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KRILL AND ZOOPLANKTON IN THE WESTERN PRYDZ BAY REGION, SEPTEMBER–NOVEMBER 1985

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Abstract: During the third Antarctic Division BIOMASS Experiment (ADBEX III) cruise (September to November 1985) to the western Prydz Bay region, Antarctica, a net sampling program was carried out using RMT 1+8 and ORI-2000 nets, in the pack-ice zone when the sea ice was near to its maximum northern extent. From these samples the composition and abundance of euphausiids and other zooplankton were investigated. A total of 75 species of zooplankton and ichthyoplankton were fully identified, as well as 15 other major taxa. The copepod *Rhincalanus gigas* was the most abundant zooplankter, with *Thysanoessa macrura* the most abundant euphausiid. The two chaetognaths *Sagitta gazellae* and *Eukrohnia hamata* were the predominant carnivores. Major zooplankton species appeared to be well established under the sea ice in October, compared with abundance estimates from the previous summer cruises (January to March). Early larval stages of *Thysanoessa macrura* and *Euphausia frigida* were abundant in October, a result of spawning as early as September and late stage furcilia larvae of *Euphausia superba* were also collected in late September–early October. A supplementary diving program found large numbers of krill under the sea ice off the Enderby Land coast showing that krill remain inshore during pack-ice development. The previous laboratory and field studies have shown that adult *Euphausia superba* either cease growing or shrink in size during winter due to the lack of food. Results from this study suggests that the smaller zooplankton may not find food limiting in winter.

1. Introduction

During the international BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) program, the Australian Antarctic Division carried out net sampling programs on four major marine science cruises to the Prydz Bay region of Antarctica. Two of these cruises were the internationally coordinated programs FIBEX (First International BIOMASS Experiment) and SIBEX II (Second International BIOMASS Experiment, phase II). The remaining two cruises were national programs ADBEX I and II (Antarctic Division BIOMASS Experiments, phases I & II). Collectively these cruises covered the austral summer period from the end of November to the beginning of March. Information has been collected during this period on the ecology of krill *Euphausia superba* in this region (HOSIE *et al.*, 1988), as well as the distribution and abundance of other zooplankton species (IKEDA *et al.*, 1984, 1986; WILLIAMS *et al.*, 1983, 1986; HOSIE and KIRKWOOD, 1986). Additional information for the western Prydz Bay region (off Enderby Land) during SIBEX I extends our knowl-

edge of krill abundance and distribution up to the end of April (MILLER, 1986). These data come from a period of minimum ice cover. However, no information existed for krill or other zooplankton in the Prydz Bay region during the period of maximum ice cover.

In September–November 1985 (austral late winter–spring), the Australian Antarctic Division carried out the third Antarctic Division BIOMASS Experiment (ADBEX III) to the western Prydz Bay region, Antarctica. The prime purpose of this cruise was to study the ecology of the Crabeater seal *Lobodon carcinophagus*. In addition, a limited net sampling program was carried out to study the distribution and abundance of euphausiids and other zooplankton in the post-winter pack-ice zone, when the sea-ice was near to its maximum northern extent (JACKA, 1983). The distribution of krill in relation to the ice edge was of particular interest. The net sampling was supplemented with a diving program to observe and collect krill from under the pack-ice.

2. Methods

2.1. *Field sampling*

A Rectangular Midwater Trawl (RMT 1+8, BAKER *et al.*, 1973) and an Ocean Research Institute conical net (ORI-2000, OMORI, 1965) were the two main net systems used for sampling krill *Euphausia superba* and other zooplankton.

The RMT 1+8 had a mesh of 300 μm for the RMT 1 and 4.5 mm for the RMT 8. The effective mouth areas of the RMT 1+8 are a function of the towing speed and trajectory (ROE *et al.*, 1980; POMMERANZ *et al.*, 1982). In this study, the towing speed of the RMT 8 ranged between 1.5 and 4 knots. However, the assumption was made that the originally designed mouth areas of 1 m^2 (RMT 1) and 8 m^2 (RMT 8) remained constant. At each station, a shallow oblique haul (0–200 m) was made. When ice conditions permitted an additional deep oblique haul (200–1000 m) was also made. The RMT 1+8 net had an electro-mechanical opening-closing mechanism, a real-time depth recorder and both nets were equipped with flowmeters. One aimed horizontal tow was also made at a target located by a Simrad EK 120 echo sounder.

The ORI-2000 net had a mouth area of 2 m^2, mesh of 2 mm. This net was used when it was unsafe to tow the RMT 1+8 net due to ice, or when the ship had stopped for the night. Vertical hauls were made usually from 1000 m, although occasional hauls varied between 10 and 2000 m. The cod end was weighted to facilitate deployment to the required depth. Hauling speed varied between 0.7 and 1.3 ms^{-1}. The volume of water filtered was determined by multiplying the mouth area by the amount of wire out.

Under-ice diving was carried out either from the ship or through two ice-holes nearby. During this study the ship was beset off Enderby Land (Station 43, Fig. 1) and constantly drifting. Krill were collected by hand nets carried by the diver. These nets were difficult to move through the water with any speed but proved to be the most successful method at hand. Observations on the behavior of krill were also achieved by means of underwater video and 16 mm cine-camera (O'BRIEN, 1987).

Complete details of the sampling program, *e.g.* sampling position, time, depth, conditions, etc., as well as detailed catch compositions are provided in HOSIE *et al.* (1987).

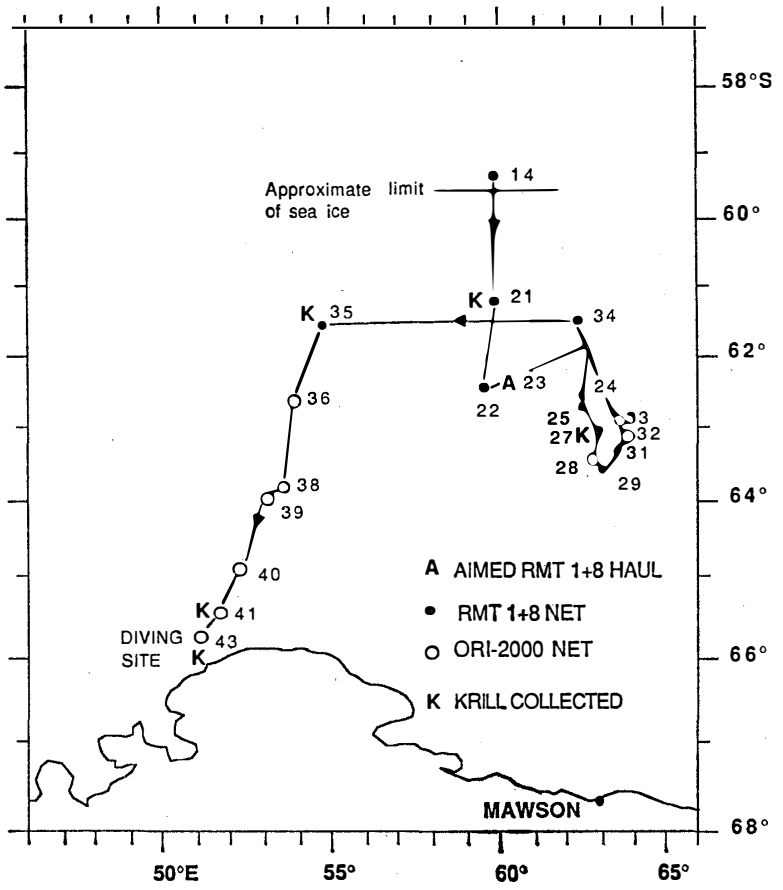

Fig. 1. Cruise track and net sampling stations. The cruise track shown is only for the duration of the net sampling program. The approximate northern limit of the sea ice as observed during the cruise is shown, together with stations where krill were collected.

2.2. *Sample processing*

On board the ship, large and fragile zooplankton (jellyfish, salps, etc.) were sorted from the rest of the specimens. All specimens were preserved in STEEDMAN's solution (STEEDMAN, 1976) for later examination at the Antarctic Division. After the cruise the krill were sorted into juvenile, male or female. Body length (standard 1, MAUCHLINE 1980) was measured to 0.1 mm and formalin-preserved body wet weight were measured, 0.001 g accuracy. Male and female krill were further classified into maturation stages according to the system of MAKAROV and DENYS (1981). Non-krill zooplankton in the RMT 8 samples were speciated, weighed and counted. Euphausiid larvae were extracted from the RMT 1, specifically identified, staged and counted under a dissecting microscope.

2.3. *Data analysis*

The length-frequency distributions were analyzed by computer for the number and parameters of age groups using the distribution mixture analysis method of MACDONALD and PITCHER (1979). The computer program MIX (P. D. M. MACDONALD and P.E.J. GREEN, 1985, Ichthus Data Systems, Hamilton, Ontario) was written in FORTRAN 77

and run on an Apple Macintosh Plus-HD20 system. The normally distributed modes identified by this method were assumed to represent year groups, on the basis that krill has a distinct annual spawning period.

3. Results

3.1. Krill

Most of the *E. superba* (156 specimens) were observed and collected by SCUBA divers at station 43, during the besetment of NELLA DAN, near the Enderby Land coast. Only 17 individuals were collected by the RMT 8 and ORI-2000 nets from the other sampling sites (Fig. 1). In addition, 3 specimens (1 juvenile and 2 furcilia) were

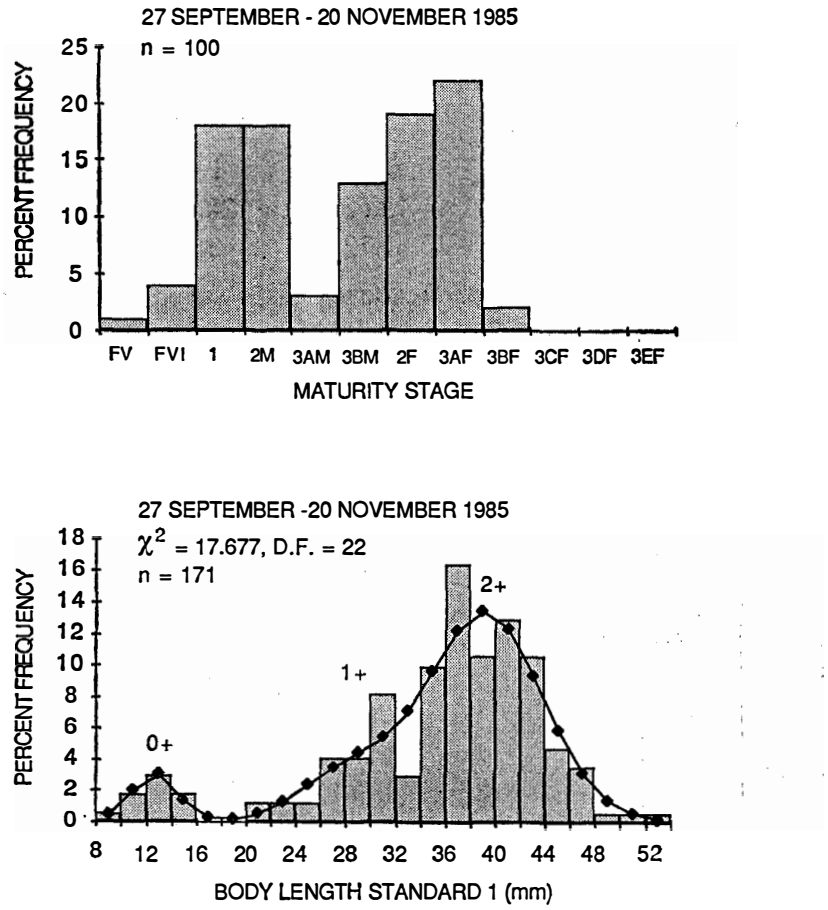

Fig. 2. Percent frequency distributions of body lengths and maturity stages of Euphausia superba. *The computed body length-frequencies by the method of MACDONALD and PITCHER (1979) is shown by the line (◆—◆). Maturity stages: Furcilia V and VI (FV, FVI), juvenile (1), sub-adult/immature male (2M), mature male with no spermatophore in ampullae (3AM), mature male with spermatophore and ready to mate (3BM), sub-adult/immature female (2F), mature female not mated (3AF), mated mature female with small ovaries (3BF), mated mature female with ovaries filling thoracic space (3CF), mated mature female with carapace swollen by enlarged ovaries-spawning female (3DF) and spent female (3EF).*

collected on 27 September 1985 by means of a small conical net, 1 m² mouth area and 500 μm mesh, drifted from the ship near the ice edge at 57°29.4'S, 85°07.0'E.

Figure 2 depicts the population structure, in relation to maturity stages and body size, of the specimens collected (not all adults were fully identified as these were used for metabolic experiments). A large portion of the specimens were sub-adults and juveniles, the latter mainly caught in October. During November at station 43, a large proportion of fully mature (3BM) males, with only two gravid (3BF) females were collected. Two furcilia were collected on 27 September (mentioned above) with other 3 furcilia collected on the 14 October at station 27.

The furcilia together with small juveniles formed the distinct 0+ year group (Fig. 2). Two more year groups were identified, *i.e.* 1+ and 2+, using the distribution mixture analysis method of MACDONALD and PITCHER (1979). No other year groups could be clearly identified in the upper body sizes, although the much larger specimens are similar in size to the groups 3+ and 4+ previously identified in Prydz Bay by HOSIE *et al.* (1988). The mean body lengths (mm) and standard deviations (SD) of the identified modal peaks are as follows:

Year Group	0+	1+	2+
Mean	12.65	28.37	39.13
SD	1.72	3.73	4.59

Figure 2 also shows the computed frequency distribution from the MACDONALD and PITCHER (1979) method. The Chi-square value of the goodness of fit was calculated as 17.677 (d.f. = 22, n = 171, P = 0.725)

3.2. *Euphausiid larvae collected by RMT 1 net*

Figure 3 shows the frequency distributions of the larval stages of the two euphau-

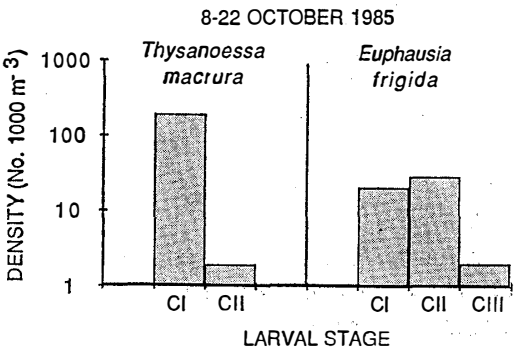

Fig. 3. Frequency distribution of euphausiid larval stages collected in the RMT 1 net for the 0–200 m oblique hauls. Note that the ordinate is a $\log_{10}$ scale. Calyptopis stages I, II and III (CI, CII, CIII).

Table 1. Estimated mean densities (No. individuals 1000 m⁻³) for euphausiid larvae collected in the RMT 1 net integrated for all sampling sites.

Depth (m)	n	*Thysanoessa macrura*			*Euphausia frigida*		
		Mean	SD	Range	Mean	SD	Range
0–200	8	183.20	274.81	6.77–799.28	49.87	110.86	0–322.13
200–1000	6	20.76	19.03	0.81– 52.95	3.12	6.46	0– 16.27

n: number of sampling sites, SD: standard deviation.

Table 2. Estimated mean densities (No. individuals 1000 m^{-3}) for all zooplankton, including ichthyoplankton, collected in the RMT 8 and ORI-2000 nets, integrated for all sampling sites and sampling methods. n=27.

Taxa	Mean	SD	Taxa	Mean	SD
Euphausia superba	0.10	0.37	*Pseudochirella polyspina*	0.12	0.28
Euphausia frigida	2.48	9.61	*Rhincalanus gigas*	99.45	121.05
Euphausia crystallorophias	0.06	0.29	*Scaphocalanus affinis*	0.05	0.14
Euphausia triacantha	0.27	0.87	*Scaphocalanus magnus*	0.02	0.07
Thysanoessa macrura	28.20	104.83	*Valdiviella insignis*	0.02	0.10
Amallothrix emarginata	0.02	0.08	Gammaridea	0.12	0.24
Amallothrix denticpes	0.14	0.30	*Cyllopus* sp.	0.26	0.96
Arietellus simplex	0.04	0.13	*Hyperiella dilatata*	10.35	47.99
Bathycalanus bradyi	0.03	0.11	*Parathemisto gaudichaudi*	0.03	0.11
Calanoides acutus	17.05	22.67	*Primno macropa*	0.16	0.32
Calanus propinquus	1.43	1.90	*Vibilia* sp.	0.17	0.70
Candacia falcifera	+	0.01	Phronimoidea	0.02	0.10
Candacia maxima	0.02	0.05	Platysceloidea	0.03	0.11
Centraugaptilus rattrayi	+	0.01	Decapoda	0.48	1.96
Chiridius polaris	+	0.01	Ostracoda	0.50	0.95
Cornucalanus chelifer	+	0.01	Mysidacea	0.37	0.97
Cornucalanus robustus	0.39	0.99	Thecosomata	1.03	1.49
Euaugaptilus laticeps	0.64	1.15	Gymnosomata	0.40	0.43
Euaugaptilus sp. cf *magnus*	0.08	0.22	Cephalopoda	0.14	0.25
Euchaeta antarctica	4.15	9.98	*Sagitta gazellae*	55.70	238.84
Euchaeta biloba	0.14	0.33	*Sagitta maxima*	1.36	1.89
Euchaeta dactylifera	0.02	0.10	*Sagitta marri*	0.68	0.92
Euchaeta farrani	0.51	1.93	*Eukhronia hamata*	11.59	16.13
Euchaeta parvula	0.02	0.10	*Tomopteris* sp.	0.59	1.05
Euchaeta rasa	0.10	0.23	Alciopidae	0.18	0.24
Euchirella rostramagna	0.56	1.15	Typhloscolecidae	0.06	0.14
Farrania frigida	0.04	0.13	*Salpa thompsoni*	3.33	6.95
Gaetanus antarcticus	0.03	0.11	*Atolla wyvillei*	0.03	0.07
Gaidius intermedius	0.03	0.10	*Periphylla periphylla*	0.03	0.10
Gaidius tenuispinus	0.10	0.30	Hydromedusae (other)	3.33	4.99
Haloptilus ocellatus	0.67	1.11	Nectophore	7.30	5.83
Heterostylites major	+	0.01	*Beroe* sp.	+	0.01
Heterorhabdus austrinus	0.09	0.15	*Callianira cristata*	0.37	1.34
Heterorhabdus farrani	0.24	0.44	Nemertea	+	0.01
Lucicutia curta	0.02	0.10	Appendicularia	0.02	0.08
Lucicutia macrocera	0.06	0.14	*Bathylagus antarcticus*	0.04	0.11
Lucicutia wolfendeni	0.22	0.44	*Benthalbella elongata*	+	0.01
Metridia curticauda	0.34	0.61	*Cyclothone* sp.	0.03	0.10
Metridia gerlachei	4.39	19.20	*Electrona antarctica*	0.15	0.26
Metridia princeps	0.23	0.52	*Gymnoscopelus braueri*	0.01	0.03
Onchocalanus magnus	0.20	0.38	*Krefftichthys anderssoni*	0.03	0.10
Pachyptilus eurygnathus	0.06	0.16	*Melanonus* sp.	+	0.01
Pleuromamma robusta	0.20	0.34	Myctophid larva	0.02	0.04
Pseudaugaptilus longiremis	0.04	0.11	*Notolepis coatis*	0.14	0.27
Pseudochirella hirsuta	0.09	0.19	*Protomyctophum bolini*	+	0.01

SD: standard deviation, +: <0.01 individuals 1000 m^{-3}.

siids *Thysanoessa macrura* and *Euphausia frigida*, for the upper 200 m. Only calyptopis larvae of these two species were collected in either the shallow or deep hauls. The frequency distributions of these stages were the same for both species in the 200–1000 m layer as that of the upper 200 m, although the overall abundances were much lower in the deeper layer (Table 1). The larvae of the other euphausiids *E. superba*, *E. crystallorophias* and *E. triacantha* were not collected by the RMT 1 net.

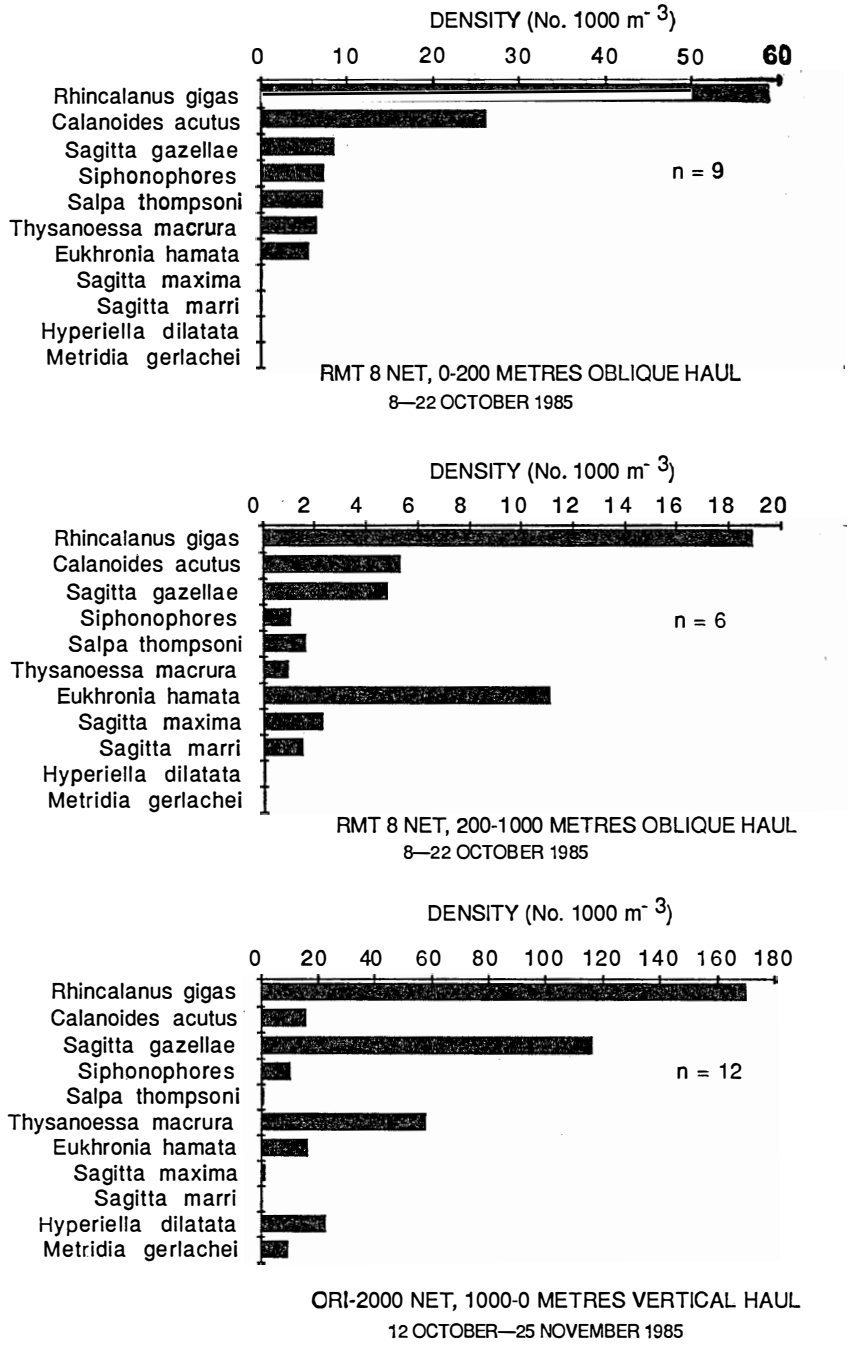

Fig. 4. Integrated mean densities of major adult zooplankton species, composing more than 2% of the total zooplankton abundance for shallow, deep RMT 8 hauls and ORI-2000 vertical hauls.

3.3. *Zooplankton*

A total of 75 species of zooplankton and ichthyoplankton were identified from the catches, as well as other 15 major taxa (Table 2). With the exception of the siphonophore nectophores, all species displayed typical patchy distributions with standard deviations exceeding the mean. The numerically most abundant species are shown in Fig. 4 for shallow, deep RMT 8 hauls and ORI-2000 vertical hauls. These were species composing more than 2% of the total zooplankton abundance for either RMT 8 or ORI-2000 hauls.

The copepod *Rhincalanus gigas* was the most abundant zooplankter at most sampling sites and for any sampling method. *Calanoides acutus* was the next most abundant copepod. *Thysanoessa macrura* was the most abundant euphausiid and next most abundant zooplankton species. The two chaetognaths *Sagitta gazellae* and *Eukrohnia hamata* were the predominant carnivores. Higher abundances tended to be recorded in the ORI-2000 net principally due to the finer mesh. However, the upper 200 m hauls had higher abundances of *R. gigas*, *C. acutus*, *S. gazellae*, siphonophores, *Salpa thompsoni* and *T. macrura*, while *E. hamata*, *Sagitta maxima* and *S. marri* were more abundant in the deeper layers. The rest of the species occurred too infrequently or only in substantial numbers in the 0–1000 m verticals, to allow any comment on their vertical distribution.

The total mean abundance of the abundant species shown in Fig. 4 for the upper 200 m water column was 171.4 individuals $1000\,m^{-3}$. This is similar to the estimate of 178.6 ind. $1000\,m^{-3}$ for the same species observed in Prydz Bay in January 1985 during the Antarctic Division SIBEX II marine science cruise (G. W. HOSIE, unpublished data, biomass estimates provided in IKEDA *et al.*, 1986). For the February–March period during FIBEX the observed mean abundance of these species was 35.7 ind. $1000\,m^{-3}$ (WILLIAMS *et al.*, 1983). Table 3 shows the comparison of the abundant sepcies (from Fig. 4) and total zooplankton abundance for these cruises.

Table 3. Comparison of abundance for the major species shown in Fig. 4 and all zooplankton, for previous cruises to the Prydz Bay region. An RMT 8 net with 4.5 mm mesh was used on all cruises, ORI-2000 hauls supplemented RMT8 hauls on ADBEX III. Only hauls within the 0–200 m water layer are compared.

Cruise Sampling period	Net (number)	Haul	*n*	Depth range (m)	Abundance all species		Major species from Fig. 4	Source
					Dens.	Biom.	Dens.	
ADBEX III								
8 October to 25 November 1985	RMT 8 and ORI-2000	Oblique Vertical	9 2	0–200 0–70	185.9	27.0	171.4	Present study
SIBEX II								
4–26 January 1985	RMT 8	Oblique	51	0–200	224.8	40.1	178.6	IKEDA *et al.* (1986) HOSIE, unpubl. data
FIBEX								
20 January to 10 March 1981	RMT 8	Horizontal	44	10–127	53.1	14.9	35.7	WILLIAMS *et al.* (1983)

Dens.: density as No. individuals $1000\,m^{-3}$, Biom.: biomass as g. $1000\,m^{-3}$, n=number of hauls.

The copepod *Calanus propinquus* generally occurred in very small numbers. However, at station 23, in a polynya, an opening-closing RMT 8 haul aimed at a hydroacoustic target located at 45–55 m depth produced a large number of *C. propinquus*, representing a density of 1492 ind. $1000\,m^{-3}$. This is probably a considerable underestimation because of the 4.5 mm mesh used on the RMT 8 net relative to the size of the copepod.

4. Discussion

In the Prydz Bay region, sea ice begins to reform in March and reaches its maximum northern extent in October (JACKA, 1983). Comparison of the abundances in Table 3 shows that the zooplankton community, especially the major species (Fig. 4), was apparently well established under the sea ice in October. By contrast the lower abundance estimates of February and March 1981 (WILLIAMS *et al.*, 1983) indicate a declining zooplankton community at the end of summer. For example, *R. gigas*, the most abundant zooplankter in October 1985 at 58.9 ind. $1000\,m^{-3}$ in the upper 200 m, had an abundance of 31.6 ind. $1000\,m^{-3}$ in January 1985 during SIBEX II and 6.4 ind. $1000\,m^{-3}$ in February–March 1981 for the same depth range (WILLIAMS *et al.*, 1983). Very low zooplankton abundances were also observed in Prydz Bay during March 1987 (G.W. HOSIE, unpublished data). The much higher abundance estimates in October, for both total and major zooplankton, compared with late summer estimates, imply that zooplankton growth and development occur during winter.

The higher abundance of *R. gigas* in the upper 200 m, compared with 200–1000 m, is inconsistent with the life history model of VORONINA (1970). VORONINA proposed that in waters south of the Antarctic Convergence, *R. gigas* lived below 500 m during winter and spring, with ascent to the upper 500 m occurring in summer. However, OMMANEY (1936) and MACKINTOSH (1937) also observed numerous *R. gigas* in the upper 250 m water layer south of the Antarctic Convergence, during October and November. Their results are more consistent with those of the present study. Some seasonal and geographical variation in the onset of the ascending migration is to be expected and is most likely linked to food availability. The higher densities of *R. gigas*, as well as other species, in the upper 200 m suggests that sufficient food was available in the surface waters. Phytoplankton in the 0–50 m layer under the pack ice (59–66°S) in October 1985 were almost entirely diatoms, with a mean cell count of $15.1 \pm 10.5 \times 10^3$ cells l^{-1} (range $3.2–54.9 \times 10^3$ cells l^{-1}, $n=78$) (Mr. A. T. DAVIDSON, pers. commun.). This value is approximately 6 times lower than the mean cell count of $89.1 \pm 59.2 \times 10^3$ cells l^{-1} (range $6.8–259 \times 10^3$ cells l^{-1}, $n=54$) for January 1985 for the same latitude in Prydz Bay (Dr. H. J. MARCHANT, pers. commun.).

Larval occurrence was restricted to calyptopis stages in October, with no advanced furcilia, indicating that the onset of spawning of both *T. macrura* and *E. frigida* was very recent. MAKAROV (1979) previously noted that spawning of these two species began in September in the Scotia Sea. No detailed data on larval development times exists at present for these species. However, comparison with development times for the larvae of *E. superba* (IKEDA, 1984) and *E. crystallorophias* (IKEDA, 1986) based on laboratory observations, suggests that larvae at the CI stage were spawned in early

September, with CIII larvae of *E. frigida* resulting from early to mid August spawning. Therefore, spawning in *E. frigida* either precedes that of *T. macrura* or the larvae of *E. frigida* have a faster development time.

In order that spawning can occur in late winter, gonads must mature during winter. The spawning period of *T. macrura* extends at least to mid January (MAKAROV, 1979; HOSIE and KIRKWOOD, 1986). Therefore, it is not unlikely that, in addition to later spawners, females having released eggs in September may produce eggs during the next 4 months. The ability to produce more than one brood per season has been reported for *E. superba* (DENYS and MACWHINNIE, 1982; ROSS and QUETIN, 1983; HARRINGTON and IKEDA, 1986) and for *E. pacifica* (ROSS *et al.*, 1982). Repeated maturation has been observed in other species of *Euphausia* and *Thysanoessa* (MAKAROV, 1975), If spawning as early as September is to be a viable reproductive strategy, for either *T. macrura* or *E. frigida*, then sufficient food must be available during winter for egg production, as well as later for continued spawning (with possible rematuration) and survival of the larvae. The alternative situation of insufficient food would result in egg production occurring at the expense of the individual's own body tissue and also a much higher larval mortality.

Despite the recent start to spawning and presence of gravid female *T. macrura*, no eggs or any naupliar stage were collected. Nor have these stages been collected in substantial numbers, at any depth, during the previous surveys using 300 μm mesh (HOSIE and KIRKWOOD, 1986; IKEDA *et al.*, 1986). This is a clear indication of the unsuitability of this mesh size for collecting these early stages, of either species, which measure between 0.42 and 0.55 mm in length (KIRKWOOD, 1982). The previous studies were concerned more with the larvae of *E. superba*, for which 300 μm mesh was adequate. Loss of eggs by damage during the sampling process is also likely (MARSCHALL and HIRCHE, 1984).

The net sampling was not very extensive but the large number of krill observed under the ice at station 43 (O'BRIEN, 1987) shows that krill remain inshore during pack-ice development. Similarly, KAWAGUCHI *et al.* (1986) observed krill overwintering under the coastal fast ice in Lützow-Holm Bay to the west of the present study area.

The mean sizes of year groups 1+ and 2+ observed in this study are comparable to values recorded by SIEGEL (1987) in the Atlantic sector in October 1983 and 1986. Moreover, the estimates for the 0+ age group are the same in both studies. Spawning in *E. superba* commences at the beginning of January in Prydz Bay. The size of group 0 in mid January 1985 was calculated as 1.2 mm, although the metanauplius stage predominated (HOSIE *et al.*, 1988). By the end of March of 1987 *E. superba* larvae in general had only progressed as far as the calyptopis stages (G.W. HOSIE, unpublished data). Although few in number, the late stage furcilia larvae present in late September–early October would have over-wintered. Further, the larger component of small juveniles in the 0+ year group seen in October shows growth and development continuing during winter. This represents an approximate growth rate of 0.047 mm d^{-1} between March and October, which is half the daily rate recorded by IKEDA (1985) in laboratory studies for this age group. The slower growth rate is most likely a result of partial food limitation experienced by the 0+ year group.

Various field and laboratory-based studies have shown that post-larval krill either

cease growing (IKEDA, 1985; SIEGEL, 1987) or shrink in body size (IKEDA and DIXON, 1982; STEPNIK, 1982; KAWAGUCHI *et al.*, 1986) during winter, when there is supposedly a paucity of food. The results of this study, however, indicate that zooplankton, smaller euphausiids and larvae may not find food limiting, or at least only partially limiting, in winter and later during the period of maximum ice cover.

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