

Species Composition and Abundance of Zooplankton in the Nearshore Beaufort Sea in Winter-Spring

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ABSTRACT. Zooplankton samples collected in winter-spring 1978-79 and in spring 1980 from under the sea ice at two sites near Prudhoe Bay, Alaska, were analyzed for species composition and abundance. Sixty-eight categories, including 48 species and 20 other categories where identification was made to genus or other higher taxonomic rank, were identified.

Calanoid copepods were dominant under the ice. As spring progressed, however, other organisms, including cyclopoid and harpacticoid copepods, hydrozoans, amphipods, larvaceans, and larval stages of planktonic and benthic invertebrates, became more numerous. Some of these organisms, such as cyclopoid and harpacticoid copepods, probably lived in the sea ice in early spring and were released into the water column as the ice melted.

A correlation matrix identified three groups of zooplankton. Group one, consisting of *Pseudocalanus* spp., had large fluctuations in numbers throughout the spring. Group two, consisting of benthic copepods, polychaetes, and the amphipod *Halirages mixtus*, became abundant when the ice began to melt. The third group, composed of all other species, had a more uniform abundance during early spring, but declined in numbers as the ice melted.

Key words: western Beaufort Sea, zooplankton, copepods, *Pseudocalanus*, cyclopoids, harpacticoids, sea ice

RÉSUMÉ. Des échantillons de zooplancton recueillis sous la glace marine près de la baie Prudhoe, en Alaska, au cours de l'hiver de 1978 et du printemps de 1979 furent analysés afin d'en déterminer les espèces et leur nombre. Soixante-huit catégories furent relevées, y compris 48 espèces et 20 autres catégories identifiées par genre ou par rang taxonomique supérieur.

Les copépodes *Calanus* figuraient en nombre supérieur sous la glace. Cependant, à mesure que le printemps avançait, d'autres organismes augmentaient en nombre, y compris des copépodes cyclopes et harpacticoides, des hydrozoaires, des amphipodes, des appendiculaires, et des invertébrés planctoniques et benthiques aux stades larvaires. Certains de ces organismes, tels les copépodes harpacticoides et cyclopes, vivent probablement dans la glace marine au début du printemps et sont libérés dans la colonne d'eau avec la fonte de la glace.

Une matrice de corrélation signale trois groupes de zooplancton. Le premier consiste de *Pseudocalanus* spp. et présente d'importantes fluctuations en nombre durant la saison entière. Le deuxième groupe consiste de copépodes benthiques, de polychètes et d'amphipodes *Halirages mixtus* et devient abondant avec la fonte. Le troisième groupe, composé de toutes les autres espèces, figurait en nombre abondant uniforme tôt durant le printemps, mais diminuait en nombre avec la fonte.

Mots clés: ouest de la mer de Beaufort, zooplancton, copépodes, *Pseudocalanus*, cyclopes, harpacticoides, glace marine

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INTRODUCTION

The earliest collections of zooplankton from the nearshore region of the arctic coast of Alaska were made during the International Polar Expedition to Point Barrow (Murdoch, 1885) and during the Canadian Arctic Expedition of 1913-18 (Bigelow, 1920; Shoemaker, 1920; Willey, 1920; Schmitt, 1919). These studies consist primarily of distribution records and taxonomic descriptions.

More recently at Point Barrow, MacGinitie (1955) briefly discussed zooplankton in terms of relative abundances and reproductive periods, while Johnson (1958) described the qualitative and quantitative composition of the inshore zooplankton community for one month during summer. Redburn (1973) described the zooplankton community in terms of species abundance and composition, life cycles, and relationship to the hydrographic regime.

Following the discovery of oil on Alaska's North Slope in 1968, a number of studies were initiated to provide basic background information about the nearshore ecosystem, but most of the invertebrate studies have been confined to benthic and epibenthic species (Crane and Cooney, 1974; Broad, 1978; Broad *et al.*, 1979; Griffiths and Dillinger, 1981) or to zooplankton collections made farther offshore (English and Horner, 1976, 1977; Horner, 1978, 1979, 1981).

At Prudhoe Bay in August, however, Horner *et al.* (1974) found three areas biologically differentiated from one another

based on zooplankton community structure and the relative abundance of species comprising the community. Inside Prudhoe Bay, the copepod *Acartia clausi* was the dominant species, with *Pseudocalanus* sp. also being numerous. Between Prudhoe Bay and the Midway Islands, *Calanus glacialis* and *Pseudocalanus* sp. were the dominant species. *Oithona similis* was present along with some barnacle larvae and crab zoea. A more diverse community occurred in the more oceanic area outside the barrier islands where *Microcalanus pygmaeus*, *Pseudocalanus* sp., and *Chiridius obtusifrons* were dominant. Meroplanktonic larvae of decapods, polychaetes, and barnacles were also present, along with juvenile shrimp and euphausiids.

This paper describes seasonal changes in species composition and abundance of zooplankton in Stefansson Sound and off Narwhal Island during winter and spring.

METHODS

Zooplankton was collected from under the annual sea ice in November 1978 and March and May 1979 in Stefansson Sound and from April to June 1980 in the Beaufort Sea off Narwhal Island (Fig. 1).

Samples were collected in November 1978 and April-June 1980 with a 0.75 m diameter ring net having a mesh size of 308 μ m. In March and May 1979, the 0.50 m diameter ring net had a mesh size of 209 μ m. Vertical hauls in Stefansson Sound

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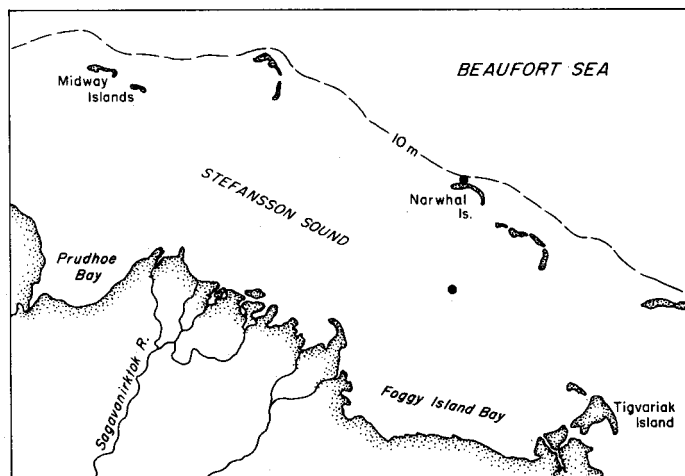


FIG. 1. Station locations.

were made by lowering the net to the bottom (5 m depth) and retrieving by hand at a constant rate. Horizontal tows in Stefansson Sound (November 1978) and off Narwhal Island were made by attaching the net ring to a line and pulley system anchored to a post placed through the ice 12 or 14 m from the sampling hole. The net was lowered through the sampling hole and hand hauled horizontally as quickly as possible to the pulley and back, fishing at an average depth of 2 m beneath the ice. Tows were timed to obtain an approximate speed of tow of 0.3 m s^{-1} .

The net was washed by dipping it several times in the sampling hole. The sample cup was removed and warmed slowly when ice was present. Samples were preserved in 4% formaldehyde buffered with sodium acetate.

All zooplankton samples were first sorted for large, rare organisms such as mysids, amphipods, euphausiids, shrimp, and fish eggs and larvae. The samples were then split in a Folsom plankton splitter (McEwen *et al.*, 1954) until a subsample containing ca. 100 specimens of the most abundant taxon was obtained. Subsamples were successively sorted until at least 100 specimens of abundant taxa or all specimens of rare taxa were counted and identified.

For copepods, samples that had previously been sorted for larger animals were subsampled with a calibrated automatic pipet to obtain a subsample containing ca. 100 specimens of the most abundant copepod species. Copepods were identified and counted by sex and copepodid stage.

The number of animals $\cdot 1000 \text{ m}^{-3}$ was calculated using the equations:

$$V (\text{m}^3) = \text{haul length (m)} \times \text{mouth area (m}^2)$$

$$\text{Number (1000 m}^3) = \frac{(A) (1000)}{V} \times 2^n$$

where V = volume of water filtered; A = number of animals counted; and n = number of times the sample was split.

A 35×35 member correlation matrix was constructed for the more common species collected in 24 net tows off Narwhal Island between April and June 1980. The Statistical Analysis System's (SAS Institute Inc., 1982) correlation procedure was

used to generate Pearson coefficients for correlating the variation in abundance (number $\cdot 1000 \text{ m}^{-3}$) over time of a species with each of the other common species collected.

In addition to the zooplankton, primary productivity, chlorophyll *a*, microalgal species and cell numbers were determined at two depths in the water column and for the bottom few centimetres of sea ice at both the Stefansson Sound and Narwhal Island sites (Horner and Schrader, 1982).

RESULTS

Description of the sampling sites

Stefansson Sound is a shallow water sound off the Alaska North Slope extending from the Midway Islands to Tivgvariak Island. It is bounded on the north by a series of barrier islands, including Narwhal Island, and on the south by the Alaskan coast (Fig. 1). Because of the protecting barrier islands, currents in the sound are weak, especially when ice is present. In the spring, salinity was near 18‰ at the water surface and 35‰ on the bottom at 5 m. Ice is present from about mid-October until late June or early July, with maximum thickness, near 2 m, occurring in early May.

The Narwhal Island site was located on a large flat pan of ice ca. 0.4 km north of Narwhal Island ($70^{\circ}24'N$, $147^{\circ}31.1'W$). Spring currents in the area are northward at ca. 2.5 cm s^{-1} (J.B. Matthews, pers. comm.). Salinity ranged from a low of 24.1‰ at the surface in early June to 35.7‰ on the bottom at 7 m depth in April–May. Only when the ice began to melt in early June was the salinity < 32 ‰ at the surface. Maximum ice thickness during this study was ca. 1.8 m.

Species composition and distribution through time

Sixty-eight categories, including 48 species and 20 other categories where identification was made to genus or other higher taxonomic rank, were identified in the samples. Relative distribution of abundance through time is given in Tables 1 and 2.

Copepods, with 24 species present, were by far the most abundant group during the winter-spring period, ranging from 28–99% of the total population at Narwhal Island and 99–100% of the population in Stefansson Sound. Calanoid copepods were the most diverse group, with 12 species, during the whole period. Cyclopoids, with 7 species, and harpacticoids, with 4 species, became more abundant in late spring. Most of the copepods in our winter samples were adults, with juveniles generally appearing in spring.

In Stefansson Sound, *Pseudocalanus* spp. constituted 97% of the total population in November, 81% in March, but only 22% in May. Adults were the most abundant stages except in March, when stages I–III were more numerous. Other calanoid copepods present in Stefansson Sound were *Derjuginia tolli*, which was relatively abundant in November, and *Acartia longiremis*, *Calanus glacialis*, *C. hyperboreus*, *Microcalanus pygmaeus*, *Eurytemora richingsi*, *Metridia lucens*, and *Limnocalanus macrurus*, all present in relatively low numbers throughout the winter-spring period (Table 1).

TABLE 1. Mean abundance (individuals·1000 m⁻³) of zooplankton in Stefansson Sound, November 1978, March and May 1979; November tows were horizontal, March and May tows vertical

Taxon	Nov (n = 20)		Mar (n = 9)		May (n = 1)	
	♂	♀	♂	♀	♂	♀
Cnidaria						
Hydrozoa						
<i>Halitholus cirratus</i>				352*		
Ctenophora						
<i>Pleurobrachia pileus</i>		23				
Polychaeta						
Unidentified larvae		23		102		
Crustacea						
Cladocera						
<i>Eubosmina longispina</i>				50		
Ostracoda — unidentified				50		
Copepoda						
Calanoida						
<i>Calanus glacialis</i>						
V		566				
III		1029		201		
II		1029				
I				453		
<i>Calanus hyperboreus</i>						
VI		472				
V		566				
<i>Microcalanus pygmaeus</i>						
VI					352	
V				101	51	
IV				101	100	385
III						385
VI	17502	234086	50	302	2038	3846
V	708585	166810	3067	503	8846	4231
IV	2425217	1833068	14468	18954	1539	8846
III		329463		50427		5000
II		2058		4726		
I				1153		2692
<i>Derjuginia tolli</i>						
VI	7714	8563				
V	1029	9206			50	
IV	39095	74176	50	302		
III		16461		50		
II		1029				
<i>Eurytemora richingsi</i>						
IV		1029				
<i>Metridia lucens</i>						
III				100		
II				352		
I				201		
<i>Limnocalanus macrurus</i>						
VI	1594	6017				
<i>Acartia longiremis</i>						
VI	2623	9257	50		1539	385
Unidentified nauplii				8087		39231
Cyclopoida						
<i>Oithona similis</i>						
VI		1594	201	2413	3846	21923
V				4022		19231
IV				3268		4231
III				201		
<i>Cyclopina gracilis</i>						4615
<i>Cyclopina</i> sp. A					769	3462
<i>Cyclopina</i> sp. B						1539
<i>Cyclopinodes</i> sp.						1153
<i>Oncaea borealis</i>			201	251		
Harpacticoida						
<i>Pseudobrydia minor</i>	Juv					27308
<i>Harpacticus superflexus</i>	VI				5000	769
<i>Tisbe furcata</i>	Juv					26923
VI						385
Mysidaceae						
<i>Mysis litoralis</i>		267		101		
<i>Mysis oculata</i>		45				
<i>Mysis relicta</i>		89				
Isopoda						
Epicaridea — unidentified				50		

(continued)

TABLE 1 (concluded)

Taxon	Nov (n = 20)		Mar (n = 9)		May (n = 1)	
	♂	♀	♂	♀	♂	♀
Amphipoda						
Hyperiidea						
Hyperiidae						
<i>Parathemisto libellula</i>		21				
Gammaridea						
Atylidae						
<i>Atylus carinatus</i>		111				
Gammaridae						
<i>Weyprechtia pinguis</i>		23				
Lysianassidae						
<i>Anonyx nugax</i>		148				
<i>Acanthostephea behringiensis</i>		21				
<i>Boeckosimus plautus</i>		455				
<i>Onisimus litoralis</i>		337				
<i>Orchomenella pinguis</i>		158				
Cirripedia						
<i>Balanus</i> — unidentified nauplii				201		
Unidentified parasitic larvae				50		
Chaetognatha						
<i>Sagitta elegans</i>		158		101		

*For animals not sexed, abundance is centered beneath month.

Among the cyclopoid copepods, *Oithona similis* was the most abundant, especially in May. Other cyclopoids, including *Cyclopina gracilis*, two unidentified *Cyclopina* species, *Cyclopinodes* sp., and *Oncaea borealis*, were also usually most common in May. Only female *O. similis* appeared in relatively large numbers. The harpacticoids *Pseudobryadia minor*, *Harpacticus superflexus*, and *Tisbe furcata*, were present only in May and only juveniles were relatively common.

Other invertebrates constituted <1% of the population in November and March and were not present in May. These included hydrozoans, ctenophores, unidentified polychaete larvae, mysids, amphipods, barnacle larvae, and chaetognaths (Table 1).

In the spring off Narwhal Island, *Pseudocalanus* spp. were also the most abundant organisms, constituting 83% of the population in April, 87% in May, and 45% in June. Mostly adults were present, but juvenile stages were also present in May and June. *Acartia longiremis* and *Eurytemora herdmani* adults were also common. A few cyclopoids were present, especially in June, and the harpacticoids *Harpacticus superflexus* and *Helectinosoma neglectum* became abundant in June (Table 2, Fig. 2).

Other invertebrates were present during the spring and generally made up <12% of the total population. Hydrozoans, including meroplanktonic species *Euphysa flammea* and *Halitholus cirratus* and the holoplanktonic species *Aeginopsis laurentii*, were present in small numbers throughout the spring. Polychaete larvae were always present, as well as large numbers of unidentified echinoderm plutei, indicating reproduction of these benthic groups. Unidentified crustacean eggs were present in April and May.

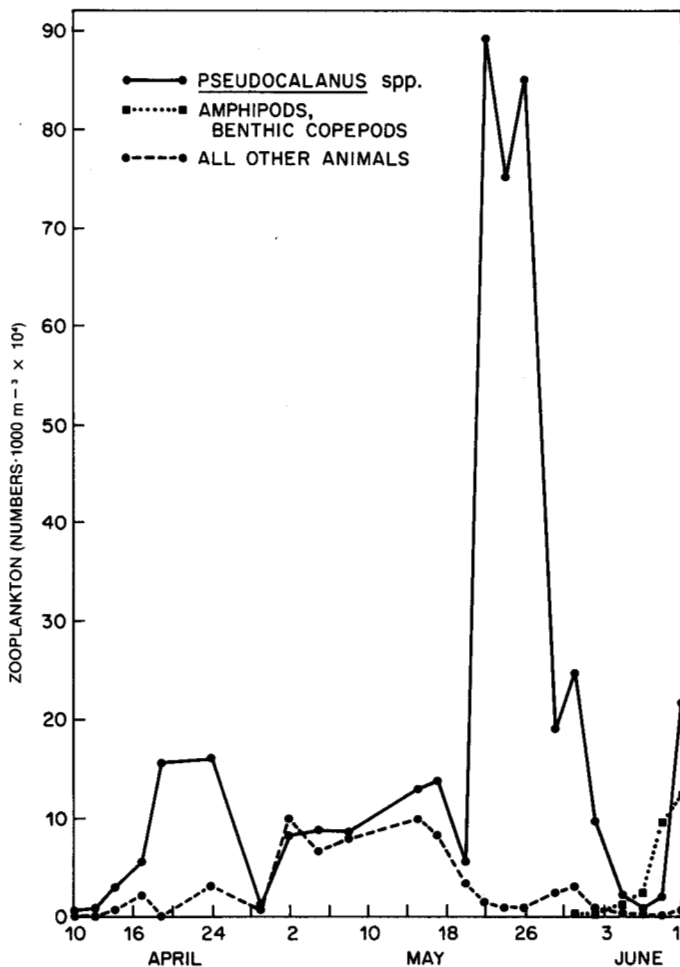


FIG. 2. Abundance of zooplankton groups off Narwhal Island, April–June 1980.

TABLE 2. Mean abundance (individuals · 1000 m⁻³) of zooplankton at Narwhal Island, April–June 1980; all tows were horizontal

Taxon	Apr (n = 7)		May (n = 11)		Jun (n = 5)	
	♂	♀	♂	♀	♂	♀
Cnidaria						
Hydrozoa						
<i>Aeginopsis laurentii</i>		173		221		383
<i>Euphysa flammea</i>		796		1154		261
<i>Halitholus cirratus</i>		91		150		87
Ctenophora						
<i>Pleurobrachia pileus</i>		12		63		17
Polychaeta						
Unidentified larvae		81		275		1396
Crustacea						
Copepoda						
Calanoida						
<i>Pseudocalanus</i> spp.						
VI	40	1466	48679	13264	2991	7872
V	23354	3307	60018	96979	4664	15596
IV	23867	8554	23499	51503	1151	6078
III				278		5302
II				8261		2082
I				276		17
<i>Eurytemora herdmani</i>						
VI			59	40		195
V	12		37	115		
IV						134
<i>Eurytemora richingsi</i>		12				
V				40		
<i>Metridia longa</i>						
III						122
II	156			37		
<i>Acartia longiremis</i>						
VI	473	762	860	1427	17	78
V		323		120		
Cyclopoida						
<i>Oithona similis</i>				99		130
<i>Cyclopina gracilis</i>						17
<i>Cyclopina schneideri</i>						182
Harpacticoida						
<i>Harpacticus superflexus</i>						
VI			674	79	15060	14401
Juv		12		362		16018
<i>Helectinosoma neglectum</i>						
VI					504	532
Juv		12				104
Mysidacea						
Unidentified larvae				63		
Isopoda						
Epicaridea — unidentified				23		
Amphipoda						
Hyperiididae						
Hyperiididae						
<i>Hyperia galba</i>				8		
Gammaridea						
Calliopiidae						
<i>Apherusa glacialis</i>		23				267
<i>Halirages mixtus</i>		947		92		2084
Gammaridae						
<i>Lagunogammarus wilkitzkii</i>		12				
Lysianassidae						
<i>Onisimus litoralis</i>		912		308		1456
Decapoda						
Unidentified Brachyura						17
Unidentified crustacean eggs		P		P		
Echinodermata						
Unidentified pluteus larvae		6926		35117		1640
Chaetognatha						
<i>Sagitta elegans</i>		12				
Chordata — Larvacea						
<i>Fritillaria</i> sp.		185		3284		1513
<i>Oikopleura labradoriensis</i>		104		1175		52
<i>Oikopleura vanhoeffeni</i>						70

The amphipods *Onisimus litoralis* and *Halirages mixtus* were common throughout the spring, while *Lagunogammarus wilkitzkii*, *Apherusa glacialis*, and *Hyperia galba* were occasionally present. The larvaceans *Fritillaria* sp. and *Oikopleura labradoriensis* were also common.

Correlation matrix

The correlation matrix distinguished groups of species whose abundance tended to vary together. Table 3 shows two such groupings. Group one, consisting of *Pseudocalanus* spp., showed high correlation within the genus but not with any other taxon. A second group consisted of polychaetes, benthic copepods, and the amphipod *Halirages mixtus*. Stage III *Pseudocalanus* spp. correlated strongly with the benthic copepods of group two but not with other stages of *Pseudocalanus*. Considering the uncertainty of the taxonomy of this genus, this suggests the presence of more than one species. These two groups do not contain all 35 members of the correlation matrix, but the remaining 18 common species varied independently of any other species and were lumped together into a third group.

Figure 2 shows abundance versus time for all three groups of zooplankton. Large fluctuations in abundance were observed for *Pseudocalanus* spp. during the sampling period. Group two, benthic copepods and amphipods, were absent or present in low numbers in our samples until the early part of June, when their numbers increased greatly. The animals that did not correlate with any of the species in our collection are plotted as a third group. Their abundance was more uniform over the sampling period but declined as the ice melted in June.

TABLE 3. Average correlation coefficients of zooplankton groups

Taxon	Stage	Sex	Average Correlation Coefficient*
Group 1			
<i>Pseudocalanus</i> spp.	VI	♂	.65
	VI	♀	.49
	V	♂	.71
	V	♀	.69
	IV	♂	.37
	IV	♀	.75
	III	Juv	-.01
	II	Juv	.66
	I	Juv	.43
Group 2			
Polychaeta			.47
<i>Halirages mixtus</i>			.34
<i>Harpacticus superflexus</i>	VI	♂	.62
	VI	♀	.63
		Juv	.60
<i>Helectinosoma neglectum</i>	VI	♂	.50
	VI	♀	.49
		Juv	.31
<i>Cyclopina</i> spp.	VI		.64

*Average correlation coefficients are calculated as the sum of the correlation coefficients of a species with all the other members of a group divided by the number of group members.

DISCUSSION

Calanoid copepods were the dominant organisms in our samples, *Pseudocalanus* spp. being the most abundant genus. Adult animals were more numerous during winter, with juveniles generally occurring in early spring, although some juvenile stages were also present in November. It has been suggested (Cairns, 1967) that *Pseudocalanus* may take two years to reach maturity. This genus is widespread in the temperate zone and at high latitudes, being abundant from the North Pacific to the North Atlantic. In temperate areas it is usually found below 50 m, but in higher latitudes it is found in cold surface waters and is more common nearshore, where it can be an important food source for fish (Brodskii, 1950). Although members of the genus *Pseudocalanus* were the most abundant organisms in our samples, they were not identified to species because of current confusion over the taxonomy of this genus (Buchanan and Sekerak, 1982; B. Frost and G. Heron, pers. comm.). Instead, we have grouped all members of this genus together as *Pseudocalanus* spp. until the taxonomic question is settled.

Calanus glacialis and *C. hyperboreus* were rarely found in our samples, although both are considered to be common in the Beaufort Sea (Shih and Laubitz, 1978). The breeding cycle of *C. glacialis* is generally not synchronized with environmental factors, and development to maturity is thought to take several years (Cairns, 1967), while *C. hyperboreus* is reported to be an opportunistic breeder, also with slow development.

Microcalanus pygmaeus lives in cold, deeper water (Brodskii, 1950), coming to the surface in winter (Digby, 1954). The spawning period is prolonged, with a new generation appearing in July (Cairns, 1967). Development takes place through the winter. Our data agree with these earlier observations from the eastern Arctic; in our samples, stage III, IV, and V individuals were found in the shallow water of Stefansson Sound from mid-November through May.

Derjuginia tolli adults, abundant in November, were not found in spring, although we have found stages II, IV, V, and VI farther offshore in August-September (Horner, 1981). This is a neritic species usually found in shallow waters of the Arctic Basin (Grainger, 1965; Shih and Laubitz, 1978).

Two *Eurytemora* species were present in our samples. *E. herdmani* is considered to be a littoral species found in less saline water in the Bering Sea and along the Alaskan north coast (Brodskii, 1950). Johnson (1956) thought it might be an expatriate from the Bering Sea, and Redburn (1973) found it at Barrow only when the surface water temperature was $>7^{\circ}\text{C}$. *E. richingsi* was originally described from >500 m in the central Arctic Ocean (Heron and Damkaer, 1976), but it has also been reported from shallow water in the Beaufort Sea (English and Horner, 1977).

Acartia longiremis is a circumpolar arctic species that is mostly neritic but also occurs in surface water offshore. It is reported almost exclusively from surface waters of arctic marginal seas and is often found near melting ice (Johnson, 1956). In our samples, adults were found in November, March, April, May, and June but were most abundant in November. Grainger (1959) thought there was a suggestion of

summer production of young with progressive development during winter. We found only adult stages in our samples.

Limnocalanus macrurus, rarely found as adults in November and May in Stefansson Sound, is primarily a freshwater species sometimes occurring in surface waters of <2‰ salinity (Grainger, 1962). Shih and Laubitz (1978) reported it as sometimes numerous in the eastern Beaufort Sea.

The most common cyclopoid copepod in our samples was *Oithona similis*. Adults were present during all sampling times, with stages III and IV present in March. This species is circumpolar in distribution (Grainger, 1959). Adult males and females of another cyclopoid, *Oncaea borealis*, were present in March. Grainger (1959) found only adults at Igloodik in the Canadian Arctic and thought development either took place elsewhere or in deeper water. Small numbers of other cyclopoids were present in May 1979 and June 1980. The May 1979 tow was a vertical one with the net lowered to the bottom in Stefansson Sound, where attached macroalgae were present. These species, *Cyclopina gracilis*, *Cyclopina* sp. A, *C.* sp. B, and *Cyclopinodes* sp., are reported to be found close to shore among algae (Sars, 1913); that may account for their occurrence in this sample, but *Cyclopina gracilis* and *C. schneideri* were also found in horizontal tows taken in June off Narwhal Island, where there were no benthic macroalgae.

The harpacticoid copepods *Pseudobryda minor* and *Harpacticus superflexus* were also found in the vertical net haul in Stefansson Sound in June, while *H. superflexus* and *Helectinosoma neglectus* were present in April, May, and June off Narwhal Island. Montagna and Carey (1978) reported *H. superflexus* to have a wide distribution in the Beaufort Sea, occurring from 5–2000 m. They found no males in their samples, collected farther offshore than ours. We found a few males in May at both the Stefansson Sound and Narwhal Island sites.

Hydrozoans became abundant in spring off Narwhal Island but were not abundant in Stefansson Sound, although *Halitho cirratus* and *Sarsia tubulosa* were present in March.

Amphipods and mysids were also important components of the nearshore ecosystem, but they were relatively sparse in our samples, probably because of our sampling methods. Of these, *Lagunogammarus wilkitzkii* is an arctic species whose distribution is almost limited by the extent of the ice. It is found associated with the undersurface of the ice rather than being strictly pelagic, although it is planktonic in areas where ice is sparse in summer (Dunbar, 1964). It apparently feeds on the ice algae and other organic matter found on the undersurface of the ice. *L. wilkitzkii* is frequently found in the stomachs of ringed seals (*Phoca hispida*) (Dunbar, 1964).

Apherusa glacialis is an arctic, circumpolar, pelagic species that lives mainly near the surface (Stephensen, 1944) and is also often found associated with the underside of the ice (MacGinitie, 1955). Polar cod (*Boreogadus saida*) may selectively feed on this species (Barnard, 1959), and it has also been found in seal stomachs (MacGinitie, 1955). Both of these amphipod species successfully breed in the arctic (Tencati, 1970).

Onisimus litoralis is an abundant, shallow water species usually occurring in brackish water (Dunbar, 1954). *Anonyx nuxax*, a circumpolar arctic-subarctic species, is confined to

shallow water on the shelf and its distribution extends into the North Sea and the Skagerak. It may be used as a food species by ducks, cod, and bearded seals (Dunbar, 1954).

Mysids were not common in our samples, probably because most of our samples were collected above the bottom.

Larvaceans were present in most samples collected off Narwhal Island but not in Stefansson Sound. The species *Fritillaria* sp., *Oikopleura labradoriensis*, and *O. vanhoeffeni* all occur widely in the arctic (Grainger, 1965) and are found at depths from 0–900 m (Leung, 1972).

Meroplanktonic larvae of polychaetes and barnacles were rarely found in Stefansson Sound, but polychaete larvae were common off Narwhal Island. Meroplankton production is apparently greater in the Chukchi and western Beaufort seas than in the eastern Beaufort Sea, perhaps because of the larger area of shallow water in the western areas (Johnson, 1956). Johnson (1956) found maximum abundance of barnacle larvae west of Point Barrow and considered that a sizeable portion of the barnacle larvae found in the western Beaufort Sea may be due to advection. Our samples were collected close to shore, possibly in an area not greatly influenced by water from the west. Also in our sampling area there is little solid substrate for adult barnacles, while polychaetes are a common constituent of the benthic community both inshore and offshore (Broad, 1978; Carey *et al.*, 1974). Large numbers of unidentified echinoderm pluteus larvae were abundant off Narwhal Island, and echinoderms, especially ophiuroids, are also conspicuous members of the benthic community (Carey and Ruff, 1977).

The numbers of the three groups identified by the correla-

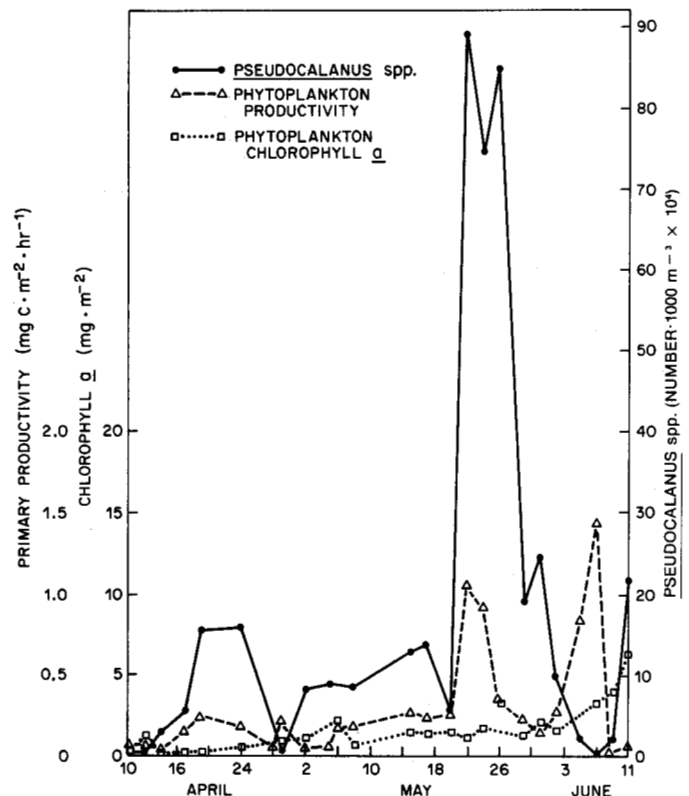


FIG. 3. Comparison of *Pseudocalanus* spp. abundance with primary productivity and chlorophyll *a* concentration off Narwhal Island, April–June 1980.

tion matrix varied during the spring. The movement of large swarms of *Pseudocalanus* spp. past our study site, as indicated in Figure 2, may have been due to the local current regime and could explain why we did not see any clear progression of life cycle stages during our study. Comparison of group-one abundance with chlorophyll *a* concentrations and primary productivity (Fig. 3) also shows no clear relationship, but an increase in both chlorophyll *a* and productivity (Horner and Schrader, 1982) after a particularly large swarm of *Pseudocalanus* spp. late in May suggests there is some grazing pressure.

The increase in amphipods, polychaetes, and benthic copepods coincided with the disappearance of the ice algae as the ice melted in June. These animals had apparently been living in the ice and utilizing the ice algal community as a concentrated source of food. Polychaetes and amphipods were present in our samples throughout the spring, however, and were thus not found exclusively within the bottom ice community.

Species composition and abundance of zooplankton in arctic Alaskan coastal waters change substantially with the onset of spring. Winter populations, primarily composed of a few species of calanoid copepods, give way to a more diverse community that includes additional copepod genera, hydrozoans, amphipods, larvaceans, and larval stages of planktonic and benthic invertebrates during spring. Data from the Prudhoe Bay area indicate that this more diverse community continues through the summer (Horner *et al.*, 1974). With the onset of winter, zooplankton populations decline in both abundance and diversity.

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