Greenland Bioscience 1

Annual Cycles of Primary Production and of Zooplankton at Southwest Greenland

Erik L. B. Smidt

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Instructions to authors. – See page 3 of cover.

Annual Cycles of Primary Production and of Zooplankton at Southwest Greenland

with figures of some bottom invertebrate larvae

Erik L. B. Smidt

GREENLAND BIOSCIENCE 1·1979

To the memory of my teacher
Professor Gunnar Thorson

Annual cycles of primary production and of zooplankton at Southwest Greenland

ERIK L. B. SMIDT
Grønlands Fiskeriundersøgelser

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Annual hydrographic observations, measurements of primary production, and sampling of zooplankton were undertaken in Southwest Greenland waters in the 1950s and –60s. In the coastal area and at the entrance to Godthåbsfjord winter cooling normally extends to the bottom, resulting in a vertical mixing of the water and an effective replenishment of nutrients at the surface. The subsequent production rate is, therefore, high with an average annual gross production calculated to about 160 g C m^{-2}. In the inner fjord regions the stratification is normally much more stable with persisting warm bottom water, and the production is, therefore, lower here than in the coastal area. The seasonal variation in the relations between daylight, primary production, phosphate, and quantity of zooplankton is, presumably, representative of the coastal waters at SW Greenland. A maximum in primary production in spring is normally followed by another maximum in late summer. The number of animals in the microplankton samples from the upper 30 m (the productive layer) is at its maximum simultaneously with the second maximum of the primary production, while the maximum of the macroplankton biomass (taken by stramin net) extends until late autumn in the coastal and outer fjord regions.

A maximum of the macroplankton biomass during winter in the deep water layers in the inner Godthåbsfjord, caused by inflow of warm bottom water, stable stratification and cooled outflowing surface water acting as a barrier to the ascent of the animals, is assumed to be normal to the open, non-threshold, W Greenland fjords.

Seasonal vertical migration of the zooplankton is indicated by Hensen net hauls from different depths. There is a concentration of zooplankton in the upper water layers in April–September and a deeper concentration from autumn to spring.

Annual cycles of various animal groups are described for holoplankton and meroplankton, separately. Holoplankters are normally dominant, copepods being the most numerous group. Meroplankters, especially bottom invertebrate larvae, are relatively numerous in the microplankton in spring and summer with *Balanus* nauplii dominant in spring and lamellibranch larvae in the following months. In a special section on fish eggs and larvae it is shown *i.a.* that cod eggs and larvae are normally concentrated in the upper 50 m, where they are much exposed to temperature variations, while eggs and larvae of American plaice occur also in deeper water. This may partly explain why the cod stock is more vulnerable to low temperatures.

It is shown that the epipelagic plankton fauna in the survey area in terms of growth and mode of development is more similar to the arctic than to the boreal fauna. It could therefore be termed subarctic, which also corresponds to the environmental conditions in the area.

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1. Introduction

Plankton sampling has been made in W Greenland waters since 1895 when "The Danish Ingolf Expedition" operated there. In connection with fisheries research, plankton sampling has been made for many years in inshore as well as in offshore waters, mainly for collecting fish eggs and larvae. However, also lists of invertebrates have been compiled for future use and publication.

Up to World War II fishery and oceanographic research including plankton sampling was made by various Danish expedition vessels: "Tjalfe" 1908–09, "Islands Falk" 1924, "Dana" 1925, and "Godthaab" 1928. Furthermore, investigations were made from motorboats 1926–27 and 1929–39. Most comprehensive were the results of the "Godthaab" Expedition 1928, published in a series of reports in "Meddelelser om Grønland"; a summary of the zoological results was given by Kramp (1963). Norwegian plankton investigations were made in Davis Strait in 1924 (Gran, 1929; Størmer, 1929).

After the war the Greenland Fisheries Investigations made regular research by R/V "Adolf Jensen" I (1946–66) and II (since 1967) in inshore and offshore waters. In collaboration with the Danish Institute for Fishery and Marine Research plankton investigations were made by R/V "Dana" at the hydrographic standard sections in Davis Strait in most of the years 1950–71, and in 1963, as part of the "Norwestlant" Survey, an international environmental investigation in the NW Atlantic sponsored by ICNAF (International Commission for the Northwest Atlantic Fisheries), the results of which were published in 1968 in ICNAF Special Publication No. 7 (a short summary by Smidt, 1971). Vessels from 8 countries took part in the survey.

In addition to the "Norwestlant" Survey, plankton research has been undertaken in Davis Strait by research vessels from different countries, among others the French "Thalassa" Expedition in 1970 (Beaudouin, 1973). Since 1962 the Oceanographic Laboratory in Edinburgh has organised towing of Continuous Plankton Recorders west of Greenland.

The present publication is the result of whole year sampling in 1950–66 of zooplankton in inshore and coastal waters, mainly in the Godthåb district, as well as measurement of primary production in the Godthåb and Julianehåb districts in several years from 1953 to 1967. The seasonal sampling and measurement were often interrupted because of fisheries research work; the results covering all the years are, therefore, accumulated in this report.

The material of fish eggs and larvae from Davis Strait has been published regularly in annual reports, while the material on invertebrate zooplankton is still unpublished, apart from that pertaining to the "Norwestlant"; however, a report is being prepared for publication.

2. Materials and methods

The present investigation is mainly descriptive and semiquantitative as all numbers on quantity of zooplankton (specimen numbers and volumes) are relative. Data on the productivity should, however, be regarded as precise. No statistical analyses have been made because of the often scattered observations and sometimes considerable fluctuations in quantities, when samples were taken in patches of newly hatched invertebrate larvae.

The sampling was made at more or less regularly operated standard stations (I–V) and at some occasionally operated stations (A and 1–7). Furthermore, at some supplementary stations in other districts stramin net hauls were made for collecting crustacean decapod larvae. The stations are shown in Fig. 1.

The material collected was worked up in the first instance in field laboratories in Greenland (Godthåb and Narssaq) and finally in laboratories in Denmark.

List of field stations

The standard Stations I–IV and Stations A and 1–7 are located in the Godthåb district, while standard Station V is in the Julianehåb district. The location of the standard stations is as follows:

St. I (63°53'N – 51°28'W, depth about 250 m). Coastal inshore locality S of Godthåb, trawling ground for *Pandalus borealis.*

St. II (64°07'N – 51°53'W, depth about 330 m). Entrance to Godthåbsfjord.

St. III (64°14'N – 51°07'W, depth about 500 m). Godthåbsfjord, Qôrqut deep, trawling ground for *Pandalus borealis.*

St. IV (64°25'N – 50°21'W, depth about 250 m). Inner part of Godthåbsfjord, Kapisigdlit kangerdluat, trawling ground for *Pandalus borealis.*

St. V (60°56'N – 45°47'W, depth 290 m). Tunugdliarfik fjord near the town of Narssaq, trawling ground for *Pandalus borealis.*

Occasionally operated stations:

A. Ameralik fjord, main channel.
1. Ameralik fjord, northern branch Itivdleq.
2. Malenebugt at Godthåb (64°10'N – 51°42'W, depths 50–100 m).
3. Godthåbsfjord, Qôrqut basin (depths about 50–150 m).
4. Godthåbsfjord, Kapisigdlit, off Itivnera (depth about 40 m).
5.–7. Godthåbsfjord near the settlement Kapisigdlit (5 outside, 6 off, 7 inside the settlement, depths about 50–100 m).

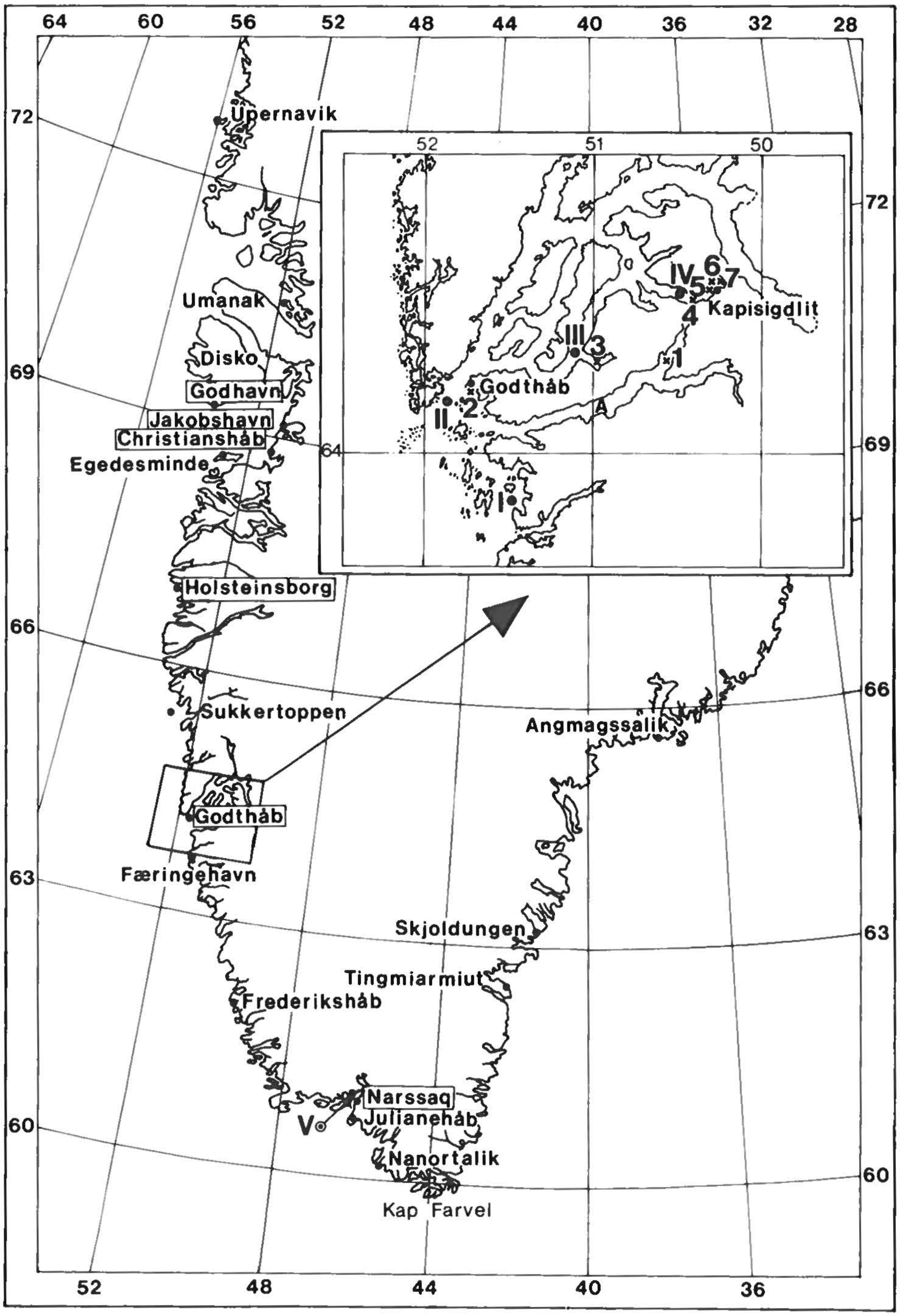


Fig. 1. Map showing standard stations I–V and the occasionally operated stations A and 1–7. Names of towns mentioned in text are framed.

Supplementary stations, stramin net hauls only:

Holsteinsborg district (Amerdloq and Ikertôq fjords). Disko Bugt (off Godhavn, mid-bay, off Christianshåb, off Jakobshavn).

Umanak district (eastern station near Umanak, western station near entrance to the fjord system).

Hydrographic observations

Temperature measurements were made at all standard stations, salinity was measured at St. II and IV, and since 1969 phosphate was measured at St. II. Measurements were made throughout the years at the international standard depths (0, 10, 20, 30, 40, 50, 75, 100, 150, 200, 250 m etc.). Water samples were analysed for salinity and phosphate at the Danish Institute for Fishery and Marine Research (Charlottenlund).

Measurement of primary production

Primary production was measured by the carbon-14 method as described by Steemann Nielsen and Aabye Jensen (1957) and Steemann Nielsen (1958a). According to instructions from Prof. E. Steemann Nielsen, *in situ* experiments were made at St. II, IV, and V. The water samples were taken at 4 depths, and after addition of carbon-14 the experimental bottles were placed at the same depths in shallow water (bottom depth about 50 m) and attached to an anchored buoy. From 1953 to 1957 the sampling and experimental depths were 0.3, 10, 20, and 30 m at St. II, and 0.3, 7, 15, and 25 m at St. IV and V. Since 1961 the sampling and *in situ* experimental depths varied in accordance with the turbidity of the water which was measured by Secchi disc readings. The 4 depths were (A) the surface (0.3 m), (D) the compensation depth, (C) half way between surface and (D), and (B) half way between surface and (C). The experiments lasted from noon to sunset, whereafter the water samples were filtered through Sartorius membrane filter (pore size 0.2 μ) collodium filters, which were then dried and counted in 1953–57 by Prof. E. Stemann Nielsen, later by the International Agency for Carbon-14 Determination.

In accordance with a revision of the technique (Steemann Nielsen, 1965; Steemann Nielsen, Wium-Andersen, and Rodhon, 1975) all productivity data from before 1965 have been increased by 45%.

Sampling of zooplankton

Sampling was made with different nets with different dimensions and mesh apertures.

Microplankton samples were taken by a small, conical net (ring diameter 30 cm, gauze No. 12 with mesh aperture about 0.12 mm), hauled vertically from 30 m depth. It was sufficiently fine-meshed to catch small planktonic invertebrate larvae. Sampling was made throughout the years, first at St. 2 and later at St. II. Some few additional samples were taken in the mid- and inner Godthåbsfjord.

The Hensen net was operated regularly at St. I–V and, occasionally, in Ameralik fjord in 1954–58. Vertical hauls were made from 50 m and from 200 or 300 m depths.

The stramin net (ring diameter 1 m, mesh aperture about 1 mm) was hauled horizontally for 30 min. at about 1.5 knot at all standard stations throughout the years at St. I–IV and, occasionally, at other stations. In the upper layers the net was hauled for 15 min. with 100 m wire followed by another 15 min. with 50 m wire. Deeper hauls were taken for 30 min. with 300, 400, 500, 600 or 700 m wire (most samples with 400, 500 or 600 m). Regular sampling was made in the Godthåb district from 1953 til 1966, but occasional sampling was made since 1946.

Hensen net and stramin net samples were preserved in c. 4% formaldehyde supersaturated with borax. Microplankton samples were preserved in alcohol or formaldehyde.

Volume and dry weight of zooplankton

Displacement volumes of fresh stramin net samples were measured onboard, however, in the first years the volumes of drained samples were measured. For the Hensen net samples displacement volumes were measured only on preserved samples. Dry weight was measured on some of the Hensen net samples after drying at c. 100°C.

Sorting and counting of zooplankton

Microplankton and Hensen net plankton were analysed in almost the same way. Specimens were counted only in diluted subsamples transferred to Petri dishes with a grid. Counting was made under binocular microscope.

Stramin net samples were divided in a flat rectangular dish by a metal cross, or subsamples were taken volumetrically. Sorting was made in flat dishes with only little water by means of a fine water-colour brush.

Identification and drawings of plankton animals

Identification was made to systematic groups, if possible to species. Most holoplanktonic species, especially the crustaceans, were identified by Vagn Kr. Hansen, M.Sc. and by E. Rosendahl Nielsen, Assistant, while the meroplanktonic animals were mostly identified by the author. For the nomenclature, "A synopsis of Canadian marine zooplankton" by Shih, Figueira, and Grainger (1971) was used.

Drawings of bottom invertebrate larvae were made by the author, using camera lucida and a monocular microscope.

3. Hydrography

The water masses at southern W Greenland consist of two components both coming from the area off southern E Greenland. In the surface the Polar Current brings cold and less saline water northwards along W Greenland, while the deeper water layer consists of warmer and more saline Atlantic water transported by the Irminger Current, a branch of the North Atlantic Current. Off the middle part of W Greenland some mixing of the currents takes place, so that the differences in temperature and salinity are smaller than off Kap Farvel. The Atlantic water intrudes the deep, open fjords such as Godthåbsfjord as a warm and saline bot-

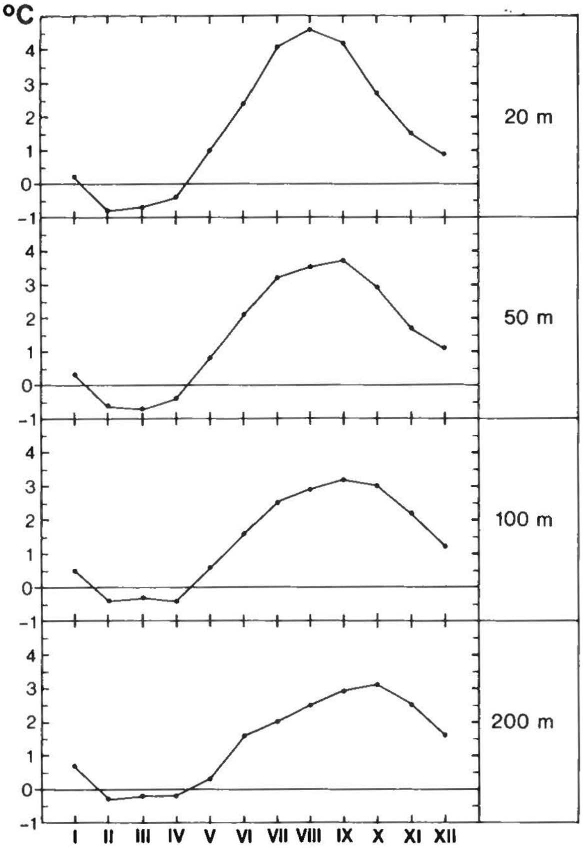


Fig. 2. St. I. Monthly mean water temperature at 4 depths in 1953–66.

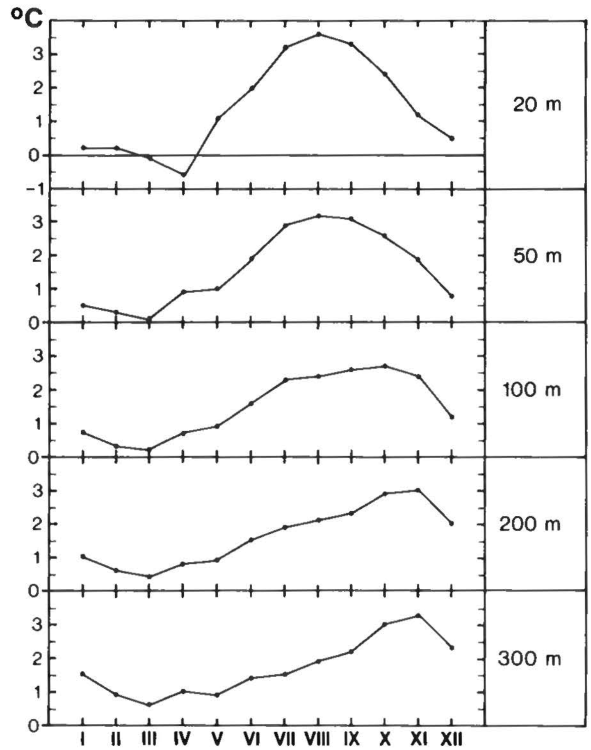


Fig. 3. St. II. Monthly mean water temperature at 5 depths in 1953–66.

tom layer and thus compensates an outflow of less saline surface water.

In the Godthåb region hydrographic observations have been made for several years since 1908, but only since 1953 fairly regular, annual observations have been made, at St. I, III, IV up to 1966, and they are still continued at St. II. Temperature and salinity were measured at standard depths, and since 1969 the phosphate concentration was measured at St. II. The results of the temperature and salinity observations are presented in Figs. 2–6, where average monthly values are shown for the years 1953–66.

The temperature conditions have been described by Hermann (Hachey et al., 1954) as follows. – "The warm bottom water must originate from the Irminger Current and it appears to reach its maximum temperature in late autumn or early winter in the latitude of Godthåb. The explanation is presumably that the water masses of the Irminger Current reaches its maximum temperature in the Irminger Sea in August, but it is late autumn or early winter before this water arrives in the vicinity of Godthåbsfjord. Since this current is deep off W Greenland, it is not subjected to heat exchanges with the atmosphere and thus undergoes only slight temperature

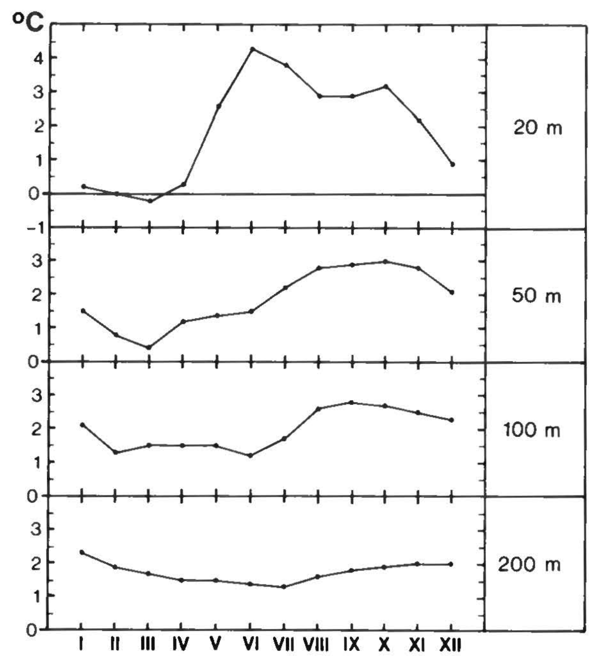


Fig. 4. St. IV. Monthly mean water temperature at 4 depths in 1953–66.

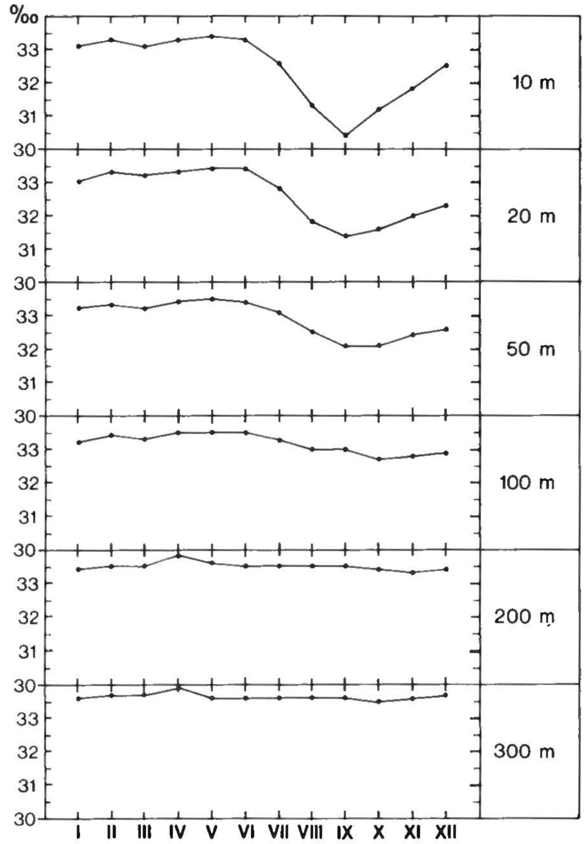


Fig. 5. St. II. Monthly mean salinity at 6 depths in 1953–66.

changes in its northward progress. – During late February the density of the winter-cooled surface layer increases to the point where vertical mixing through convectional overturn reaches to the bottom. At this time, the warm bottom water disappears from the entrance to Godthåbsfjord, but in the inner part of the fjord, where the stability of the surface water is very great, the warm bottom water persists throughout the spring and summer months."

This characteristics of the temperature conditions in the Godthåb region has fully been confirmed by later observations, especially by detailed annual observations at the fjord entrance as described by Herman (1957–63). Figs. 2–4 show that surface water temperatures follow the temperatures of the atmosphere. In the deep water layers the seasonal variations are largest in the coastal region (St. I), smaller at the fjord entrance (St. II), and only slight in the inner fjord region (St. IV).

The variations in salinity (Figs. 5–6) are considerable in the surface layers at all stations, while they are only slight in the bottom layers. The variations in the surface layer are most pronounced in the inner fjord region (St. IV) where the salinity decreases very much in June–July, and the effect is still considerable but retarded down to about 50 m depth where a minimum is reached in September. At the fjord entrance the decrease in salinity starts about a month later in the surface layer where it reaches its minimum in September. In the inner fjord regions the decrease in salinity is mainly caused by the outflow of fresh water from the rivers and melted snow, but in the coastal region and in the fjord entrance there is also an addition of low salinity water from melted pack-ice in the Polar Current.

The differences between the hydrography of the coastal regions and the inner Godthåbsfjord influence the primary productions and the zooplankton. In the outer regions the enrichment of the surface water with nutrients due to vertical mixing of the water masses in winter and early spring and the following stabilisation of the water layers cause a rich primary production, while the constant stability in the inner fjord regions results in a smaller production.

The hydrographic conditions described here are considered representative for most of the southern W Greenland waters. As shown by Horsted (Horsted and Smidt, 1956, 1965) the conditions in Julianehåb Bugt and in the fjords in the southernmost part of W Greenland are much alike the conditions described for the Godthåb district. In Julianehåb Bugt a vertical mixing of the water masses occurs in winter while the layerings are stable in the fjords, where the effect of the Polar Current is more pronounced than in the Godthåb region. Consequently, the primary production measured

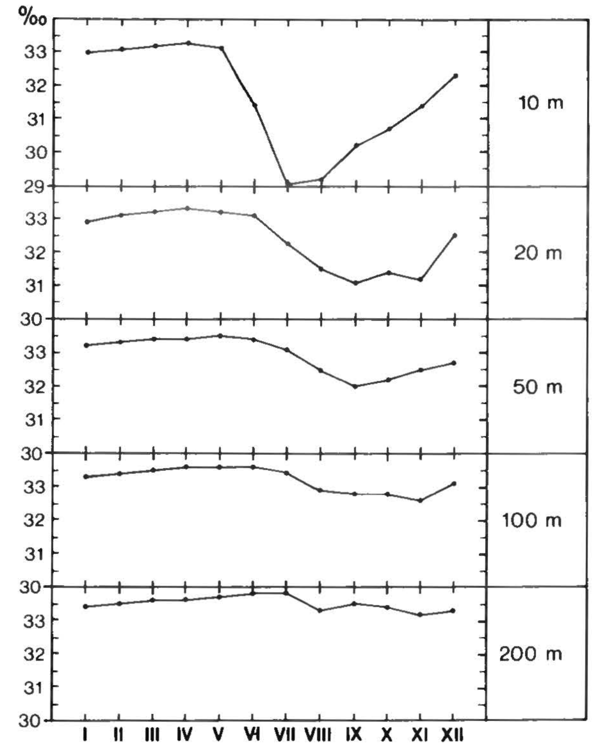


Fig. 6. St. IV. Monthly mean salinity at 5 different depths in 1953–61.

Table 1. Phosphate (μg atom PO_4–P per litre) at St. II in the upper water layer (average of 10, 20, and 30 m, 41 days of observation) and at 100 m (39 days of observation). Overlapping 2-months' means in 1969–76.

Depth m	JAN FEB	FEB MAR	MAR APR	APR MAY	MAY JUN	JUN JUL	JUL AUG	AUG SEP	SEP OCT	OCT NOV	NOV DEC	DEC JAN
10–30	0.77	0.79	0.82	0.67	0.58	0.50	0.47	0.46	0.46	0.51	0.62	0.77
100	0.76	0.82	0.89	0.71	0.61	0.55	0.60	0.72	0.63	0.66	0.92	0.93

in the fjord Tunugdliarfik was smaller than in the inner Godthåbsfjord.

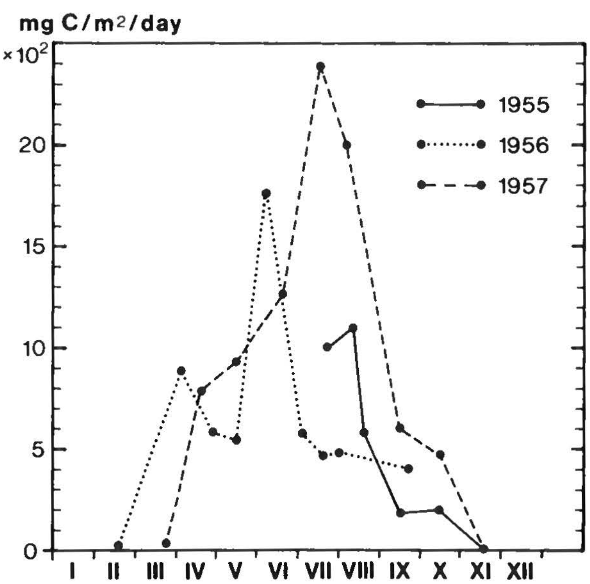
Phosphate was normally measured at St. II at the standard depths from the surface to 100 m. The results, presented in Table 1 and in Fig. 12 (sect. 4) show considerably lower values in the productive months than in the winter months. Furthermore, the values are generally lower in the upper productive water layer than at 100 m depth.

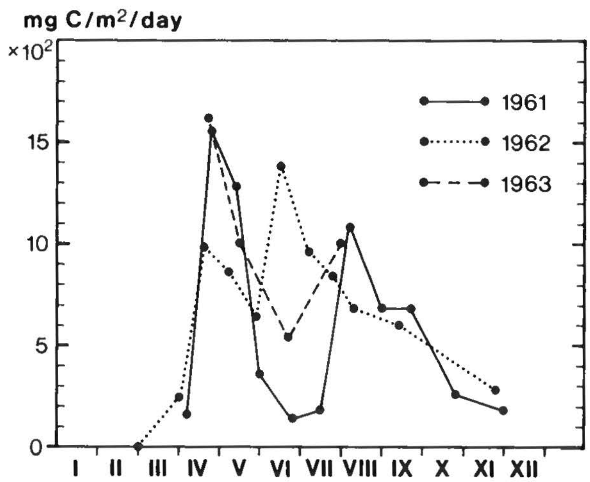
4. Primary production

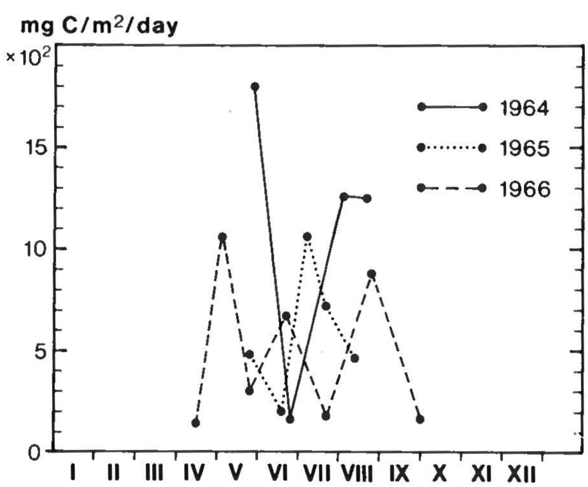
The primary production has been measured by the carbon-14 method, described in sect. 2, at the entrance to and in the inner part of Godthåbsfjord (St. II and IV), and in the fjord Tunugdliarfik (St. IV). The results from all stations from 1953–56 were published by Steemann Nielsen (1958b), who later published the revised figures for St. II from 1955–56 (Steemann Nielsen, 1975). – All measurements are shown in Table 2 and in Figs. 7–11.

Godthåbsfjord entrance (St. II)

The production rates in different years (1955–57 and 1961–66) are shown in Figs. 7–9, which show considerable variations from year to year, but unfortunately some of the years are only covered fragmentarily. Normally, a maximum in April or May is followed by a decrease which again is followed by one or two additional maxima (in 1957 the two maxima fused). In Fig. 12 the values from all years are averaged per month, showing a maximum in spring and another in late summer. The average total gross production per year was calculated to about 160 g C m^{-2}.







Figs. 7–9. St. II. Rate of gross production, mg C m^{-2} day^{-1}, 1955–57 and 1961–66.

The inner Godthåbsfjord (St. IV)

Relatively few measurements of the productivity were made during the years 1955–57 (Fig. 10). An estimate of the total annual production is, therefore, less reliable than that for St. II. The average total gross production per year was calculated to about 110 g C m^{-2}, which is lower than at the fjord entrance. The reason for this is the constant stability of the water layers described in sect. 3, giving a slower replenishment of the nutrients.

The Tunugdliarfik fjord (St. V)

Productivity measurements were made in 1953–54 and 1956, and as for St. IV relatively few measurements were made. The results shown in Fig. 11 indicate an essentially lower annual production than in the inner Godthåbsfjord, the average total gross production per year being only about 50 g C m^{-2}. Also here the water

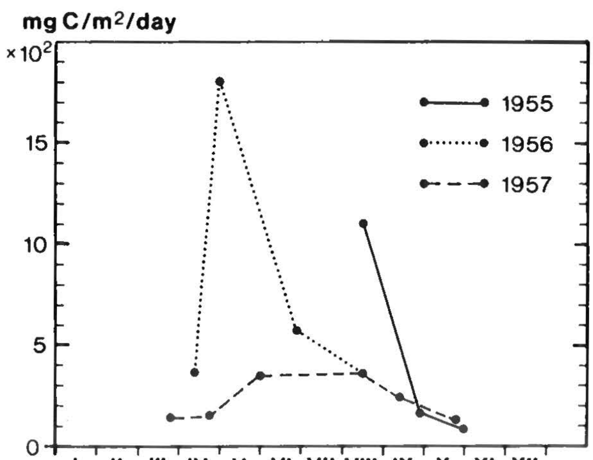


Fig. 10. St. IV. Rate of gross production, mg C m^{-2} day^{-1}, 1955–57.

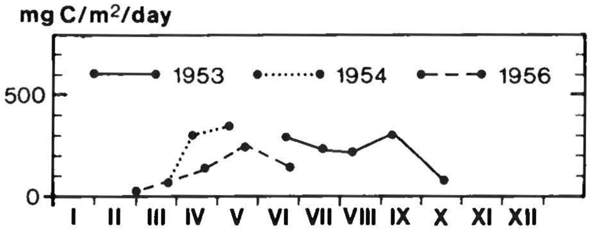


Fig. 11. St. V. Rate of gross production, mg C m^{-2} day^{-1}, 1953, 54, and 1956.

layers are stable, and the light Polar Current water, which dominates the surface water at the southernmost W Greenland, prevents the ascent of the heavier nutrient rich oceanic water.

General remarks on primary production

The relations between daylight, primary production, phosphate consumption, and zooplankton, as shown in Fig. 12, are most likely representative of a great part of the southern W Greenland coastal waters. The succession of two or more productive maxima from spring to late summer is probably caused by increased regeneration of the nutrients due to the summer heating of the upper water layers. This was confirmed by more detailed investigations carried out in Disko Bugt (northern W Greenland) in 1973–75 by O. Norden Andersen (pers. comm.), who found up to three maxima of nutrient concentration and primary production during the year. It also tallies with the succession of phytoplankton maxima found by Digby (1953) in Scoresby Sund

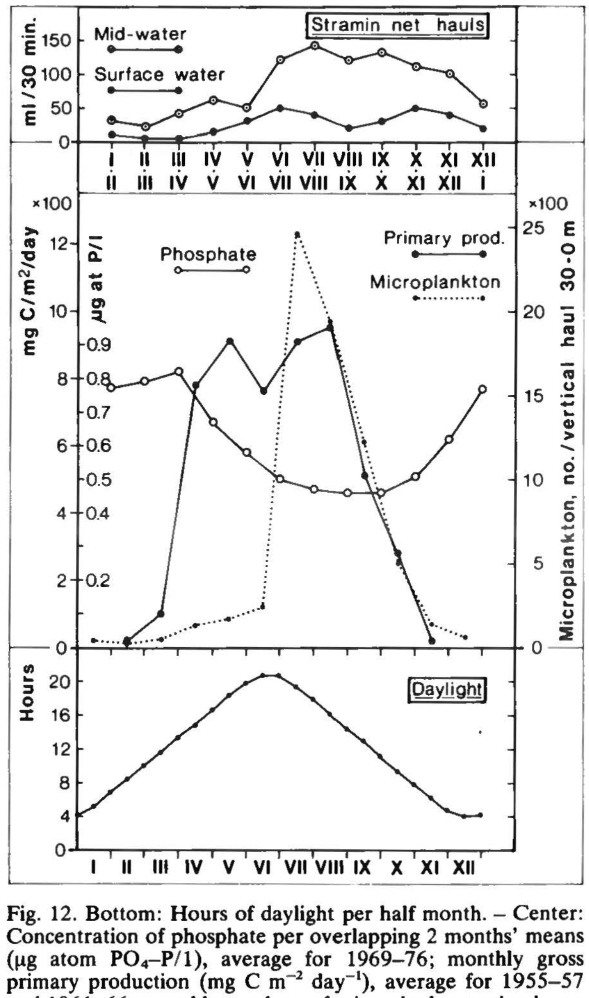


Fig. 12. Bottom: Hours of daylight per half month. – Center: Concentration of phosphate per overlapping 2 months' means (µg atom PO_4–P/1), average for 1969–76; monthly gross primary production (mg C m^{-2} day^{-1}), average for 1955–57 and 1961–66; monthly numbers of microplankton animals per 30–0 m vertical haul, average for 1955–67. – Top: Biomass, ml per 30 min. stramin net haul per overlapping 2 months' means in surface water (50–100 m wire) and mid water (300–600 m wire), average for 1953–66. – Entrance to Godthåbsfjord (St. II).

Table 2. Primary gross production rate (mg C m^{-2} day^{-1}) at St. II, IV, and V, per half month in different years, and averaged per month for all years. Total montly production (mg C m^{-2}) and total annual production (g C m^{-2}) are calculated for each station. – At St. IV, July (17929) is the mean of June and Aug.

Locality	Year	Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Total annual production in g m^{-2}
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
Godthåbsfjord	1955												1015	1109	584	175		189			22	
St. II	56		23			876	587		542	1760		571	474				413					
	57			32		280	793	935			1257	2393		2016		493			465		13	
	61					149	1560	1275		358	135	180		1001		676	682		269			
	62			18	251		989	867	643		1380	969	847	688		602			281			
	63						1622	1006			545		1011									
	64								1810		166	1256	1249									
	65								492		208	1066	629	458								
	66					138		1060	308		685		173		874			173				
	67								1123		1118			872								
	Average	23		100		777		915		761		910		950		505		275		18		
	Tot. pr. month	644		3100		23310		28365		22830		28210		29450		15150		8525		540		160
Godthåbsfjord	1955													1102			165		77			
St. IV	56					357		1802			567			363								
	57				135		151		351					358		239			126			
	Average			135		254		1077		567		?		608		202		102				
	Tot. pr. month			4185		7620		33387		17010		(17929)		18848		6060		3162				108
Tunugdliarfik fjord	1953										286		233	216		307			68			
St. V	54			19			128		249		144											
	56				67	302			345													
	Average			43		215		297		215		233		216		307		68				
	Tot. pr. month			1333		6450		9207		6450		7223		6696		9210		2108				49

(northern E Greenland). Furthermore, in the North Atlantic, Corlett (1953) found distinct, succeeding seasonal maxima of diatoms during 1948–50. No studies on the succession of phyto-plankton species have been made in the survey area. However, a very detailed account of the phytoplankton of the waters west of Greenland was given by Grøntved and Seidenfaden (1938) showing the succession of species.

It is further seen in Fig. 12 that the animal number in the micro-zooplankton samples from the upper 30 m (the productivity layer) is at its maximum simultaneously with the second maximum of the primary production in July–August while the maximum of the macro-zooplankton continues until late autumn.

In the inner fjord regions the primary productivity period is normally a little shorter than in the coastal region due to ice-cover. Also in the northern part of W Greenland (*e.g.* Disko Bugt) and in the northern E Greenland the ice-cover shortens the productivity period.

The productivity is noticeably smaller in the inner fjord regions than in the coastal region because a constantly high stability of the water layers in the inner regions reduces the replenishment of the nutrients in the surface layers.

5. Zooplankton – general part

As the zooplankton was collected with different types of nets with different mesh apertures (sect. 2) it is most appropriate to describe the various size groups separately in this general survey, though no sharp lines can be drawn between the groups.

5.1. Microplankton

The microplankton is defined here as the fraction of the zooplankton which is sampled with the microplankton net. It mainly consists of small crustaceans and bottom invertebrate larvae, but also some bigger animals are included. Annual samples were taken at the entrance to Godthåbsfjord (St. II and 2), while only a few samples were taken in the mid- and inner fjord areas.

The composition and quantity of the microplankton throughout the year are shown in Table 3 and Fig. 13. It

Table 3. Monthly average numbers of microplankton animals per vertical haul (30–0 m) at St. II and 2, 1955–63. – Numbers of hauls are in brackets; in some cases different numbers of hauls were analysed for different holoplankton groups, *e.g.* (4/5). *) Excl. *Aglantha* and *Aeginopsis*. – **) Mainly *Balanus* nauplii.

	No. of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Zooplankton total	animals (hauls)	402 (4/5)	232 (5)	525 (5/6)	1339 (7)	1694 (6/7)	2446 (4/5)	24623 (8)	19452 (6)	12200 (7)	5033 (5)	1439 (2/3)	631 (6/7)
Holoplankton total	animals (hauls)	400 (4/5)	230 (5)	509 (5/6)	158 (7)	681 (6/7)	1884 (4/5)	17159 (8)	18721 (6)	11839 (7)	4977 (5)	1424 (2/3)	628 (6/7)
Holoplanktonic crustaceans	animals (hauls)	389 (4)	226 (5)	509 (5)	156 (7)	653 (6)	1735 (4)	14345 (8)	17767 (6)	11385 (7)	4892 (5)	1404 (2)	618 (6)
Copepoda (excl. nauplii)	animals (hauls)	386 (4)	218 (5)	264 (5)	69 (7)	339 (6)	1098 (4)	7498 (8)	12891 (6)	10596 (7)	4501 (5)	1280 (2)	580 (6)
Other holopl. groups	animals (hauls)	10 (5)	3 (5)	r (6)	2 (8)	28 (7)	149 (5)	2814 (8)	945 (6)	454 (7)	85 (5)	20 (3)	10 (7)
Meroplankton total	animals (hauls)	2 (5)	2 (5)	16 (6)	1181 (8)	1013 (7)	562 (5)	7464 (8)	731 (6)	361 (7)	56 (5)	15 (3)	3 (7)
Hydromedusae*	animals	0	0	0	0	0	5	10	6	1	1	0	0
Bottom invertebrate larvae total	animals	2	2	16	1181	1013	557	7454	725	360	55	15	3
"Actinula"	animals	0	0	0	r	r	0	55	185	1	1	0	0
Polychaete larvae	animals	1	r	r	26	74	127	172	198	60	10	8	1
Crustacean larvae**	animals	r	2	16	1130	105	47	150	7	3	r	0	r
Lamellibranch larvae	animals	0	0	0	20	802	369	7021	312	288	40	7	1
Echinoderm larvae	animals	0	0	0	4	30	11	46	20	7	2	r	0
Other larvae	animals	r	0	0	r	2	3	10	3	1	2	0	r

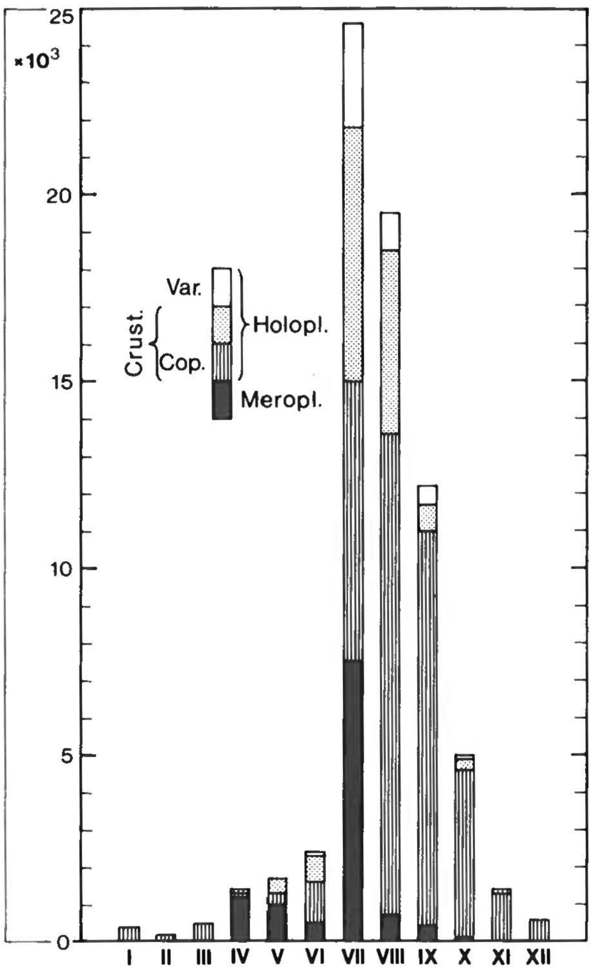


Fig. 13. Monthly animal numbers per microplankton haul, 30–0 m, at St. II and 2, average for 1955–67. – Meroplankton comprises mainly bottom invertebrate larvae. – Holoplankton separated into copepods, other crustaceans, and various other animal groups.

is seen that the animal numbers increase during April–June, followed by a large maximum in July, after which there is a decline to a minimum in December–March. However, it should be noted that several animals most likely stay in deeper water during winter like several mesoplankters taken by the Hensen net, and are, therefore, not taken with the microplankton net, which was only operated in the upper productive layer. Fig. 12 shows that the microplankton maximum coincides with the second maximum of primary production.

Among the holoplanktonic animals, smaller copepods (especially the harpacticoid *Microsetella norvegica*) and copeod nauplii are absolutely dominant. Other holoplanktonic crustaceans are Cladocera and Euphausiacea, and other holoplanktonic animals than crustaceans are Protozoa, *Aglantha digitale* juv., Siphonophora, Ctenophora, Turbellaria, Rotatoria, Polychaeta, Pteropoda, Chaetognatha, and Copelata (sect. 6.1).

The meroplanktonic animals are mainly different types of bottom invertebrate larvae with *Balanus* nauplii dominating in April and lamellibranch larvae dominating in the following months. Hydromedusae (excl. *Aglantha digitale*) are few, and fish larvae are very scarce in the microplankton. It is remarkable that while holoplanktonic animals are present the whole year, the meroplanktonic animals are almost absent in November–March. (For further details see sect. 6.2.).

5.2. Meso- and macroplankton

While the microplankton mainly consists of animals from about 0.1 to about 1 mm, the macroplankton

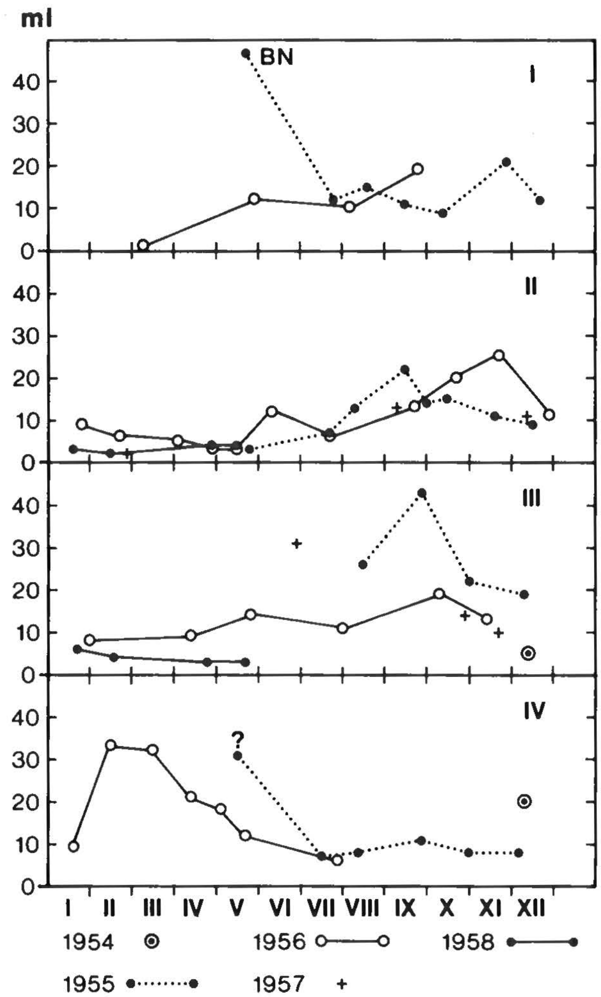


Fig. 14. Biomass, ml, per Hensen net haul at St. I–IV by year. Haul depths 200 m at St. I and IV, and 300 m at St. II and III. BN indicates *Balanus* nauplii dominant. – ? indicates that zooplankton only constituted part of the total volume of 60 ml, phytoplankton being an essential component.

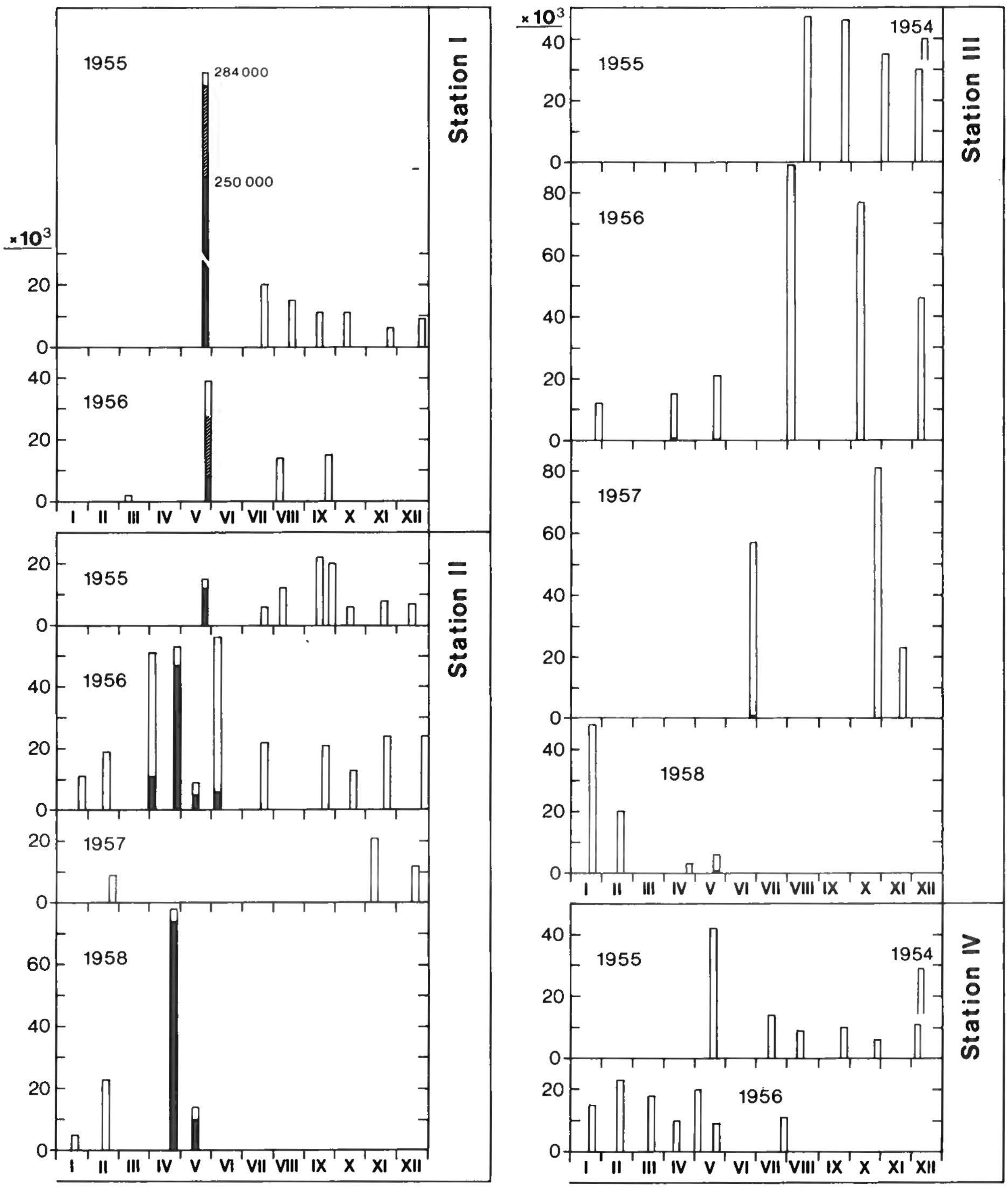


Fig. 15. Animal numbers per Hensen net haul at St. I–IV in different years. Haul depths 200–0 m at St. I and IV, and 300–0 m at St. II and III. – Black sections indicate meroplankton, mainly *Balanus* nauplii. Euphausiid nauplii (hatched sections) were dominant in holoplankton at St. I in May.

mainly consists of animals more than 1 mm in size. The fraction taken with the Hensen net, including many microplankton animals, is here termed as mesoplankton, while the fraction taken with the stramin net is termed as macroplankton. In sect. 6, the term macroplankton is used for both Hensen and stramin net samples.

Mesoplankton (Hensen net samples)

Hensen net samples were taken annually in 1955–58 at the standard stations, and some supplementary samples were, further, taken in Ameralik fjord. The hauling depths were 50–0 and 200–0 or 300–0 m. Fig. 14 illustrates the biomasses (volume), and Fig. 15 the specimen numbers and the composition of samples. The main features of these details are different from station to station as stated below.

The seasonal variation in biomass of samples from the deep hauls is much alike at St. I–III (apart from the deviation at St. I in May 1955 due to a very dense swarm of newly hatched *Balanus* nauplii). The main trends were minimal quantities of biomass at the beginning of the year (January–April/May) and maximal quantities in summer and autumn. In the inner fjord branch (St. IV), where the deep water temperatures are almost uniform throughout the year, the feature is quite the opposite with maximal quantities at the beginning of the year, followed by a decline to minimal quantities in summer and autumn, the explanation for which is given in sect. 5.4.

These features are less pronounced for numbers than for biomass, *i.a.* due to variation in size of the animals. Numerically the copepods are absolutely dominant, apart from samples taken in the coastal area (St. I and II) in April–May when dense swarms of *Balanus* and euphausid nauplii were dominant (Fig. 15). In sect. 6.1.6. it is shown that species composition and abundance of copepods differ between the Hensen net and microplankton samples, *Calanus, Pseudocalanus, Microcalanus, Euchaeta,* and *Metridia* being frequent in the former.

A series of hauls (at different localities and in different years) indicated vertical seasonal migrations, plankton animals generally accumulating in the upper 50 m in April–August and *vice versa* in the other months. Hauls 50–0 m, and 300–0 m or 200–0 m were made with very short intervals at 35 stations. The total specimen numbers in the 300/200–0 m hauls are given as average numbers per 50 m columns. When specimen numbers are greater in 50–0 m hauls than the average of 50 m sections in the deep hauls it is concluded that animals were more abundant in the upper 50 m water layers than in the deeper layers, while greater numbers per 50 m sections in the deep hauls indicated concentrations below 50 m. At two stations in November and December hauls were made from 300–0 m and from 200–0 m; the animal numbers per 50 m hauling were greatest in the deepest hauls indicating an accumulation of specimens deeper than 200 m. It was also seen that meroplankters (mainly *Balanus* nauplii and other bottom invertebrate larvae) were practically limited to the upper 50 m in April–July. At two stations in April and May meroplankters (*Balanus* nauplii being dominant) were numerous both in the upper 50 m and below. At all other stations meroplankters were absent or scarce. The seasonal vertical distribution is illustrated in Table 4.

A series of 22 Hensen net samples were dried and weighed; the results are shown in Fig. 16. The average weight of one ml preserved plankton was 110 mg, var-

Table 4. A: Seasonal, relative vertical zooplankton abundance at 35 Hensen net stations, hauls from 50–0 m and from 300/200–0 m averaged in 50 m sections, see text. – B: Seasonal and vertical occurrence of meroplankton animals at the same stations. – Godthåbsfjord and Ameralik fjord 1955–58.

Relative abundance	Number of stations per month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A: Total zooplankton												
1. More abundant in 50–0 m hauls than in deeper 50 m sections				1	2	2	3	2				
2. Equally abundant in 50–0 m hauls and in deeper 50 m sections				2	2				1			
3. More abundant in the deeper 50 m sections than in 50–0 m hauls	1	2	1	1	1			1	4	4	2	3
B: Meroplankton												
1. Limited to 50–0 m hauls				2	2	2	1					
2. Abundant both in 50–0 m and deeper hauls				1	1							
3. Absent or scarce in both types of hauls	1	2	1	1	2		2	3	5	4	2	3
All stations	1	2	1	4	5	2	3	3	5	4	2	3

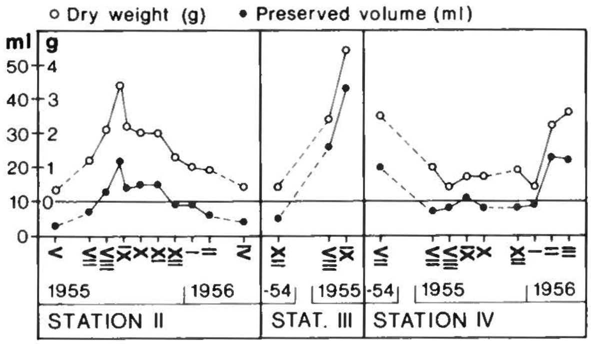


Fig. 16. Preserved volume (ml) and dry weight (g) of Hensen net samples.

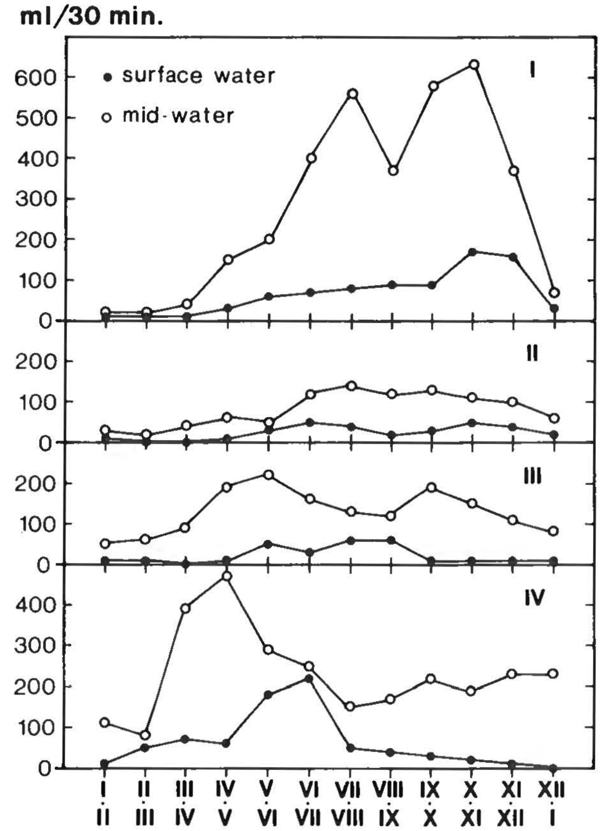


Fig. 17. Biomass, ml, per 30 min. stramin net haul in surface and mid-water at St. I–IV, overlapping 2 months' means for all years. Surface hauls 100–50 m wire, deep hauls 300 to 700 m wire. (St. I, 1953–62, deep hauls 400 m wire. – St. II, 1953–67, deep hauls 300–600 m wire. – St. III, 1953–62, deep hauls 400–700 m wire. – St. IV, 1953–65, deep hauls 400 m wire).

ying from 40 to 170 mg depending on the composition of the plankton. There was, furthermore, a difference between stations; at St. II the average dry weight per ml was 150 mg, at St. IV 90 mg. The material is too limited to allow a statistical analysis, but the values tally well with measurements made by Ahlstrom and Trailkill (1962), who found values from 56 to 100 mg per g preserved plankton. Bé, Forns, and Roels (1971) found ratios between displacement volume, wet weight, dry weight and ash-free dry weight to be 15.9 : 13.0 : 1.1 : 1. Thus 1 ml displacement volume is equivalent to 69 mg dry weight, and one g wet weight is equivalent to 85 mg dry weight, which seems to agree fairly well with the above mentioned measurements.

Macroplankton

Stramin net samples were taken annually at the standard stations, though in some years not regularly, the most regular sampling being made at the entrance to Godthåbsfjord (St. II, 1953–67). Nets were hauled with 50–100 m wire (hauling depth c. 10–25 m) as a standard, and additional, deeper hauls were taken with 300–700 m wire (hauling depth c. 70–160 m) most frequently with 400–600 m wire. The biomass was measured as ml fresh plankton (drained or displacement volume) per 30 min. hauling, and because of considerable variations and a scarcity of hauls in some months the volume was calculated as two months' overlapping means for all years (Table 5, Fig. 17).

Table 5. Volume (ml) per 30 min. stramin net haul at different depths (surface and mid-water), calculated as 2-months' overlapping means for all years of sampling at St. I–IV.

Station and years	m wire	No of hauls	Jan Feb	Feb Mar	Mar Apr	Apr May	May Jun	Jun Jul	Jul Aug	Aug Sep	Sep Oct	Oct Nov	Nov Dec	Dec Jan
I	50–100	51	7	10	7	30	60	70	80	90	90	170	160	30
1953–62	400	42	16	20	35	150	200	400	560	370	580	630	370	70
II	50–100	97	10	4	4	14	30	50	40	20	30	50	40	20
1953–67	300–600	84	30	20	40	60	50	120	140	120	130	110	100	60
III	50–100	43	5	10	2	7	50	30	60	60	5	8	7	6
1953–62	400–700	39	50	60	90	190	220	160	130	120	190	150	110	80
IV	50–100	74	5	50	70	60	180	220	50	40	30	20	5	4
1953–65	400	69	110	80	390	470	290	250	150	170	220	190	230	230

Generally the volumes of samples from the deep hauls were larger than those from the surface hauls. The seasonal variations in the deep samples are very similar to those in the deep Hensen net samples. At St. I–III the volumes are smallest in January–March/April/May, the maximal quantities occurring in summer and autumn, followed by a decrease in November/December. At St. IV, however, the sequence was almost the opposite; a short winter minimum in January–February being followed by a maximum in early spring, March–April, after which the volumes were mostly medium-sized till the end of the year. The surface plankton volumes mostly followed the pattern in the deep plankton volumes at all stations, but with a delay of one to two months.

In the inner fjord branch (St. IV) it is remarkable that while the maximal volumes of the deep Hensen net samples were in February–March, the maximal volumes of the deep stramin net samples were found about one to two months later, and the maximal volumes of the surface stramin net samples occurred as late as in May–June. In winter there seems, therefore, to be a concentration of plankton animals in the deeper water layers from where a migration to medium depths takes place in spring, and finally to the surface in early summer, (sect. 5.4.).

Sorting of invertebrates to systematic groups or species and counting of specimens were made only in 1961–62. Copepods are less dominant in the macroplankton than in the micro- and mesoplankton samples. In the macroplankton samples *Aglantha, Aeginopsis, Dimophyes,* euphausiids and chaetognaths play a more dominant role than in the other samples. Among meroplankters, crab zoeans are frequently abundant in late spring and summer.

All fish eggs and larvae were sorted, identified, and counted in the whole material (sect. 6.2.4.).

5.3. Megaloplankton

Big medusae and Ctenophora were removed from the stramin net samplers and discarded; they are not included in volumes or specimen numbers.

Amongst Scyphomedusae, *Aurelia* and *Cyanea* are frequently observed in the surface in July–September when the latter sometimes hampers gill-net fishery in the coastal zone. *Periphylla* is common in the deep, warm Atlantic water, and it is often taken by the shrimp trawls.

5.4. General remarks on zooplankton

The microplankton in the upper 30 m at the fjord entrance (St. II and 2) had its maximal specimen numbers in July–August when the primary production had its second maximum, followed by a rapid decrease. In the same area the maximal volumes of macroplankton in summer and autumn occur later than the microplankton maximum.

The variation in macroplankton biomass concurred with the water temperature variation at different depths. At St. I, II, and III nearly the same sequence was found with a minimum in early spring and a long lasting maximum during summer and autumn. In the innermost fjord area (St. IV), where the deep water temperatures remain nearly constant during the year, there is an accumulation of zooplankton near the bottom in winter as the animals are transported with the intruding deep warm water masses while the cold upper water layer acts as a barrier. In early spring there is an ascent to mid-water layers, and not till the upper water layers have been heated in late spring and summer do the animals ascend to the outflowing surface water. The gradual upward migration is shown in Fig. 18.

Seasonal vertical migrations similar to what is known from other northern seas are indicated by Hensen net hauls from different depths as shown in Table 4. There seems to be an accumulation in the upper water layers in April–September, and an accumulation in deeper water from autumn to spring. In the seasonal vertical migrations copepods are dominant, see sect. 6.1.6. where references are given to observations on such migrations in other North Atlantic areas. It is further seen that meroplankters, mainly bottom invertebrate larvae, are normally limited to the upper 50 m layer and occur mainly in April–July.

The microplankton maximum in July is possibly a

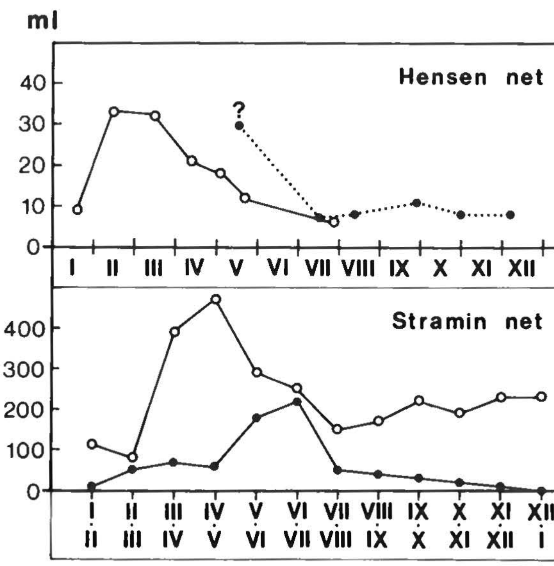


Fig. 18. Monthly variation in biomass at different levels in inner fjord region (St. IV) indicating seasonal upward migration. – Above: Volume, ml, per Hensen net haul, 300–0 m, probably mainly indicating the biomass near the bottom. • 1955, o 1956. – Below: Biomass, ml, per 30 min. stramin net haul, overlapping 2 months' means for 1953–65. o mid-water hauls (400 m wire, depth about 100 m), • surface hauls (100–0 m wire, depth about 10–25 m).

continuation of an earlier maximum found deeper than 30 m. Indications of this are the occurrence of copepod nauplii below 50 m in the Hensen net samples in spring and the occasionally very numerous swarms of *Balanus* nauplii in April–May. As *Calanus* nauplii in Stages I and II do not feed (Marshall and Orr, 1956) they are independent of food production in the upper water layers.

Diurnal migrations were not observed as all sampling was made by day. However, such migrations are probable as the offshore stramin net hauls in Davis Strait showed that night hauls are richer than day hauls (unpubl.), and similar observations were made from R/V "Dana" in the North Atlantic (Jespersen, 1954). Of the comprehensive literature on day and night migrations reference is made to the review with a bibliography given by Cushing (1951). Hardy and Bainbridge (1954) made experimental observations on the vertical migrations of several plankters, and Mileikovsky (1973) has summarised data from literature on the active daily movements of pelagic larvae of marine bottom invertebrates.

Data from the *Pandalus borealis* fishery at W Greenland clearly showed diurnal variation with bigger catches by day than by night (Smidt, 1978). The most considerable diurnal variation is seen in the autumn, when the variation in light intensity is maximal, while less significant diurnal variations in catches are observed in December and in June–July, when the variation in light intensity is minimal. It is, therefore, believed that variation in light intensity is the primary cause of the migrations of shrimps, concurring with the migrations of the plankton animals upon which they partly feed.

Dry weight measurements on preserved Hensen net samples showed in most cases an acceptable estimate of the biomass. On the average 1 ml of preserved biomass is equivalent to 110 mg dry weight.

Holoplankters dominate normally in the zooplankton, crustaceans, especially copepods, being the most numerous group. Meroplankters, especially larvae of bottom invertebrates, are, however, relatively numerous, especially in the microplankton, in spring and summer (Fig. 13). Numerically, *Balanus* nauplii, lamellibranch larvae, and polychaete larvae are dominant. In the microplankton samples *Balanus* nauplii are dominant in April being replaced by lamellibranch larvae as dominant in the following months with very high numbers in July. Polychaete larvae are numerous in June–August.

In the Hensen net samples the smaller invertebrate larvae are underrepresentated as they escape through the mesh apertures. However, *Balanus* nauplii are retained, and due to dense swarms in the coastal area and at the fjord entrance (St. I and II) they were dominant in most samples in April–May. In the stramin net samples zoeans of crustacean decapods, especially crab zoeans, were common in spring and summer.

Plankton animals of different geographic origin occur in the survey area. According to literature (Einarsson, 1945; Ekman, 1953; Grainger, 1962; Hansen, 1960; Jespersen, 1934; Kramp, 1939, 1942abd, 1961; Wiborg, 1955) the following fauna elements are represented. Examples of species are given. Apart from medusae with polyp stages they are all holoplankters.

Arctic animals. – Medusae: *Sarsia princeps, Bougainvillia superciliaris* (neritic), *Ptychogena lactea, Aeginopsis laurentia* (neritic), *Aurelia limbata* (neritic, W Greenland and northern Pacific waters). – Ctenophora: *Mertensia ovum.* – Copepoda: *Calanus glacialis, C.hyperboreus, Metridia longa.* – Amphipoda: *Parathemisto libellula, P. abyssorum.* – Euphausiacea: *Thysanoessa raschii.* – Pteropoda: *Limacina helicina.*

Arctic- and subarctic-boreal animals. – Medusae: *Aglantha digitale* (oceanic), *Sarsia tubulosa* (neritic), *Rathkea octopunctata* (neritic), *Cyanea capillata* (neritic), *Aurelia aurita* (neritic). – Copepoda: *Euchaeta norvegica, Acartia longiremis* (neritic), *Microsetella norvegica* (shallow, coastal waters at W Greenland). – Cladocera: *Podon leucarti* and *Evadne nordmanni* (both neritic). – Euphausiacea: *Meganyctiphanes norvegica, Thysanoessa longicaudata, T. inermis.* – Pteropoda: *Limacina retroversa, Clione limacina.*– Chaetognatha: *Sagitta elegans* (in southern W Greenland mainly neritic), *Sagitta maxima* (deeper water).

Cold-water and eurythermal cosmopolites. – *Periphylla periphylla* (oceanic, bathypelagic). – Siphonophora: *Physophora hydrastatica* and *Dimophyes arctica* (both oceanic eurythermal, penetrating into the Subarctic and Arctic respectively). – Ctenophora: *Beroe cucumis.* – Copepoda: *Calanus finmarchicus.* – Amphipoda: *Hyperia galba, Parathemisto gaudicaudi.* – Polychaeta: *Tomopteris septemtrionalis.* – Chaetognatha: *Eukrohnia hamata.*

Some species occur mainly in the inner fjord regions, while others mainly occur closer to Davis Strait, and others are uniformly distributed. Among the copepods, *Pseudocalanus* spp., *Metridia longa, Oncaea borealis,* and *Microsetella norvegica* were most frequent in the inner fjord regions, while species of *Calanus* and *Microcalanus* were mainly or exclusively found in the coastal regions. Among other groups, *Podon* sp. and *Sagitta elegans* prefer the inner fjord regions, while *Physophora hydrostatica* and *Mertensia ovum* occur mainly in the coastal region.

In spite of considerable numbers of bottom invertebrate larvae in the plankton relatively few species were represented. This agrees with the general rule that few bottom animals in the arctic and antarctic shelf areas have pelagic, planktotrophic (feeding on plankton) larvae.

Studies by Thorson (1936, 1950, 1965) show an increasing percentage of species with pelagic larvae from arctic to tropical seas. This trend, "Thorson's Rule" (exemplified in Fig. 19), was confirmed by other authors, but modified by Ockelmann (1965), whose studies in lamellibranchs showed that only species with

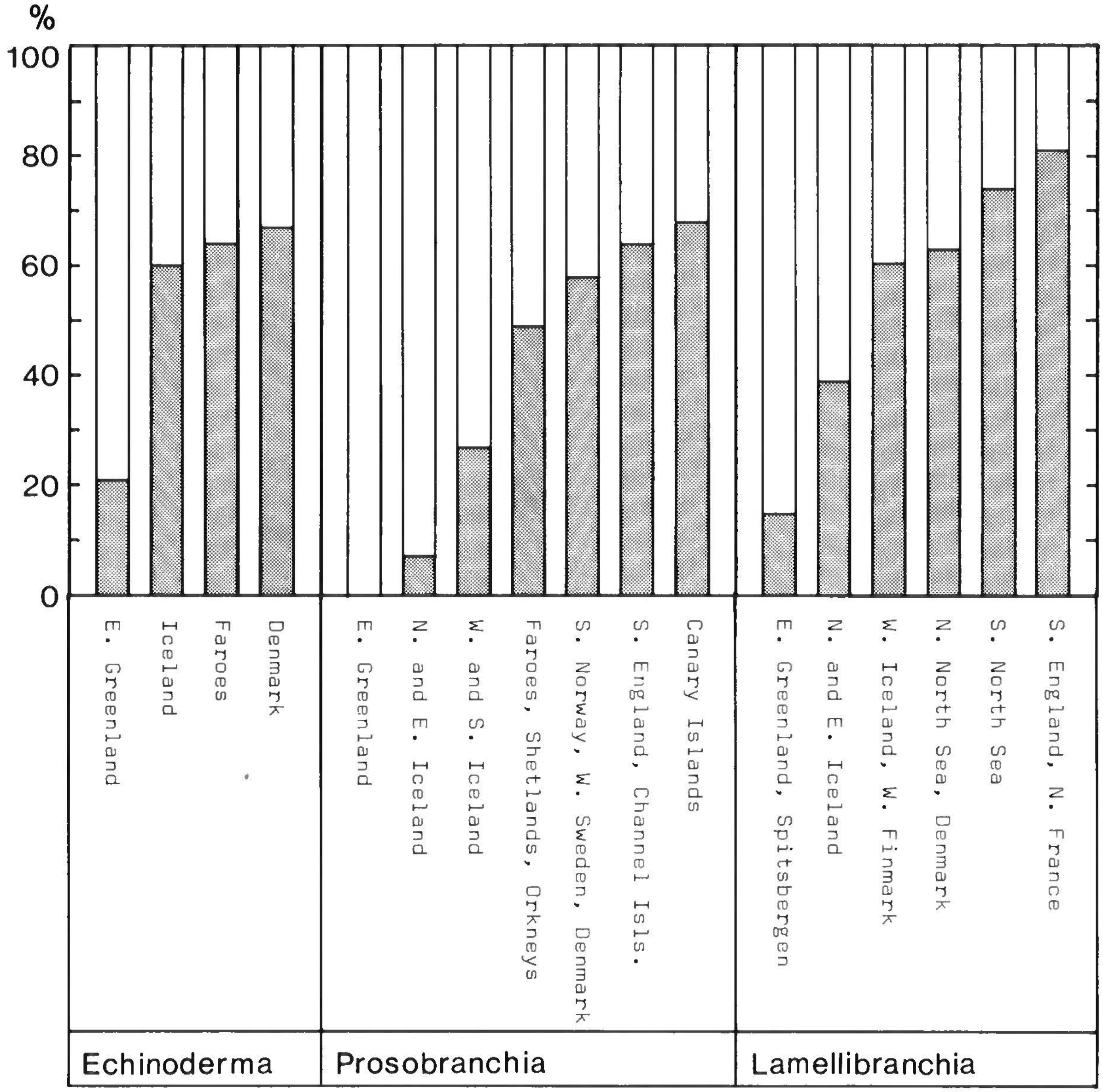


Fig. 19. Percentage of bottom invertebrate species with pelagic, planktotrophic development in various geographical regions. Echinoderms and prosobranchs redrawn after Thorson (1936 and 1950, resp.); lamellibranchs redrawn after Ockelmann (1958, 1965).

a planktotrophic development are few in the cold water shelf areas, while species with a lecithotrophic (feeding on nutriment from the egg) pelagic or non pelagic development are common. Ockelmann (l.c.) further demonstrated that lamellibranch species with a short pelagic, lecithotrophic development dominated in the deep sea, where previously a non pelagic development was considered to be normal (*i.a.* Thorson, 1936).

Several bottom invertebrate groups in the area have planktotrophic, pelagic larvae: In polychaetes 17 (abt. 8%) of about 215 species, in lamellibranchs 8 (abt. 13%) of about 62 species, and in prosobranchs 3 of about 103 species. Among crustaceans and echinoderms there are several species with pelagic larvae, and a few larvae belonging to other groups were observed.

Most of the W Greenland bottom invertebrates with pelagic, planktotrophic larvae have a wide geographical range including boreal or even tropical seas. According to a comprehensive literature, reviewed by Wilson (1952) and Thorson (1961), supplemented by *i.a.* Scheltema (1966) many larvae are able to prolong their pelagic life; a connection between the W Greenland stocks of bottom animals and other stocks is, therefore, probable. It is noteworthy that the *Polydora ciliata* larva is the most common polychaete larva at W Greenland

and that this species has a world-wide distribution. Experiments have shown that the larva is able to prolong its pelagic life for several weeks (Smidt, 1951).

Fish larvae of several species occur mainly in small numbers, most numerously in the stramin net samples. General remarks on fish eggs and larvae are given in sect. 6.2.4.

6. Zooplankton – special part

In this synopsis information on plankton animals from all gears is given. Animal numbers are given in tables or figures and in the text, when possible. In some tables the relative frequencies are given in symbols: o = not observed, r = rare, + = moderate frequency, c = common (numerous), and cc = very common. When average numbers are given in tables r indicates less than 1 or 10. Numbers of hauls are in brackets.

6.1. Holoplankton

6.1.1. Protozoa

Noctiluca scintillans (Macartney). Observed at St. II and 2 in few numbers only in the microplankton (Aug. 1957, Oct. 1955) but numerously in a Hensen net sample (St. II, Sep. 1956).

Radiolaria. Few specimens observed in microplankton and Hensen net samples at St. II and 2 (Feb. 1956, Sep. 1955) and at St. IV (May 1956).

Tintinnidae. Few specimens observed in the microplankton at St. 2 (Feb. 1956) and c. 1000 specimens at St. IV (Sep. 1957).

6.1.2. Coelenterata

Hydromedusae

Aglantha digitale (O. F. Müll.). Data on occurrence at W Greenland given by Kramp (1942d, 1959) and Bainbridge and Corlett (1968).

Frequent at all stations. Juv. (Table 6) occur in the microplankton in upper water layers mainly in summer (July–Sep.). The older stages, taken by Hensen and stramin net (Tables 7 and 8), occur in the intermediate and deeper water layers later in the year (Sep.–Dec.) in the coastal and mid-fjord areas (St. I–III), and numerously throughout the year in the inner fjord area (St. IV). The explanation seems to be that the deeper water temperatures are much more uniform throughout the year at St. IV than at the other stations (sect. 3).

Aeginopsis laurentii Brandt. Being a narcomedusa it is holoplanktonic, but nevertheless neritic in occurrence (Kramp, 1942d). Some few specimens present in microplankton and Hensen net samples, but in stramin net samples it was frequently observed throughout the year. Biggest number in a stramin net sample was 4800 in the inner Godthåbsfjord (St. IV, Dec. 1961, 400 m wire).

Table 6. Juvenile *Aglantha digitale* in microplankton samples at St. II and 2. Average numbers per haul per month, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	r	r	0	0	0	r	60	49	27	8	r	r
Hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

Table 7. *Aglantha digitale* (all stages) in Hensen net samples. Specimens per haul per month in different years at different stations.

St. and Haul depth	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I	1955					14		44	30	13	460	650	300
200–0 m	1956			1		21			3	650			
II	1955					0		9	40	45	160	85	160
300(200)–	1956	13	4		3	0	7	4		520	750	600	220
0 m	1957		22									376	30
	1958	11	1		0	0							
III	1954												200
300–0 m	1955								30	3		126	130
	1956	22			18	65			50		180	150	
	1957						8				148	0	
	1958	31	13		7	16							
IV	1954												1500
200–0 m	1955					250		150	230	360	250		240
	1956	225	400	144	400	180			38				

Table 8. *Aglantha digitale* in stramin net hauls. Specimens per 30 min. deep hauls, 1961–62. r = less than one.

St. and Wire length	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
II	1961		18					30		6280	1240	1130	1100
400/500 m	1962	123	12	6							r		
IV	1961					100		1840		6180	1240	2560	15000
400 m	1962	2350	9	10	870								

Siphonophora

Data on occurrence at W Greenland are given by Kramp (1942a).

Physophora hydrostatica Forskål. Few specimens observed in Hensen and stramin net samples from outer stations (I and II) in July–Oct., presumably originating from Davis Strait where the species is common. Not observed in the mid- and inner fjord areas.

Dimophyes arctica (Chun). Nectophores and eudoxids occurred frequently throughout the year at all stations in Hensen and stramin net samples, most frequently in the inner fjord areas (Tables 9 and 10), nectophores and eudoxids being almost equally frequent.

Ctenophora

Data on occurrence at W Greenland are given by Kramp (1942b).

Beroe cucumis O. Fabr. Some small specimens and fragments of big ones taken at all stations throughout the year by Hensen (200/300–0 m) and stramin net (400–600 m wire). Some specimens observed in the microplankton from Feb. to Nov.

Mertensia ovum (O. Fabr.). Some specimens taken with all gears at outer stations (I and II, June–Sep. and Dec.), and very few at mid- and inner fjord stations (III and IV).

Table 9. *Dimophyes arctica* (nectophores and eudoxids) in Hensen net samples from different stations. Numbers per haul in different months and years. r = less than one.

St. and Haul depth	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I	1955					0		0	8	34	23	r	r
200–0 m	1956			1		0			16	23			
II	1955					20		6	50	216	20	14	7
300(200)–	1956	21	60		20	8	6	48		76	60	74	14
0 m	1957		190									0	40
	1958	9	3		3	34							
III	1955								70	60		65	90
300–0 m	1956	93			1200	350			170		190	260	
	1957						280				410	364	
	1958	270	140		190	21							
IV	1954												195
200–0 m	1955					150		150	50	154	94		150
	1956	110	244	260	600	750		1540					

Table 10. *Dimophyes arctica* (nectophores and eudoxids) per 30 min. stramin net haul per month, 1961 and 1962.

St. and Wire length	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
II	1961		4					90		570	216	15	238
400/500 m	1962	58	29	10							0		
IV	1961					4500		9000		230	304	1550	5500
400 m	1962	176	92	460	2640		0						

Table 11. Monthly average numbers of Rotatoria per microplankton haul (30–0 m), St. II and 2, 1955–63. r = less than 10. Haul numbers in brackets.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	0	0	0	0	0	140	2658	350	370	64	r	r
Hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

6.1.3. Turbellaria

Single specimens observed a few times in microplankton samples at St. II and IV in June–Aug. (1956–61).

6.1.4. Rotatoria

This group was numerously observed in microplankton samples from all stations in Godthåbsfjord with maximum numbers in July, up to c. 10 000 specimens (St. II, 1957). Table 11 shows annual numbers at the entrance to Godthåbsfjord.

6.1.5. Polychaeta

Tomopteris sp. Few specimens taken with all types of nets in all seasons in Godthåbsfjord in 1955–61. According to Wesenberg-Lund (1936; 1950) *T.septemtrionalis* Quatrefage is the only abundant species at W Greenland; however, some other species are also recorded in literature: *T.cavellii* Rosa, *T.krampi* Wesenberg-Lund, *T.nisseni* Rosa, *T.planktonis* Apstein.

6.1.6. Crustacea

All identifications to species or genus were made by V. K. Hansen and E. Rosendahl Nielsen. – It should be noted that eggs of *Calanus* and euphausids dealt with here are not included in Figs. 13 and 15 and in Table 3 (sect. 5).

Copepoda

Data on species at W Greenland are given by Stephensen (1913), Størmer (1929), Jespersen (1934), Maclellan (1967), and Bainbridge and Corlett (1968).

Copepods comprise the most numerous and important group of the zooplankton. Copepod numbers compared to numbers of other animal groups in the plankton samples are shown in Figs. 13 and 15, and in Table 3 (sect. 5).

Copepods in the microplankton samples. – Total numbers of nauplii and later stages are shown in Fig. 20. Identification to species or genus was only made in 13 samples taken at St. II and 2, and in 3 samples at St. IV. Results are shown in Table 12.

As it appears from Table 12 small-sized species are dominant, especially *Oithona* (mostly *similis*) and *Microsetella norvegica,* followed by the somewhat larger

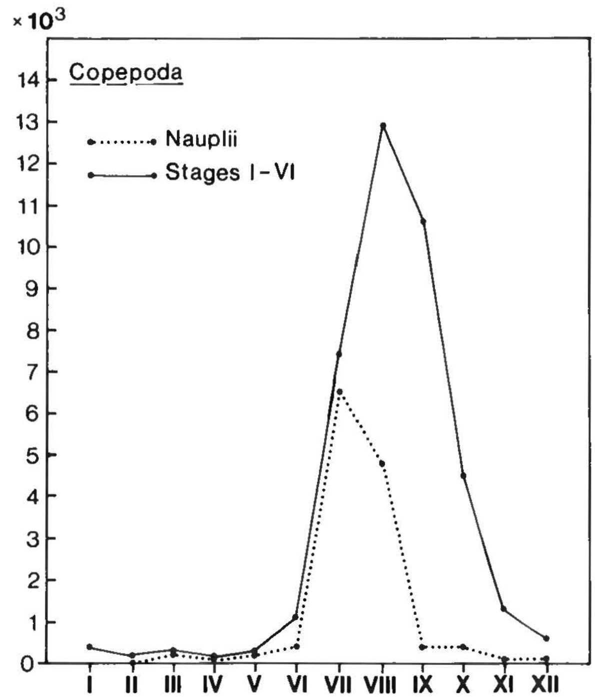


Fig. 20. Monthly numbers of copepod nauplii and later stages (Cop. I–VI) in microplankton samples (30–0 m hauls), St. II and 2, average for 1955–63.

Acartia longiremis, the larger *Calanus finmarchicus* being less numerous.

It seems that harpacticids (*Microsetella norvegica* when identifications have been made) are more numerous in microplankton samples taken in shallower than in deeper water (Table 13). Especially at the low water stations in the inner fjord area the harpacticids are numerous. Harpacticoida is in the main a bottom-living animal group. This may explain the dominance in shallow water plankton.

Copepods in Hensen net samples. – Identified species or genera were not counted as specimens, but relative frequencies are given in Table 14.

Developmental stages of copepod species. – Eggs of *Calanus* observed in microplankton samples but only counted in samples from St. II in 1961–62, shown in Table 15. No eggs were seen in the Hensen net samples, since they pass through the mesh apertures.

Table 12. Specimen numbers of copepod species or genus per microplankton haul (30–0 m) in 1955 and 1957–59. In months with more than one sample, minimum and maximum numbers are given. r = less than 10.

Species or genus	Jan	Feb	Apr	May	Jul	Aug	Sep	Dec
Calanus finmarchicus	20	0	0	0	40–160	r–150	r	r
Pseudocalanus elongatus	5	0	0	0	0	r	r	r
Pseudocalanus minutus	0	0	0	0	0	r–75	r	0
Microcalanus sp.	115	0	r	0	0–60	r–150	r–110	40
Centropages hamatus	0	0	0	0	0	r	0	0
Metridia longa	0	0	0	0	0	0–20	0	0
Acartia longiremis	0	0	0	0	300	40–50	r–500	0
Oithona similis and *O. spinirostris*	160	47	5	10	100–2900	50–36000	r–1600	400
Oncaea sp.	0	r	r	20	0	0–90	r	0
Corycaeus sp.	0	0	0	0	0–40	0	r	0
Microsetella norvegica	60	27	r	60	600–1100	1800 29600	900–1800	800
No. of samples examined	1	1	1	1	3	5	3	1

Table 13. Harpacticoida (mainly *Microsetella norvegica*) as % of total copepod numbers in microplankton samples from different depths in Godthåbsfjord.

Area	St.	Depth m	No. of samples	Harpacticids (in %) Average	Range
Fjord entrance	2	abt. 50	16	79.7	62–99
	II	abt. 350	19	46.4	r–89
Mid- and inner fjord	3	abt. 50	1	97.8	
	4	abt. 40	1	99.7	
	7	abt. 50–200	2	83.0	80–86
	IV	abt. 230	3	74.0	45–97

Table 15. Number of *Calanus* eggs per vertical microplankton haul (30–0 m) at St. II, 1961–62.

Year	Month	Date	Eggs	Month	Date	Eggs	Month	Date	Eggs
1961	March	28	342						
1962	March	31	330	Apr.	24	0	May	7	288
1962							May	26	250

Table 16. Monthly average numbers of copepod nauplii per microplankton haul (30–0 m) at St. II and 2, 1955–63).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nauplii	7	9	178	77	211	369	6530	4750	435	391	117	57
Hauls	(4)	(5)	(5)	(7)	(6)	(4)	(8)	(6)	(7)	(5)	(2)	(4)

Copepod nauplii (all species) were counted in the microplankton samples; the numbers throughout the year are shown in Table 16 and in Fig. 20. However, in some cases distinction from euphausiid nauplians has not been made.

In Fig. 20 the maximum of nauplii occurs, naturally, earlier (July) than the maximum of later stages (Aug.), but it is remarkable that the maximum number of nauplii is lower than that of later stages. The explanation may be that only the last part of the nauplii maximum is represented in the microplankton samples, and possibly an earlier and major part of the maximum is staying deeper than 30 m. In Hensen net samples there was an earlier maximum of big nauplii (Apr.-June) mainly

Table 14. Monthly relative frequencies of species or genera in Hensen net samples from St. I–IV, 1954–58. For symbols see page 27.

Species or genus	St.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calanus finmarchicus	I			+		c–cc		cc	cc	cc	cc	c	cc
	II	cc	0–+		r	r–+	c	+	+	0–cc	cc	c–cc	c–cc
	III	+–c	c		r	r			r	r	c	r–c	r
	IV	r	r	r	r	r		r	r	0	r		r
Calanus glacialis	I			+		0–cc		0	0–c	0–cc	0	0	r
	II	cc	0–r		0	0–r	r	0	0	0	0–r	0	0
	III	0			0	0			0	0	0	0	0
	IV	0	0	0	0	0		0	0	0	0		0
Calanus hyperboreus	I			0		0		0	0	0–r	r	c	0
	II	+	0–+		0–r	r–+	0	r–+	r	0–c	+	+–c	0–+
	III	r			r	r			0–r	0–r	0	r	r
	IV	r	r	r	r	0–r		0–r	r	0	0		r
Pseudocalanus minutes and/or *P. elongatus*	I			0		0		0	0	0	0	0	0
	II	0	0–cc		cc	+–c	c	c–cc	0	c–cc	0–c	0	0–cc
	III	c–cc			cc	cc			c–cc	cc	cc	0–cc	cc
	IV	cc	cc	c	c	c		cc	cc	c	cc		c–cc
Microcalanus pusillus and sp.	I			c		0		0	cc	cc	c	c	c
	II	0–c	0		r	0–r	0	0–r	0	r–+	r–c	r–cc	0–cc
	III	+			0	0			0	0	r	cc	0
	IV	0	r	c	+	r–c		0	0	r	0		0–+
Euchaeta norvegica	I			0		0		0	0	0	0	0	0
	II	r	0–r		r	r	0	0–r	r	0	0	0–r	0
	III	r			r	0			r	r	0	0	0–r
	IV	0	r	r	r	r		0	0	0	0		0
Temora longicornis	I			0		0		0	0	0	0	0	0
	II	r	0		0	0	0	0	0	0	0	0	0
	III	0			0	0			0	0	0	0	0
	IV	0	0	0	0	0		0	0	0	0		0
Metridia longa	I			0		0		0	0	0–r	+	c	r
	II	c	r		0	0–r	r	r	cc	0–r	+–c	0–+	+
	III	+			+	r			+–cc	cc	c	c–cc	r–c
	IV	r	+	c	c	+–cc		r	c	c	+		+
Pleuromamma robusta	I			0		0		0	0	0	0	0	0
	II	0	0		0	0	0	0	0	0	0	0	0
	III	0			0	0			0	0	0	0	0
	IV	0	0	0	0	r		0	0	0	0		0
Acartia longiremis	I			0		0		0	0	0	0	0	0
	II	r	0–r		r	0–r	r	0–r	0	r	0–r	0–r	0–r
	III	r			0	0			0	r	0	0–r	0–r
	IV	0	0	0	0	0		0	0	r	r		0–r
Oithona spinirostris and *O. similis*	I			0		0		r	0	0	0	0	0
	II	r	0–r		r	0–r	r	0–+	0	0–r	r–+	0–+	0–r
	III	r–c			r	+			r–+	r	r	0–r	r
	IV	0	0	r	r	r		r–+	r	+	+		r–+
Oncaea borealis and *O.* sp.	I			0		0		0	0	0	0	0	0
	II	r	0		0	r	0	+	0	r–+	0–r	0	0
	III	r			r	+			0–c	0	c	r	c–+
	IV	r	r	0	0	+–c		+	r	r	r		r–c
Microsetella norvegica a.o.harpacticids	I			0		0		0	0	0	0	0	0
	II	0	0		r	0	0	0	0	0	0	0	0
	III	0			r	r			r	0	r	0	0
	IV	0	0	0	0	r–+		0	0	r	r		0–r
Monstrillidae	I			0		0		0	0	0	0	0	0
	II	0	0		r	0	0	0	0	r	0	r	0
	III	0			0	0			0	0	0	0	0
	IV	0	0	0	0	0		0	0	0	0		0
Number of samples examined	I			1		2		1	2	2	1	1	1
	II	1	3		2	2	1	2	1	3	2	2	2
	III	2			1	1	1		2	1	1	2	2
	IV	1	1	1	1	2		2	1	1	1		2

Table 17. Monthly occurrence of copepodite stages (I–VI) in microplankton and Hensen net samples. All stations. (cop = the various stages are pooled).

Species or Genus	Net type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calanus finmarchicus	Micro	II–IV	0		0	0		I–II	I–V	I–VI			IV–VI
	Hensen	cop +VI	V –VI	VI	IV –VI	I –VI	I –VI	I –VI	III –V	II –VI	III –V	IV –VI	IV –VI
Calanus glacialis	Hensen	cop +VI		VI		III –V	III –VI		IV –V		V	V	V
Calanus hyperboreus	Hensen	III –VI	III –V	IV –VI	IV –V	I –VI	0	I –V	III –V	III –VI	cop +IV	III –V	II –V
Pseudocalanus sp.	Micro	IV	0		0	0		0	IV –VI	cop +VI			0
	Hensen	cop +VI	IV –VI		IV –VI	III –V	cop +VI	cop +VI	cop +VI	cop +VI	IV –VI	cop +VI	III –VI
Microcalanus pusillus and sp.	Micro	cop	0		cop	0		cop	cop	cop			cop +VI
	Hensen	?	?	?	VI	V –VI	0	?	?	cop +VI	VI	cop +VI	III –VI
Euchaeta norvegica	Hensen	V –VI	V	V	V –VI	III –VI	0	III –V	IV –VI	V	0	VI	V
Metridia longa	Micro	0	0		0	0		0	II –III	0			0
	Hensen	V –VI	IV –VI	cop +VI	cop +VI	I –VI	?	cop +VI	I –VI	II –VI	III –VI	cop +VI	cop +VI
Acartia longiremis	Micro	0	0		0	0		cop	cop +VI	cop +VI			0
	Hensen	VI	VI		VI	VI	cop +VI	VI	0	cop +VI	V –VI	VI	cop +VI
Oithona sp.	Micro	cop +VI	cop +VI		cop +VI	cop +VI		cop +VI	cop +VI	cop +VI			?
Oncaea sp.	Micro	?	?		cop	?	0	?	cop +VI	VI			?
Corycaeus sp.	Micro	?	?		?	?		VI	?	?			?
Microsetella norvegica	Micro	?	?		?	?		?	cop +VI	I –II			?
	Hensen	0	0	0	?	?		?	0	?	?		?

deeper than 50 m. Possibly the Hensen net nauplii mostly belong to *Calanus* while the major part of the small microplankton nauplii may belong to *Microsetella norvegica*, and they are believed to escape through the mesh apertures of the Hensen net.

The occurrence throughout the year of different copepodite stages (I–VI) in microplankton and Hensen net samples is shown in Table 17. Comments to the table are given below (General remarks on Copepoda).

Survey of copepod species. – *Calanus finmarchicus* (Gunnerus). Scarce in microplankton samples, very numerous in the macroplankton (Hensen net samples) at outer stations (I and II), less frequent at the mid-fjord station (III) and scarce at the inner fjord station (IV).

Calanus glacialis Jaschnov. Observed only in macroplankton samples and only at outer stations (I and II). – The species was described as late as 1955 (Jaschnov, 1955) and confirmed among others by Grainger (1961).

Calanus hyperboreus Krøyer. Observed only in the macroplankton (Hensen net samples), less frequent than the other *Calanus* species. It occurs at all stations, most frequently at the fjord entrance (St. II).

Pseudocalanus minutus (Krøyer) and *elongatus* Boeck. Scarce in microplankton samples but very numerous in the macroplankton (Hensen net samples) at all fjord stations throughout the year, in some samples extremely numerous. Not observed at the coastal St. I.

Microcalanus pusillus G. O. Sars and *M.* sp. Less frequent in the microplankton samples but numerous in the macroplankton (Hensen net samples) at all stations especially in the coastal area (St. I) in all seasons.

Euchaeta norvegica Boeck. Not observed in microplankton samples. Few specimens found in Hensen net samples from all fjord stations throughout the year. Not observed at the coastal St. I.

Centropages hamatus (Lilljeborg). Observed only once in a microplankton sample (St. 2, Aug. 1955).

Temora longicornis (O. F. Müll.). Observed only once in a Hensen net sample (St. II, Jan. 1956).

Metridia longa (Lubbock). Scarce in microplankton samples but numerous in the Hensen net samples in all seasons, mostly at the fjord stations.

Pleuromamma robusta (Dahl). Observed only in a Hensen net sample (St. IV, May 1956).

Acartia longiremis (Lilljeborg). Numerous in microplankton samples in July–Sep. Scarce in Hensen net samples in all seasons at all fjord stations. Not observed in the coastal area (St. I).

Oithona similis Claus and *O.spinirostris* Claus. These were found in microplankton samples throughout the year, very numerously in July–Sep. *O.similis* being dominant. Less frequent in Hensen net samples (escaping through the mesh apertures) at fjord stations, and observed only once in the coastal area (St. I).

Oncaea borealis G. O. Sars and *O.*sp. Scarce in microplankton samples. Occurs in Hensen net samples from all fjord stations throughout the year, most numerously at mid- and inner fjord stations (III and IV), and observed only once in the coastal area (St. I).

Corycaeus sp. Few specimens observed in microplankton samples in July–Sep. (St. II, 1957). Not observed in Hensen net samples.

Microsetella norvegica (Boeck) and possibly some other harpacticids. Dominant in the microplankton samples with a maximum in July–Sep. More frequent in samples from shallower than from deeper water and most numerous at mid- and inner fjord stations (Table 13).

Monstrillidae. Few specimens observed in Hensen net samples (St. II, Apr., Sep., Nov., 1955–56).

General remarks on Copepoda. – From Tables 12 and 14 it is seen that some small-sized species, which are numerous and dominant in the microplankton samples, are scarce or not present at all in the macroplankton samples as they escape through the Hensen net apertures (*Acartia longiremis, Oithona similis* and *Microsetella norvegica*). Other species, numerous or more or less frequent in Hensen net samples, are scarce or not present in microplankton samples (*Calanus* spp., *Pseudocalanus* spp., *Euchaeta norvegica,* and *Metridia longa*).

Some species occur mainly in the coastal water and at the fjord entrance and are scarce or absent in the mid- and inner fjord areas (*Calanus finmarchicus* and *glacialis, Microcalanus pusillus*). Other species found frequently in the fjord are scarce or absent in the coastal area (*Metridia longa* and *Pseudocalanus* spp.).

According to literature (Jespersen, 1934; Hansen, 1960; Grainger, 1962; Bainbridge and Corlett, 1968; Glover and Robinson, 1968) several copepods are special cold-water species, namely *Calanus glacialis, C.hyperboreus, Pseudocalanus minutus, Metridia longa, Acartia longiremis, Oncaea borealis,* while others are more or less eurythermal.

Table 17 shows main features of the annual cycle for some species. Copepodite Stage I of *Calanus finmarchicus, C.hyperboreus* and *Metridia longa* occurs from May onwards in agreement with the earlier occurrence of nauplii in the Hensen net samples (maximum in Apr.–June (July)).

In the microplankton samples a maximum of small nauplii was found as late as July–Aug. They are probably *Microsetella norvegica* nauplii, the adults being abundant in these samples as well as being frequently recorded in Hensen net samples. The lower abundance in the latter samples is due to the small size of the species (escaping through the mesh apertures).

Only data for *Calanus finmarchicus* give an almost complete picture of the life cycle (Table 18). However, it should be noted that nauplii from Hensen net samples were not identified to species or genus.

Table 18 indicates one *Calanus finmarchicus* generation per year, which is in accordance with previous studies in the same area (Maclellan, 1967) and with the extensive survey "Norwestlant" in Davis Strait from Apr. to July 1963 (Bainbridge and Corlett, 1968). Also in the arctic E Greenland fjords the species seems to have one generation per year (Ussing, 1938; Digby,

Table 18. The life cycle of *Calanus finmarchicus* in Godthåbsfjord and in coastal area. (Nauplii not identified). –?– = few specimens observed once, probably not normal. ? = occur possibly, but not observed.

Stage		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nauplii					---	---	---	---					
Copepodite	I					---	---	---	---	---			
	II	–?–				---	---	---	---	---			
	III	–?–				---	---	---	---	---	---		
	IV	---	?	?	---	---	---	---	---	---	---	---	---
	V	---	---	?	---	---	---	---	---	---	---	---	---
	VI	---	---	---	---	---	---	---	---	---	---	---	---

1954). In boreal waters, however, there are more than one generation per year.

Other species showed less distinct life cycles. Maclellan (*l.c.*) found that *Calanus glacialis* in the outer Godthåbsfjord region had a prolonged spawning with a maximum already in March. It was further noted by Maclellan (*l.c.*) that the "large form" and "small form" of *C.finmarchicus* studied by Digby (1954) in E Greenland show life cycles similar to those of *C.glacialis* and *C.finmarchicus* in Godthåbsfjord, which makes it probable that Digby's "large form" refers to *C.glacialis.*

Metridia longa seems to have a life cycle much like that of *C.finmarchicus* in Godthåbsfjord, Stage I occurring from May to Aug., Stages II and III onwards to Sep. and Oct. Some females of *Euchaeta norvegica* were seen with spermatophores from Jan. to Apr., and Stage III was observed already in May. Thus this species probably has an early spawning.

Hensen net hauls from various depths (50–0 and 300/400–0 m) indicate seasonal vertical migrations (Table 4, sect. 5.2.) in which the copepods are dominant. Such seasonal migrations have been recorded in arctic, subarctic, and boreal waters by several authors: At W Greenland (Maclellan, 1967), at E Greenland (Ussing, 1938; Digby, 1954), in the Norwegian Sea (Gran, 1902; Sømme, 1934; Wiborg, 1954; Østvedt, 1955), w of Scotland (Marshall and Orr, 1955).

The scarcity of *Metridia longa* in the microplankton samples, all from 30–0 m depth, may be due to its preference for deeper strata (Jespersen, 1934, p. 96; Digby, 1954, p. 330).

An exceptional observation of the dominant role of copepods as herbivores was recorded in a Hensen net sample full of phytoplankton (St. IV, May 1955), where a large number od *Metridia longa* was seen with maxillae and maxillipeds clogged with phytoplankton.

Cladocera

Podon (*leuckarti* G. O. Sars ?) and *Evadne* (*nordmanni* Lovén ?) have been taken at all stations with microplankton and Hensen net. As seen in Table 19 both have maximum in July–Aug. The more numerous *Podon* occurred most frequently in the inner fjord area, where the highest number in a microplankton sample was 1560 specimens (St. IV, Aug. 1959), while the highest number in the outer fjord area was only 413 specimens (St. II, July 1959).

Ostracoda

Data on species at W Greenland are given by Stephensen (1913).

Concoecia elegans G. O. Sars and *C.obtusata* G. O. Sars. Both species observed in macroplankton samples from all fjord stations throughout the year in relatively small numbers, but only once at the coastal st. I. The highest number was 640 *C.elegans* in a Hensen net sample (St. IV, May 1955, 200–0 m). Their absence in the microplankton samples may indicate that they stay below 30 m.

Amphipoda

Data on species at W Greenland are given by Stephensen (1913).

Gammaridea and Hyperiidea were present in macroplankton samples from all stations in relatively small numbers, their absence in microplankton samples probably being due to their quick movements.

Gammaridea were present throughout the year. The highest number in a Hensen net sample was c. 100 (St. I, Sep. 1955, 200–0 m), while the highest number in a stramin net sample was only 27 (St. II, Jan. 1962), 400 m wire).

Hyperiidea were observed throughout the year. *Parathemisto abyssorum* Boeck was the most common species (highest number in a Hensen net sample was 170, St. III, Apr. 1956, 300–0 m). – The following species were present only in small numbers: *Parathemisto gaudicaudi* (Guerin), *P.libellula* (Lichtenstein), *Hyperoche medusarum* (Krøyer), *Hyperia galba* (Montagu), and *H.medusarum* (Müller).

Mysidacea

Data on species in W Greenland waters are given by Stephensen (1913, 1933).

Boreomysis nobilis G. O. Sars. – Few specimens found in Godthåbsfjord (Feb.–May 1954) and in Ameralik fjord (May 1954) in stramin net samples with hauls with 500–800 m wire. – Single specimens were taken by Hensen net in Godthåbsfjord (Aug.–Sep. 1956). Most likely several specimens escape the plankton nets because of their quick movements. – The species is often seen in *Pandalus* trawl catches indicating a deeper occurrence, *i.e.* near the bottom.

Table 19. Monthly average numbers of Cladocera per microplankton sample (30–0 m) at St. II and 2, 1955–63. r = less than one.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Podon	0	0	0	0	0	r	80	104	11	r	0	0
Evadne	0	0	0	0	0	r	13	17	6	0	0	0
No. of samples	(4)	(5)	(5)	(7)	(6)	(5)	(8)	(6)	(7)	(5)	(2)	(6)

Euphausiacea

Data on species at W Greenland are given by Stephensen (1913, 1933), Einarsson (1945), and Bainbridge and Corlett (1968).

Thysanoessa longicaudata (Krøyer), *T.inermis* (Krøyer), and *T.raschii* (M. Sars) were common in the survey area, while *Meganyctiphanes norvegica* (M. Sars) was rare (observed only once at St. 2, Jan. 1956).

Einarsson (*l.c.*) gives detailed information in the distribution and development of euphausiids in W Greenland waters: Only *Thysanoessa raschii* and *T.inermis* spawn to some extent in the coastal waters. In W Greenland waters both species mature at an age of two years followed by spawning in approximately the same period. Throughout the summer the larvae of the two species are found in the same stages of development (Fig. 21). *Thysanoessa longicaudata* matures at an age of one year, and spawning seems to be limited to water of Atlantic origin. *Meganyctiphanes norvegica* does not seem to spawn in W Greenland waters.

The material of eggs and larval stages analysed by Einarsson was collected by Dr. Paul M. Hansen in 1933–39 in coastal and inshore waters between Godthåb and Holsteinsborg districts. The net used was a 1 m stramin net with a fine-meshed silk bag. The wire length varied from 50 to 300 m.

The material of the present survey is presented in Tables 20–23. In microplankton samples (mainly St. II and 2) eggs and the Nauplius, Calyptopis, and early Furcilia stages were present. In Hensen net samples, eggs and all developmental stages were present at all stations. In stramin net samples adolescents and adults were present at all stations.

Considerable quantities of eggs were found in Apr.–July at St. I–III, but the main spawning seems to take place in Apr.–May. At St. IV large quantities of eggs were also found in July–Aug. Nauplii were most numerously found in May–June, the highest numbers pertaining to the coastal region and the fjord entrance (Fig. 15, sect. 5). The highest numbers of adolescents and adults were found in the inner fjord region, the maximum number in one stramin net haul being 8000 (St. IV, Sep. 1961, 100–50 m wire).

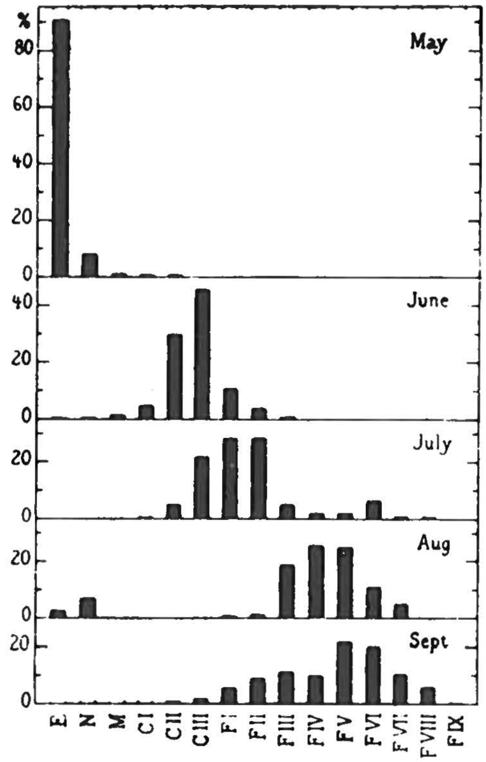


Fig. 21. Occurrence of larval stages of *Thysanoessa raschii* and *T.inermis* during the summer in W Greenland coastal waters. E: eggs; N: Nauplii; M: Metanauplii; C: Calyptopis; F: Furcilia. – Percentage numbers per 30 min. 1 m stramin net haul. (After Einarsson, 1945).

An accumulation of adults in the inner fjord region in the later half of the year may explain the large quantities of eggs found there in July–Aug. These eggs are possibly of *Thysanoessa raschii*, which according to MacDonald (1928) has one spawning period in spring and another in autumn in Loch Fyne (Scotland). Einarsson (1945, p. 125) found eggs of this species as late as Aug. at W Greenland, and he is further (*l.c.*) of the opinion, that it is predominantly a fjord form.

In offshore W Greenland waters Bainbridge and Corlett (1968) found maximum numbers of euphausiid

Table 20. Monthly average numbers of euphausiid stages in microplankton hauls (30–0 m) at St. II and 2. r = few specimens.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eggs (1957–63)	0	0	0	14	140	0	r	0	0	0	0	0
Nauplii (1955–63)	0	0	r	11	66	110	170	5	20	0	6	0
Calyptopis and Furcilia (1955–63)	0	0	0	0	2	4	30	2	0	0	0	0
Hauls exam. for:												
Eggs	3	4	4	5	5	2	5	4	3	3	1	4
Larvae	4	5	5	7	6	4	8	6	7	5	2	6

Table 21. Numbers of euphausiid eggs in Hensen net hauls. r = few; + = not counted, present.

St. and Haul depth	Year	Feb	Mar	Apr	May	Jun	Jul	Aug
I	1955				200		250	0
200–0 m	1956		0		6300			360
II	1955				1200		750	0
300–0 m	1956	0		5500	1000	3800	2000	
	1958	50		21440	2640			
III	1955							0
300–0 m	1956			0	0			0
	1958	0		1060	1080	0		
IV	1955				r		1500	4000
200–0 m	1956	0	0	0	+		0	

Table 22. Numbers of euphausiid nauplii in Hensen net hauls. Numbers in brackets are uncertain, r = few specimens, + = present, not counted.

St., Haul depth	Year	Apr	May	Jun	Jul	Aug
I	1955		30000		10	0
200–0 m	1956		20500			60
II	1955		0		0	0
300–0 m	1956	+	(2800)	(200)	r	
	1958	670	350			
III	1955					0
300–0 m	1956	r	100			0
	1958	75	600			
IV	1955		0		0	0
200–0 m	1956	0	(50)		0	

eggs and nauplii in Hensen net samples in June. Most likely they are *Thysanoessa longicaudata*, the later stages of which species are by far the most numerous euphausiids in stramin net samples from the area (the "Norwestlant" Survey 1963).

Natantia

Sergestes arcticus Krøyer. – A single specimen was taken by stramin net (St. II, Sep. 1955, 600 m wire). – This species is sometimes found in *Pandalus* trawl catches (Horsted and Smidt, 1956). Further data on occurrence at W Greenland are given by Stephensen (1913, 1935).

6.1.7. Gastropoda

Data on Pteropoda at W Greenland are given by Kramp (1961), and Bainbridge and Corlett (1968).

Limacina helicina (Phipps) and *L.retroversa* Fleming. While *L.helicina* is a cold-water species occurring abundantly in the entire W Greenland area, *L.retroversa* is a warm-water species only found off southern W Greenland. – In the survey area *L.helicina* was common at all

Table 23. Numbers of *Thysanoessa*, all species, all stages from Calyptopis to adult, in Hensen net hauls. r = few specimens.

St. Haul depth	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I	1955					225		21	8	3	1	7	9
200–0 m	1956			2		0			0	13			
II	1955					r		20	20	40	9	2	10
300–0 m	1956	4	16		r	0	0	20		23	14	3	5
	1957		9									0	0
	1958	3	0		0	0							
III	1954												3
300–0 m	1955								43	6		4	30
	1956	6			5	1			51		9	1	
	1957						0				13	0	
	1958	0	1		0	1							
IV	1954												10
200–0 m	1955					0		27	10	120	2		18
	1956	10	2	6	1	4		3					

Table 24. Monthly average numbers of *Limacina* juv. per microplankton haul (30–0 m) at St. II and 2, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	r	r	0	r	r	1	31	527	17	10	6	2
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

stations, while *L.retroversa* was recorded only in the coastal area and at the fjord entrance (St. I, II, 2).

In the microplankton samples juvv. occurred with a maximum in Aug. (Table 24). – Pelagic egg masses as described by Lebour (1932) for *L.retroversa* were not observed; they have possibly been overlooked. – A description of the general biology of *L.retroversa*, especially its feeding, was given by Morton (1954).

In the macroplankton samples *Limacina* spp. occurred throughout the year. The maximum number in a Hensen net haul was 400 *L.helicina* juv. (St. IV, Sep. 1955, 200–0 m).

Clione limacina (Phipps). It is a cold-water species and according to Kramp (1961) with a similar distribution off W Greenland as that of *Limacina helicina.*

Pelagic egg masses and the early stage with a larval shell, described by Lebour (1931), were not observed; they have possibly been overlooked. – In the microplankton samples juvv. occur in small numbers in Apr.–Nov. with a maximum number of 300 in one haul (St. I, Sep. 1961). – In macroplankton samples all sizes occur in small quantities throughout the year at all stations.

6.1.8. Chaetognatha

Data on distribution in W Greenland waters were given by Kramp (1918, 1939) and by Bainbridge and Corlett (1968). Three species, all widely distributed off W Greenland, were found in the area investigated: *Sagitta elegans* Verrill, *S.maxima* (Conant), and *Eukrohnia hamata* (Möbius).

S.elegans was dominant in all samples, most frequently occurring in the inner fjord areas. According to Kramp (1939) it is restricted to the coastal waters in Davis Strait. The species seems to have one generation annually in Greenland waters (Kramp *l.c.*, pp. 12–14). However, in arctic and subarctic Canadian waters where conditions are much similar to those in Greenland waters Dunbar (1962) found a two year life cycle (sect. 7).

In the microplankton samples small specimens of *S.elegans* were present in small numbers at all fjord stations in Apr.–Oct., the largest number in one sample being 64 (St. IV, Aug. 1957).

In the Hensen and stramin net samples chaetognaths often constitute an essential part of the biomass, *Sagitta elegans* being by far the most numerous species throughout the year. Less frequent was *Eukrohnia hamata,* also occurring throughout the year. *Sagitta maxima* was rarely observed in the samples, but it is often observed in shrimp trawl meshes, which indicates an occurrence in the deep, warm water layers.

Table 25 shows the total numbers of chaetognaths in Hensen net samples throughout the year at the entrance to Godthåbsfjord (St. II) and in the inner Godthåbsfjord (St. IV). The largest concentrations were found in the inner fjord area.

In the stramin net samples the largest number at the fjord entrance was 650 specimens in one haul (St. II, Oct. 1961, 400 m wire), and in the inner fjord area it was as much as 25 150 (St. IV, Dec. 1961, 400 m wire).

6.1.9. Copelata

Records of the species at W Greenland are given by Kramp (1942). The species in the survey area are presumably *Oikopleura vanhoeffeni* Lohmann, *O.labradorienses* Lohmann, and *Fritillaria borealis* Lohmann.

Table 25. Monthly average numbers (nearest ten) of total chaetognaths per Hensen net haul at the Godthåbsfjord entrance (St. II, 300–0 m) and in the inner fjord area (St. IV, 200–0 m).

St. Depth, m No. of hauls Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
II 300–0 25 1955–58	30	40	?	10	10	10	10	80	120	30	70	40
IV 200–0 14 1954–56	250	170	140	80	80	?	170	170	240	130	?	270

Table 26. Monthly average numbers of Copelata per microplankton haul (St. II and 2, 1955–63). r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	8	1	r	r	28	8	58	27	5	0	r	0
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

In the microplankton samples *Oikopleura* sp. and *Fritillaria* sp. occurred in relatively small numbers with a maximum in July (Table 26).

In the macroplankton samples Copelata were present throughout the year, usually in small numbers. The largest number in one Hensen net sample was 730 (St. IV, Aug. 1955, 200–0 m).

Cyanea capillata (L.). Small specimens occasionally taken by stramin net at all stations in June–Oct. Frequently observed swimming in upper water layers in summer and autumn, when they are a nuisance to gill net fishery.

Ephyra stages of *Aurelia* or *Cyanea* present in May–June 1956 in Hensen net samples in small numbers in mid Godthåbsfjord.

6.2. Meroplankton

6.2.1. Pelagic Generations (Medusae)

Hydromedusae (excl. *Aglantha* and *Aeginopsis*). – Data on species in W Greenland waters are given by Kramp (1942d, 1959).

In all samples hydromedusae occurred in small numbers throughout the year, but mainly Apr.–Oct.

Sarsia tubulosa (M. Sars). Few specimens in samples at all stations from Apr. to Dec.

Sarsia princeps (Haeckel) and *S.* sp. Few specimens in macroplankton samples in Godthåbsfjord, July–Aug.

Euphysa aurata Forbes? Few specimens in samples from the inner Godthåbsfjord (St. IV) from Aug. to Jan.

Bougainvillia superciliaris (L. Agassiz). Small numbers in all samples at all stations. Apr.–Sep.

Rathkea octopunctata (M. Sars). Frequent at all stations, Apr.–Oct.

Catablema vesicarium (A. Agassiz) and/or *C.multicirrata* Kishinouy. Small numbers in macroplankton samples at all stations, May–Sep.

Ptychogena lactea A. Agassiz. Frequently observed in shrimp trawl meshes, which indicates occupancy of deep, warm water layers. Few were taken with stramin net (St. II, Sep.–Oct.).

Staurophora mertensi Brandt. Few specimens taken with stramin net in Godthåbsfjord in July and Sep.

Obelia sp. Few specimens found in microplankton and Hensen net samples from Godthåbsfjord in June –Oct.

Scyphomedusae. – Data on species in W Greenland waters are given by Kramp (1942d).

Periphylla periphylla (Peron and Lesueur). The species often taken with shrimp trawl in the deep, warm water layers including the inner Godthåbsfjord. Frequent in deep stramin net hauls in Davis Strait.

Aurelia limbata (Brandt) and/or *A.aurita* (L.). Small specimens taken by stramin net at all fjord stations in June–Oct. Frequently observed swimming in summer and early autumn.

6.2.2. Epitokous polychaete stages

Autolytus sp. Small numbers in macroplankton (Hensen and stramin net) samples at all stations throughout the year. According to Wesenberg-Lund (1947) the most common species are *A.prolifer* (O. F. Müll.) and *A.prismaticus* (O. Fabr.).

Nereis pelagica L. Epitokous specimens not observed in the samples, but as they are frequently observed in Davis Strait they probably also occur in the survey area, where the species is common on the bottom.

6.2.3. Pelagic bottom invertebrate larvae

Bottom invertebrate larvae constitute by far the greatest part of the meroplankton. They occur in considerable numbers from Apr. to Sep. (Fig. 13, sect. 5.1.). At times they form an essential part of the microplankton, but they are scarce in macroplankton samples, most of them passing through the meshes. *Balanus* nauplii, however, are numerous in Hensen net samples.

Anthozoa

The Arachnactis stage (Fig. 22A). This stage most likely belongs to *Cerianthus lloydii* Gosse, as it agrees with the larva described by Carlgren (1906) and by Nyholm (1943). Few specimens observed in microplankton and Hensen net samples in Godthåbsfjord (all stations, May–Aug. 1955–63). – Add. recorded from W Greenland waters (Carlgren, 1928).

Hydrozoa

The Actinula stage (Fig. 22B). – The Actinula of *Tubularia larynx* was described by Allman (1871). The present larvae belong most likely to *Tubularia indivisa* L. or possibly to *T.regalis* Boeck, both species being known from W Greenland waters (Kramp, 1914, 1932). – The larvae were commonly present in microplankton samples from the fjord entrance (St. II and 2, Ju-

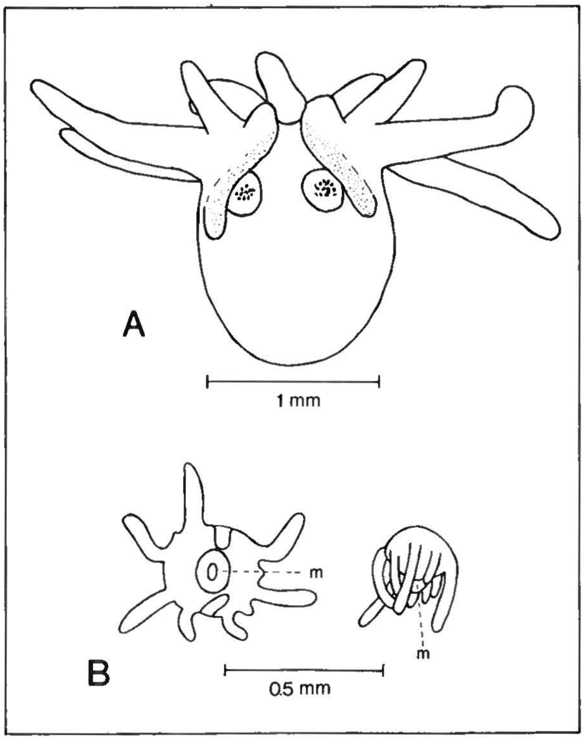


Fig. 22. A. Arachnactis stage of *Cerianthus lloydii* Gosse (?). Microplankton, St. 2, 17/7 1956. – B. Actinula stage of *Tubularia indivisa* L. or *T.regalis* Boeck. Microplankton, St. 2, 10/7 1956. m = mouth. – A and B drawn from preversed specimens.

ly–Aug.) and were observed once in the mid-fjord (St. III). Table 27 shows the occurrence by month. The largest number recorded in one sample was 900 (St. II, Aug. 1959).

Nemertina

Few Pilidia observed in microplankton samples from Godthåbsfjord (St. II and IV, June–Aug. 1956–60).

Bryozoa

Few Cyphonautes observed in microplankton samples from the outer part of Godthåbsfjord (St. II and 2, Nov. 1955, Jan. 1958).

Polychaeta

In the microplankton samples polychaete larvae constitute one of the dominant groups among bottom animal larvae. Table 3 (sect. 5.1.) and Fig. 23 show total numbers of polychaete larvae in the microplankton throughout the year. Maximum numbers occur in June–Aug. The largest total number in one microplankton sample was 1050 (St. 2, Aug. 1955).

In Hensen net samples polychaete larvae were sometimes present in considerable numbers, but most of them probably escaped through the meshes. The largest number in one Hensen net sample was 1400 (St. I, May 1955, 200–0 m).

Survey of different polychaete larvae. – Trochophora and Metatrochophora stages. These stages, mainly belonging to Polynoidae and Phyllodocidae, occurred in microplankton samples in relatively small numbers in Apr.–Aug. reaching a maximum in June, with an average of 36 larvae per haul. The highest number was 107 larvae in one haul (St. II, June 1960).

Harmothoe (total). Nectochaeta stages were observed in microplankton samples in small numbers from May to Sep.; the largest number in one haul being 68 (St. II, July 1956). The largest number in one Hensen net haul was c. 500 (St. I, May 1955).

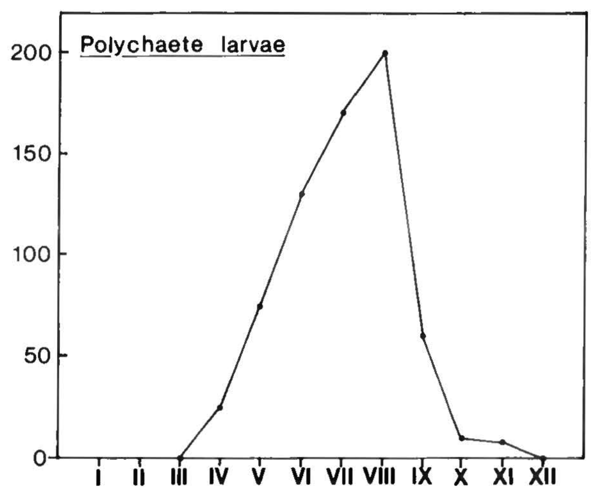
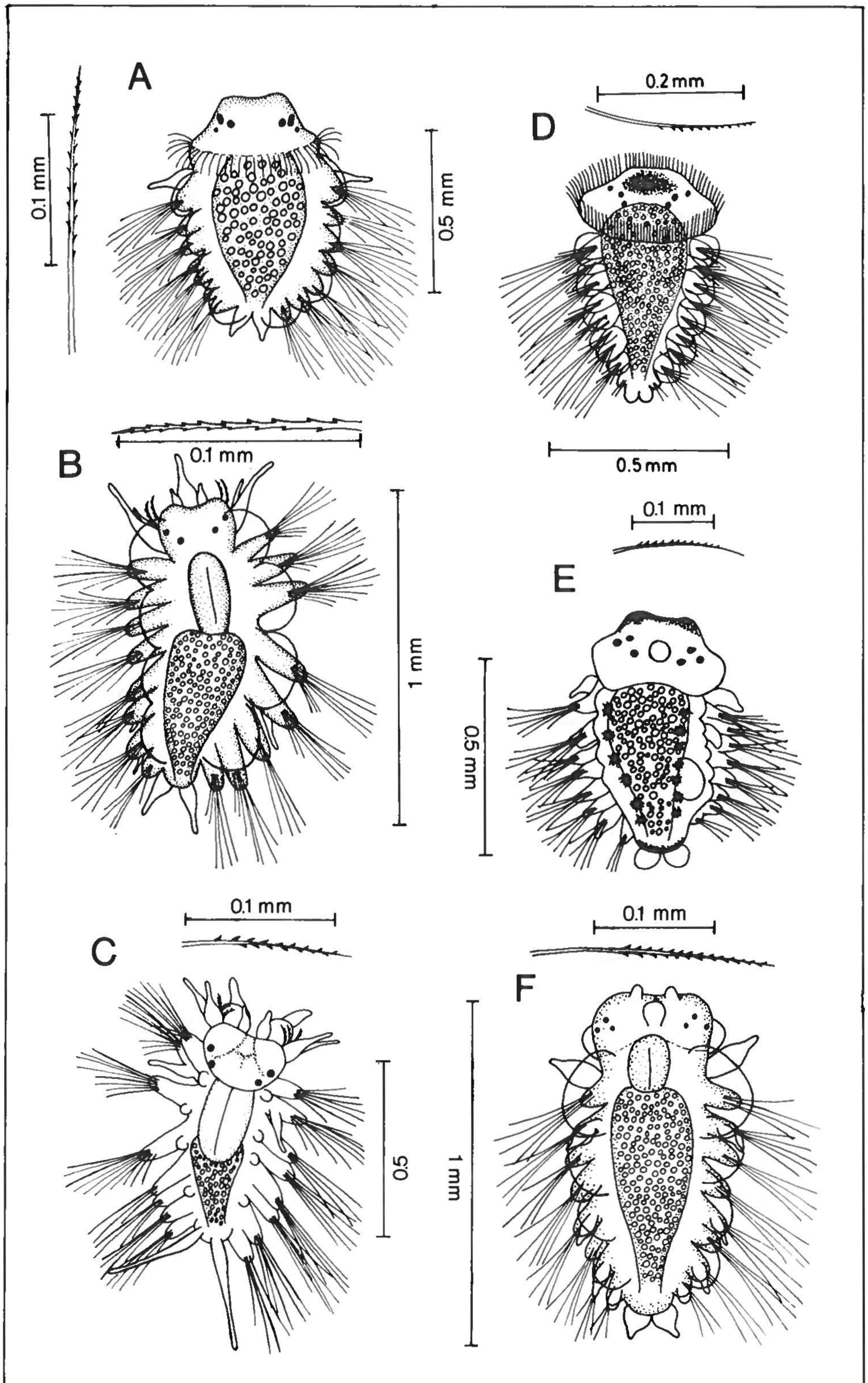


Fig. 23. Monthly numbers of polychaete larvae in microplankton samples (30–0 m hauls), St. II and 2, average for 1955–63.

Table 27. Monthly average numbers of Actinula per microplankton haul (30–0 m) at St. II and 2, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	0	0	0	r	r	0	55	185	1	1	0	0
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)


A
0.1 mm
0.5 mm
B
0.1 mm
1 mm
C
0.1 mm
0.5
D
0.2 mm
0.5 mm
E
0.1 mm
0.5 mm
F
0.1 mm
1 mm

Harmothoe imbricata (L.), (Fig. 24, A–B). The Metatrochophora and Nectochaeta stages, described by Thorson (1946), Rasmussen (1956), and Mileikovsky (1959), are the dominant polynoid larvae in the samples. Add. are very common in the area.

Harmothoe sarsi Kinberg ? (Fig. 24, C). A larva, similar to that described by Korn (1958), was observed in microplankton samples from the inner Godthåbsfjord (St. IV, Aug. 1959). Add. recorded from W Greenland waters (Wesenberg-Lund, 1950).

Gattyana cirrosa (Pallas) – (Fig. 24, D–F). The identification is confirmed by Dr. Erik Rasmussen in accordance with a description by Thorson (1946). – Single larvae observed in microplankton samples in May–June (St. II, 1956). – Add. very common in the area.

Pholoe minuta (Fabr.), – (Fig. 25, A). Dr. B. Åkesson (Sweden) identified the larva on the basis of material from Isefjord, Denmark (unpublished). Description was published by Sveshnikov (1960). – Few specimens observed in the microplankton in May–Oct. (St. II and 2, 1955–60). – Add. common in shallow water in the area.

Eteone longa (Fabr.), – (Fig. 25, B). The larva, described by Thorson (1946), was observed in small numbers in microplankton samples in Jan. and June–July (St. II and 2, 1955–60). The largest number in one haul was 29 (June 1960). – Add. common in shallow water in the area.

Phyllodoce groenlandica (Ørsted), – (Fig. 25, C–D). The Trochophora, Metatrochophora, and Nectochaeta stages were described by Thorson (1946). Few larvae observed in microplankton samples in June–July (St. II and 2, 1955 and 1958). A Metatrochophora of *Phyllodoce* sp. recorded as late as Oct. (St. 2, 1955). – Ad. *Phyllodoce groenlandica* common in shallow water in the area.

Nereis pelagica (L.), – (Fig. 25, E). The Nectochaeta was described by Wilson (1932a), Thorson (1946), and Rasmussen (1956). – Few specimens observed in microplankton samples in June–July and in Dec. (St. II and 2, 1955–61). – Add. very common in the area at various depths.

Glycera capitata Ørsted, – (Fig. 25, F). The larva of *G.alba*, described by Thorson (1946), is very similar to the present larva. *G.alba* is not recorded from W Greenland waters, but *G.capitata* is common in the area at various depths.

Scoloplos armiger (O. F. Müll.), – (Fig. 25, G). The non-pelagic larval stage was described *i.a.* by Thorson (1946) and Smidt (1951). – One specimen observed in a microplankton sample in May 1960 (St. II), presumably whirled up in the water from the bottom. Add. very common in the area on sandy bottom at shallow depths, where egg masses were observed as early as in Jan. in the tidal zone.

Pelagic eggs and larvae described by Sveshnikov (1960) and referred to *Scoloplos armiger* most probably belong to another species. Several authors have given thorough description of the egg masses fixed to the bottom and the non-pelagic larvae (summarized by Thorson, 1946).

Pygospio elegans Clap., – (Fig. 26, A–B). The greatly varying larval stages were described by Thorson (1946), Smidt (1951), Hannerz (1956), and Rasmussen (1937). – Two larval types, I and II, occurred in small numbers in microplankton samples in Feb.–Oct., with a maximum in Apr.–July (St. II, 1956–63); the largest number in one sample was 40 (July 1963). Few specimens were observed at St. III in July 1963. – Larvae also found in Hensen net samples from outer stations in May (largest number 900 specimens, St. I, May 1955). – Add. recorded from W Greenland waters (Wesenberg-Lund, 1950), where they are numerous in the tidal zone of the survey area (E. Rasmussen, personal communication).

Polydora ciliata (Johnston), – (Fig. 26, C). Larval stages were described by Leschke (1903), Wilson (1928), Thorson (1946), and Hannerz (1956). – The most numerous polychaete larva in microplankton samples from outer Godthåbsfjord, where it occurred from Apr. to Nov., with a maximum in May–Sep. (Table 28). The largest number in one microplankton sample was c. 1000 (St. 2, Aug. 1955). – Also observed in samples from the mid- and inner fjord, and occurred in small numbers in Hensen net samples from St. II.

Add. occur in shallow water in the area, where they seem to be very numerous. – Rasmussen (1973) is of the opinion that *Polydora ligni* Webster is a variety of *P.ciliata;* their larvae are much alike.

Prionospio malmgreni Clap., – (Fig. 26, D–E). Larval stages of *Prionospio* were described by Hannerz (1956). A larva described by Thorson (1946) and referred to *Disoma multisetosum* should be referred to *Prionospio malmgreni*. – The *Prionospio* larvae occurred in small numbers in microplankton samples at St. II and 2 in Apr.–Aug. – Add. of *P.malmgreni* found in shallow water close to the survey area (J. B. Kirkegaard and M. Lindholm Andersen, pers. comm.).

Nerine foliosa (Audouin and Milne-Edwards)? – The characteristic Trochophora in its perforated egg mem-

Fig. 24. A–B *Harmothoe imbricata* (L.). Microplankton St. II; A from 24/11 1959; B from 18/7 1959. Both with black eye pigmentation, a third pair of eyes located on the sides of the prostomium of B not visible on the drawing. – C *Harmothoe sarsi* Kinberg (?). Microplankton, St. IV, 18/8 1959. Prostomium with faint brown pigmentation. Black eyes, a pair of small eyes on the sides of prostomium not visible on the drawing. – D–F *Gattyana cirrosa* (Pallas). Microplankton. D from St. 2, 13/6 1956. Prostomium with brown pigmentation. E from St. 2, 16/5 1956. Prostomium with brown pigmentation, dorsal side with black pigment spots. One dorsal antenna on prostomium. F from St. 2, 2/6 1956. One dorsal antenna on prostomium. – A–C and E–F drawn from preserved specimens, D from live specimen. – Single setae are drawn.

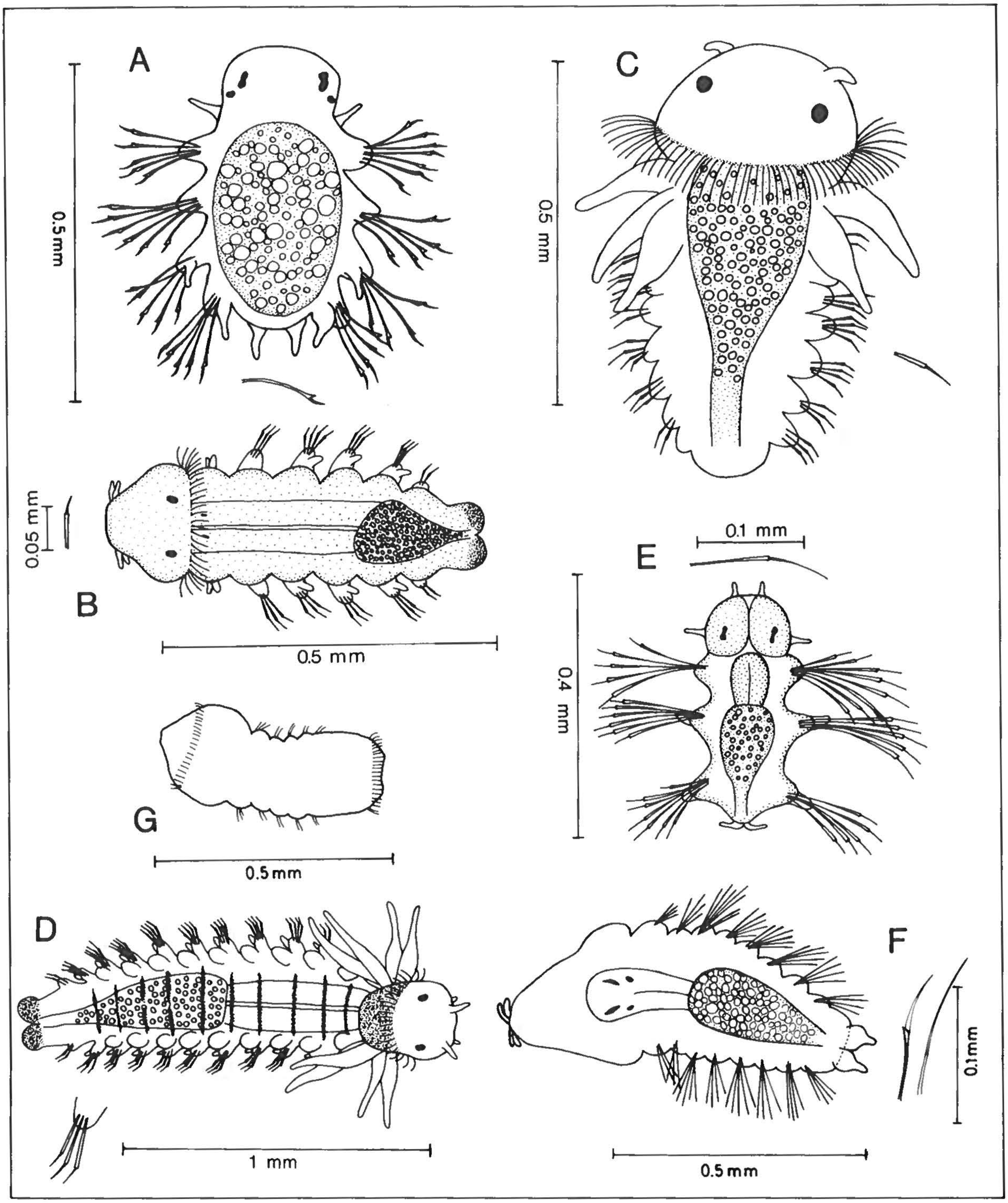


Fig. 25. A *Pholoe minuta* (O. Fabr.). Microplankton, St. 2, 28/10 1955. – B *Eteone longa* (O. Fabr.). Microplankton, St. 2, 13/6 1956. Yellow-green pigment spots scattered over body. Jaws faintly visible. – C Metatrochophora of phyllodocid. Microplankton, St. 2, 28/10 1955. – D *Phyllodoce groenlandica* (Ørsted). Microplankton, St. 2, June 1956. Brown pigmentation on prostomium, dorsal side, and posterior end. – E *Nereis pelagica* (L.). Microplankton, St. 2, 13/6 1956. Brown pigmentation on prostomium. – F *Glycera capitata* Ørsted. Microplankton, St. II, 11/12 1957. Formation of jaws visible. – G *Scoloplos armiger* (O. F. Müller). Microplankton, St. II, 21/5 1960. – A–E drawn from live specimens, F–G from preserved specimens. – Single setae are drawn.

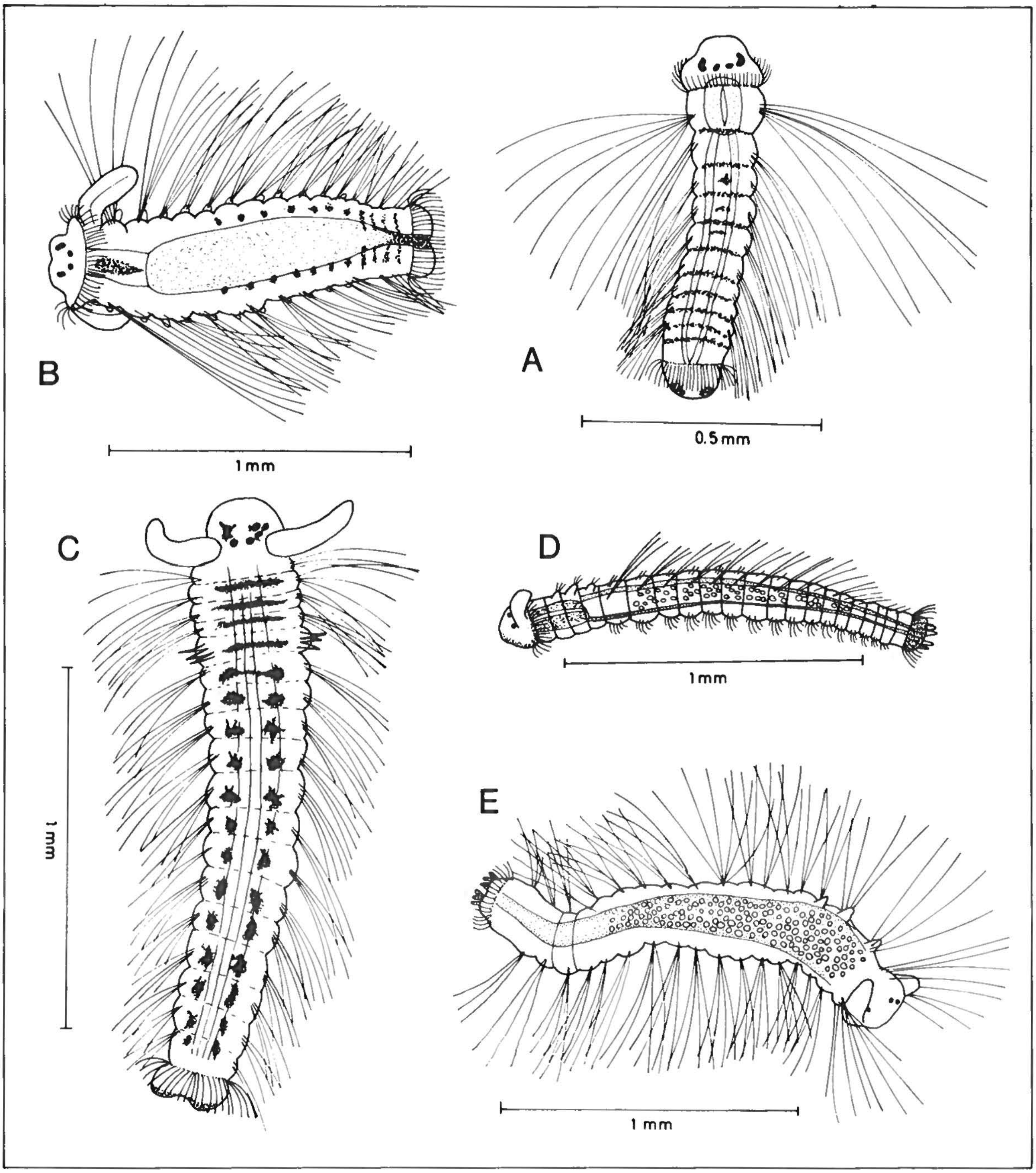


Fig. 26. A–B *Pygospio elegans* Claparède. A, Type I. Microplankton, St. II, 21/4 1960. Black and dark brown dorsal pigmentation. B, Type II. Microplankton, St. II, 21/5 1960. Black dorsal pigmentation. – C *Polydora ciliata* (Johnston). Microplankton, St. 2, 23/7 1956. Black dorsal pigmentation. – D–E *Prionospio malmgreni* Clap. Microplankton, D from St. 2, June 1956. Three first segments with dorsal appendages. Pygidium with 4 cirri. Brown pigmentation on prostomium, in oesophagus, and on pygidium. E from St. 2, 18/8 1955. Pygidium with 6 cirri. – A–C and E drawn from preserved specimens, D from live specimen.

brane, described by *i.a.* Thorson (1946) and Hannerz (1956), was observed in small numbers in microplankton samples from St. II (Apr. 1956 and 1957). – Add. so far not recorded from Greenland waters but may have been overlooked.

Capitella capitata (O. Fabr.), – Fig. 27, A). The larva,

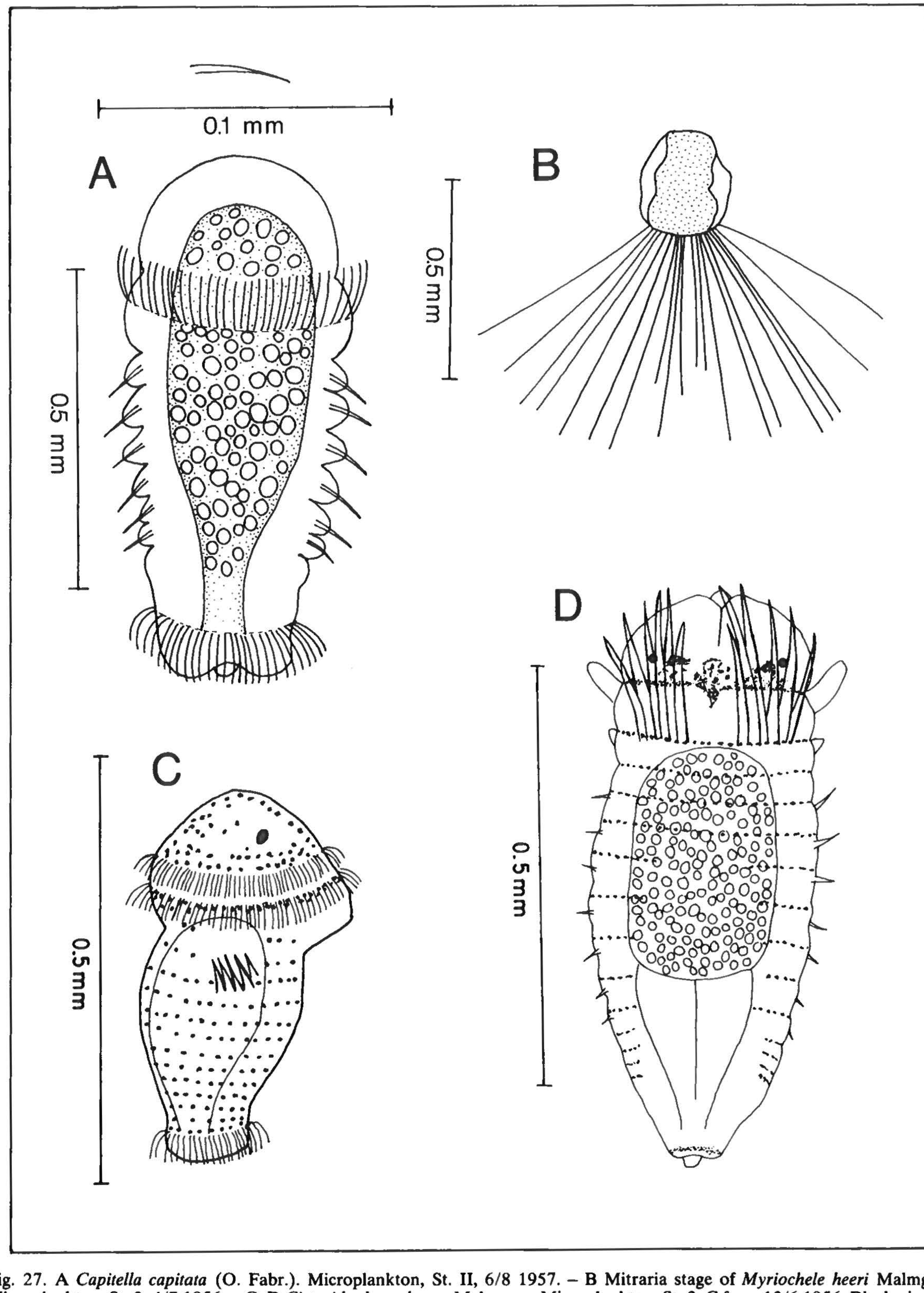


Fig. 27. A *Capitella capitata* (O. Fabr.). Microplankton, St. II, 6/8 1957. – B Mitraria stage of *Myriochele heeri* Malmgren. Microplankton, St. 2, 4/7 1956. – C–D *Cistenides hyperborea* Malmgren. Microplankton, St. 2. C from 13/6 1956. Black pigment spots in transverse rows. D from 2/7 1956. Black pigmentation on prostomium and segments. – A and B drawn from preserved specimens, C and D from live specimens.

Table 28. Monthly average numbers of *Polydora* larvae per microplankton haul at St. II and 2, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	0	r	0	5	45	26	100	180	56	7	r	0
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

described by *i.a.* Leschke (1903) and Thorson (1946), observed in small numbers in microplankton samples from St. II (May–Aug. 1957 and 1960). – Add. widely distributed at W Greenland (Wesenberg-Lund, 1950).

Myriochele heeri Malmgren, – (Fig. 27, B). A Mitraria larva, similar to the one described by Thorson (1946) observed in small numbers in microplankton samples from St. II and 2 (June–July and Nov., 1956–60). – Add. very common in W Greenland waters.

The Mitraria of *Owenia fusiformis* Delle Chiaje, described by Wilson (1932b), is quite different and has not been observed. However, add. of this species are also common at W Greenland.

Arenicola marina (L.). The larva, described by Blegvad (1923), Newell (1948), and Smidt (1951), was observed in small numbers in microplankton samples from St. II and 2, Oct.–Jan. 1955–59. – Add. very numerous in the tidal zone and in shallow water at W Greenland.

Cistenides hyperborea Malmgren, – (Fig., C–D). The larvae, not known from literature, are common in microplankton samples from all stations in June–Sep. Largest number in one sample was 235 (St. II, July 1958). – It was, further, observed in Nov. 1956 (St. II) in a Hensen net sample. Add. very common in the survey area and one of the most common polychaetes in W Greenland waters, hence there is good reason to refer the larvae to this species.

Crustacea

Larvae of benthic crustaceans play an important role in the plankton, with nauplii of *Balanus* dominating in microplankton (Fig. 28, Table 29) and Hensen net samples, and zoeans of crabs in stramin net samples.

Balanus larvae. – The nauplii of *Balanus* spp. are very numerous in the microplankton with a maximum in Apr., while Cypris stages occur in small numbers only (Table 29).

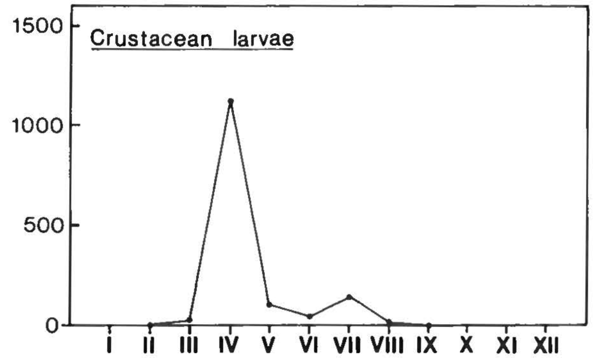


Fig. 28. Monthly numbers of benthic crustacean larvae in microplankton samples from St. II and 2. Average per haul, 30–0 m, in 1955–63.

Hensen net samples from outer stations (I and II) showed very large numbers of nauplii in Apr. and May (June), while they were relatively scarce at mid- and inner fjord stations (III and IV). The diagrams in Fig. 15 (sect. 5.) showed wide fluctuations in animal numbers, and at times nauplii of *Balanus* were quite dominating the plankton reaching a maximum number of 250 000 specimens in one haul (St. I, May 1955, 200–0 m). These fluctuations are probably caused by swarming larvae. As was the case in microplankton samples, Cypris stages were found in only small numbers also in the Hensen net samples. Data on *Balanus* larvae in Hensen net samples are given in Table 30. The larvae have not been identified but may belong to the following species which have been recorded as adults: *Balanus balanoides* (L.) is very numerous in the entire tidal zone, while *B.crenatus* Bruguière and *B.balanus* (L). are common at greater depths. According to Petersen (1966), the duration of the pelagic stages of *Balanus balanoides* is mainly from mid-Apr. to end of June at Godthåb, which agrees well with the data given here.

Table 29. Monthly average numbers of all bottom crustacean larvae and of *Balanus* larvae (Nauplii and Cypris) per microplankton haul at St. II and 2, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All larvae	r	2	16	1130	105	47	150	7	3	r	0	r
Nauplii of *Balanus*	0	2	15	1128	103	19	146	6	3	r	0	r
Cypris of *Balanus*	0	0	0	0	1	11	4	1	r	0	0	0
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

Table 30. Numbers of *Balanus* larvae in Hensen net samples. r = rare.

St. Haul depth, m	Stages	Year	Apr	May	Jun	Jul	Aug	Sep
I 200–0	Nauplius	1955		250000		15	0	2
		1956		7400			125	0
	Cypris	1955		325		2	2	0
		1956		260			5	0
II 300–0	Nauplius	1955	11200	12000		50	200	50
		1956	47000	4500	4800	240		0
		1958	74200	10080				
	Cypris	1955	0	r		1	20	0
		1956	2	10	300	2		0
		1958	0	0				
III 300–0	Nauplius						30	0
		1956	800	10			0	
		1957			0			
		1958	60	1040				
	Cypris	1955					20	
		1956	0	0			r	
		1957			900			
		1958	0	0				
IV 200–0	Nauplius	1955		0		0	0	0
		1956	0	40		r		
	Cypris	1955		0		r	r	r
		1956		0		r		

Decapod larvae. – A survey on crustacean decapod larvae in W Greenland waters was given by Stephensen (1935).

The larvae were caught in all nets, the largest numbers in stramin net samples taken in different W Greenland waters from Umanak to Julianehåb. It appears that while crab zoeans were usually most frequent in the surface hauls, zoeans of other species such as ***Pandalus borealis*, were generally most frequent** in mid-water samples (Horsted and Smidt, 1956, p. 42).

Brachyura. – Zoea stages occurred frequently in the macroplankton samples (Hensen and stramin net samples, Table 31); however, because of swarming they occurred very irregularly. The highest number in a Hensen net sample was 670 (St. I, Aug. 1955, 200–0 m), while it was 4000 in a stramin net sample (St. IV, July 1961, surface haul). The Megalops stage occurred in Hensen net samples in July–Oct., generally only few in number (maximum 160 at St. I., Aug. 1955).

In the microplankton samples few zoeans were present in Apr.–May, 70 being the highest number (St. 2, June 1956). The Megalops stage was not observed.

Species identification of the larvae has not been made. A major part probably belongs to *Hyas coarctatus* Leach, which is very common in all shallow

Table 31. Numbers of crab larvae in Hensen net samples from St. I and II.

St. Haul depth, m	Stage	Year	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
I 200–0	Zoea	1955				450		18	670	0	0
		1956	0			30			12	0	
	Megalops	1955				0		0	160	9	1
		1956	0			0			0	4	
II 300–0	Zoea	1955	1		200	180		0	0	1	0
		1956				100	110	1			
		1958	0		10	16					
	Megalops	1955	0		0	0	0	0	r	6	0
		1956				0		0			
		1958	0		0	0					

Table 32. Larval stages of *Pandalus borealis* at W Greenland.

	May	Jun	Jul	Aug	Sep
Stages	1	1–2–3	1–2–3–4	4–5–6	4–5–6

waters while *Hyas araneus* (L.) is very rare. *Chionoecetes opilio* (O. Fabr.) may also be represented, adults being common at 200–400 m depth.

Eupagurus pubescens Krøyer. The Zoea stage in small numbers in Hensen net samples (max. 25) from all stations in Apr.–Sep. Frequent everywhere in stramin net samples (Horsted and Smidt, *l.c.*).

Pandalus spp. The Zoea stage, mainly of *P. borealis* Krøyer, occurred in small numbers in Hensen net samples in Apr.–Sep. (highest number 180; St. I, May 1955, 200–0 m). In stramin net samples Apr.–Sep., the largest numbers observed over the shrimp grounds (max. 280, St. IV, July 1961). Occurrence in stramin net samples from different districts demonstrates abundance over the rich shrimp grounds off Godhavn, Jakobshavn, and Christianshåb in Disko Bugt (Fig. 1), (Horsted and Smidt, *l.c.*).

Berkeley (1930) described 6 larval stages at British Columbia, and similar stages were observed in Davis Strait and SW Greenland Fjords (Stephensen, 1935; Klimenkov, Berenboim, and Lysy, 1978; the present author). A summary of occurrence (Table 32) indicates a larval development of 4–5 months.

Spirontocaris spp. Few zoeans of different species observed May–Dec. in Hensen and stramin net samples from Umanak to Julianehåb (Horsted and Smidt, *l.c.*).

Sabinea septemcarinata (Sabine) and *Pontophilus norvegicus* (M. Sars). Few zoeans in stramin net samples from SW Greenland fjords (Horsted and Smidt, *l.c.*).

Gastropoda

The larvae are only few in numbers in the plankton occurring in the microplankton from Apr. to Dec. with maximum in July (Table 33).

Lacuna vincta (Montagu) = *L.divaricata* (O. Fabr.), – (Fig. 29, A). The Veliger stages were described by *i.a.* Thorson (1946). It is the only regularly occurring prosobranch larva in the microplankton, where it occurs in small numbers in Apr.–Oct. (Dec.), and most frequently in July, when the highest number in one haul was 32 (St. II, July 1963). – Add. very common in the *Laminaria* and *Fucus* zones with eggmasses found on seaweeds.

Velutina velutina (O. F. Müll.), – (Fig. 29, B). An Echinospira larva, much like that described by *i.a.* Thorson (1946) and referred to *V.velutina,* occurred regularly in Hensen and stramin net samples from all stations in Apr.–Oct., but only once in a microplankton sample. The largest number in a Hensen net sample was 42 (St. III, May 1956, 300–0 m), and 35 specimens in a stramin net haul (St. IV, July 1961, 400 m wire).

Add. of *V.velutina* and *V.undata* Brown occur in the area, and they are widely distributed in W Greenland waters (Thorson, 1951), but *V.velutina* seems to be the most abundant. – The development of *V.undata* is unknown. Egg capsules and embryos described by Thorson (1935) and referred to this species proved later on to belong to *Admete viridula* (O. Fabr.) (Thorson, 1944). However, *V.velutina* being arctic-boreal and *V.undata* arctic in their distribution it is probable that the latter has a non-pelagic development, typical of arctic animals. Consequently it is reasonable to refer the pelagic larva to *V.velutina.*

Unidentified prosobranch larva (Fig. 29, C). A prosobranch larva with much black pigmentation was observed in small numbers in microplankton samples (July 1956, St. II and III).

Opistobranch larvae (excl. *Pteropoda*). Some small larvae with egg-shaped shells (Fig. 29, D) typical of many nudibranchs were observed in small numbers in the microplankton (Apr.–Oct., St. II, 2, and IV).

Larvae with sinistral, helicoid shells, typical of several tectibranchs, were observed in the microplankton in very small numbers in May–Dec. at all fjord stations.

Lamellibranchia

Lamellibranch larvae constitute by far the most numerous meroplankton group in the microplankton at all fjord stations. Fig. 30 shows the average total numbers of larvae by month, and Table 34 the numbers of the different size groups.

It is seen that there are two peaks in the numbers of larvae, a smaller in May dominated by small unidentifiable (shell diameter about 200 μ or less) and a large in July with bigger larvae dominating. The largest numbers per haul were 5000 small unidentifiable in May 1960 (St. II) and 45 850 big larvae (not identified) in July 1963 (St. II). In the inner fjord the maximum number was 3300 larvae (St. IV, Aug. 1959).

The curve in Fig. 30 resembles a curve for lamellibranch larvae at Ella Ø, NE Greenland, published by Thorson (1936, p. 47). Here lamellibranch larvae also

Table 33. Monthly average numbers of gastropod larvae (excl. Pteropoda) per microplankton haul, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	0	0	0	r	r	2	9	2	1	2	0	r
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

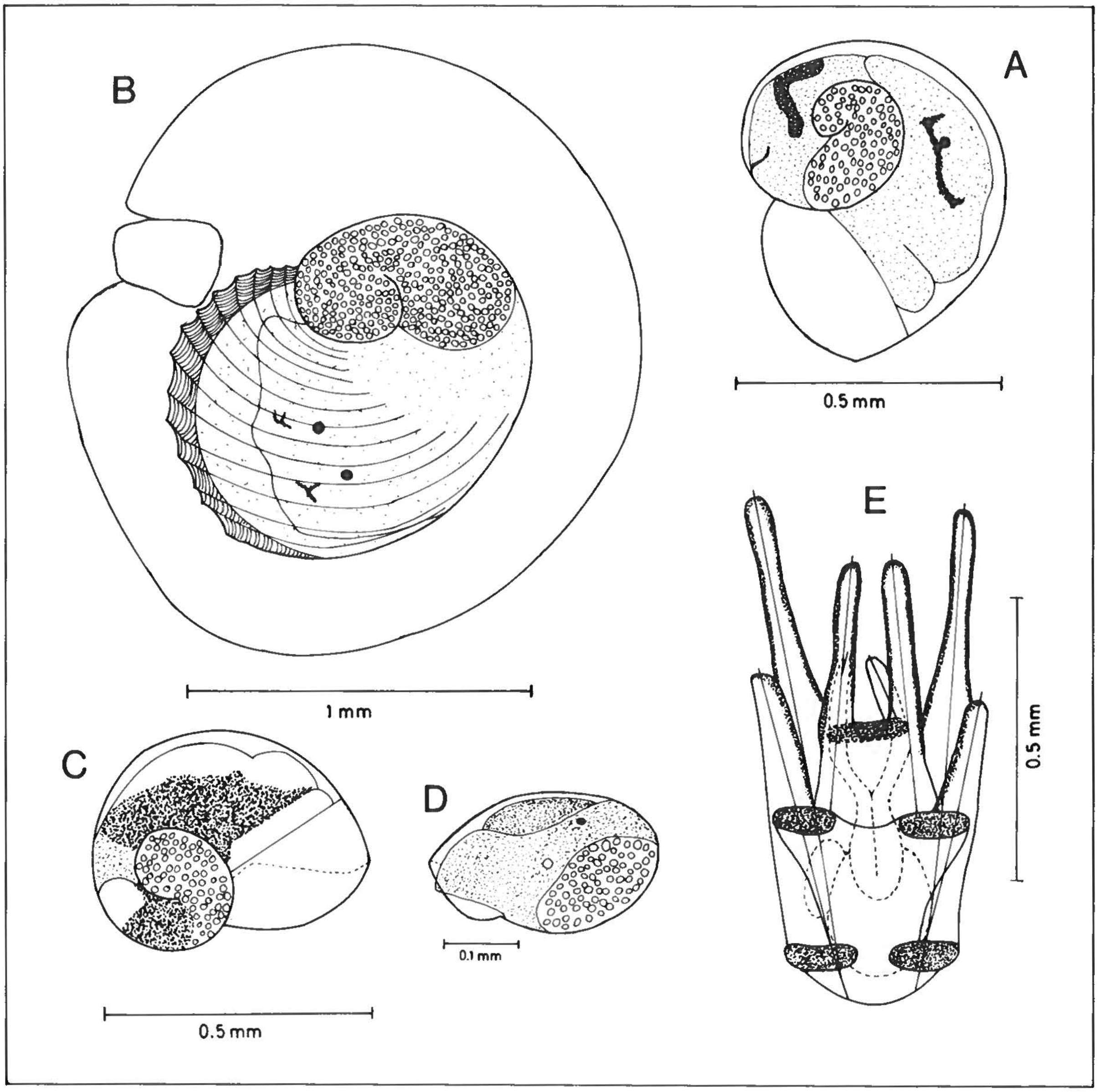


Fig. 29. A *Lacuna vincta* (Montagu) = *L.divaricata* (O. Fabr.). Microplankton, St. IV, 18/8 1959. Black pigmentation on velum and in testine. – B *Velutina velutina* (O. F. Müller). Echinospira larva from microplankton, St. 2, 18/6 1956. Liver faintly yllow. – C unknown prosobranch larva with black pigmentation. Microplankton, St. 3, 11/7 1956. – D opistobranch larva. Microplankton, St. 2, 4/7 1956. – E *Strongylocentrotus.* Microplankton, St. II, 18/7 1957. Dark-violet pigmentation. – A and C-E drawn from preserved specimens, B from live specimen.

Table 34. Monthly average numbers of lamellibrach larvae per microplankton haul, separated into small unidentifiable and big larvae. St. II and 2, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small larvae	0	0	0	20	790	360	500	100	25	0	3	r
Big larvae	0	0	0	0	10	10	6500	210	265	40	4	r
Total	0	0	0	20	800	370	7000	310	290	40	7	1
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

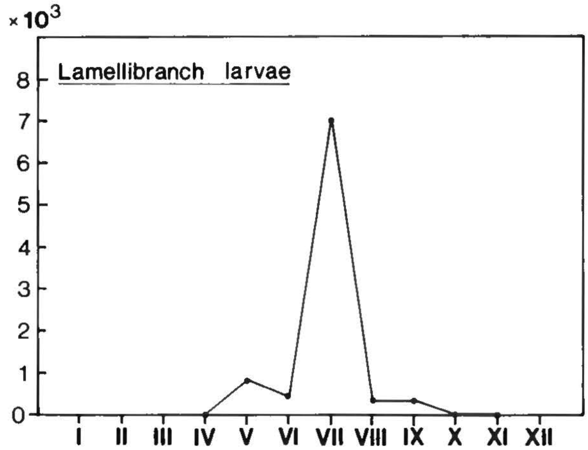


Fig. 30. Monthly numbers of lamellibranch larvae in microplankton samples from St. II and 2. Average per haul, 30–0 m, in 1955–63.

occurred in considerable numbers during a fairly long period (May–Aug.).

In Hensen net samples from different fjord stations (II, III, IV) some bigger lamellibranch larvae were observed in June–Sept.

According to Ockelmann (1958) the following E Greenland species, which are also common at W Greenland, have planktotrophic, pelagic larvae: *Mytilus edulis* L., *Chlamys islandicus* (O. F. Müll.), *Serripes groenlandicus* (Bruguiere), *Cardium ciliatum* Fabr., *Macoma calcaria* (Chemnitz), *Hiatella bysifer* (Fabr.) by Ockelmann *l.c.* named *H.arctica* (L.)), and *Mya truncata* L.

Some microplankton samples from St. II were later analysed by Ockelmann, who found the most numerous larvae to be *Mytilus edulis, Mya truncata, Hiatella bysifer*, and *Macoma calcaria*, followed by *Chlamys islandicus, Serripes groenlandicus*, and *Cardium ciliatum (pers. comm.)*. – *Macoma baltica* (L.) larvae were not observed, add. are, however, known from the survey area.

The present author has identified the larvae of *Mytilus edulis* (max. number in a haul 50 specimens, Sept. 1957, St. II) and of *Mya truncata* (max. number in a haul 1600 specimens, July 1959, St. II).

Echinoderma

Echinoderm larvae occurred at all stations in the period Mar.–Jan. (mainly in May–Sept.) in microplankton and Hensen net samples, and a few times in stramin net samples.

Asteroidea. – Most Greenland species are known to have non-pelagic development (Mortensen, 1927; Thorson, 1936). – A Bipinnaria stage occurred in small numbers in microplankton in May–Aug. at all fjord stations. Largest number in one haul 73 postlarvae (St. IV, Aug. 1959). – The larvae probably belong to *Asterias rubens* L., the add. of which are common in the area.

Ophiuroidea. – The dominant type of echinoderm larvae in the samples is the Ophiopluteus commonly observed in microplankton and Hensen net samples throughout the year, except in Feb., maximum being in July. The annual occurrence in microplankton is shown in Table 35. The largest numbers in one haul were 250 (St. II, July 1958) and 710 (St. IV, July 1959).

Identification as to species was often difficult or impossible due to bad preservation. By far the most common larva was *Ophiopholis aculeata* (O. F. Müll.), the add. of which are abundant in the area. Further, a larva referred to *Ophiocten sericeum* (Forbes) was observed a few times (St. 2, Oct. 1955, Apr. 1956). Also larvae of *Ophiura sarsi* Lütken and *O.robusta* (Ayres) may possibly occur, add. being common in W Greenland waters.

Descriptions and illustrations of these larvae are published by *i.a.* Mortensen (1897, 1898, 1931), Olsen (1942), and Thorson (1934, 1946).

Echinoidea. – *Strongylocentrotus droebachiensis* (O. F. Müll.) and *S.pallidus* (Sars), – (Fig. 29, E). The Echinopluteus was regularly observed in few numbers in Apr.–Aug. at all fjord stations in microplankton and

Table 35. Monthly average numbers of Ophiopluteus stages per microplankton haul at St. II and 2, 1955–63.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	0	0	0	3	16	15	41	19	7	2	0	0
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

Table 36. Monthly average numbers of *Strongylocentrotus* larvae per vertical microplankton haul (30–0 m) at St. II and 2, 1955–63. r = less than one.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Specimens	0	0	0	1	7	3	3	r	0	0	0	0
No. of hauls	(5)	(5)	(6)	(8)	(7)	(5)	(8)	(6)	(7)	(5)	(3)	(7)

Hensen net samples. In Apr. and May mainly younger stages occurred. Specimen numbers per month in microplankton samples are shown in Table 36. The largest number in one haul was 40 young larvae (St. II, May 1960).

Mortensen (1897, 1898) described a late Pluteus stage from Danish waters as "Echinopluteus coronatus", which he in 1924 and 1927, however, referred to *S.droebachiensis*. Thorson (1936, pp. 18–20) found the same larva in E Greenland fjords, where *Strongylocentrotus* is the only "regular" echinid, but he gives no illustration. Also in W Greenland waters *Strongylocentrotus* is the only "regular" echinid, *S.droebachiensis* being very common in shallow water. According to Jensen (1974) *S.pallidus* is a distinct species, common at Greenland, mainly in deeper water than *S.droebachiensis*. The larvae may partly be *S.pallidus*.

Holothurioidea. – Numerous, lecithotrophic, red, slipper-shaped larvae about 1 mm long are often visible in the in- and offshore surface waters in summer, and occur in microplankton and Hensen net samples from Apr. to Oct. According to Runnström and Runnström (1919, pp. 8–9) and Mortensen (1927, pp. 398 and 417) they are the larvae of either *Cucumaria frondosa* (Gunnerus) or *Psolus phantapus* (Strussenfelt). The larva of the latter species is described by Thorson (1946).

6.2.4. Pelagic fish eggs and larvae

From 1946 to 1964 fish eggs and larvae were identified and counted in stramin net samples from Godthåbsfjord, Ameralik fjord, and the coastal area. The main purpose was to follow the spawning of the cod, especially in Godthåbsfjord where the greatest local, inshore W Greenland cod stock is living.

Literature on fish eggs and larval stages is referred to below, among which two handbooks (Ehrenbaum, 1905–09; Russell, 1976).

Fish eggs

Cod, *Gadus morhua* L. Literature: Ehrenbaum (1905–09), Russell (1976). – Earlier investigations on cod eggs and larvae at W Greenland are summarized by Hansen (1946, 1968). It was shown that fjord stocks have their main spawning places in the inner fjord branches and creeks, while offshore cod spawn mainly in deep waters on the western slopes of the fishing banks in Davis Strait.

The Godthåbsfjord cod stock has its most important spawning place in the fjord branch of Kapisigdlit (St. IV) and especially in the inner creek (St. 5, 6, 7), where the largest numbers of eggs were found. In Ameralik, a threshold fjord S of Godthåbsfjord, there is only a small local cod stock, and eggs are only found numerously in the fjord branch Itivdleq (St. 1). In the coastal area (St. I) and at the entrance to Godthåbsfjord (St. II) only small numbers of eggs were found. – Tables 37 and 38 show the distribution of eggs in the survey area.

As is seen from the tables egg numbers increase from the coastal (St. I) to the inner fjord area (St. IV). Normally the main spawning seems to take place in Apr., and when the highest egg numbers were found in early June 1949 this was due to late and very intensive

Table 38. Maximum numbers of cod eggs per 30 min. stramin net haul (100–50 m wire) at various stations.

St.	Eggs	Year	Month	Date
I	140	1960	May	4
II	180	1949	June	1
III	31000	1949	June	1
IV	270000	1949	June	1

Table 37. Monthly average numbers of cod eggs per 30 min. stramin net haul (100–50 m wire) at various stations. r = less than one.

St.	No. of eggs and hauls	Feb	Mar	Apr	May	Jun	Jul	Years
I	eggs	0	0	3	28	r	0	1954–64
	hauls	(3)	(5)	(8)	(8)	(7)	(6)	
II	eggs	0	2	14	30	30	r	1947–64
	hauls	(9)	(10)	(11)	(13)	(9)	(9)	
III	eggs	0	28	91	51	5175	0	1947–62
	hauls	(5)	(4)	(7)	(7)	(6)	(4)	
IV	eggs	8	1996	21071	7512	24598	r	1947–64
	hauls	(8)	(9)	(12)	(10)	(11)	(6)	
II	eggs	0	2	14	30	11	r	all years
III	eggs	0	28	91	51	10	0	excl. 1949
IV	eggs	8	1996	21071	7512	58	r	

spawning in that year. The explanation is probably very low water temperatures due to an exceptionally cold winter and a long-lasting ice cover which delayed spawning and which subsequently resulted in the explosive character of the spawning in the fjord. At the bottom of Table 37, egg numbers from 1949 have been excluded in order to give a more normal picture of the spawning.

The most concentrated spawning seems to take place in small, shallow-watered fjord branches, such as Itivdleq in Ameralik (St. 1), the inner Qôrqut basin (St. 3), and Kapisigdlit creek (St. 5, 6, 7). Table 39 shows egg numbers from some stramin net samples taken in Godthåbsfjord in the branch of Kapisigdlit (St. IV) and at St. 5, 6, and 7 near the settlement of Kapisigdlit. There is a pronounced increase in egg numbers towards the innermost station. However, dispersal may have taken place between the first and last hauls.

Net hauls for cod eggs from various depths show that the eggs are practically limited to depths mainly less than 50 m, at least during the greatest part of the period in question. Stramin net hauls with 100–50 m wire and with 400, 500 or 600 m wire made simultaneously at the same positions showed that the average egg numbers in deep hauls were only about 10% of those from upper water layers. These hauls were made in various years at different stations, and the results are summarised in Table 40. Furthermore, a series of vertical stramin net hauls from different depths were made near Kipisigdlit (St. 5) in the spawning season. The results given in Table 41, show that egg numbers per haul did not increase when hauls were made from depths more than 30 m.

In two cases, on 10 June 1959 and 10 June 1963, the egg numbers were greater in the deep than in the upper hauls at St. IV. This may be due to lower salinity in the surface layer since, at that time, much fresh water from melted snow and from the river Kapisigdlit enters the fjord. Experimental research by Sundnes *et al.* (1965) showed that low salinities at the surface will keep the cod eggs below this layer, while the buoyancy of the eggs was found to be independent of pressure and temperature.

American plaice, *Hippoglossoides platessoides* (O. Fabr.). Literature: Petersen (1904), Ehrenbaum (1905–09), Russell (1976).

Unlike cod eggs, the eggs of the American plaice are more evenly distributed at the standard stations with a slight tendency towards denser concentrations in the coastal zone (St. I) as seen in Tables 42 and 43. However, the highest egg numbers were found in the fjord branch Itivdleq in Ameralik, where the average number per 30 min. stramin net haul in May was c. 1000 (7 hauls in 1950–63, maximum egg number 3500), while the average egg number in the fjord outside Itivdleq only amounted to 260 (7 hauls in 1952–58).

Stramin net hauls at various depths showed that eggs of American plaice are distributed much deeper than cod eggs. Table 44 shows that the average egg numbers in hauls from about 10–25 m depth and from about 90–130 m depth were nearly the same, and possibly eggs occur in considerable numbers at even greater depths.

Greenland halibut, *Reinhardtius hippoglossoides* (Walbum). – Literature: Smidt (1969). – In March–May few eggs were taken by the stramin net (wire lengths 100–50 and 500 m) at outer stations (I and II), while none were taken at mid- and inner fjord stations. Apart from 11 eggs taken in one haul at St. II (March 1964), only single eggs were taken in 8 hauls in the years 1954–63.

Several investigations have shown that the W Greenland stock of Greenland halibut spawns in deep warm water in the southern part of Davis Strait, from where the larvae later ascend and drift northwards along W Greenland (Jensen, 1935; Smidt, 1968, 1969). The eggs taken at St. I and II are assumed to originate from the spawning area in Davis Strait. No other eggs nor any larvae have been observed in the W Greenland fjords.

Table 39. Numbers of cod eggs per 30 min. stramin net haul at stations near Kapisigdlit, Apr. 1958. Because of the depth the wire length was only 50 m at the inner stations.

Locality	No. of eggs Apr. 9	No. of eggs Apr. 23–24	Wire m
St. IV	3500	120000	100–50
St. 5 outside Kapisigdlit	235200	444000	50
St. 6 off Kapisigdlit		315000	50
St. 7 inside Kapisigdlit	1050000		50

Table 40. Numbers of cod eggs in stramin net hauls with 100–50 m wire and 400, 500 or 600 m wire at standard stations, 1955–63. It should be noted that eggs in deep hauls may have been caught while the net passed the upper water layer.

Wire m	Haul depth m	No. of hauls	Total egg no.	% egg no.
100–50	c. 10–25	48	312559	100
400/500/600	c. 90–130	48	30428	10

Table 41. Numbers of cod eggs per vertical stramin net haul from different depths at Kapisigdlit (St. 5), 24 Apr., 1958.

Haul depth m	Eggs per haul
10	779
20	1502
30	1844
50	1864
75	1788
100	1865
150	1431

Table 42. Monthly average numbers of American plaice eggs per 30 min. stramin net haul at standard stations. r = less than one.

St.	No. of eggs and hauls	Mar	Apr	May	Jun	Jul	Years
I	eggs hauls	r (6)	160 (13)	360 (13)	130 (10)	r (12)	1954–64
II	eggs hauls	20 (12)	60 (18)	160 (16)	70 (12)	r (14)	1947–64
III	eggs hauls	0 (5)	60 (8)	160 (9)	140 (6)	r (6)	1947–62
IV	eggs hauls	r (12)	20 (21)	120 (13)	100 (11)	r (11)	1947–64

Table 43. Maximum numbers of American plaice eggs in 30 min. net hauls at standard stations.

St.	No. of eggs	Month	Year	Wire, m
I	1300	May	1962	400
II	350	June	1956	100–50
III	770	May	1950	100–50
IV	870	May	1950	100–50

Table 44. Numbers of American plaice eggs in stramin net hauls at various depths at standard stations and in Ameralik, 1955–64.

Wire m	Haul depth m	No. of hauls	Total egg no.	% egg no.
100–50	c. 10–25	47	5020	100
400/500/600	c. 90–130	47	5236	104

Fish larvae

Several fish larvae have been identified to species or systematic groups. Several biologists and technicians have made the identifications, and as not all of them had the same experience unreliable data have been excluded.

Capelin, *Mallotus villosus* (O. F. Müll.). – Literature: Schmidt (1906), Templeman (1948). – Larvae were taken by stramin net at all standard stations and at some other stations from Apr. to Nov. (Dec.), most frequently in June–July. The larvae seem to be more frequent at fjord than at coastal stations (Table 45), and generally more numerous in hauls from about 10–25 m depth than from greater depths.

Bathylagus benedicti Good and Bean. – The stalk-eyed larva was discribed by Tåning (1931). – Single specimens taken in deep stramin net hauls at the Godthåbsfjord entrance (St. II, Apr. 1960, May 1963).

Cod, *Gadus morhua* L. and Greenland cod, *Gadus ogac* Richardson. – Literature on cod larvae: Schmidt (1905, 1906), Ehrenbaum (1905–09), Russell (1976).

Table 45. Maximum numbers of capelin larvae at different stations by 30 min. stramin net hauls during all years.

St.	Larvae	Month	Year
I	88	July	1962
II	108	July	1963
III	51	July	1962
IV	380	July	1958
1	535	July	1962

The larvae of *Gadus ogac* were hatched in an aquarium at the laboratory in Godthåb by Jens Kreutzmann, and the youngest stage was drawn (not publ.). However, distinction of later stages from cod larvae is difficult and perhaps even impossible.

Tables 46 and 47 show average and maximum numbers of larvae per 30 min. stramin net hauls. They are remarkably few in relation to the egg numbers, especially in the fjord branch of Kapisigdlit (St. IV) where the main spawning takes place, and from where eggs and larvae are rapidly dispersed by current to other parts of the fjord.

It is noticeable, that the maximum numbers of larvae in the coastal area (St. I) and at the fjord entrance (St. II) were found in 1957 when surface temperatures were very high and cod larvae unusually numerous in Davis Strait. The 1957 year-class became one of the richest in the W Greenland cod fishery. It should further be noted that maximum numbers of larvae in the mid-fjord (St. III) occurred in 1949, in which year also the maximum egg numbers were found in the inner fjord areas (Table 38), from where the larvae had possibly drifted.

Similar to cod eggs also the larvae seem to form denser concentrations in the uppermost water layer, but as shown in Table 48 the data are only few. In Icelandic waters Magnusson *et al.* (1965) found maximum abundance of cod larvae in 15–18 m depth.

Arctic cod, *Boreogadus saida* (Lepechin). – Literature: Schmidt (1905), Ehrenbaum (1905–09), Russell (1976). – One larva taken with stramin net (St. I, May 1960).

Table 46. Monthly average numbers of cod larvae per 30 min. stramin net hauls (100–50 m wire) at standard stations. x indicates partly *Gadus ogac*?, r = less than one.

St.	No. of larvae No. of hauls	Apr	May	Jun	Jul	Aug	Sep	Years
I	larvae hauls	0 (9)	5x (7)	3x (7)	6 (8)	1 (4)	0 (3)	1954–64
II	larvae Hauls	rx (10)	1 (13)	14x (10)	13 (11)	0 (6)	r (7)	1946–65
III	larvae hauls	rx (7)	r (7)	36 (6)	2 (5)	r (6)	0 (2)	1946–62
IV	larvae hauls	0 (13)	4 (12)	4 (11)	2 (7)	0 (7)	0 (4)	1946–65

Table 47. Maximum numbers of cod larvae in 30 min. stramin net hauls (100–50 m wire) at standard stations.

St.	Max. no. of larvae	Month	Year
I	38	July	1957
II	134	July	1957
III	210	June	1949
IV	42	May	1950

Table 48. Numbers of cod larvae in stramin net hauls with 100–50 m and with 400, 500 or 600 m wire at standard stations, 1955–63.

Wire, m	Haul depth, m	No. of hauls	Total no. of larvae	% no. of larvae
100–50	c. 10–25	21	57	100
400/500/600	c. 90–130	21	13	23

Table 49. Maximum numbers of sand eel larvae in 30 min. stramin net hauls at standard stations. ? = identification questionable.

St.	Max. no. of larvae	Month	Year	Wire, m
I	53	May	1960	100–50
II	93	Mar.	1961	500
III	?2	June	1957	100–50
IV	?2	Aug.	1958	100–50

Table 50. Numbers of American plaice larvae in stramin net hauls with 100–50 m and 400 or 500 m wire at St. I–IV, 1960–64.

Wire, m	Haul depth, m	No. of hauls	Total no. of larvae	% no. of larvae
100–50	c. 10–25	18	50	100
400/500	c. 90–110	18	33	66

Macruridae. – Literature: Ehrenbaum (1905–09). – One specimen, possibly belonging to *Coryphaenoides rupestris* Gunnerus, was taken (St. II, July 1955).

Sand eel, *Ammodytes lancea dubius* Reinhardt and/or *A. lancea marinus* Raitt. – Literature: Ehrenbaum (1905–09), Einarsson (1951, 1955), Kändler (1941), Macer (1967), Russell (1976). – The larvae are common in stramin net hauls from coastal and outer fjord areas (St. I and II), where they have been observed from Dec. to Aug. but only numerously in Jan.–May. They seem to be more frequent in hauls from about 90–130 m depth than from about 10–25 m depth. A few specimens recorded from the mid- and inner fjord stations (St. III and IV) may not have been correctly identified. Add. very common on the offshore fishing banks in Davis Strait but only scarce in the fjords. The maximum numbers of larvae are shown in Table 49.

Wolffish, *Anarhichas* spp. – Literature: The larval stage of *A.lupus* was described by Ehrenbaum (1905–09). – A few larvae taken by stramin net at all standard stations and at some other stations from Jan. to July. Identification as to species has not been made; they may, however, belong to *Anarhichas lupus* L. *A.minor* Olafsen, and *A.latifrons* Steenstrup, which are all common in W Greenland waters.

Pholis spp. – Literature: The larva of *Pholis gunellus* was described by Ehrenbaum (1905–09), and Russell (1976). – Single *Pholis* larvae taken by stramin net at St. II (Apr. 1962, June 1957) and in a creek in the inner Godthåbsfjord (May 1952). Possibly they are either *P.gunellus* (L.) or *P.fasciatus* (Bloch), both species being common in W Greenland waters.

Stichaeus punctatus (O. Fabr.)? – Literature: A larva described by Dunbar (1947) is questionably referred to *S.punctatus*. – Several larvae possibly belonging to this species taken by stramin net at all stations in Apr.–July, most frequently in May, during 1947–65. Since many identifications are questionable, no specimen numbers could be given.

Lumpenus spp. – Literature on *L.lampretaeformis:* Ehrenbaum (1905–09), Dunbar (1947), Russell

(1976). – Some larvae, referred to the genus *Lumpenus*, taken in small numbers by stramin net at nearly all stations in Mar.–July during 1947–62. They may be referred to *L.maculatus* (Fries), *L.lampretaeformis* (Walbum), *L.fabricii* Reinhardt, or – less probable – to the more northern *L.medius* Reinhardt.

Redfish, *Sebastes marinus* (L.). – Literature: Jensen (1922), Tåning (1961), Russell (1976). – Few larvae taken by stramin net at all standard stations and in the Qôrqut basin (St. 3), where many redfish congregate in spring (May) and are taken in pound nets. Redfish larvae are scarce in W Greenland waters, and the rich stocks of young and adults must, therefore, be recruited mainly from the rich larval concentrations off the southernmost part of W and E Greenland (Tåning, 1949; Magnusson, 1968).

Cottidae. – Cottid larvae often taken by stramin net at nearly all stations during 1946–64 but only in small numbers. They occur from Jan. to July, but mainly in Apr.–July. – *Acanthocottus scorpius* (L.), description by Ehrenbaum (1905–09), Russell (1976), was dominant, and the maximum number in one stramin net haul was 56 larvae (St. II, May 1956). Add. are very common in coastal waters.

Leptagonus decagonus (Bloch). – Literature: Schmidt (1908). Larvae often taken in small numbers by stramin net at nearly all stations in Apr.–Aug. during 1952–63.

Aspidophoroides spp. – The larval stage of *A.olrikii* Lütken was described by Dunbar (1947). Larvae, most likely of *A.monopterygius* (Bloch), frequently taken by stramin net at nearly all stations in Aprl.–Aug. Add. *A.monopterygius* are most common in the area, however, some larvae may be of the less frequent *A.olrikii*. Highest larval number in a 30 min. haul was 35 (St. I, June 1964).

Lumpsucker, *Cyclopterus lumpus* L. – Literature: Ehrenbaum (1905–09), Russell (1976). Juvv. taken in small numbers at all stations in all months during 1955–65. They may have been transported by drifting seaweed.

Liparidae. – Literature on *Liparis liparis:* Ehrenbaum (1905–09), Russell (1976). – Few larvae taken by stramin net at St. I and II and once in a creek in the inner Godthåbsfjord (Apr.–Sept., 1954–65). They may be referred to *Liparis liparis* (L.) and *Careproctus reinhardti* Krøyer, add. of which are common at W Greenland in relatively deep water.

American plaice, *Hippoglossoides platessoides* (O. Fabr.). – Literature: Petersen (1904), Ehrenbaum (1905–09), Nichols (1971), Russell (1976). – In spite of the large number of eggs only small numbers of larvae were caught by stramin net. They were taken at nearly all stations from Mar. to Nov., the highest number in one haul being 13 (St. II, Apr. 1960).

It has been mentioned that American plaice eggs occur in deeper layers than cod eggs. The same is the case for the larvae of the two species, although the tendency is not so pronounced for larvae as for eggs. However, data on larvae are only few (Table 50).

General remarks on fish eggs and larvae

The occurrence of pelagic eggs of cod and American plaice indicate their spawning areas and periods. The local cod stock in the Godthåbsfjord spawns mainly in the inner fjord branches, especially the Kapisigdlit branch (St. IV and 5–6), from where they drift by current to other parts of the fjord. Usually, the main spawning takes place in Apr. – Eggs of the American plaice are more uniformly distributed in the area investigated, but with a tendency to denser concentrations in coastal waters. The maximum egg numbers are generally found in May.

The concentrations of cod eggs are usually found in the surface water down to 30–50 m depth, while eggs of the American plaice are evenly distributed from the surface down to more than 100 m depth. As the greatest temperature variations take place in the upper water layers (from surface to less than 100 m depth) the cod eggs are more exposed to low temperatures in the cold years. This may be part of the explanation why the cod stock is more dependent on temperature variations (cold and warm years) than is the American plaice. The same tendency, but not so pronounced, seems to hold for the larvae since the American plaice larvae have a deeper vertical distribution than the cod larvae. The vertical distribution of eggs and larvae may thus partly explain the great fluctuations in the year class strengths of the W Greenland cod stock in relation to surface-water temperatures, while the eggs and larvae of the American plaice are better protected against temperature variations.

The Greenland halibut eggs, rich in yolk and spawned in the deep warm water in the southern Davis Strait, are even better protected, and the few eggs taken in coastal waters and at the fjord entrance are supposed to originate from Davis Strait.

The cod and American plaice larvae are very few in relation to egg numbers. Especially the cod larvae in the Kapisigdlit spawning area (St. IV) are few, and the explanation is probably that eggs and larvae are rapidly transported by surface current to other parts of the Godthåbsfjord system.

The larvae of the two important fish food species, the capelin and the sand eel, are quite differently distributed. The capelin spawns mainly in the tidal zone in the fjords, and the larvae are, therefore, most abundant in the upper water layer in the inner fjord regions. Otherwise, the sand eel occurs mainly on the offshore fishing banks and in the coastal zone, and the larvae are, therefore, almost exclusively found in offshore and coastal waters and at the fjord entrance.

Among the other fish larvae, the very few redfish larvae should be mentioned. There are very rich stocks of young and adult redfish in W Greenland waters, but in spite of this only few larvae were found in most parts of the area. The reason is, that the greater part of the W Greenland stocks are recruited from the rich larval populations off the southermost part of W and E Greenland (Tåning, 1949; Magnusson, 1968).

7. Discussion

Primary production

The high rate of primary production measured at the entrance to Godthåbsfjord agrees with the high production rates measured along the coast of southern W Greenland (Steemann Nielsen, 1958b, 1975; Steemann Nielsen and Hansen, 1961), where a gross production of more than 500 mg C m^{-2} day^{-1} was measured in July–Aug. between latitudes 62°N and 67°N. At the entrance to Godthåbsfjord the gross production was about 900 mg C m^{-2} day^{-1} in the same months (Table 2, sect. 4). Furthermore, high values of phytoplankton biomass in the coastal waters W of Greenland indicate a high production (Gillbricht, 1968). It is, therefore, justifiable to consider the annual production at the entrance to Godthåbsfjord, *i.e.*, about 160 g C m^{-2} $year^{-1}$, as representative of the production off SW Greenland.

Lower rates of production measured in the inner fjord regions (St. IV and V) agreed well with the production measured at Godhavn in Disko Bugt (Petersen, 1964; unpubl. data by Norden Andersen). A constantly high stability of the water layers, reducing the replenishment of nutrients in these inner regions, as well as a shorter period of productivity due to ice-cover, explain the lower annual gross production.

A considerable variation in production was found from year to year at the entrance to Godthåbsfjord with the highest production measured in 1957, also a year with high water temperatures. In the same year unusually abundant cod larvae were found in W Greenland waters, resulting in one of the richest cod year classes known in the Greenland fishery (sect. 6.2.4.).

The annual gross primary production measured in W Greenland waters is high in comparison with those found in temperate productive seas such as the Danish waters, about 100 g C m^{-2} $year^{-1}$ (Steemann Nielsen, 1975), and the northern North Sea, from 45 to 110 g C m^{-2} $year^{-1}$ (Steele, 1958) depending on localities.

In Jørgen Brønlund Fjord, NE Greenland, Andersen (1977) estimates only *c.* 10g C m^{-2} $year^{-1}$.

Zooplankton

The general seasonal sequence of the zooplankton biomass in the coastal regions shows, at all depths, a minimum in early spring and a prolonged maximum in summer and autumn. However, in the inner fjord (St. IV) the pattern is the reverse with an accumulation of macroplankton animals in the deep water layers during winter, due to the formation of a "hydrographic trap" (inflow of warm bottom water and stable water stratification with winter-cooled outflowing surface water, which forms a barrier to the ascent of the animals accumulated in the deeper water, Fig. 18, sect. 5.4.). This is assumed to be the norm to the open, non-threshold, W Greenland fjords such as Tunugdliarfik fjord, studied by Horsted (Horsted and Smidt, 1956, 1965). There are good indications of seasonal, vertical migration (Table 5, sect. 5.2.), but only when the upper water layers have been heated in late spring are the animals able to ascend to the outflowing surface water.

Diurnal migrations were not observed as all sampling was undertaken by day, but indications of such migrations are given in sect. 5.4. As the microplankton samples were taken only by day from 30 m depth, the animal numbers are believed to be relatively low.

Plankton animals of different geographic origins are present in the area investigated, and examples are given (sect. 5.4.) of species grouped as arctic, subarctic-boreal, cosmopolitan, oceanic, and neritic. Apart from some medusae all the species listed are holoplanktonic. Most of the bottom invertebrates with pelagic larvae (not listed in sect. 5.4.) have, furthermore, a wide geographic range within the boreal or Atlantic regions. Among polychaetes with planktonic larvae some even have a cosmopolitan distribution, *e.g. Nereis pelagica* and *Polydora ciliata.*

The terms arctic, subarctic, and boreal have been used without giving difinitions. Various viewpoints regarding definition have been presented in the literature, and some of these should be mentioned and discussed.

Lemche (1941) groups the various species in high-arctic, low-arctic, pan-arctic etc. from an ecological point of view according to their tolerance to temperature in the area in which they live and propagate, but the terms are not associated with more distinct geographic boundaries.

Ekman in his "Zoogeography of the Sea" (1953) operates with geographic regions from a faunistic point of view, and for a relatively large number of species and genera natural boundaries could be drawn in accordance with environmental factors.

Dunbar (1953, p. 75) delimits the arctic and subarctic zones from an environmental point of view on the basis of the different currents and water masses of polar and non-polar origin. – "The marine arctic [is] formed of those areas in which unmixed water of polar origin (from the upper layers of the Arctic Ocean) is found in the surface layers (200–300 metres at least)." – "The marine subarctic is defined as those marine areas where the upper water layers are of mixed polar and non-polar origin. By far the greater part of the marine subarctic lies on the Atlantic side, extending from the Scotian shelf and Hudson Strait to the Barents and Kara Seas, and including almost the whole coast of W Greenland, the waters around Newfoundland and Iceland, much of the Norwegian Sea, and the waters off the west coast of Spitsbergen." – "For the large and rather ill-defined region south of the subarctic, the term "boreal" is used here." – See also Dunbar (1951, 1968).

Some authors prefer to use certain isotherms as boundaries, *e.g.* Einarsson (1945) who used the mean annual isotherm for 0°, 5°, and 10° C at 100 m depth as boundaries for the arctic, subarctic, and boreal regions respectively.

The environmental and faunistic boundaries are, of course, only arbitrary and subject to periodic fluctuations. In practice, the environmental parameters seem to be most appropriate, but anyway, the epipelagic fauna of SW Greenland is in the subarctic zone whatever faunistic or environmental definitions are used. Regarding the bathypelagic fauna, other terms, as used by Ekman (1953), should be employed.

Seasonal plankton studies in other regions in the north Atlantic show a great similarity in seasonal cycles but with a slower population turnover in the arctic than in the boreal region as discussed by Grainger (1959). By way of comparison some examples of important holoplanktonic species are given below. Some species mature later in the arctic-subarctic than in the boreal regions.

In the arctic and subarctic regions *Calanus finmarchicus* normally has one generation per year, as found by Ussing (1938) and Digby (1954) in the arctic NE Greenland fjords, and by Maclellan (1967) and in the present survey in subarctic SW Greenland. In Canadian arctic waters Grainger (1959) found one and often less than one complete generation in a year. In the northern boreal region in the Norwegian Sea (66°N, 2°E) Østvedt (1955) found one major spawning in the spring and a second spawning of minor importance in late summer. Lie (1965) found one spawning per year at Spitsbergen, two in northern Norway, and three in southern Norway. In the southern boreal Clyde Sea area three distinct annual generations were found by Marshall and Orr (1955).

Among euphausiids, *Thysanoessa raschii* and *T.inermis* mature in the arctic and subarctic regions when two years old, while in the boreal region they are only one year old when maturing (Einarsson, 1945).

In the arctic and subarctic Canadian waters Dunbar (1962) demonstrated that *Sagitta elegans* has a two-year life cycle with two-phase (alternating) breeding cycles, while Clarke *et al.* (1943) found two broods per year on Georges Bank. According to Kramp (1939) and Ussing (1938) the W and E Greenland populations of this species seem to have one generation per year. However, Jakobsen (1971) indicates the possibility of two-year cycles as the research areas of Dunbar and Kramp partly overlap. A very detailed investigation made by Jakobsen (*l.c.*) in Oslo Fjord indicated one brood per year, as in the Irish Sea (Pierce, 1941). According to Russell (1932) the species has 4 or 5 generations annually in the English Channel, but Jakobsen (*l.c.*), having discussed the literature on *S.elegans* thoroughly, presumes a lower number.

Regarding the bottom invertebrates in the shelf area, a relatively small number of species with a pelagic, planktotrophic development seems to place the fauna of the survey area nearer to the arctic than to the boreal fauna. According to "Thorson's rule" (Fig. 19), few species have planktotrophic, pelagic larvae in arctic waters with a short period of productivity, while the percentage numbers of species with such larval stages increase with increasing temperatures southward. A relatively high number of polychaete species with pelagic larvae in the survey area may be explained by the ability, common for this group, to prolong the pelagic life which makes long distance transport from warmer regions possible. In the Norwegian and Barents Seas Mileikovsky (1968) found that "most larvae remain in the water masses above the zones inhabited by their parents". It is in accordance with high larval mortalities that only few larvae are transported far away. However, Mileikovsky (*l.c.*) found some larvae, especially of lamellibranchs and polychaetes, in the open sea far from the shelf area, and a pelagic dispersal is thus probable (discussion, sect. 5.4.).

The examples given above indicate that the epipelagic plankton fauna in the survey area is more similar to the arctic fauna in terms of growth rate and mode of development than to the boreal fauna and it could, therefore, be termed subarctic from a biological point of view. This phenomenon should be taken into consideration in the evaluation of the productivity of the W Greenland waters.

The present survey was made in a period with relatively high temperatures in the upper water layers, but since 1968 the temperatures have generally decreased in W Greenland waters resulting *i.a.* in failing recruitment of the cod stock. Rich cod year classes are correlated with high surface water temperatures during the early larval stages (Hermann *et al.*, 1965). In the present survey it is shown that cod eggs and larvae normally concentrate in the upper water layers where they are much exposed to temperature variations, while, by comparison, eggs and larvae of the American plaice are more deeply distributed and thus better protected against low temperatures. This is, presumably, partly the explanation why the cod stock is much more vulnerable to low temperatures than the American plaice stock in Greenland waters.

There seems to be a direct effect of changes in temperature on the survival of cod larvae (Hermann *et al.*, *l.c.*), and possibly this effect is primarily the duration of the development time of eggs and larvae. Furthermore, there seems to be also an indirect effect; Bainbridge and McKay (1968) suggest that the survival of the larvae may depend on the degree of synchronization of the commencement of active feeding with the timing of the spring spawning and overall abundance of the early stages of *Calanus*. They found that cod larvae off W Greenland are feeding almost entirely on nauplii and copepodites of *Calanus finmarchicus*.

In Icelandic coastal waters Bainbridge and McKay (*l.c.*) found that the food of cod larvae showed greater diversity, and that cod larvae stomachs from Icelandic waters contained about twice the amount of food found in those caught off W Greenland. It was, furthermore, shown that the differences observed in the diet of cod larvae from the two areas reflect the diversity of neritic zooplankton off Iceland compared with that of the zooplankton off W Greenland. In this connection it should be stressed that the zooplankton in the W Greenland inshore waters includes an important component of neritic zooplankters, *i.a. Balanus* nauplii, lamellibranch larvae, Cladocera, and euphausid nauplii. It is, therefore, suggested that food conditions for the cod larvae are better in the inshore than in the offshore W Greenland waters.

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Greenland Geoscience

1979. No. 1. C. K. Brooks:
»Geomorphological observations at Kangerdlugssuaq, East Greenland«. 21 pp.

The Kangerdlugssuaq area is mainly comprised of two contrasting rock groups: on the one hand the easily-eroded lavas and sediments of late Mesozoic to early Tertiary age and on the other the highly resistant Precambrian gneisses. Intermediate between these two types in terms of behaviour with respect to erosion are the Tertiary plutonic complexes and the basaltic areas along the coast which have been intruded by intense dyke swarms.

In the late Mesozoic the area was a peneplain, and low relief apparently persisted throughout the volcanic episode as there is good evidence that the lava plateau subsided during its formation. During this period ocean-floor spreading gave rise to the embryonic Danmark Stræde. Shortly after the volcanic episode the Kangerdlugssuaq area became the centre of a massive domal upwarping which has been a dominant feature of the land-forms up to the present day. The original surface of the dome has been reconstructed on the basis of topographic and geological evidence to show that it was elliptical in form with a major axis of at least 300 km in length and a height above present sea-level of about 6.5 km. However, subsequent isostatic effects are not considered in deriving these figures. The updoming is estimated to have occurred about 50 m.y. ago.

Several kilometres thickness of sediments and lavas were eroded off this dome at an early stage exposing the gneissic core, which still stands in alpine peaks up to about 2.7 km altitude in the central part, and dumping ca. 50000 km³ of sediment on the continental shelf. The erosion was effected by a radial, consequent drainage system, relicts of which can still be found. Kangerdlugssuaq itself may owe its origin to a tectonic line of weakness formed in response to doming, but there are also good arguments for its being purely erosional. The erosion of the dome was probably fluviatile but all trace of this stage been obliterated the subsequent glaciation.

In the period between the Eocene and the early Miocene, possibly around 35 m.y. ago, the entire area underwent epeirogenic uplift raising the undeformed parts of the original lava plateau to around 2.5 km above sea-level. A present this plateau is undergoing dissection from the seaward side, but considerable areas are still preserved under thin, horizontal ice-caps.

A brief description of the various types of glaciers, an impermanent, ice-dammed lake and the areas of ice-free land is given. In the Pleistocene, the Kangerdlugssuaq glacier was considerably thicker than at the present time and extended far out over the shelf, excavating a deep channel here. Finally some observations on the coastlines are presented.

1979. No. 2. Svend Karup-Møller and Hans Pauly:
»Galena and associated ore minerals from the cryolite at Ivigtut, South Greenland«. 25 pp.

Silver- and bismuth-rich galena concentrates have been produced for more than 70 years as a byproduct in the dressing of the crude cryolite from Ivigtut, South Greenland.

Concentrates from the years 1937 to 1962 contained from 0.44 % Ag and 0.74 % Bi to 0.94 % Ag and 1.93 % Bi. Conspicuous increases in the content of these elements appeared twice within this time interval, namely in 1955 and in 1960. Thus it seems that crude cryolite from specific areas within the mine carried galena high in silver and bismuth. This promoted a detailed study of the common Ivigtut galena and associated sulphides.

An outline of the geological setting of the deposit is given. The deposit is divided into two main bodies – the cryolite body and the quartz body. Both are subdivided into units characterized by their content of siderite and fluorite. Galena samples from these units and from rock types surrounding the deposit have been studied.

Galena from units characterized by siderite follows the compositional pattern found in the galena concentrated, whereas the sparse galena mineralizations from unirs characterized by fluorite contain much smaller amounts of silver and bismuth, less than 0.2 %. However, within the fluorite-bearing units, two peculiar parageneses reveal high contents of silver and bismuth expressed by the presence of particular minerals such as marildite-aikinite and gustavite.cosalite respectively.

Further trace element studies on selected galena samples emphasize Sn and Te as chemically characteristic of the galena and of the sulphide-carbonate phase of the deposit.

The temperature of formation of the main part of the deposit is placed at 550–400°C, and between 300 and 200°C certain parts of the fluorite cryolite and the fluorite zone.

Greenland Bioscience

1979. No. 1. Erik L. B. Smidt:
»Annual cycles of primary production and of zooplankton at Southwest Greenland«. 53 pp.

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