

Micronekton and Macrozooplankton in the Open Waters Near Antarctic Ice Edge Zones (AMERIEZ 1983 and 1986)

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Summary. Micronekton and macrozooplankton assemblages (0–1000 m) were sampled from the open ocean in the vicinity of marginal ice zones in the southern Scotia and western Weddell Seas using midwater trawls. Small regional differences in species composition were found in the differing hydrographic settings with the Scotia Sea being slightly more diverse. Most species exhibited broad vertical ranges with no distinct pattern of vertical movement. Exceptions were mesopelagic fish and *Salpa thompsoni* which undertook diel vertical migrations. Biomass was high (2.4–3.1 g DW/m²), comparable to Pacific subarctic waters. *Euphausia superba* and *Salpa thompsoni* were the numerical and biomass dominants, representing over 50% of the total numbers and standing stocks. In terms of biomass, euphausiids were the most important group at shallow depths (0–200 m) but were surpassed by salps in the Scotia Sea and mesopelagic fish in the Weddell Sea when all depths down to 1000 m were considered. Pelagic fish biomass (3.3–4.4 g WW/m²) greatly exceeded published estimates for birds (0.025–0.070 g WW/m²), seals (0.068–0.089 g WW/m²) and whales (0.167 to 0.399 g WW/m²), making mesopelagic fish the most prevalent krill predators in the Antarctic oceanic system.

Introduction

The Southern Ocean has traditionally been characterized as a simple ecosystem, largely dominated by the Antarctic Krill (*Euphausia superba*). However, only recently have authors (Clarke 1985; Hempel 1985) suggested that the Southern Ocean contains several ecosystems, each more complex than has generally been thought. The misconception was due to the scarcity of information on species other than *E. superba*. The amount of work concerning *E. superba* has grown at a tremendous rate while other pelagic micronekton and macrozooplankton species (animals 2–20 cm in length) have been given little attention.

Despite intensive sampling by many nations, quantitative data on the Antarctic oceanic community (0–1000 m) are rare. Most work concerns species composition, geographic distribution and taxonomy (Andriashev 1965; Bekker and Evseenko 1987; Dewitt 1971; Iwasaki and Nemoto 1986; Kock 1982; Mackintosh 1934; Miya et al. 1986; Nagata 1986; Piatkowski 1985 a, b; Pommeranz 1978; Wasmer 1986; Worner 1979). Only a few papers discuss patterns of vertical distribution (Efremenko 1987; Piatkowski 1985 b; Mujica and Asencio 1985) with even fewer (Piatkowski 1985 a, b) reporting absolute abundances. In many studies, abundance and biomass data on macrozooplanktonic and micronektonic species, other than *E. superba*, are fragmentary.

Euphausia superba dominates the Southern Ocean pelagic ecosystem but other species, particularly *Salpa thompsoni*, squid, and mesopelagic fish, can be very important elements. For example, *Salpa thompsoni* can exceed the numerical abundance of *E. superba* (Piatkowski 1985 a, b). Mesopelagic fish (Asencio and Moreno 1984; Hopkins 1985; Rowedder 1979; Williams 1985) and squid (Nemoto et al. 1985) are important predators on krill, the dominant prey in the diets of both groups. Krill, mesopelagic fish, and squid, in turn, are major sources of food for seals, whales, and seabirds (Everson 1977). Without information on abundance and standing stock of Antarctic macrozooplankton and micronekton species any ecosystem model of the Southern Ocean will be incomplete. This paper presents a description of the vertical structure, species composition, numerical abundances and standing stocks of an Antarctic oceanic faunal assemblage in the Scotia and western Weddell Seas down to 1000 m.

Methods

Micronekton and macrozooplankton were sampled as part of the Antarctic Marine Ecosystem Ice Edge Zone (AMERIEZ) project during November–December 1983 and March 1986 in the open water near

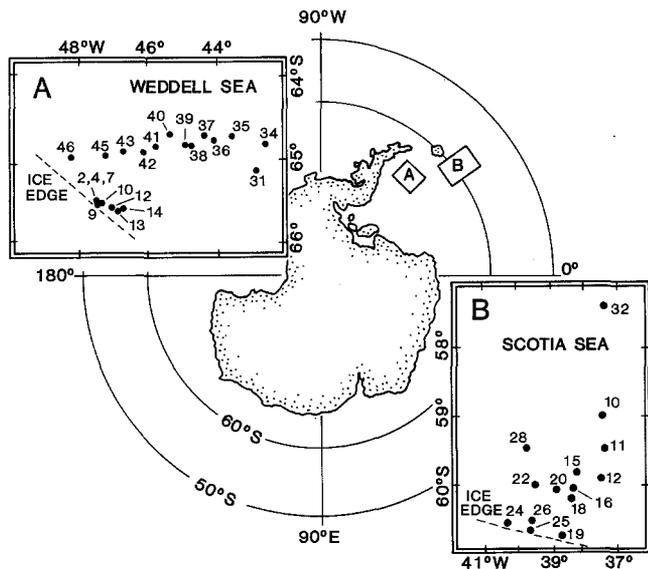


Fig. 1. Sampling areas in the Weddell Sea (A) and the Scotia Sea (B). Numbers are tow numbers corresponding to those in Table 1

marginal ice zones. Most samples were taken relatively distant from the ice edge so this data is most representative of open oceanic regions. In 1983 samples were taken in the southern Scotia Sea while the 1986 sampling area was in the western Weddell Sea (Fig. 1).

Sampling was conducted using a 9 m² mouth area, opening-closing modified Tucker trawl with a 4 mm mesh main net tapering to a 1 mm plankton cod end net (Davies and Barham 1969). Trawls were towed at an average speed of 2 knots. Simple jug-type cod ends as well as thermally protecting cod ends (Childress et al. 1978) with 1 mm liners were used. The trawl was opened and closed with clock actuated releases (Davies and Barham 1969). The volume of water filtered was estimated with a dial type flowmeter (Hopkins and Baird 1975) activated only when the net was fishing. Trawling depth was estimated by wire angle triangulation and continuously recorded with a time-depth recorder mounted on the trawl frame. A collapsible 0.75 m, 163 micron mesh plankton net was concurrently fished while nested within the mouth of the trawl (Hopkins and Torres 1988). Micronektonic or macrozooplanktonic animals (2–20 cm) captured in the plankton net were included with the trawl catch. This size range precluded the analysis of larval fish and larger zooplankton species.

Thirty-five tows performed during the two sampling periods were used in this study (Table 1 and Fig. 1). Fourteen discrete depth tows (7 night, 7 day) taken in 1983 and 21 discrete tows (13 night, 8 day) during 1986 were the basis for determining vertical depth ranges, vertical migratory patterns, as well as integrated abundance and biomass estimates.

All trawl catches were preserved in a buffered 5–10% formaldehyde solution, shipped to the laboratory, and stored in 50% isopropyl alcohol. However, prior to preservation, subsampling of the tow catch (1–2 l) was often required because of the considerable salp (*Salpa thompsoni*) biomass. In the laboratory, salps from the preserved subsample were counted and weighed collectively with numbers and biomass subsequently being extrapolated to the entire catch. All other species were sorted from the tow catch and subsample, then enumerated, individually weighed, and identified to the lowest possible taxon. Preserved length-wet weight and fresh length-wet weight regressions for common species (Donnelly et al., in review; J.J. Torres, unpublished data) were not significantly different (all *t*-tests, $P > 0.05$). Ctenophores were sorted prior to subsampling and counted. Their weight was estimated by taking volume measurements and assuming 1 l of ctenophores equaled 1000 g. Ctenophores were not identified to species. Dry weight (DW) was computed by subtracting water content (determined by drying fresh frozen specimens to constant weight at

60°C) from measured wet weights (WW). Dry weight estimates were emphasized in this study because the ease of their conversion to organic carbon (Omori 1969) facilitates use in ecosystem modelling. However, wet weight biomass values were also presented for comparison.

Each taxon's integrated abundance (number/m²) for the water column was calculated by dividing its number in the catch by the water volume filtered for each tow, multiplying that quotient by the vertical range (in meters) of that tow, and then summing all tows vertically. This procedure was performed for day and night tow series over two depth ranges, 0–200 m and 0–1000 m. Integrated biomass values (mg DW/m²) were determined using an identical protocol. Nighttime abundances were greater than daytime catches (Fig. 3 a–h), suggesting daytime net avoidance. Therefore nighttime values were taken as the most accurate estimates for abundance and biomass.

Hydrographic data were collected from CTD casts taken near our trawling positions D.G. Mountain and B.A. Huber, unpublished data; Husby and Muench 1988).

Results

Hydrographic Setting

Three water masses can be discerned from the temperature and salinity profiles taken in both oceanic regions

Table 1. Trawl data from 1983 (Scotia Sea) and 1986 (Weddell Sea)

Tow no.	Depth (m)	Lat. (S)	Long. (W)	Local time		Vol. filt. (10 ³ m ³)
				Open	Close	
1983						
10	270–400	58° 52.4	37° 35.6	2315	0115	7.1969
11	430–500	59° 21.6	37° 20.4	1204	1404	11.2077
12	0–90	59° 56.8	37° 24.8	0046	0120	1.5390
15	600–1000	59° 43.3	38° 06.8	2200	0000	7.4016
16	0–100	60° 01.6	38° 21.2	0846	0938	2.3706
18	100–170	60° 15.5	38° 45.6	1057	1157	4.6611
19	100–200	60° 40.9	38° 35.7	2311	0011	4.7448
20	200–290	60° 01.6	38° 49.1	0828	0928	4.0545
22	390–530	59° 56.1	39° 18.5	1212	1342	5.0184
24	190–280	60° 28.2	40° 32.9	1009	1139	8.3295
25	350–550	60° 28.1	39° 48.5	1828	1958	5.1372
26	250–370	60° 24.5	39° 29.0	0004	0134	4.5657
28	500–900	59° 30.7	39° 44.7	1022	1222	3.1384
32	0–125	57° 12.4	37° 36.7	2340	0045	2.1816
1986						
2	0–50	65° 31.8	47° 31.9	1726	1822	2.2041
4	0–50	65° 36.4	47° 37.8	2106	2203	2.4267
7	200–300	65° 33.0	47° 25.0	0405	0505	2.5755
9	260–380	65° 38.0	47° 24.7	0913	1013	4.5787
10	50–115	65° 36.6	47° 15.7	1350	1450	3.1250
12	40–90	65° 43.3	47° 03.0	2234	2334	3.6630
13	170–260	65° 49.5	46° 52.2	0110	0210	2.3581
14	340–470	65° 47.4	46° 39.3	0349	0449	2.2092
31	0–100	65° 11.9	42° 59.8	0030	0422	10.6742
34	0–55	64° 50.6	42° 40.2	0024	0126	2.7980
35	150–250	64° 39.6	43° 37.5	1515	1615	5.8379
36	200–310	64° 43.9	44° 09.0	2232	2332	3.7478
37	0–40	64° 36.4	44° 18.4	0104	0210	2.4038
38	400–560	64° 50.8	44° 43.2	1111	1211	3.3196
39	550–750	64° 49.1	44° 57.1	1423	1523	2.9418
40	530–710	64° 42.6	45° 19.5	2233	2333	2.7472
41	900–1000	64° 50.6	45° 44.6	0235	0335	2.4038
42	650–920	64° 54.5	46° 05.9	1226	1357	3.8919
43	100–150	64° 56.2	46° 44.2	2205	2305	3.7180
45	100–150	64° 56.6	47° 12.7	1108	1203	2.5549
46	0–50	65° 02.4	48° 11.4	2100	2154	2.5526

Table 2. Micronekton and macrozooplankton species list and vertical distribution. Depths of peak numerical abundances are in parentheses. Data primarily based on discrete 1983 and 1986 samples. Abbreviations are n = sample size from discrete tows unless noted, S = Scotia Sea, W = Weddell Sea, and B = Both areas

Species (n)	Day range (m)	Night range (m)	Area
Fish			
<i>Bathylagus antarcticus</i> (189)	100–980 (650–920)	0–1000 (170–470)	B
<i>Electrona antarctica</i> (288)	170–980 (650–920)	0–710 (0–300)	B
<i>Electrona carlsbergi</i> (1)		0–260	S
<i>Gymnoscopelus braueri</i> (63)	190–980 (500–980)	0–1000 (160–300)	B
<i>Gymnoscopelus opisthopterus</i> (39)	650–980 (500–980)	100–1000 (250–370)	B
<i>Gymnoscopelus bolini</i> (1)	0–1000*		W
<i>Gymnoscopelus nicholsi</i> (1)		0–1000*	W
<i>Krefflichthys anderssoni</i> (5)	200–530	b 270–400	S
<i>Protomyctophum bolini</i> (2)	190–280	b 270–400	S
<i>Cyclothone microdon</i> (28)	390–920	600–1000	B
+ <i>Cyclothone</i> sp. (3)		350–550	B
<i>Notolepis coatsi</i> (343)	50–980 (200–750)	b 100–1000 (100–500)	B
△ <i>Benthalbella elongata</i> (2)	500–980		S
△ <i>Paradiplospinus gracilis</i> (4)	190–980		S
△ <i>Nansenia antarctica</i> (4)	0–1000*		S
△ <i>Cyanomacrurus piriei</i> (3)	0–1000*		S
△ <i>Poromitra crassiceps</i> (1)	0–1000*		S
Crustaceans			
<i>Euphausia superba</i> (13323)	0–980 (0–50)	0–1000 (0–100)	B
<i>Euphausia triacantha</i> (192)	200–280	0–400	S
<i>Thysanoessa macrura</i> (1011)	0–920 (260–560)	b 0–1000 (100–460)	B
<i>Cylopus lucasii</i> , 1983 (43)		b 100–1000 (350–550)	B
<i>Cylopus lucasii</i> , 1986 (158)	50–560 (50–115)	0–300 (0–50)	B
<i>Cyphocaris richardi</i> (20)	650–920	340–470	B
<i>Cyphocaris faueri</i> (5)		40–1000	B
<i>Primno macropa</i> (16)	50–920	0–710	B
<i>Eusirus microps</i> (1)	340–470		W
<i>Parandania boeckii</i> (3)	390–530	270–400	S
<i>Vibilia stebbingi</i> (3)		b 100–710	B
<i>Lanceola</i> sp. (2)		100–300	W
<i>Nematocarcinus lanceopes</i> (123)	0–920 (0–50)	0–260 (0–90)	B
<i>Pasiphaea scotiae</i> (44)	650–980	b 100–1000	B
<i>Petalidium foliaceum</i> (2)	0–1000*	600–1000	B
<i>Gigantocypris mulleri</i> (3)	0–1000*	b 350–1000	B
<i>Boreomysis sibogae</i> (1)		0–1000*	W
<i>Boreomysis inermis</i> (1)		600–1000	S
<i>Eucopia australis</i> (2)		600–1000	S
Molluscs			
<i>Galiteuthis glacialis</i> (59)	50–750 (50–370)	b 100–1000 (100–450)	B
<i>Alluroteuthis antarcticus</i> (3)	0–200	530–710	W
<i>Clio pyramidata</i> (953)		0–50	W
Macrozooplankton			
<i>Salpa thompsoni</i> , 1983 (82881)	100–980 (200–530)	0–550 (350–550)	B
<i>Salpa thompsoni</i> , 1986 (10523)	50–920 (50–115)	0–1000 (0–50)	
<i>Sagitta gazellae</i> (2522)	0–920 (200–530)	0–1000 (270–550)	B
<i>Sagitta marri</i> (228)	400–920	270–1000	B
<i>Eukrohnia hamata</i> (818)	100–920	100–1000	B
<i>Calycopsis borchgrevinki</i> (117)	100–750 (400–550)	0–710 (100–450)	B
△ <i>Stygiomedusa gigantea</i> (1)		0–1000*	W
<i>Atolla wyvillei</i> (34)	50–980	100–1000	B
<i>Periphylla periphylla</i> (19)	150–920	0–1000	B
<i>Tomopteris carpenteri</i> (24)	0–290	0–200	B
<i>Travislopsis coniceps</i> (3)	0–200	0–200	B
<i>Vanadis antarctica</i> (95)	0–500	0–470	B

* 0–1000 m oblique tow

△ Found in tows not listed in Table 1

+ Described as *Cyclothone sumiae* (Kobayashi, unpublished Ph d 1973)

b Found in surface-feeding seabirds (D.G. Ainley, personal communication)

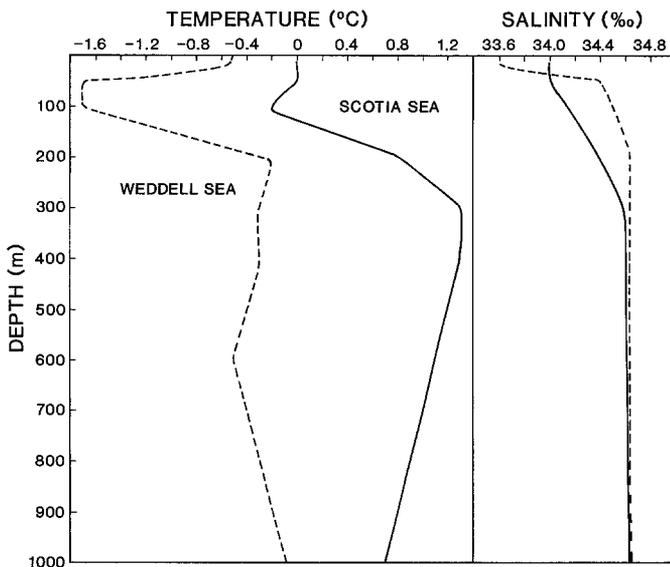


Fig. 2. Hydrographic profiles in study sites. Dotted line (---) is the Weddell Sea and solid line (—) is the Scotia Sea

(Fig. 2). A surface layer about 50 m thick overlaid a second much colder layer (Winter Water). The Winter Water layer was centered at 100 m extending from about 50 m to below 200 m. A third warmer zone extended from below 200 m to the maximum depths sampled in this study. The hydrographic profiles from the Scotia Sea were typical (Stein 1986) of the warmer Weddell-Scotia Confluence (WSC) while the water properties indicated by the profiles from our Weddell site were similar to those found by Foster and Carmack (1976) from the Weddell Gyre, a relatively stable, well-defined oceanic system. The geographic position of the WSC, on the other hand, has been shown to be highly variable (Stein 1986). According to our hydrographic data, the WSC was present near the Scotia Sea sampling site but absent from the Weddell Sea area during the sampling periods.

Species Composition and Vertical Distribution

Forty-nine species of macrozooplankton and micronekton were collected from the two study sites (Table 2). Regional differences were present but subtle. Diversity was marginally higher in the Scotia Sea with a total of 41 species, of which 11 (27%) were found only there. The Weddell Sea had 37 species, of which 8 (22%) were collected only in that region. While most of the species unique to their respective areas were rare, two relatively abundant species (*Euphausia triacantha* – Scotia Sea; *Clio pyramidata* – Weddell Sea) were found solely in one region. Larger predatory fish (*Benthalbella elongata*, *Paradiplospinus gracilis*, *Cyanomacrurus piriei*) were found only in the Scotia Sea. The capture of *Poromitra crassiceps* is the first known record of this species from the Antarctic (Ebeling and Weed 1973). *Salpa thompsoni* was the only salp identified from either sampling site.

Cephalopods were probably under-represented because many can swim faster than the net was towed.

The vertical depth ranges shown in Table 2 were relatively broad with many species occurring from the surface to the deepest depths sampled. Only the fish (*Bathylagus antarcticus*, *Electrona antarctica*, *Gymnoscopelus braueri*, *G. opisthopterus*, and *Notolepis coatsi*) exhibited strong diel migratory patterns (Fig. 3a–d). Of these five fishes only *N. coatsi* was never found in surface waters (0–50 m tows). However, *N. coatsi* and two myctophids (*Krefflichthys anderssoni* and *Protomyctophum bolini*) were found in the stomachs of surface-feeding seabirds (D.G. Ainley, personal communication) so these species also show vertical migration to surface waters (Table 2). *Cyclothone microdon*, a deep-dwelling gonostomatid, did not migrate. *Salpa thompsoni* (Fig. 3e) and *Cylopus lucasii* (Fig. 3f) undertook weak migrations. The dominant euphausiids, *E. superba* and *Thysanoessa macrura* (Fig. 3g, h), and all other macrozooplankton apparently did not migrate. However, as with the fish, several crustaceans and one squid were found in seabirds indicating shallower distributions than found from our trawl catches (Table 2).

Cylopus lucasii and *S. thompsoni* were the only species that showed inter-annual differences in vertical ranges as both tended to reside deeper in 1983 (Table 2, Fig. 3e, f). In both years depths of peak abundance were identical for the two species despite the year to year shift in overall vertical range.

Abundance and Standing Stock

Euphausia superba and *S. thompsoni* were the numerically dominant species representing over 50% of all organisms sampled in the two areas (Table 3). Other common species include the euphausiid, *Thysanoessa macrura* and the chaetognaths *Sagitta gazellae* and *Eukrohnia hamata*. These five species accounted for over 88% of all micronekton and macrozooplankton collected (Table 3).

Euphausia superba was, on the average slightly less abundant in the upper 1000 m of the Scotia Sea ($4.3/m^2$) than the Weddell Sea ($6.1/m^2$) but considering the patchy distribution of this species these values were probably not different. On the other hand, the average abundance of *S. thompsoni* was considerably higher in the Scotia Sea ($145.3/m^2$ vs $5.6/m^2$).

The standing stock values presented in Table 4 illustrate that most of the biomass was produced by only a few species. Notably, *E. superba*, *S. thompsoni*, *E. antarctica*, *G. braueri*, *G. opisthopterus*, *B. antarcticus* and the coronate scyphomedusa *Periphylla periphylla* accounted for over 85% of total dry weight biomass during both years. *Euphausia superba* contributed over 31% of total dry weight standing stock averaged over both sampling periods. With *S. thompsoni* averaging about 22% of total dry biomass over both periods, these two numerically dominant species also represented over 50% of all dry weight standing stocks.

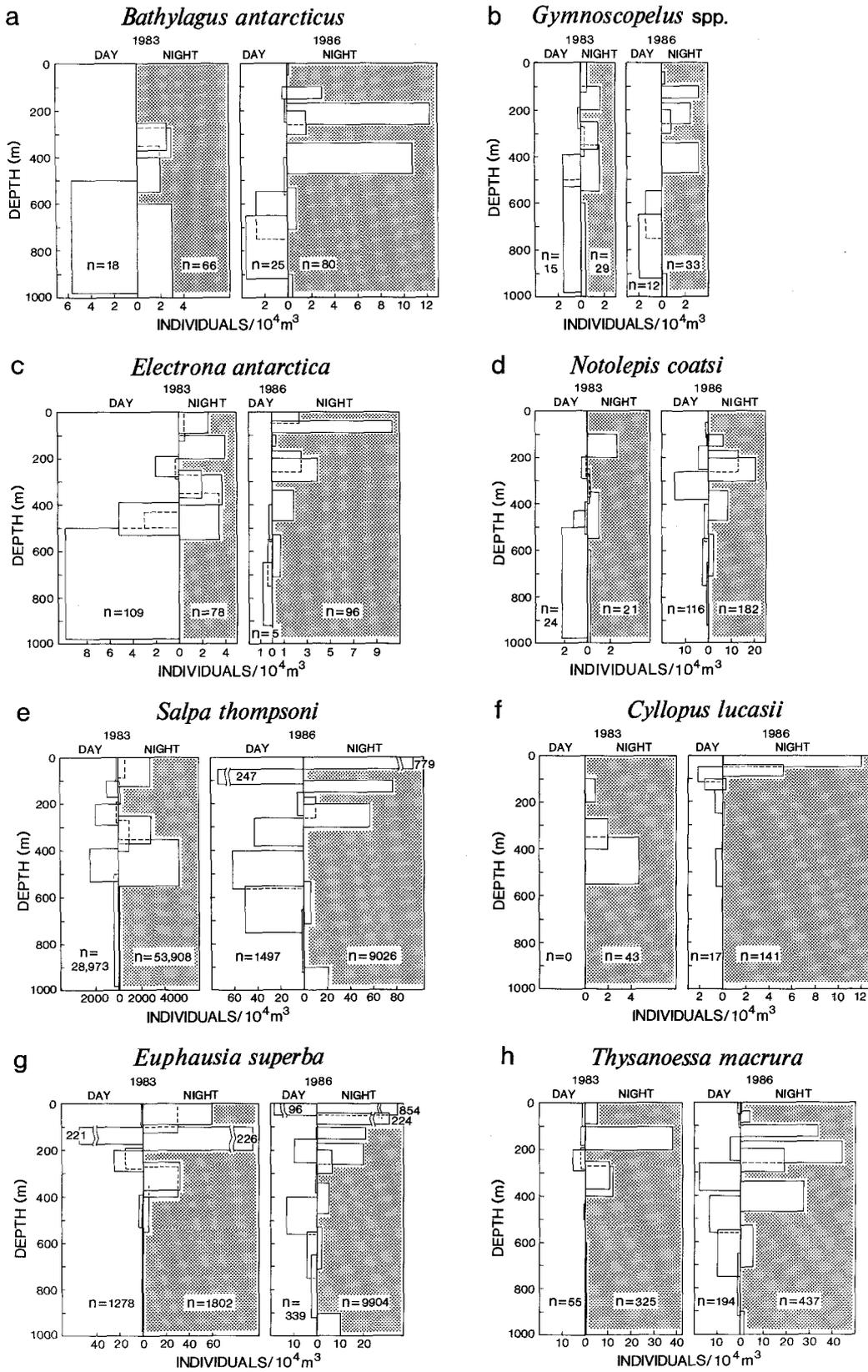


Fig. 3. Diel vertical distribution of eight important species. n = numbers of specimens collected

Table 3. Numerical abundances (No./m²) for important micronekton and macrozooplankton on the open water near ice margins. Integrated estimates based on discrete night tows. Percentage contribution of total numbers by each group in parentheses. Sampling sites: 1983, Scotia Sea; 1986, Weddell Sea

Species	0–200 m		0–1000 m	
	1983	1986	1983	1986
No. of tows	3	7	7	13
<i>Euphausia superba</i>	3.11	5.59	4.34	6.05
<i>Thysanoessa macrura</i>	0.41	0.41	0.91	1.31
<i>Salpa thompsoni</i>	17.48	4.32	145.33	5.62
<i>Sagitta gazellae</i>	0.38	0.36	1.88	2.08
<i>Eukrohnia hamata</i>	0.03	0.18	0.85	2.73
Subtotal	21.41 (98.5)	10.86 (91.7)	153.31 (98.9)	17.79 (88.4)
<i>Electrona antarctica</i>	0.07	0.08	0.18	0.17
<i>Bathylagus antarcticus</i>	0	0.08	0.20	0.15
<i>Gymnoscopelus</i> spp.	0.01	0.03	0.05	0.13
<i>Notolepis coatsi</i>	0.03	0.09	0.06	0.51
<i>Cyclothone microdon</i>	0	0	0.11	0.06
Subtotal	0.11 (0.5)	0.28 (2.4)	0.60 (0.4)	1.02 (5.1)
Others	0.22 (1.0)	0.70 (5.9)	1.10 (0.7)	1.31 (6.5)
Total	21.74 (100.0)	11.84 (100.0)	155.01 (100.0)	20.12 (100.0)

Table 4. Taxonomic composition and biomass (mgDW/m²) of important micronekton and macrozooplankton in open water in the vicinity of ice edge zones. Wet biomass values (mgWW/m²) are in parentheses. Column biomass estimates based on integrated discrete night tows as in Table 3

Species	0–200 m		0–1000 m	
	1983	1986	1983	1986
Euphausiacea				
<i>Euphausia superba</i>	773 (2371)	616 (1889)	1077 (3303)	667 (2046)
<i>E. triacantha</i>	3 (9)	–	8 (25)	–
<i>Thysanoessa macrura</i>	7 (20)	8 (23)	15 (43)	27 (77)
Subtotal	783 (2400)	624 (1912)	1100 (3371)	694 (2123)
Thaliacea				
<i>Salpa thompsoni</i>	105 (2143)	137 (2796)	1156 (23592)	159 (3245)
Pisces				
<i>Electrona antarctica</i>	74 (226)	132 (404)	314 (960)	273 (835)
<i>Gymnoscopelus braueri</i>	1 (3)	17 (51)	128 (383)	86 (258)
<i>G. opisthopterus</i>	55 (182)	46 (152)	81 (268)	304 (1007)
<i>Krefflichthys anderssoni</i>	–	–	2 (7)	–
<i>Bathylagus antarcticus</i>	–	60 (432)	216 (1554)	283 (2036)
<i>Cyclothone microdon</i>	–	–	31 (84)	20 (54)
<i>Notolepis coatsi</i>	<1 (1)	1 (5)	1 (5)	9 (44)
Other	–	40 (120)	–	40 (120)
Subtotal	130 (412)	296 (1164)	773 (3261)	1015 (4354)
Coelenterata				
<i>Periphylla periphylla</i>	–	235 (13823)	6 (353)	240 (14118)
<i>Atolla wyvillei</i>	–	2 (118)	1 (59)	32 (1882)
<i>Calyropsis borchgrevinki</i>	<1 (6)	1 (59)	<1 (12)	2 (118)
Other Cnidaria	–	1 (59)*	–	16 (941)
Ctenophora	–	99 (1021)	–	99 (1021)
Subtotal	<1 (6)	338 (15080)	7 (424)	389 (18080)
Other Micronekton/ macrozooplankton	9 (30)	52 (173)	96 (320)	120 (400)△
Total	1027 (4991)	1447 (21125)	3132 (30968)	2377 (28202)

* Excludes 1 specimen of *Stygiomedusa gigantea*

△ Excludes 1 specimen of *Alluroteuthis antarcticus*

Total dry biomass of all micronekton and macrozooplankton for the 0–1000 m zone ranged from 3.1 to 2.4 g DW/m² in 1983 and 1986, respectively (Table 4). Biomass in the upper 200 m varied between 1.0 and 1.5 g DW/m² in 1983 and 1986. Euphausiids, principally *E. superba*, were the dominant biomass group in shallow waters (0–200 m) but mesopelagic fish (in 1986) and salps (in 1983) were the most important taxa in the entire epimesopelagic zone (0–1000 m) of both regions. *Electrona antarctica*, a shallow living myctophid, was the most important fish species in the upper 200 m. However, when the entire sampling range (0–1000 m) was considered, the dry weight biomass contribution of two deeper dwelling fish species (*B. antarcticus* and *G. opisthopterus*) exceeded that of *E. antarctica* in 1986.

Wet weight biomass estimates for the upper 1000 m ranged from 31.0 to 28.2 g WW/m² in the Scotia (1983) and Weddell Seas (1986), respectively (Table 4). Gelatinous zooplankton (salps and coelenterates) were responsible for over three quarters of wet weight estimates but only about one third of dry weight values.

Discussion

The species lists for both sampling areas were representative of typical Antarctic oceanic fauna (Mackintosh 1934). Abundant neritic species like *Pleuragramma antarcticum*, *Euphausia crystallorophias* and *Antarctomysis* spp. were notably absent. Decapod shrimps, which are typically abundant in oceanic systems (Hopkins and Lancraft 1984; Maynard et al. 1975) were uncommon, being represented by only three rare species.

The proximity of the WSC and its associated warmer waters during the Scotia Sea cruise undoubtedly contributed to the differences in taxonomic composition between the two regions. *Euphausia triacantha*, most common near or just south of the WSC (Kirkwood 1982), predictably occurred only in our Scotia Sea samples. *Electrona carlsbergi*, *Krefflichthys anderssoni* and *Protomyctophum bolini* are all subantarctic myctophids (Bekker and Evseenko 1987; Efremenko 1987; Miya et al. 1986; Zasel'slii et al. 1985) that were also found only in the Scotia Sea. *Salpa thompsoni*, usually associated with the West Wind Drift, was much less common in the Weddell sea. This was an observation in accord with that of other authors (Mackintosh 1934; Piatkowski 1985 b; Witek et al. 1985) who noted the absence of that species in the Weddell Sea. While *S. thompsoni* is known to vary seasonally (Foxton 1966; Piatkowski 1985 b) the above studies (Mackintosh 1934; Piatkowski 1985 b; Witek et al. 1985) were also performed in spring and summer months so the changes in abundance are probably the result of geographic not seasonal effects.

Salpa thompsoni showed a weak vertical migration pattern, an observation well documented by Piatkowski (1985 a, b). *Cylopus lucasii* exhibited vertical distribution patterns identical to the salp. The two species had the same depths ranges in both years even though the ranges

for both were deeper in the Scotia Sea. It is probable that *C. lucasii* is a symbiont with salps in a manner similar to other vibiliid amphipods (Madin and Harbison 1977).

Except for *Cyclothone*, a well known non-migratory genus (Maynard 1982; Miya and Nemoto 1986), all of the abundant mesopelagic fish migrated to surface waters at night. Infrequently encountered fish (*K. anderssoni* and *P. bolini*) also migrated to the surface as indicated by their presence in the diet of shallow-diving seabirds (D. G. Ainley, personal communication). Because of the vertical migrations undertaken by mesopelagic fish and salps, these important biomass species that live at greater depths during the day were available to highly mobile nocturnal predators like mammals, birds and other fish.

Euphausia superba did not vertically migrate nor did any of the other macrozooplanktonic species. This observation is consistent with that of Piatkowski (1985 a, b) who found the same lack of vertical migration among the macrozooplankton. Many of the macrozooplankton are probably poor swimmers and would not normally undergo vertical migrations but euphausiids from other regions typically do (Mauchline and Fisher 1969). It has been speculated that vertical migration (McLaren 1963) and schooling (Cushing and Jones 1968) are behaviors to avoid predation. *Euphausia superba* may obviate the need to escape visual predators by occurring in dense swarms during the day (Piatkowski 1985 a, b) rather than vertically migrating to the poorly-lighted mesopelagic zone.

Because of the nature of this study (broad geographical coverage during two seasons) separation of geographical and seasonal effects were difficult. Some results argue that both areas (or seasons) were similar, suggesting that the effects were minimal. For example, in both collections the numerical dominants were the same. Standing stocks were similar between collections, *S. thompsoni* being the notable exception with geographical differences in abundance. There were no differences in vertical distribution patterns except in *S. thompsoni* and the associated *C. lucasii* and these patterns may be related to geographical differences. Any conclusions regarding seasonal trends must await further data.

The Scotia and Weddell Seas had relatively high micronekton and macrozooplankton standing stocks when compared to other oceanic areas. Dry weight nighttime biomass (0–1000 m) was 4–5 times more than that found by Hopkins and Lancraft (1984) in the Gulf of Mexico (0.573 g DW/m²; data adjusted from ash free dry weight). However, Antarctic nighttime dry weight biomass in the upper 200 m was similar to that collected by Percy (1976) from subarctic waters off Oregon (1.027–1.447 vs 1.320 g DW/m², respectively). Total Antarctic fish biomass (3.261–4.354 g WW/m²) was also more similar to that measured from the subarctic (3.600 g WW/m²) by Percy and Laurs (1966) than that collected in low latitude areas like the Gulf of Mexico (1.462 g WW/m²; Hopkins and Lancraft 1984) or off Hawaii (1.265 g WW/m²; Maynard et al. 1975).

The importance of deeper-dwelling groups such as fish and salps has been underestimated in the Antarctic Ocean. *E. superba* was surpassed in biomass contribution (wet and dry) by *S. thompsoni* in the Scotia Sea and mesopelagic fish in the Weddell Sea. Mesopelagic fish biomass for the entire Southern Ocean ($38.1 \times 10^6 \text{ km}^2$; El-Sayed 1978) was computed as $133\text{--}191 \times 10^6$ tons, a value very close to that estimated by Russian surveys ($140\text{--}190 \times 10^6$ tons; Kock 1987). It is also ten times that calculated for all Antarctic bottom fish (Kock 1987). Despite potential underestimates due to net avoidance, our estimates of mesopelagic fish biomass (3.3 to 4.4 g WW/m^2) greatly exceeded that for Antarctic birds ($0.025\text{--}0.070 \text{ g WW/m}^2$), seals ($0.068\text{--}0.089 \text{ g WW/m}^2$) and whales ($0.167\text{--}0.399 \text{ g WW/m}^2$) as estimated by Ainley (1985) and Laws (1977). Thus, on the basis of biomass alone, mesopelagic fish are the most prevalent predators on krill in the Antarctic oceanic system.

The study sites can be characterized as low diversity oceanic faunal assemblages. Tropical-subtropical oceanic ecosystems have four to five times the number of fish and crustacean species (Hopkins 1981; Hopkins and Lancraft 1984) as were found in both Antarctic areas combined. Similarly, in terms of fish species alone, the study areas were more typical of subarctic regions like the Bering Sea (17 species: Pearcy et al. 1979) than temperate waters off California (52 species: Rainwater 1975) or the tropical-subtropical Gulf of Mexico (over 100 species: Hopkins and Lancraft 1984). The low species number (49) and the fact that two (*E. superba* and *S. thompsoni*) account for over 50% of both numbers and dry biomass suggest a vulnerability to perturbation, especially if many species have slow growth rates and low reproductive turnover as has been noted (Hempel 1985). No long lived organism (whales, seals and bottom fish) has sustained a fishery after the virgin stocks were depleted (Kock 1987). There are some indications that the reduction of whales has left a surplus of krill uneaten (Everson 1977) that has apparently had profound positive effects on krill predators like seals (Bengtson and Laws 1985) and negative effects on krill competitors like herbivorous copepods (Kawamura 1986). The effects of the whale and krill fisheries on micronekton and macrozooplankton are unknown, underscoring the need for more information on food web structure and life histories of ecosystem components other than *E. superba*.

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