–100	31 0–100	32 0–100	33 0–100	36 0–100	37 0–100	38 0–100	39 0–100	40 0–100	41 0–100
Acartia longiremis		32	54	92	4				30	50	3	10	738	2030	810	4		
Calanus finmarchicus	25	320	1512	552	114	56	104	21	270	110	779	9348	328	1566	270	188	36	31
Calanus hyperboreus	200	300	168	12	25	24	64	13	11	1							108	20
Calanus spp. juveniles		384	540	184	76	84	52	8	30	15	10	+	14	27	10	3	6	220
Centropages mcmurrichi													2	3	6			
Chiridius obtusifrons	20	2													1			
Eucalanus bungii		1																
Eurytemora herdmani					1								1	3	4			
Gaidius tenuispinus																	1	
Heterorhabdus norvegicus				1	1		1											
Metridia longa	144	8	216	92	38	84	9	4	90	1			1	4	15	12	288	22
Oithona spp.	2200	832	3240	2576	3800	3780	5044	336	5715	825	410	738	656	3422	2970	235	2196	968
Oncaea spp.	2200	256	378	782	608	1232	1924	84	1170	220	123	+	+	58	+	24	1476	660
Pareuchaeta norvegica		2	4		9	5	10	3	9					1		3	27	11
Scaphocalanus magnus																	3	
Scolecithricella minor						1	10	2										
Scolecithrix brevicornis																		1
Tortanus discaudatus													1	1	1			
Microcalanids*	12925	2012	4644	828	418	392	4784	210	2160	2750	1025	246	2419	11484	9100	659	2700	1582
Copepod nauplii	9075	1152	1620	1334	1216	392	1092	42	990	165	82	308	902	4524	2610	118	684	440

*Includes *Microcalanus pygmaeus* and *Pseudocalanus minutus*.

Table 7. Copepods: eastern Beaufort Sea — 1951. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	63 0–100	64 0–100	65 0–100	66 0–100	67 0–100	69 0–100	70 0–100	71 0–100	72 0–100	73 0–100	74 0–100	75 0–100	76 0–100	77 0–100	78 0–100	79 0–100	82 0–100	86 0–100	92 0–100
Acartia longiremis	2																		
Calanus finmarchicus	280	296	36	14	231	30	31	112	35	28	70	50	210	340	488	32	95	27	23
Calanus hyperboreus		2	1	17	+	14	14	168	50	84	136	324	+	85	+	23	50	28	3
Calanus spp. juveniles	280	222	36	65	77	24	184	112	244	51	369	1080	840	680	1220	504	193	10	83
Chiridius obtusifrons								3	2		1	1							
Eurytemora herdmani	2																		
Gaidius brevispinus									1										
Gaidius tenuispinus		1	2						6		1	2					5		
Heterorhabdus norvegicus									3			2							
Metridia longa	315	21	252		1			224	244		98	756	17	85	244		483	9	3
Oithona spp.	6370	3478	1404	715	2156	1800	4224	13944	4514	3315	2522	9072	3465	3485	1403	6328	2512	2548	6308
Oncaea spp.	1470	666	72	293	655	975	1024	2576	1708	765	984	2376	840	595	549	1400	773	672	1204
Pareuchaeta norvegica	9	1		2	4	19	14	14	10	6	11	5				2	2	10	8
Scaphocalanus magnus									3		1	1							
Scolecithricella minor		3	2		1			12	8	2	4	6					24		
Microcalanids*	3220	5180	216	427	732	900	768	5376	3782	1785	3752	4536	945	765	915	1176	435	840	748
Copepod nauplii	1960	888	252	195	154	600	576	728	1708	1326	1230	1512	1260	1020	793	560	145	420	664

*Includes *Microcalanus pygmaeus* and *Pseudocalanus minutus*.

Table 8. Miscellaneous plankton: Chukchi Sea area — 1950. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	3 0–5	4 0–58	5 0–100	6 0–100	7 0–61	8 0–72	9 0–90	10 0–109	11 0–150	12 0–230	13 0–46	15 0–122	16 0–91	17 0–107	19 0–100	20 0–100	21 0–100	23 0–145	26 0–69	27 0–137	28 0–100	29 0–91	30 0–90
Amphipods		1				76	3	5	1	6	9	2	13	6	15	6	6			3	7	1	1
Barnacle nauplii	333	420	3080	770	1663	1820	300	1126	305	217	2319	98	653	+	278	1760	1248	104	552	1485	836	968	3966
Barnacle cyprids	804	3300	2474	7810	2079	4900	3120	2085	237	118	2182	162	544	113	1	1188	1056	52	236	278	308	176	721
Crab zoeae	16	+	18	11			2		4	1								1	4		1	2	1
Thysanoëssa inermis				1					1														
Thysanoëssa longipes														1									
Thysanoëssa raschii				2		1		1	1					1									
Euphausiid nauplii			+			70																	
Euphausiid furcilia		8		1				1										1					
Macruran larvae	6	+	8	57	43	575	14	5	6		2	4	3			4		3	5	2	1	1	8
Ostracods								1	+	8					3			1					1
Annelid larvae		120	51	165	901	1050	360	542	68	39	+	65	182				96	91	+	232	+	264	875
Larvaceans		840	101	825	693	210	240	250		118	6002	780	400	151	648	396	144	65	158	557	264	88	1494
Echinoplutii					+																		
Ophioplutii				715	208	280	120	83			+	65	1				+	26	+	46		176	
Lamellibranch larvae	59	+		55	485	1050	420	417		+	+	65			556	220	+	65	+	186	88		+
Limacina helicina	+						+	125		39	273		182		463	88				93	264	176	

Table 9. Miscellaneous plankton: western Beaufort Sea — 1950. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	54 0–100	55 0–100	57 0–100	58 0–100	60 0–91	62 0–61	64 0–27	66 0–46	69 0–100	73 0–100
Amphipods	7			5	7	3	3	22	23	6
Barnacle nauplii										37
Barnacle cyprids	+			+				11	1	402
Crab zoaeae										1
Thysanoëssa raschii				2			1			
Euphausiid furcilia										2
Macruran larvae								+		
Ostracods	8	10	13	19		13	2			2
Annelid larvae							+	+		+
Larvaceans	158	78	+	31	147	+	+		155	110
Lamellibranch larvae	+									
Limacina helicina	237	195	93	·246	221	114		156	103	183

Table 10. Miscellaneous plankton: eastern Beaufort Sea — 1950. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	32 0–46	33 0–91	34 0–46	35 0–91	36 0–91	37 0–100	38 0–100	39 0–100	40 0–15	41 0–67	44 0–30	46 0–100	49 0–100	51 0–86	53 0–100
Amphipods	4	1	7	2	3	1						6		10	2
Barnacle nauplii	2	1				1				2					
Barnacle cyprids	2						1						94		
Ostracods		13	2				2							2	4
Annelid larvae		+	275		+				+						
Larvaceans	+	+	733	+	273			258			+	150	+	+	282
Ophioplutii			+	+		+									
Lamellibranch larvae		+		87	+					+	+		+		
Limacina helicina	+	+	550	87	897	303	161	301	+	468	+	38	1269	159	94

Table 11. Miscellaneous plankton in deep tows — 1950. Not adjusted to standard tow.

Station Depth sampled in metres	18 0–110	18 190–597	71 0–50	71 145–250	71 430–700
Amphipods		1			3
Barnacle nauplii	1		1		
Barnacle cyprids		2	226	26	1
Crab zoeae			4		
Euphausiid furcilia			2		
Macruran larvae			10		
Ostracods		12		60	104
Annelid larvae			150	17	+
Larvaceans			1391	10	44
Ophioplutii			1		
Lamellibranch larvae			113		
Limacina helicina		+	338		

Table 12. Miscellaneous plankton: Chukchi Sea area — 1951. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	1 0–36	5 0–100	6 0–63	7 0–100	8 0–50	9 0–100	10 0–60	11 0–100	12 0–100	13 0–100	14 0–100	15 0–100	16 0–100	43 0–100	44 0–100	45 0–100	50 0–100	53 0–100	60 0–100
Amphipods	3	2				2		1			4	10			2	3	11	4	2
Barnacle nauplii	7822	3960	1321	13888	3772	4392	1575	846	1960	344	462	129	774	2	1				
Barnacle cyprids	244	6380	11060	39432	1476	6954	19845	23594	7630	7095	6258	2021	1763	2450	1625	2860	2		
Crab zoeae		21	10	2	4	117	32	5	3	2			2	2	2	5			
Thysanoëssa inermis		1																	
Thysanoëssa raschii				1										1					
Euphausiid nauplii				7															
Euphausiid furcilia		4	11		2	35	12	12	8		6	1	5	2	9	3			
Macruran larvae		20	3	22	8	35	5	5	12	10	3	1	3	1	1	2			
Ostracods			3							2							4	2	
Annelid larvae	5133	770	660	1736	574	1098	420	376	560	860	210	172	43		375				
Larvaceans		1760	+	2108	1230	1464	630	470	1050		420	215		196		520	+		+
Echinoplutii	7089				820				+	43									
Ophioplutii		220			1640				+	43					375				
Lamellibranch larvae	24689	1760	4622	6448	5904	2562	4095	4136	2310	1376	840	129	430	98	1125	130			
Limacina helicina						+								392	125	390	4	+	477

Table 13. Miscellaneous plankton: western Beaufort Sea — 1951. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	17 0–16	20 0–50	22 0–100	24 0–100	25 0–100	27 0–100	28 0–100	29 0–100	30 0–100	31 0–100	32 0–100	33 0–100	36 0–100	37 0–100	38 0–100	39 0–100	40 0–100	41 0–100
Amphipods		2	7	6	5	2			5				1		1	1		
Barnacle nauplii	34		1							55	3		123	290	180			
Barnacle cyprids		512	6264	644	38				2475	440	2870	4797	1517	2900	3150	306	+	
Crab zoaeae					2							6	3					
Thysanoëssa raschii			1															
Euphausiid furcilia		2	4	2					7	1	16	23	3	13	2	1		
Macruran larvae			4							2	4	2	7	12	4	1		
Ostracods			13	31	10	1			6								28	5
Annelid larvae	+	128	54							+	+		+	174	180	24		
Larvaceans	+	128	+			56	208	21	45	110	82	+	451	638	540	141		12
Echinoplutii										1			82	174				
Ophioplutii	38	+	54											58				
Lamellibranch larvae		64	756	46					1080	220	82	246	902	3654	1800	+		
Limacina helicina							156	168	225	110		13				24	648	176

Table 14. Miscellaneous plankton: eastern Beaufort Sea — 1951. Number per haul adjusted to 0–100-metre vertical tow. (+ = present).

Station Depth sampled in metres	63 0–100	64 0–100	65 0–100	66 0–100	67 0–100	69 0–100	70 0–100	71 0–100	72 0–100	73 0–100	74 0–100	75 0–100	76 0–100	77 0–100	78 0–100	79 0–100	82 0–100	86 0–100	92 0–100
Amphipods								15	21	1	8	10			1	2	6		
Barnacle cyprids	980	2			1							2	3	1	4	5	3		
Euphausiid furcilia	2																		
Ostracods			6		+			22	19		18	10					3	2	
Annelid larvae		+												+					
Larvaceans	105	148		163	270	825	384	448	610	306	2275		630	765	976	1064	435	112	208
Echinoplutii												+							
Ophioplutii		1		+								+	+	+					
Lamellibranch larvae	280	+	+	+	+	+					+		+	+		+	+		
Limacina helicina	315	222	360	423	308	975	960	224	854	153	+	864	840	1360	488	392	725	224	125

Table 15. Barnacles: summary of naupliar and cyprid stages.

	1950			1951		
Area	Chukchi Sea	Western Beaufort Sea	Eastern Beaufort Sea	Chukchi Sea	Western Beaufort Sea	Eastern Beaufort Sea
Period	Aug. 11–16	Aug. 25–30	Aug. 18–23	Aug. 12–15 Sept. 3–7	Aug. 23–29	Sept. 14–21
Nauplii	24301	37	6	41248	683	0
Cyprids	33944	414	97	140689	25913	1001
Ratio nauplii/cyprids	0.72:1.00	0.09:1.00	0.06:1.00	0.29:1.00	0.03:1.00	0.00:1.00
Av. no. per station	2532	45.1	6.86	9576	1478	52.68

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