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# Demersal fish fauna of the Weddell Sea, Antarctica

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**Abstract:**The demersal fish fauna of the southern and eastern Weddell Sea is described. The following species were recorded for the first time in this area: *Aethotaxis mitopteryx*, *Bathyraja eatoni*, *B. maccaini*, *B.* sp2 (FAO-list), *Bathydraco marri*, *Dissostichus mawsoni*, *Macrourus holotrachys*, *Muraenolepis* sp., *Notothenia coriiceps*, *Notothenia kempi*, *Psilodraco spec.* and *Trematomus nicolai*. In terms of biomass the dominant species on the very narrow eastern continental shelf were *Chionodraco myersi* (49%), *Trematomus eulepidotus* (11%), *C. hamatus* (7%), *T. lepidorhinus* (6%), *Pagetopsis maculatus* (5%) and *T.scotti*, *Cryodraco antarcticus*, *Cygnodraco mawsoni* and *Pleuragramma antarcticum* (4% each). The highest density of individuals and greatest biomass was found between 400 and 650 m water depth. Here, *C. myersi*, *T. eulepidotus* and *T. lepidorhinus* dominated the catches. The shallow shelf area was inhabited by smaller species such as *T. scotti*, *T. centronotus*, *P. maculatus*, *Artedidraco skottsbergii*, *A. shackletoni*, and *Prionodraco evansii*.In the southern Weddell Sea *Akarotaxis nudiceps*, *Dolloidraco longedorsalis*, *Gerlachea australis*, *Pleuragramma antarcticum*, and *Trematomus loennbergi* were dominant. Members of the Channichthyidae occurred only occasionally, most of these are *Dacodraco hunteri*. The biomass of the demersal fish fauna was estimated to be 0.3 to 1.6 t km$^{-2}$ on the Vestkapp shelf and 0.1 to 0.4 t km$^{-2}$ for Gould Bay. Biomass values greater than 1.0 t km$^{-2}$ were found at the shelf edge.

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**Key words**: Artedidraconidae, Bathydraconidae, Channichthyidae, Nototheniidae, distribution, biomass.

## Introduction

The demersal fish fauna of the Southern Ocean comprises about 200 species, mostly from six families of the perciform suborder Notothenioidei (Andriashev 1965, 1987). During the isolation of the Antarctic continent for the last 30 million years, the environmental conditions have changed to low water temperatures and a pronounced seasonally variable coverage by sea ice. The monophyletic notothenioids adapted well to these conditions and were able to occupy a large number of very different ecological niches. This has lead to a large variety of morphological forms, e.g. the sea scorpion-like Artedidraconidae, herring-like *Pleuragramma antarcticum* or hake-like *Dissostichus mawsoni*. As a result of this capability to adapt, the notothenioids contribute more than 90%, in both numbers and biomass, to the demersal fish fauna in the Southern Ocean (Dewitt 1971, Ekau 1988, Tiedtke & Kock 1989).

The major part of the continental shelf in the Weddell Sea is situated between 74 and 78° S, i.e. an extension of about 450 km. Along the eastern coast the shelf is narrow, with a maximum extension of about 90 km. Typical water depth is 200 to 500 m. Shallower areas are mostly covered by the continental ice sheet, which forms the coast line along the eastern and southern part of the Weddell Sea. Due to the weight of the continental ice, the shelf edge lies in 500 to 600 m water depth.

As part of the Weddell Gyre, a coastal current flows along the shelf ice edge to the south west (Fig. 1). North of Halley Bay at 75° S, the current forks into two branches: along the continental shelf edge to the west, and along the ice edge and the Filchner trench to the south. A small gyre is situated on the southern shelf plateau. Several water masses occur in the Weddell Sea and three of them may influence the fauna on the shelf areas.

1. The oceanic Warm Deep Water (WDW) with temperatures between 0 and +0.8°C, which fills the deeper layer of the Weddell basin. Its upper boundary lies in 600 to 800 m, i.e. the shelf edge.
2. The cold and less saline Eastern Shelf Water (ESW) with temperatures between -2 and -1.6°C which occurs on the continental shelf.
3. The Ice Shelf Water (ISW) is situated along both sides of the Filchner Trench in about 700 to 1000 m depth (solid arrows in Fig. 1). This has potential temperatures from -2.4 to -2°C. Detailed reviews of the hydrography of the Weddell Sea are given by Carmack & Foster (1977), Hellmer & Bersch (1985) and Hellmer (1989).

Previous work in the Weddell Sea (i.e. Kock *et al.* 1984, Schwarzbach 1988) was concerned primarily with large scale observations on the fish fauna. The aim of this study was to describe in detail the demersal fish fauna and the influence of bottom topography and hydrography on its distribution and composition in a well defined area. The very narrow shelf off Vestkapp was selected for this purpose and

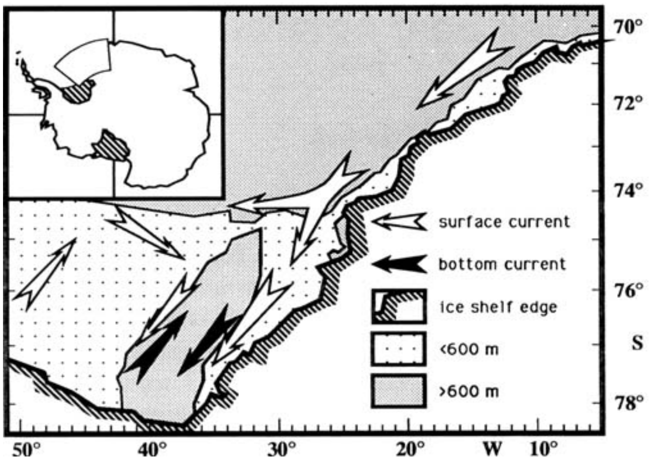


**Figure 1:** A diagramatic representation of the eastern Weddell Sea, Antarctica showing the main surface and bottom currents as well as the ice shelf edge. The border between light and dense stippled areas represents the 600 m isobath.

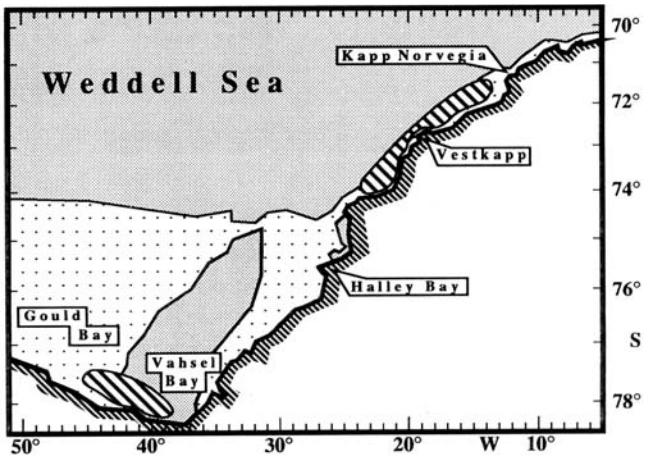


**Figure 2:** A diagramatic representation of the south eastern part of the Weddell Sea, Antarctica. The solid black zones mark the areas investigated during *Polarstern* cruises ANT III and ANT V. The depth zonation shown is similar to Figure 1.

compared with data from the Gould Bay, the southern, predominantly ice-covered shelf plateau.

## Material and Methods

The material for the present study was collected during two cruises of the German RV *Polarstern* in January and February 1985 (ANT III/3) and during October and November 1986 (ANT V/3). The fishing areas were located along the eastern shelf and in the southern part of the Weddell Sea (hatched area in fig. 2). A total of 16 bottom trawls were carried out, 13 on the eastern shelf and 3 in Gould Bay. Trawling depth was between 200 and 670 m, and trawling speed was 4 knots. Due to the very irregular bottom topography, trawling time varied between 9 and 60 minutes. The gear was a commercial bottom trawl with a 140 foot head-line and a mouth opening of 22 m width by 3 m height (K.-H. Kock, personal communication). Mesh size in the cod end was 20 mm.

In addition a small Agassiz trawl with a mouth opening of 3 m by 1 m and a mesh size of 10 mm was used to sample depths between 170 and 1150 m. The data obtained with this gear were used to define the vertical distribution boundaries of the different species, but were not used for biomass estimation.

Detailed station lists of the cruises are given by Hempel (1985) and Schnack-Schiel (1987).

The catches were sorted and identified to species level according to Fischer & Hureau (1985). Liparids and zoarcids were identified only to family level. In all, 12 *Pogonophryne* species could be separated, some of them still undescribed. The material was passed to Dr. R. Eakin, Portland, USA, for further preparation. Rajids were identified by Dr. M. Stehmann, Hamburg, FRG.

The fish were measured (total length TL and standard length SL in mm) and weighed (fresh weight FW in g, small specimens <100 mm to 0.1g). To express biomass distribution, the bottom trawl hauls were standardized to 30 min trawling time and to 1 km² swept area. Biomass (B) as tonnes per km² was calculated as follows:

$$B = \frac{C}{(v_t \times t_t \times W_N)}$$

where C is the catch in metric tons, $v_t$ the trawling speed, $t_t$ the trawling time and $W_N$ the horizontal width of net opening. Depending on the different trawling times, mainly during ANT V/3, the swept areas varied from 24 000 to 160 000 m². A 30 min haul corresponds to a swept area of 81 000 m².

## Results

### *General species composition*

A total of 12 211 specimens were caught during the two cruises. From these 11 935 specimens (98%) belonged to the four families (Artedidraconidae, Bathydraconidae, Channichthyidae and Nototheniidae) of the perciform suborder Notothenioidei. Within these families a total of 38 species together with about 12 unidentified species of the genus *Pogonophryne* could be distinguished.

In addition to the notothenioid species, a small number (276) of Liparididae, Macrouridae (*Macrourus holotrachys*), Muraenolepidae (*Muraenolepis* sp.), Rajidae (*Bathyraja eatoni*, *B. maccaini*, *B.* sp.2 (Fischer & Hureau 1985)) and Zoarcidae were collected.

A detailed list of the fish species by individuals, caught on all stations during both cruises, was published by Ekau (1988). The composition of the bottom trawl catches by biomass is given in Table I.

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**Table I:** Species composition of botton trawl catches during 'Polarstern' cruises ANT III and ANT V. Stations are arranged according to depth, region and cruise. Biomass values for the different species and families are given in kg×30min$^{-1}$. Mean biomass values were calculated for the two regions and the cruises. In addition the last line gives the total biomass for each station in t×km$^{-2}$.

| Area | Vestkapp - ANT V | | | | | | | Vestkapp - ANT III | | | | | | Gould Bay-ANT III | | | Vestkapp | | | Gould |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | 10592 | 10593 | 10531 | 10537 | 10594 | 10580 | 10536 | 6287 | 6286 | 6248 | 6348 | 6345 | 6247 | 6300 | 6298 | 6299 | ANT | ANT | ANT | Bay |
| Trawling time/min | 15 | 9 | 23 | 16 | 10 | 14 | 13 | 30 | 30 | 46 | 59 | 60 | 30 | 30 | 30 | 30 | V | III | V+III | ANT III |
| Depth/m | 235 | 330 | 420 | 430 | 467 | 460 | 551 | 203 | 390 | 419 | 423 | 475 | 666 | 595 | 646 | 667 | | | | |
| | | | | | | | | | | | | | | | | | mean | mean | mean | mean |
| *Artedidraco loennbergi* | 0.01 | 0.02 | 0.13 | 0.56 | 0.48 | 0.21 | 0.02 | - | - | 0.03 | 0.23 | 0.10 | - | - | - | - | 0.20 | 0.06 | 0.14 | - |
| *Artedidraco orianae* | - | 0.07 | 0.08 | - | 0.99 | - | - | 0.10 | 0.10 | 0.35 | - | 1.30 | - | - | - | - | 0.16 | 0.31 | 0.23 | - |
| *Artedidraco shackletoni* | 0.26 | 0.10 | 0.05 | 0.01 | - | 0.05 | - | 0.20 | - | - | 0.06 | - | - | - | - | - | 0.07 | 0.04 | 0.06 | - |
| *Artedidraco skottsbergi* | 0.46 | 0.09 | - | - | - | - | - | 0.20 | - | 0.01 | 0.04 | - | - | - | - | - | 0.08 | 0.04 | 0.06 | - |
| *Dolloidraco longedorsalis* | - | - | 0.10 | 0.01 | 3.45 | - | - | 0.05 | 0.11 | 0.26 | 0.41 | 3.05 | - | - | 0.60 | 0.25 | 0.51 | 0.65 | 0.57 | 0.28 |
| *Histiodraco velifer* | - | 0.30 | 0.04 | 0.09 | - | 0.11 | - | - | - | - | 0.21 | - | - | - | - | 0.05 | 0.08 | 0.04 | 0.06 | 0.02 |
| *Pogonophryne spp.* | - | 1.07 | 1.80 | 0.75 | 3.00 | 1.29 | 0.40 | 0.34 | 0.58 | 1.24 | 3.53 | 2.95 | 7.38 | 0.38 | 0.55 | 1.22 | 1.19 | 2.67 | 1.87 | 0.72 |
| ΣArtedidraconidae | 0.73 | 1.65 | 2.20 | 1.42 | 7.92 | 1.66 | 0.42 | 0.89 | 0.79 | 1.89 | 4.48 | 7.40 | 7.38 | 0.38 | 1.15 | 1.52 | 2.29 | 3.81 | 2.99 | 1.02 |
| *Akarotaxis nudiceps* | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.46 | 0.26 | 0.30 | - | - | - | 0.34 |
| *Bathydraco macrolepis* | - | - | - | - | - | - | - | - | - | - | 0.05 | - | - | - | - | - | - | 0.01 | - | - |
| *Bathydraco marri* | - | - | - | 0.25 | - | - | - | - | - | - | 0.02 | - | - | - | 0.03 | - | 0.04 | - | 0.02 | 0.01 |
| *Cygnodraco mawsoni* | 1.22 | 2.83 | 1.30 | 5.25 | 0.36 | 8.36 | - | 0.69 | 1.50 | 1.43 | 10.43 | 1.50 | - | - | - | - | 2.76 | 2.59 | 2.68 | - |
| *Gerlachea australis* | - | - | - | - | 0.45 | - | - | 0.36 | - | - | - | 0.02 | - | 0.09 | 1.15 | 3.40 | 0.06 | 0.06 | 0.06 | 1.55 |
| *Gymnodraco acuticeps* | 1.00 | 2.07 | 1.70 | - | 0.39 | - | - | 0.91 | - | - | 0.08 | - | - | - | - | - | 0.74 | 0.17 | 0.47 | - |
| *Prionodraco evansii* | 0.08 | 0.07 | - | 0.02 | - | - | - | 0.02 | 0.05 | - | - | - | - | - | - | - | 0.02 | 0.01 | 0.02 | - |
| *Psilodraco spec.* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.04 | - | - | - | 0.01 |
| *Racovitzia glacialis* | - | - | 0.30 | 0.69 | 2.46 | - | 0.10 | 0.05 | 0.76 | 0.20 | 0.49 | 1.35 | 0.16 | 2.27 | 1.10 | 1.20 | 0.51 | 0.50 | 0.50 | 1.52 |
| *Vomeridens infuscipinnis* | - | - | - | - | - | - | - | - | - | - | 0.06 | 0.01 | - | 0.02 | 0.04 | - | - | 0.01 | 0.01 | 0.02 |
| ΣBathydraconidae | 2.30 | 4.97 | 3.30 | 6.21 | 3.66 | 8.36 | 0.10 | 2.03 | 2.31 | 1.63 | 11.13 | 2.88 | 0.16 | 2.84 | 2.58 | 4.94 | 4.13 | 3.36 | 3.77 | 3.45 |
| *Chaenodraco wilsoni* | 0.19 | - | 0.67 | - | 0.78 | 0.15 | - | - | - | - | - | - | 0.02 | - | - | - | 0.26 | - | 0.14 | - |
| *Chionodraco hamatus* | 6.86 | 20.33 | 3.16 | 0.94 | 29.40 | 3.69 | - | 1.80 | - | 0.08 | - | - | - | - | - | - | 9.20 | 0.31 | 5.10 | - |
| *Chionodraco myersi* | - | - | 11.01 | 15.00 | 1.20 | 16.50 | 260.8 | 2.10 | 5.24 | 8.61 | 82.30 | 14.55 | 46.60 | 0.11 | 0.58 | - | 43.50 | 26.57 | 35.69 | 0.23 |
| *Cryodraco antarcticus* | 0.44 | 3.80 | 3.00 | 1.22 | 9.60 | 1.07 | 9.23 | 0.50 | 2.52 | 2.28 | 4.57 | 0.40 | 1.31 | 0.16 | 0.18 | - | 4.05 | 1.93 | 3.07 | 0.11 |
| *Dacodraco hunteri* | - | - | - | - | - | - | - | - | - | - | - | 0.10 | 0.25 | 0.29 | 0.70 | 2.00 | - | 0.06 | 0.03 | 1.00 |
| *Pagetopsis macropterus* | - | - | 0.21 | - | - | - | - | 0.07 | 0.10 | - | - | - | - | - | - | - | 0.03 | 0.03 | 0.03 | - |
| *Pagetopsis maculatus* | 5.90 | 28.20 | 0.72 | 3.34 | 4.71 | 1.97 | - | 1.40 | 0.39 | 0.03 | 0.17 | - | - | 0.06 | 0.23 | - | 6.41 | 0.33 | 3.60 | 0.10 |
| ΣChannichthyidae | 13.39 | 52.33 | 18.76 | 20.50 | 45.69 | 23.38 | 270.0 | 5.87 | 8.25 | 11.00 | 87.04 | 15.04 | 48.18 | 0.62 | 1.70 | 2.00 | 63.44 | 29.23 | 47.65 | 1.44 |
| *Aethotaxis mitopteryx* | - | - | - | - | - | - | - | - | - | - | 0.33 | - | - | - | - | 0.12 | - | 0.06 | 0.03 | 0.04 |
| *Dissostichus mawsoni* | - | - | - | - | - | - | - | - | - | - | 5.68 | - | 3.70 | 8.40 | - | - | - | 1.56 | 0.72 | 2.80 |
| *Notothenia coriiceps* | - | - | - | - | - | - | - | - | - | - | - | - | 3.00 | - | - | - | - | 0.50 | 0.23 | - |
| *Notothenia kempi* | - | - | - | - | - | - | - | - | - | - | - | - | 0.23 | - | - | - | - | 0.04 | 0.02 | - |
| *Pagothenia bernacchii* | 1.14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.16 | - | 0.09 | - |
| *Pagothenia borchgrevinki* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.09 | - | - | - | - | 0.03 |
| *Pagothenia hansoni* | - | 2.63 | 0.52 | - | - | - | - | 1.00 | - | - | 0.61 | 0.03 | - | - | - | - | 0.45 | 0.27 | 0.37 | - |
| *Pleuragramma antarcticum* | - | - | 0.17 | - | 1.80 | - | - | - | 1.00 | 0.11 | 1.14 | 0.75 | 0.80 | 4.80 | 3.70 | 22.00 | 0.28 | 0.63 | 0.44 | 10.17 |
| *Trematomus centronotus* | 1.80 | 6.90 | 0.07 | - | 0.84 | - | - | 1.20 | - | - | - | - | - | - | 0.14 | - | 1.37 | 0.20 | 0.83 | 0.05 |
| *Trematomus eulepidotus* | 4.94 | 17.03 | 18.25 | 7.69 | 15.21 | 11.36 | 1.64 | 14.30 | 2.71 | 2.61 | 5.33 | 0.50 | 0.15 | - | - | - | 10.87 | 4.27 | 7.82 | - |
| *Trematomus lepidorhinus* | 1.90 | 3.67 | 2.82 | 1.31 | 2.58 | 3.43 | 2.60 | 1.59 | 2.50 | 2.61 | 5.33 | 13.80 | 7.30 | - | 0.25 | 0.30 | 2.62 | 5.52 | 3.96 | 0.18 |
| *Trematomus loennbergii* | - | - | - | - | - | - | - | - | 0.01 | - | 0.15 | 0.80 | 0.25 | 2.50 | 1.20 | 4.15 | - | 0.20 | 0.09 | 2.62 |
| *Trematomus nicolai* | - | - | 3.13 | - | - | - | - | - | - | 0.49 | 1.29 | - | - | - | - | - | 0.45 | 0.30 | 0.38 | - |
| *Trematomus scotti* | 2.04 | 18.80 | 2.88 | 0.28 | 2.73 | 0.58 | 0.20 | 1.20 | 4.00 | 0.30 | 3.62 | 1.20 | 0.04 | - | - | - | 3.93 | 1.73 | 2.91 | - |
| ΣNototheniidae | 11.82 | 49.03 | 27.84 | 9.28 | 23.16 | 15.37 | 4.44 | 19.29 | 10.22 | 6.11 | 23.50 | 17.08 | 15.47 | 15.70 | 5.38 | 26.57 | 20.13 | 15.28 | 17.89 | 15.88 |
| ΣNotothenioidei | 28.24 | 108.0 | 52.11 | 37.41 | 80.43 | 48.77 | 275.0 | 28.08 | 21.57 | 20.64 | 126.1 | 42.41 | 71.19 | 19.54 | 10.80 | 35.03 | 89.99 | 51.67 | 72.30 | 21.79 |
| *Bathyraja eatonii* | - | - | - | - | 14.10 | - | - | - | - | - | 0.23 | - | - | - | - | - | 2.01 | 0.04 | 1.10 | - |
| *Bathyraja maccaini* | 0.40 | - | 0.26 | - | - | - | - | 0.95 | 3.90 | - | - | - | 2.00 | - | - | - | 0.09 | 1.14 | 0.58 | - |
| *Bathyraja sp.2*(FAO-atlas) | - | - | - | - | - | - | - | - | - | - | 0.43 | 0.11 | - | - | - | - | - | 0.09 | 0.04 | - |
| *Muraenolepis spec.* | - | - | - | - | - | - | 0.05 | - | - | - | - | - | - | - | - | - | 0.01 | - | 0.00 | - |
| *Macrourus holotrachys* | - | - | - | - | - | - | - | - | - | - | - | - | 8.90 | - | - | - | - | 1.48 | 0.68 | - |
| *Liparidae* | - | 0.22 | - | 0.01 | 1.92 | 0.06 | 0.53 | - | - | 0.10 | 0.01 | 0.10 | 0.06 | - | 0.10 | - | 0.39 | 0.05 | 0.23 | 0.03 |
| *Zoarcidae* | - | 0.02 | - | 0.14 | 0.26 | 0.38 | 0.04 | - | 0.18 | 0.44 | 0.47 | 0.21 | 0.28 | 0.08 | - | - | 0.12 | 0.26 | 0.19 | 0.02 |
| Σ (kg/30min) | 28.64 | 108.2 | 52.37 | 37.56 | 96.71 | 49.21 | 275.6 | 29.03 | 25.65 | 21.18 | 127.3 | 42.82 | 82.43 | 19.62 | 10.90 | 35.03 | 92.62 | 54.73 | 75.13 | 21.8 |
| Σ (t/km2) | 0.35 | 1.33 | 0.64 | 0.46 | 1.19 | 0.60 | 3.38 | 0.36 | 0.31 | 0.26 | 1.56 | 0.53 | 1.01 | 0.24 | 0.13 | 0.43 | 1.14 | 0.67 | 0.92 | 0.27 |

The total biomass varied between 21 and 276 kg $30min^{-1}$, i.e. 0.26 and 3.4 t $km^{-2}$ on the eastern shelf. Except for the very high value of 3.4 t $km^{-2}$ at station 10536, the values are of the same order of magnitude for both cruises, 0.3 to 1.6 t $km^{-2}$ in summer and 0.4 to 1.4 t $km^{-2}$ in spring. The highest biomass values, more than 1 t $km^{-2}$, were found in greater depths between 500 and 700 m at the shelf edge. On the shelf plateau, biomass was less than 0.4 t $km^{-2}$. Very low biomass was found in Gould Bay: 0.1 to 0.4 t $km^{-2}$ (see also Fig. 3).

Off Vestkapp, *Chionodraco myersi* was the predominant species, comprising on average of 49.4% of the biomass from the 13 hauls. Other abundant species were *Trematomus eulepidotus* (10.8%), *Chionodraco hamatus* (7.0%), *T. lepidorhinus* (5.5%), *Pagetopsis maculatus* (5.0%), *Cryodraco antarcticus* (4.2%), *T. scotti* (4.0%), *Cygnodraco mawsoni* (3.7%) and *T. centronotus* (1.1%). The other species totalled less than 1%. Thus, 66% of the total biomass of the demersal fish on the Vestkapp shelf was represented by channichthyids and 25% by nototheniids.

On the southern shelf, in Gould Bay, a completely different fish fauna was collected. While off Vestkapp, channichthyids dominated the catches deeper than 500 m, in Gould Bay 73% of the biomass was represented by nototheniid species, while channichthyid species comprised only 16%. *Pleuragramma antarcticum* was the dominant fish in the bottom trawls (with an average of 46.7% in three hauls). It was followed by *Dissostichus mawsoni* (12.8%), *Trematomus loennbergi* (12.0%), *Gerlachea australis* (7.1%), *Racovitzia glacialis* (7.0%), *Dacodraco hunteri* (4.6%), *Akarotaxis nudiceps* (1.6%) and *Dolloidraco longedorsalis* (1.3%). All other species made up less than 1% of the biomass.

Besides the marked difference in the species composition between Vestkapp and Gould Bay, a depth-dependent shift in the species distribution was observed off Vestkapp (Fig. 4). In shallow waters down to about 400 m nototheniid species were dominant or of similar importance to channichthyids, however, the percentage decreased in deeper water to less than 20 %. Correspondingly, the percentage of channichthyids increased with depth from about 50 to 90 %. The percentage of the artedidraconids and bathydraconids was low and had a maximum of about 15 % at 400 to 500 m.

The changes of the species composition within the various families is discussed below.

*Artedidraconidae*

Representatives of this family occurred in water depths from 200 m to 1150 m. The maximum biomass was found around 500 m (Fig. 4), which corresponds more or less to the upper shelf edge. The most abundant species was *Dolloidraco longedorsalis* with its maximum abundance between 400 and 500 m. In shallow water, *Artedidraco* spp. were the dominant species, but mainly by numbers and not by biomass. The lower distributional boundary of this genus seems to be 500 m. Another abundant group was *Pogonophryne* with

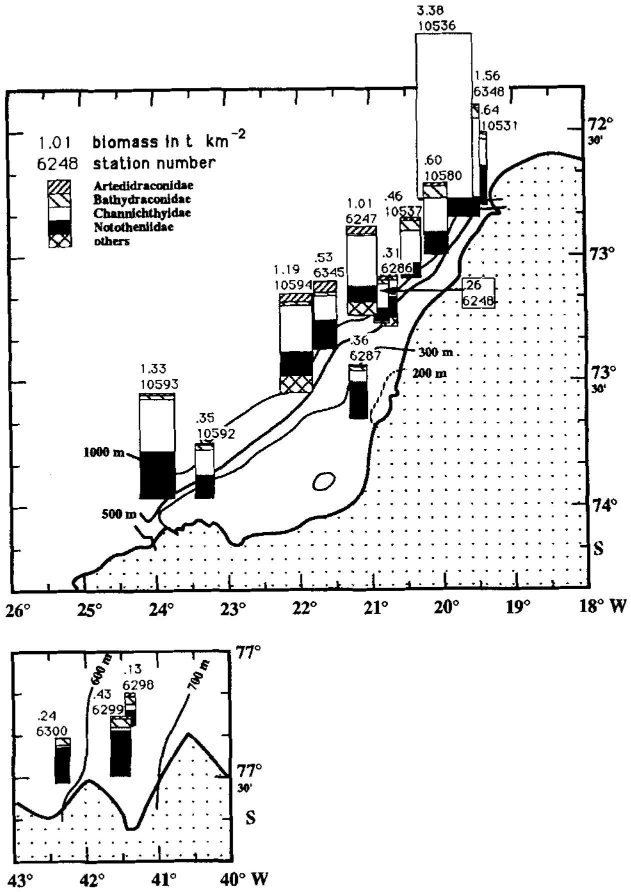


**Figure 3:** Distribution of biomass sampled by bottom trawls during *Polarstern* cruises ANT III and ANT V. The area of the boxes represents the biomass in t $km^{-2}$ for the four notothenioid families and the non-notothenioid taxa. The lower right edge of the boxes indicates to the position of the station. The dotted area represents the ice shelf edge.

about 12 species and a maximum biomass in 400 to 500 m water depth. *Pogonophryne* and *Dolloidraco* were the only genera of this family occurring in Gould Bay.

*Bathydraconidae*

The bathydraconids had their maximum densities at depths of around 450 m, i.e. the upper shelf edge (Fig. 4). They were collected in small numbers down to 1150 m. The most common species off Vestkapp was *Cygnodraco mawsoni* with maximum densities in about 450 m water depth. *Gymnodraco acuticeps* was found only in waters less than 400 m deep. The dominant species in the Gould Bay were *Gerlachea australis* and *Akarotaxis nudiceps*. *Racovitzia glacialis* was the only species which occurred at nearly all stations deeper than 400 m, both off Vestkapp and in Gould Bay.

The total biomass of the two families Artedidraconidae

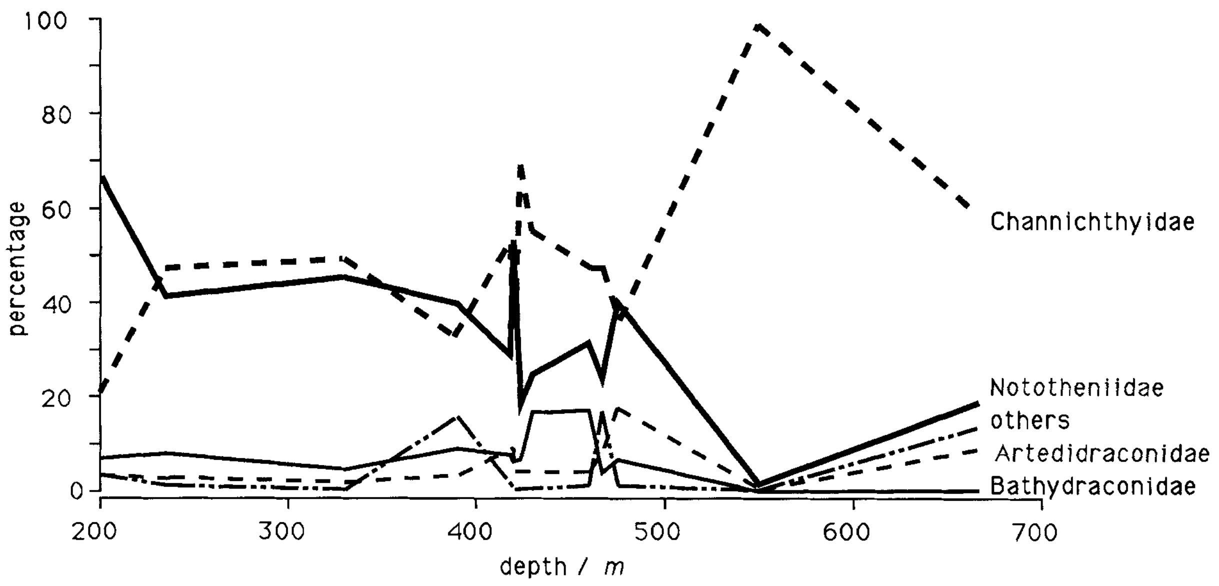


**Figure 4:** The relationship between biomass and water depth for the four notothenioid families, as a percentage of the total catch in the bottom trawls.

and Bathydraconidae, was of the same order of magnitude: 2.6 and 3.7 kg $30min^{-1}$ (0.03 and 0.05 t $km^{-2}$), respectively, as a mean for the 16 hauls.

*Channichthyidae*

The species of overwhelming dominance in the hauls was *Chionodraco myersi*, contributing 75% of the mean biomass. The main distribution area of this species was on the northern part of the shelf in water depths between 400 and 670 m. On the southern part of the shelf, but in shallower water (from 200 to 460 m) the sibling species *C. hamatus* occurred. This species made up about 10% of the biomass of the channichthyids. A third species was *Pagetopsis maculatus*, caught mainly in spring in depths less than 400 m. In Gould Bay, only 38 specimens of channichthyids were caught, 25 belonging to the species *Dacodraco hunteri*.

All other species were very low in abundance. The total biomass of channichthyids is ten times that of bathydraconids: 39 kg $30min^{-1}$ for the whole area, 48 kg $30min^{-1}$ for the Vestkapp area.

*Nototheniidae*

Nototheniid fish were found at all depths from 200 m to 1150 m. The mean biomass was 17.5 kg $30min^{-1}$ (17.9 kg $30min^{-1}$ off Vestkapp, 15.9 in Gould Bay). Species composition was found to vary with area, season and depth.

A total of 14 species could be identified, of which 5 dominated the biomass. Off Vestkapp the species with the highest density was *T. eulepidotus*, and this was the dominant species from shallow waters down to about 450 m. At this depth it was replaced by *T. lepidorhinus*, a similar species. *Trematomus scotti*, a very small species, had its maximum abundance in shallow waters. Only a few specimens were collected in depths down to 670m.

Other species of this family occurred only in small numbers. Some of them show depth preferences. For example *Aethotaxis mitopteryx* was found only at depths greater than 420 m, and most of the specimens were caught with the Agassiz trawl at depths greater than 1000 m. *Dissostichus mawsoni* was caught only in summer, at depths between 420 and 670 m. Specimens of the genus *Notothenia* (20 *N. kempi* and 1 *N. coriiceps*) occurred only in very deep hauls between 620 (station 10575, Agassiz trawl) and 670 m (station 06247).

The distribution of *Pagothenia bernacchii* and *P. hansoni* was restricted to the continental shelf, down to 470 m. *T. centronotus* was collected mainly between 200 and 350 m, although single specimens occurred down to 460 m. *T. nicolai* was found only on the northern part of the shelf, off Drescher Inlet, at depths around 420 m. In Gould Bay the biomass was dominated by *Dissostichus mawsoni*, *T. loennbergi* and big specimens of *Pleuragramma antarcticum*. Few specimens of *Aethotaxis mitopteryx*, *T. centronotus* or *T. lepidorhinus* were found. During the summer, *P. antarcticum*, *D. mawsoni* and *T. loennbergi* also occurred off Vestkapp, but with low biomass.

*Length distribution*

For five of the dominant species, the length distribution was analyzed. Fig. 5 shows the variation of mean length with depth in *Trematomus eulepidotus*, *T. lepidorhinus*, *T. scotti*, *Chionodraco myersi*, and *Pagetopsis maculatus* from the Vestkapp shelf area. In the three *Trematomus* species length increases with depth. During summer, specimens *T. eulepidotus* smaller than 150 mm occur only at shallow stations (Fig. 5a). Larger specimens, between 150 and 300 mm, were found in depths greater than 300 m. In spring, small specimens < 150 mm were very scarce, and length ranged from about 170 to 270 mm over the entire depth range.

*T. lepidorhinus* had a wide depth range from 200 to 670 m (Fig. 5b). Down to about 400 m specimens between 50 and 200 mm were caught. Deeper than 400 m, the maximum length increased to 300 mm and at the very deep stations, only large specimens between 170 and 300 mm were collected. In both spring and summer mean length increased in depth. However in spring the small size classes were much more dominant in deeper water.

The variation of length with depth is not as obvious in *T. scotti* as in the former species (Fig. 5c). The whole size range occured down to 500 m, but the mean length increased from about 80 mm at 200 m water depth to 120 mm at 500 m. There was no significant difference between summer and spring. Neither *Chionodraco myersi* (Fig. 5d) nor *Pagetopsis maculatus* (Fig. 5e) showed any significant increase in size with depth. *P. maculatus* ranges from 140 to 200 mm over the entire depth range, while *C. myersi* showed two size cohorts, which correlated with season but not depth. Specimens caught in spring were somewhat larger than in summer.

## Discussion

The division of the Southern Ocean into biogeographical provinces goes back to Regan (1914), Norman (1938) and Nybelin (1947) and was finally formulated for the fish fauna by Andriashêv (1965, 1987). Dewitt (1971) was the first to suggest that the Weddell Sea should be allocated to the East Antarctic Province, and Kock *et al.* (1984) and Schwarzbach (1988) were both able to confirm this hypothesis for the majority of the fauna. Both authors used a small Agassiz trawl. The bigger fishing gear used during *Polarstern* cruise ANT III and ANT V, allowed the following species to be recorded from the Weddell Sea for the first time: *Aethotaxis mitopteryx*, *Bathyraja eatoni*, *B. maccaini*, *Bathydraco marri*, *Dissostichus mawsoni*, *Macrourus holotrachys*, *Notothenia coriiceps*, *Notothenia kempi*, *Psilodraco* sp. and *Trematomus nicolai*. *Psilodraco* sp. could not be related to *Psilodraco breviceps*. It may be a new species (A.P. Andriashev, personal communication 1988).

A comparison with the Antarctic Peninsula, which belongs to the West Antarctic Province, showed marked differences in the species composition. While *Trematomus* was the predominant nototheniid genus in the Weddell Sea, *Notothenia* and *Nototheniops* species were predominant in the Antarctic Peninsula and the Scotia Arc areas (Targett 1981, Tiedtke & Kock 1989). Only a few specimens of *Notothenia* species were found off Vestkapp, at bottom temperatures between 0.0 and 0.5 °C. These species are circumantarctic, but they generally avoid very low temperatures and do not appear on the high Antarctic shelf. Among the channichthyids, *Chionodraco myersi*, *Cryodraco antarcticus*, *Dacodraco hunteri* and *Pagetopsis maculatus* were dominant in the Weddell Sea, whereas around the Antarctic Peninsula, *Chaenocephalus aceratus*, *Champsocephalus gunnari* and *Pseudochaenichthys georgianus* are dominant (Kock 1981, Kock *et al.* 1985, Tiedtke & Kock 1989).

Within the Weddell Sea, a subdivision of the benthic fauna between the eastern and the southern continental shelf area has been found by Voss (1988)who proposed three communities (eastern shelf, Filchner trench, and southern shelf). An analogous separation into three communities has been shown for the fish fauna by Schwarzbach (1988). Based on summer data, Schwarzbach (1988) found *Akarotaxis nudiceps* and *Gerlachea australis* for the bathydraconids, *Dolloidraco longedorsalis* for the artedidraconids and *Trematomus loennbergi* for the nototheniids to be dominant species on the southern shelf. Channichthyids, except for *Dacodraco hunteri*, were nearly excluded from this community. This distribution pattern is supported by the results presented in this paper, even if the detailed relationship between the species differs due to the different gear used in the two studies. It is likely that large numbers of *Pleuragramma antarcticum* could be caught with the bottom trawl, but not with the Agassiz trawl. This species also dominated the pelagic catches in the area (Hubold & Ekau 1987).

The shelf south of Vestkapp, the second investigation area during ANT III and ANT V, is only small (about 220 km long and 50 km deep with an area of 5200 km$^2$).

The faunal composition was comparable to the "Eastern Shelf Community", defined by Schwarzbach (1988). The southern part of the shelf is relatively flat and shallow. The bottom is covered by sponges and bryozoans (Gutt 1988, Voss 1988), which in their turn serve as habitat for many small benthic animals like polychaetes, molluscs and holothurians. Such substrata offer food and protection for benthic fish and many small species and specimens were found here. In contrast the northern part of the shelf is steep and narrow and here the continental shelf edge is close to the ice shelf edge. This provides a different hydrological situation and a different habitat. Bentho-pelagic species (e.g. *Chionodraco myersi*, *Trematomus eulepidotus*, *T. lepidorhinus*, *Cygnodraco mawsoni*), feeding on krill or pelagic fish (Schwarzbach 1988), dominate here, mainly at greater depths, and can reach high densities and a large biomass.

In general the fish biomass on the Vestkapp shelf is low. On the shelf plateau, values between 0.3 and 0.4 t km$^{-2}$ were found. The biomass at the shelf edge in water depths between 500 and 600 m was somewhat higher. Values between 0.8 and 1.4 t km$^{-2}$ were found, with one catch of 3.4 t km$^{-2}$, an extremely high value for the Weddell Sea. The depth at which high biomass values occurred (400-600 m) corresponded

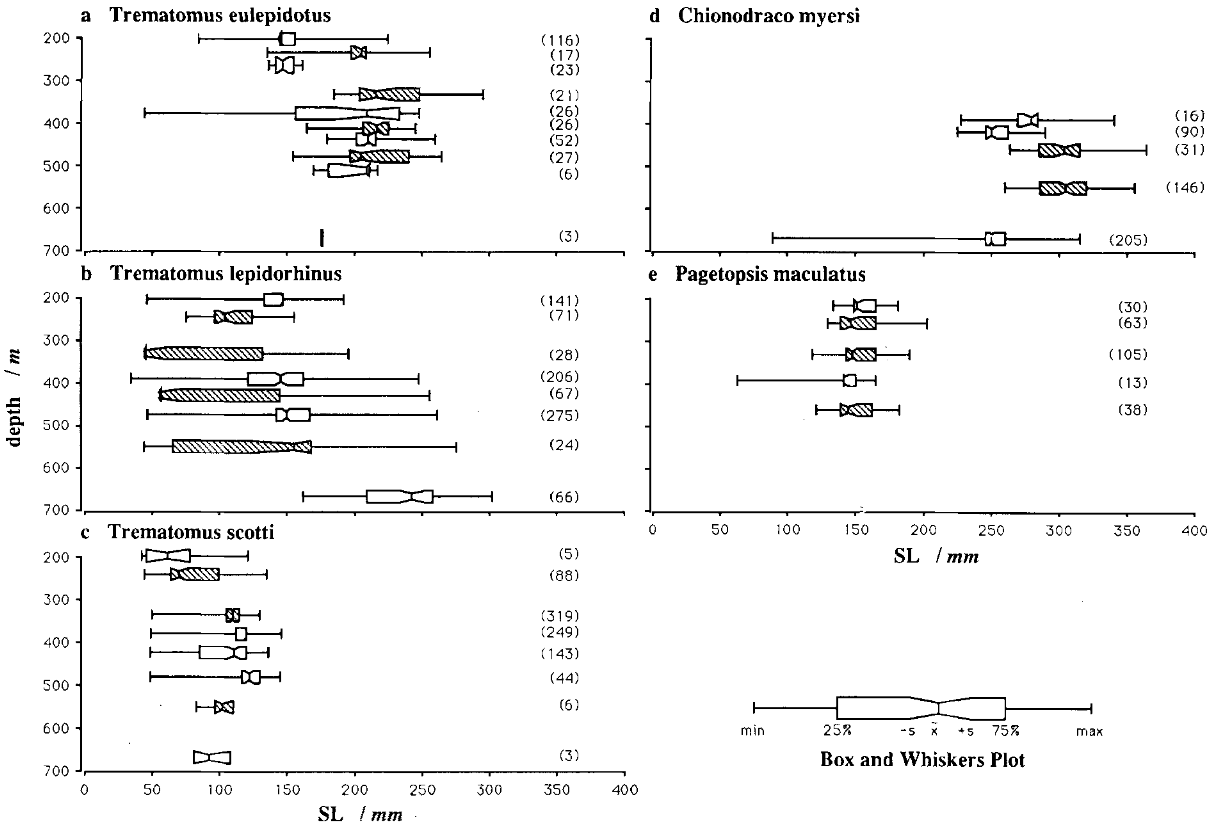


**Figure 5:** Variation of standard length with water depth in six notothenioid species (a: *Trematomus eulepidotus*, b: *T. lepidorhinus*, c: *T. scotti*, d: *Chionodraco myersi*, e: *Pagetopsis maculatus*). The number of specimens measured in each sample is given in brackets. Hatched boxes represent stations from *Polarstern* cruise ANT V (spring), blank boxes ANT III (summer). Data are shown as median, x̄, with a single standard deviation, 25% and 75% percentiles and the minimum and the maximum value, in a box and whiskers plot.

with the continental shelf edge, as well as with the boundary between the Warm Deep Water and the Eastern Shelf Water (Hellmer & Bersch 1985). During *Polarstern* cruise ANT V, off Vestkapp the temperature below 400 m increased rapidly and was about 0°C at 500 to 700 m depth (E. Fahrbach, personal communication 1988).

High Antarctic fish species are generally thought to live at constantly low temperatures near the freezing point of seawater, -1.8°C. The results presented in this paper show, that at least some of the high Antarctic species live at temperatures up to +0.5°C. They tend to concentrate along the shelf edge and form large aggregations. Only the small species and some large predatory species live in the -1.8°C cold water on the shallower parts of the shelf. This "avoidance" of constantly cold water as observed off Vestkapp may be the reason why a totally different species composition was found in Gould Bay. The potential temperature at those stations (during *Polarstern* cruise ANT III) was between -2.2 and -2.0°C (Hellmer 1989, fig. 3a).

Compared to the Weddell Sea, the fish biomass from the Antarctic Peninsula is about ten to fifteen times higher. The catch per unit effort (CPUE) along the Vestkapp shelf was between 40 and 260 kg $h^{-1}$ (station 10536: 550 kg $h^{-1}$), and in Gould Bay it was between 20 and 70 kg $h^{-1}$. In contrast to these low values, Kock *et al.* (1985) found CPUE values of 600 to 2000 kg $h^{-1}$ for *Notothenia gibberifrons* in the Antarctic Peninsula, Elephant Island and South Georgia areas. Similar values were observed for other species and Sosinski & Skora (1988) found a total biomass of between 4.4 and 6 t $km^{-2}$ on the South Georgia shelf. Ehrich (1980) calculated an average fish biomass of 9.3 t $km^{-2}$ (i.e. 1600 kg $h^{-1}$) for the Patagonian Shelf and Ursin (1979) estimated the fish biomass in the North Sea to 17 t $km^{-2}$, that is a CPUE of about 3000 kg $h^{-1}$. The South Georgian and the Scotia Arc region (as well as the North Sea) are heavily exploited, in contrast to the Weddell Sea. Nevertheless there is a difference in biomass between the Weddell Sea and the other areas in the order of 10 to 100. Due to slow fish growth in High Antarctic waters (Ekau 1988, Hubold & Tomo 1989), the difference in productivity may be even higher.

The results of length distribution suggest vertical and seasonal migrations for the most dominant demersal or bentho-pelagic species *Chionodraco myersi*, *Trematomus eulepidotus* and *T. lepidorhinus*. The size range of *T. eulepidotus* was similar in both seasons, but the percentage of large specimens was higher in spring. This may be caused by a vertical migration of this bentho-pelagic species. The larvae hatch in winter (Ekau 1989) and undergo a pelagic period of development until their second summer, when they are about 50 to 70 mm long. Then they change to a bentho-pelagic life style (Ekau 1988, Hubold & Ekau 1987, Hubold in press). The change from pelagic to bentho-pelagic life may result in a seasonally changing, vertical size segregation as it has been shown for *Pleuragramma antarcticum* by Hubold (1985) and Hubold & Ekau (1987). As the vertical height of the mouth of the bottom trawl is about 3 m, different size classes were caught in the two seasons.

Larvae of *T. lepidorhinus* were scarce in the pelagic zone (Hubold & Ekau 1987). Specimens of 45 to 60 mm occurred at or near the bottom at depths from 200 to 550 m. The percentage of adults was higher in summer, indicating a seasonally varying vertical migration similar to that assumed for *T. eulepidotus*.

Small specimens of *Chionodraco myersi* (< 220 mm) and *Pagetopsis maculatus* (<120 mm) were under represented in the catches. Larvae and juveniles of *C. myersi* and *P. maculatus* with sizes of 40 to 120 mm and 40 to 70 mm, respectively, were caught by Hubold & Ekau (1987) with pelagic trawls. There seem to be two different size groups present of *C. myersi* in spring and in summer. In summer, the majority were 250 to 280 mm long, whereas in spring the length varied between 280 and 320 mm. The different size groups may indicate different stocks in spring and summer.

*T. scotti* did not show any significant differences in length distribution between spring and summer. This very small benthic species was very sedentary in contrast to the bentho-pelagic species, mentioned above.

Three species of fish form the staple food for Weddell seals in the eastern Weddell Sea, namely *Pleuragramma antarcticum*, *Chionodraco myersi* in spring and *Trematomus eulepidotus* in summer (Plötz & Ekau in press). The highest biomass values of *C. myersi* and *T. eulepidotus* in the bottom trawls were found directly off the Drescher Inlet, the site of one of the two seal colonies along the ice shelf south of Vestkapp (J. Plötz, personal communication 1989). The very narrow continental shelf off Drescher Inlet with its high fish biomass seems to offer good conditions for seals. One aim for the future will be to find out whether such areas with high fish density are requirements for seal colonies and whether there is a relation between fish biomass or species composition and the size of the seal colony.

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