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# NOTOTHENIOID FISHES FROM THE WEDDELL SEA AND THEIR HABITAT, OBSERVED BY UNDERWATER PHOTOGRAPHY AND TELEVISION

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***Abstract:*** About 3000 photographs and 21 hours of video were used to analyze and describe the habitat and some peculiarities of the behavior of high Antarctic notothenioid fish. These direct observations were made during three cruises of the German research vessel "POLARSTERN" to the shelf of the Weddell Sea (ANT III, 1984/85; ANT VI, 1987/88; ANT VII, 1988/89). Operating depth of the vehicles was between 100 and 1200 m.

In total, 987 specimens of more than 20 fish species were identified. The total area observed at 98 stations was estimated as 3000 m$^2$ for the photographs and 12300 m$^2$ for the video. The most abundant species were *Chionodraco myersi* with 192 and *Trematomus lepidorhinus* with 159 specimens observed. They are followed by *Trematomus scotti* (103), *Dolloidraco longedorsalis* (56), *Trematomus eulepidotus* (51) and *Prionodraco evansii* (41). Most of the species found are known to be demersal. But also benthopelagic species like *Trematomus eulepidotus*, *C. myersi* or *Neopagetopsis ionah* (18) were found near or above the bottom. While the real demersal fish (*e.g. Trematomus centronotus* or *Trematomus loennbergii*) were observed directly on the bottom, within or even on the benthic organisms, the video pictures show that benthopelagic species such as *Trematomus eulepidotus* or *N. ionah* swim some centimeters above the bottom. For some of the species a relation to the kind of substratum can be shown. Species composition depends on water depth and latitude.

## 1. Introduction

The demersal fish fauna in the Antarctic Ocean comprises about 200 species. Fifty percent of these belong to the perciform suborder Notothenioidei, including six families (ANDRIASHEV, 1987). Four of these families with a total of 50 species are found in the Weddell Sea: The Artedidraconidae, Bathydraconidae, Channichthyidae and Nototheniidae (EKAU, 1988). The monophyletic notothenioids have adapted themselves better to the environmental conditions on the high Antarctic shelf than other phyletic groups. This has led to a number of morphological adaptations, which allowed the occupation of different ecological niches, and to an overwhelming dominance in terms of biomass and individuals. This group constitutes more than 95% in the bottom fish fauna (EKAU, 1990). First classification of the species into ecological types, *e.g.* benthic, bentho-pelagic or pelagic was based on morphological measurements and food analysis (ANDRIASHEV, 1987; HUGHES, 1981; MILLER, 1987; PERMITTIN AND TAVERDIEVA, 1978;

KOCK *et al.*, 1984; TARGETT, 1981). The comparison of their body shape and coloration with other well-known fish species led to hypotheses about their life styles. It is easy to imagine that herring-like *Pleuragramma antarcticum*, hake-like *Dissostichus mawsoni* and sea scorpion or goby-like artedidraconids may have life styles similar to those of their boreal counterparts. Detailed studies on morphological variation within one species or genus can serve to classify the species which are not as obvious as *P. antarcticum* (VOSKOBOINIKOVA, 1980, 1982; EASTMAN and DEVRIES, 1982, 1985; IWAMI, 1985; EKAU, 1988). These hypotheses on their life style, however, should be proved by direct observations.

Underwater photography has a tradition from the early fifties (VEVERS, 1951) with mainly descriptive character of the sea floor fauna (LEMCHE *et al.*, 1976) to modern approaches to biomass estimations (OHTA, 1983; NUMANAMI *et al.*, 1986), controlling net sampling (SHIPEK, 1967; ORTNER *et al.*, 1981; DYER *et al.*, 1982) and observing behavior of animals (THIEL and RUMOHR, 1979; MARSCHALL, 1988). In this study, both a still camera and a video camera were used to describe habitat and behavior of high Antarctic notothenioid fish. While trawl catches normally result in an integrated, disordered sampling of the animals, where community analysis can be done only on a large scale, underwater photography allows a fine-scale description of the nearby surroundings of a fish. This may lead to an analysis of the preferences of cohabitating animals. The photographs were also used to analyze the species composition and diversity in the different areas of investigation Kapp Norvegia, Vestkapp, Halley Area and Vahsel Bay in comparison to trawl catches. We tried a quantitative approach to the species composition of demersal fish in the Weddell Sea to estimate the reliability of the dominance of different species compared to net data.

Direct observations on the deeper shelf of the Antarctic continent are scarce. BULLIVANT (1959) took a series of photographs at four stations in the McMurdo Sound. Our observations are the first from the high Antarctic shelf of the Weddell Sea.

## 2. Methods

### 2.1. *Area of investigation*

The observations were made during three cruises of the German research vessel "POLARSTERN" to the Weddell Sea in 1985 (ANT III), 1988 (ANT VI) and 1989 (ANT VII). The cruises were conducted for a general investigation of the benthos. The observation sites are shown in Fig. 1. Detailed information on the observation stations is given in HEMPEL (1985), FÜTTERER (1988) and ARNTZ *et al.* (1990).

### 2.2. *Video observations*

The video observations were made with a Remotely Operated Vehicle (ROV: sprint 103) at 16 stations on the continental shelf (Fig. 1). The system consisted of three major components: 1. The vehicle itself was equipped with a still camera, a color and a black-and-white video camera, lights, strobes, compass, depth sensor, electronic control unit and 5 thrusters for operating the vehicle. 2. A winch with a 120 m long tether cable. 3. The board units consisted of two joy-sticks and a key board for operating the whole system, a video recorder and a monitor for on-line ob-

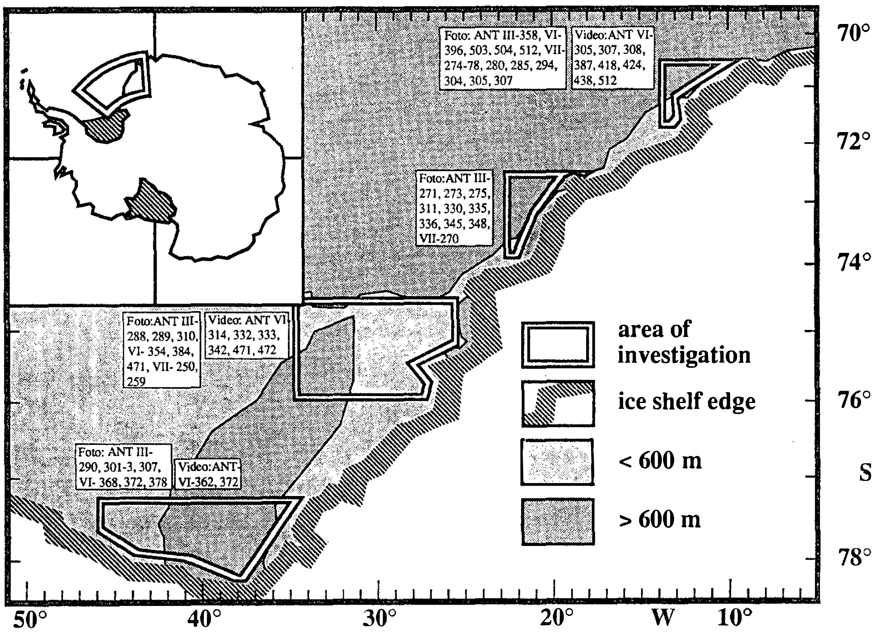


*Fig. 1. Investigated areas in the Weddell Sea. Photo and Video stations during the three cruises of RV "POLARSTERN" ANT III, VI and VII are listed. The 600 m isobath represents the shelf edge.*

servations of the video images and operating information (*e.g.* depth, time code, gyro-heading, etc.).

During deployment of the ROV, the ship drifted at an average speed of about $0.5\,\mathrm{nm \cdot h^{-1}}$, mainly due to the coastal current. Thus the ROV was used as a drifting system with a minimum of active movements to obtain transects as linear as possible. The vehicle was kept 15 to 70 cm above the bottom to avoid obstacles. Exact co-ordinates from starting and end points of the transects in some stations, were taken from "Global Positioning System" (GPS) navigation. The length of the transect could thus be estimated within an error of 5%. For the other stations, the ships navigation was determined by dead reckoning, based on satellite navigation. This is less accurate than GPS navigation, but has resulted in similar length data for the transects. For the calculation of the sea floor area observed with the ROV, we made several assumptions:

1. The difference between start and end positions of the cast was assumed to be a linear distance with regard to time and space.

2. The speed of the drifting vehicle was assumed to be constant. In case of an obviously lower speed for a certain phase, the calculated area was reduced by a roughly estimated factor (0.5 in station VI-307, 0.1 in station VI-472).

3. Each cast was classified into temporal sections with the following spatial width of the area observed. The width was defined as an imaginary line, dissecting the lower one-third and the upper two-thirds of the video image:

a) 45– 85 cm, average: 60 cm
b) 86–130 cm, average: 100 cm
c) 131–190 cm, average: 160 cm.

The temporal lengths of these sections could be read from the time code in the video image. They were converted to spatial distances as proportions of the total operating time. Not usable sequences, *e.g.* descending and ascending phases of the gear and sequences out of focus, were discarded. The sum of these spatial sections, multiplied by the estimated width, yielded a total area for each station.

4. On the basis of the gyro-heading recorded by the vehicle, factors were estimated to correct the non-linearity of the transsects. These factors ranged between 1.1 and 2.0.

Based on the uncertainties and factors mentioned above, we assume a bias of the areas calculated in the range of $\pm 30\%$.

The observed areas were estimated as 5800 $m^2$ ($\doteqdot$7.4 h) off Kapp Norvegia, 6000 $m^2$ ($\doteqdot$11.3 h) in the Halley area and 500 $m^2$ ($\doteqdot$1.3 h) in Vahsel Bay.

### 2.3. *Underwater-photography*

Photographs were made with a 70 mm underwater camera, described in detail by GUTT (1988). The camera was triggered at a constant distance to the sea floor. Thus the size of the vertically photographed area could be calculated. At one station during ANT VII the triggger weight could be seen on a photograph and a direct calculation of the sizes of the photographed objects from the known size of the weight could be done. Pictures were taken at random without control on the sampling site. Altogether approx. 3300 pictures were taken at 58 stations, representing approximately 3025 $m^2$: 915 $m^2$ off Kapp Norvegia, 510 $m^2$ off Vestkapp, 600 $m^2$ in the Halley area and 1000 $m^2$ in Vahsel Bay. The areas are indicated in Fig. 1. About two-thirds of the areas photographed were on the continental shelf (100 to 600 m water depth) and one-third on the upper continental slope (600 to 1200 m).

### 2.4. *Identification of the species*

Species composition of the demersal fish fauna of the Weddell Sea is mostly known from former works by KOCK *et al.* (1984), EKAU (1988, 1990) and SCHWARZBACH (1988). The identification of the taxa on the photographs and the video images to species level was possible only in 793 of the 987 fishes observed (80.3%). Eighty-two specimens (8.3%) were identified to generic level, 50 (5.1%) to family level and in 62 (6.3%) cases it was only possible to identify them as "fish". The overall species composition is compared with the species composition of the fishery stations of two Antarctic cruises (ANT III, ANT V) with RV "POLARSTERN" to the same area, corrected to a swept area of 1000 $m^2$. During these cruises, a 3 m by 1 m Agassiz trawl with 10 mm mesh size and a 140 foot bottom trawl (mouth opening 22 m width by 3 m height) with a mesh size of 20 mm in the cod end were used. Details on the fishery station data are given by EKAU (1990).

## 3. Results

### 3.1. *Description of the areas of investigation*

The shelf around Kapp Norvegia is mainly populated by bryozoan and sponge associations. Ophiurids, low-growing sponges and ascidians are numerous. The percentage of populated surface is variable, but generally high (60 to 90%). Kapp

Norvegia is the most populated of the four areas. Fifty percent of the area pictured was covered with biogenic substratum. Most of the area is without any stones or only with small stones. Operating depth was 100 to 1100 m (mean 380 m).

The shelf off Vestkapp is populated by bryozoans and hydrozoans. Other groups such as low-growing sessile suspension feeders or ophiurids are found only on 10% of the photographs. The covering of the sediment is less than off Kapp Norvegia (10 to 50%), but is between 1 and 50%. Only 10% of the pictures showed biogenic substratum, but a high percentage of photos revealed small or large stones, 33 and 23%, respectively. Operating depth was between 240 and 960 m (mean 490 m).

The investigation area off Halley is populated by bryozoans/hydrozoans and low-crescending sponges and ascidians. Ophiurids are common. The percentage cover is low (less than 10%). The sediment is sandy and sometimes had small stones. About 27% of the photographs showed biogenic substratum. Working depth was 220 to 1200 m (mean 400 m).

The benthic fauna of Vahsel Bay was very poor and the substratum consisted mostly of sand with small stones. The percentage cover was mostly less than 1%. The benthic fauna consisted mainly of ophiurids, which appeared on 7% of the pictures. Operating depth of the vehicles was 240 to 1200 m (mean 840 m).

### *3.2. Quantitative analysis of photo and video observations*

In total, 987 specimens were observed. Twenty-five fish species could be identified. The most frequent species were *Chionodraco myersi* with 192 (19.5%) and *Trematomus lepidorhinus* with 159 individuals (16.1%). They were followed by *T. scotti* (103; 10.4%), *Dolloidraco longedorsalis* (56; 5.7%), *T. eulepidotus* (51; 5.2%) and *Prionodraco evansii* (41; 4.2%) (Fig. 2a). The overall taxa composition on the photographs and the video is similar to the overall species composition of bottom trawl catches (Fig. 2b). The most abundant species identified in Agassiz trawl and bottom trawl catches (number of catches; 52, number of fishes caught: 12211) are *T. scotti* (15.5%), *C. myersi* (10.7%), *T. lepidorhinus* (10.4%), *T. eulepidotus* (9.7%), *D. longedorsalis* (8.5%) and *Pagetopsis maculatus* (6.5%).

Different species compositions were observed by underwater photography in the four areas of investigation (Table 1). Highest species diversity was found off Kapp Norvegia and Halley with 31 and 29 taxa, respectively, on the shelf off Vestkapp and in Vahsel Bay only 12 and 18, respectively. The video tapes and photographs showed a similar species composition and nearly the same number of specimens per unit area. Comparing the data in the different areas, a large variation is found in fish density on photographs and video images. The relationship is between 5.3: 1 for Kapp Norvegia, 1 : 1 for Vahsel Bay and 1 : 2.4 for Halley area. In Vahsel Bay, both photographs and video images revealed very low numbers of specimens, 26 and 13, respectively, which is about 26 specimens per 1000 $m^2$ for both. Low densities were also found on photographs off Halley and on video images off Kapp Norvegia (37 and 33 specimens per 1000 $m^2$, respectively). Observations on photographs off Vestkapp and on videos off Halley resulted in relatively high densities of 86 and 89 specimens per 1000 $m^2$. The highest density of fish with 172 specimens per 1000 $m^2$ was found on photographs of the Kapp Norvegia shelf. Most of the fishes observed were young *Trematomus lepidor-*

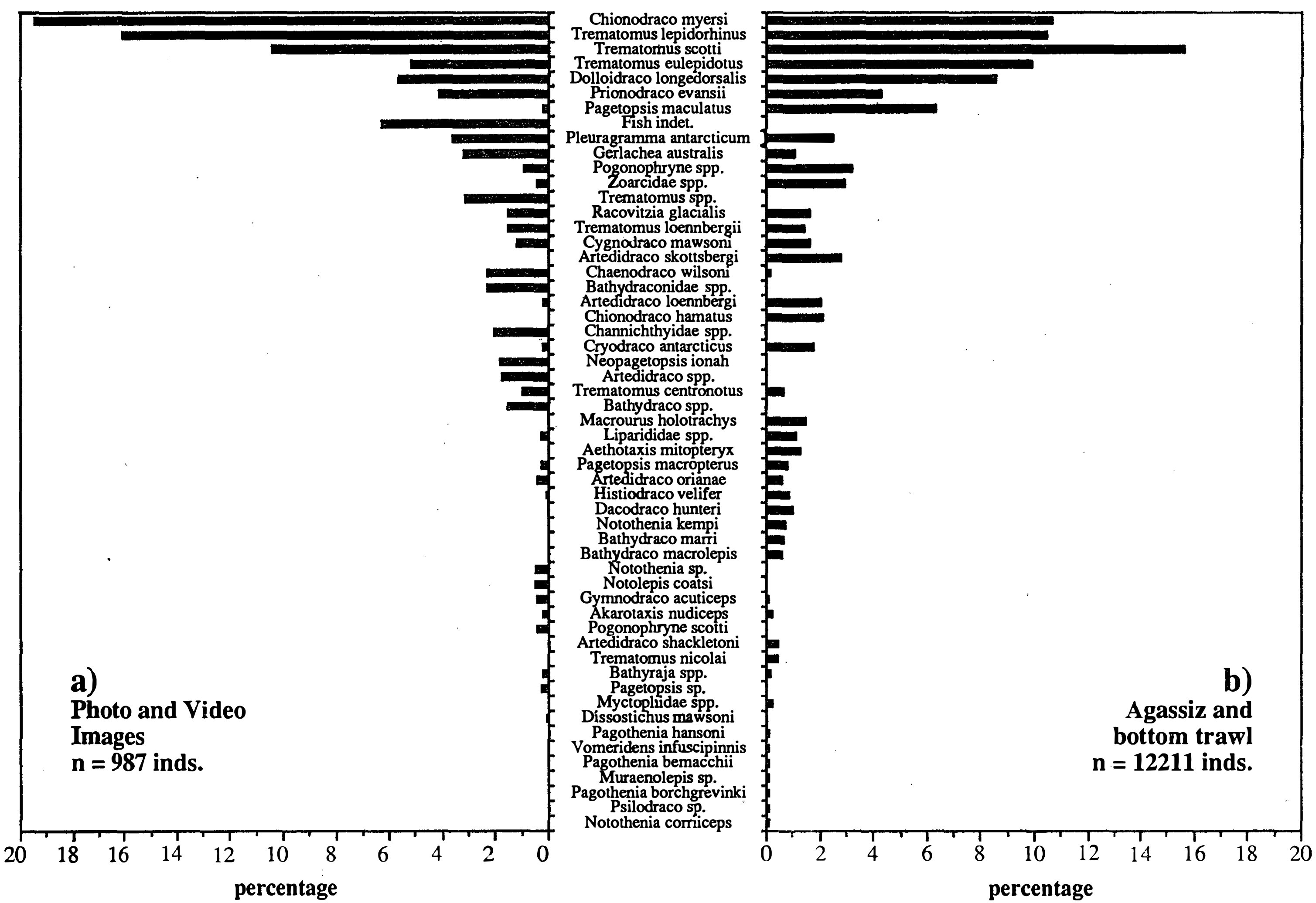


*Fig. 2. The species composition of fishes based on the photographs and video images. A total of 249 and 738 fishes have been observed on 3300 photographs (≑3026 m²) and 21 hours of video tapes (≑12311 m²), respectively. b) The species composition of fishes based on Agassiz and bottom trawl catches during RV "*Polarstern*" cruises ANT III and V. A total of 52 Agassiz trawl and bottom trawl catches resulted in 12211 fishes.*

*Table 1. Percentage of species on photos and videos in the different areas Kapp Norvegia, Vestkapp, Halley Bay and Vahsel Bay. For method for calculation of the areas for the photographs and video images, see chapter "Material and Methods".*

| Area | Kapp Norvegia | | Vestkapp | | Halley Bay | | Vahsel Bay | | Total of photo stations | Total of video stations | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Photo | Video | Photo | Video | Photo | Video | Photo | Video | | | |
| Area photographed/m² | 914 | 5813 | 511 | 0 | 592 | 5982 | 1009 | 516 | 3026 | 12311 | 15337 |
| Number of fishes observed | 157 | 190 | 44 | — | 22 | 535 | 26 | 13 | 249 | 738 | 987 |
| Artedidraconidae | | | | | | | | | | | |
| *Artedidraco loennbergi* | 0 | 0.5 | 0 | — | 0 | 0.2 | 0 | 0 | 0 | 0.3 | 0.2 |
| *Artedidraco orianae* | 1.9 | 0.5 | 0 | — | 0 | 0 | 0 | 0 | 1.2 | 0.1 | 0.4 |
| *Artedidraco* sp. | 0 | 2.1 | 4.5 | — | 4.5 | 1.3 | 7.7 | 7.7 | 2.0 | 1.6 | 1.7 |
| *Dolloidraco longedorsalis* | 1.9 | 0 | 4.5 | — | 4.5 | 9.3 | 0 | 0 | 2.4 | 6.8 | 5.7 |
| *Histiodraco velifer* | 0.6 | 0 | 0 | — | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.1 |
| *Pogonophryne scotti* | 0.6 | 0 | 0 | — | 0 | 0.6 | 0 | 0 | 0.4 | 0.4 | 0.4 |
| *Pogonophryne* spp. | 2.5 | 0 | 0 | — | 0 | 0.6 | 7.7 | 0 | 2.4 | 0.4 | 0.9 |
| Bathydraconidae | | | | | | | | | | | |
| *Akarotaxis nudiceps* | 0 | 0 | 0 | — | 0 | 0 | 7.7 | 0 | 0.8 | 0 | 0.2 |
| *Bathydraco* sp. | 1.9 | 1.1 | 4.5 | — | 4.5 | 1.3 | 0 | 0 | 2.4 | 1.2 | 1.5 |
| Bathydraconidae spp. | 0 | 1.1 | 0 | — | 4.5 | 3.7 | 0 | 0 | 0.4 | 3.0 | 2.3 |
| *Cygnodraco mawsoni* | 1.9 | 2.1 | 0 | — | 0 | 0.9 | 0 | 0 | 1.2 | 1.2 | 1.2 |
| *Gerlachea australis* | 0 | 0 | 0 | — | 4.5 | 5.6 | 3.8 | 0 | 0.8 | 4.1 | 3.2 |
| *Gymnodraco acuticeps* | 0 | 0 | 2.3 | — | 0 | 0.6 | 0 | 0 | 0.4 | 0.4 | 0.4 |
| *Prionodraco evansii* | 0 | 4.2 | 20.5 | — | 22.7 | 2.2 | 26.9 | 0 | 8.4 | 2.7 | 4.2 |
| *Racovitzia glacialis* | 1.3 | 0.5 | 0 | — | 4.5 | 2.1 | 0 | 0 | 1.2 | 1.6 | 1.5 |
| Channichthyidae | | | | | | | | | | | |
| *Chaenodraco wilsoni* | 0 | 0.5 | 0 | — | 0 | 4.1 | 0 | 0 | 0 | 3.1 | 2.3 |
| Channichthyidae spp. | 0.6 | 2.6 | 0 | — | 0 | 2.4 | 0 | 7.7 | 0.4 | 2.6 | 2.0 |
| *Chionodraco myersi* | 1.3 | 16.3 | 11.4 | — | 4.5 | 28.2 | 7.7 | 0 | 4.0 | 24.7 | 19.5 |
| *Cryodraco antarcticus* | 0.6 | 0 | 0 | — | 0 | 0.2 | 0 | 0 | 0.4 | 0.1 | 0.2 |
| *Neopagetopsis ionah* | 0 | 0.5 | 0 | — | 0 | 2.8 | 0 | 15.4 | 0 | 2.4 | 1.8 |
| *Pagetopsis macropterus* | 0 | 0.5 | 0 | — | 0 | 0.2 | 3.8 | 0 | 0.4 | 0.3 | 0.3 |
| *Pagetopsis maculatus* | 0 | 0 | 0 | — | 0 | 0 | 0 | 15.4 | 0 | 0.3 | 0.2 |
| *Pagetopsis* sp. | 0 | 1.1 | 0 | — | 0 | 0 | 0 | 7.7 | 0 | 0.4 | 0.3 |
| Nototheniidae | | | | | | | | | | | |
| *Dissostichus mawsoni* | 0 | 0 | 0 | — | 4.5 | 0 | 0 | 0 | 0.4 | 0 | 0.1 |
| *Notothenia* sp. | 3.2 | 0 | 0 | — | 0 | 0 | 0 | 0 | 2.0 | 0 | 0.5 |
| *Pleuragramma antarcticum* | 0 | 0 | 0 | — | 0 | 6.5 | 0 | 7.7 | 0 | 4.9 | 3.6 |
| *Trematomus centronotus* | 1.3 | 3.7 | 0 | — | 0 | 0.2 | 0 | 0 | 0.8 | 1.1 | 1.0 |
| *Trematomus eulepidotus* | 0.6 | 20.0 | 2.3 | — | 4.5 | 1.9 | 0 | 0 | 1.2 | 6.5 | 5.2 |
| *Trematomus lepidorhinus* | 70.1 | 11.1 | 11.4 | — | 4.5 | 3.9 | 3.8 | 0 | 47.0 | 5.7 | 16.1 |
| *Trematomus loennbergii* | 1.3 | 0 | 0 | — | 13.6 | 0.7 | 19.2 | 7.7 | 4.0 | 0.7 | 1.5 |
| *Trematomus scotti* | 2.5 | 11.6 | 20.5 | — | 9.1 | 11.8 | 3.8 | 15.4 | 6.4 | 11.8 | 10.4 |
| *Trematomus* sp. | 1.9 | 7.9 | 4.5 | — | 0 | 1.9 | 3.8 | 0 | 2.4 | 3.4 | 3.1 |
| Others | | | | | | | | | | | |
| *Bathyraja* sp. | 0 | 1.1 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.2 |
| Fish indet. | 1.9 | 10.5 | 9.1 | — | 9.1 | 5.8 | 3.8 | 7.7 | 4.0 | 7.0 | 6.3 |
| Liparididae spp. | 0.6 | 0 | 0 | — | 0 | 0.2 | 0 | 7.7 | 0.4 | 0.3 | 0.3 |
| *Notolepis coatsi* | 0 | 0.5 | 0 | — | 0 | 0.7 | 0 | 0 | 0 | 0.7 | 0.5 |
| Zoarcidae spp. | 1.3 | 0 | 4.5 | — | 0 | 0 | 0 | 0 | 1.6 | 0 | 0.4 |

*hinus* (70%) of about 6 to 8 cm.

Dominance of species varies in the different areas. Off Kapp Norvegia, more than 50% belong to nototheniid species, mainly *T. lepidorhinus*, *T. eulepidotus* and *T. scotti*. Off Vestkapp, nototheniids such as *T. lepidorhinus* and *T. scotti* and bathydraconids like *P. evansii* are dominant with approx. 40 and 27%, respectively. Off Halley, nototheniid species constitute only about 30 to 35%, but channichthyids with a percentage of also 35 and bathydraconids with 20 to 35% have a similar dominance. The dominant species within the families have changed in comparison to the northern areas. *T. loennbergii* and *T. scotti* support 15 to 20% of the fish, while *C. myersi* has its maximum dominance in this area with 28%. *P. evansii* may be called also as common with 23%. The dominant species in Vahsel Bay are *T. loennbergii*, *T. scotti*, *P. maculatus*, *Neopagetopsis ionah* and *P. evansii*.

On video images from the Halley area, a number of pelagic *Pleuragramma antarcticum* and *Notolepis coatsi* were found. This observation was made during descending of the ROV. *P. antarcticum* formed a swarm about 30 to 100 m above the bottom.

### 3.3. *Qualitative analysis of photo and video observations*

Most of the species found are known to live demersaly. However, benthopelagic species such as *Trematomus eulepidotus*, *Chionodraco myersi* or *Neopagetopsis ionah* were frequently found at the bottom. While the truly demersal fish (*e.g. T. centronotus*, *T. scotti* or *T. loennbergii*) were resting directly on the bottom, between or even on the benthic organisms, the video pictures showed that the benthopelagic species *T. eulepidotus* or *Neopagetopsis ionah* swim at a distance of some centimeters to decimeters above the bottom (Fig. 3). They use their well-developed pelvic fins for slow and steady swimming. While resting on the bottom, they stand on their ventral and anal fins.

The true demersal species rest directly on the bottom and actually lie on their stomach (Fig. 4). They move slowly by creeping on their ventral fins. This leads to characteristic tracks in the sediment (Fig. 5).

For some of the species, a relationship to the kind of substratum is found besides a dependance on water depth and latitude. On the shelf of Kapp Norvegia, juveniles of *T. lepidorhinus* were found in close association with a dense population of bryozoans and hydrozoans. *Trematomus centronotus* was generally found within dense populations of sponges and bryozoans/hydrozoans. Other, specially larger species such as *Cygnodraco mawsoni* (Fig. 6) or the channichthyid species seem to prefer more open habitats, or at least areas without high-growing sponges or other benthic animals. *Pogonophyrye* sp., *Trematomus loennbergii* or *Chionodraco myersi* were often found on sandy substratum without any other larger benthic organisms.

The video images showed some peculiarities in the behavior of notothenioid fishes. The S-shaped body positioning is the typical reaction to the vehicle lights. *Cryodraco antarcticus* uses its pelvic fins in combination with its snout to form a tripod and hide behind a sea fan in a vertical position. *T. eulepidotus* hides inside a sponge. With the approach of the vehicle, it dived deeper into the cup-shaped sponge. In *T. centronotus* the coloration with yellow patches and white dots is related to the substratum consisting of bryozoans and hydrozoans. Some of these observations on video images are shown as line-drawings (Fig. 7), because of the poor reproducibility of video prints.

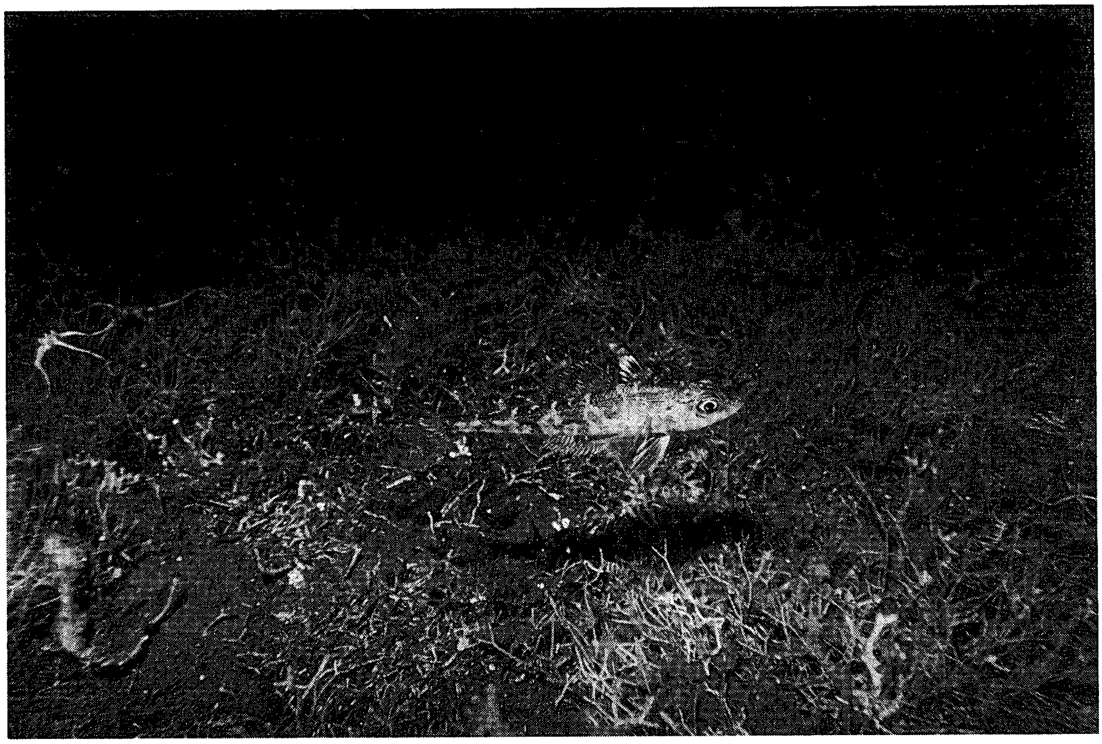

*Fig. 3.* Trematomus eulepidotus, *swimming near the bottom. Photograph taken at station ANT VI-308, water depth 194 m.*

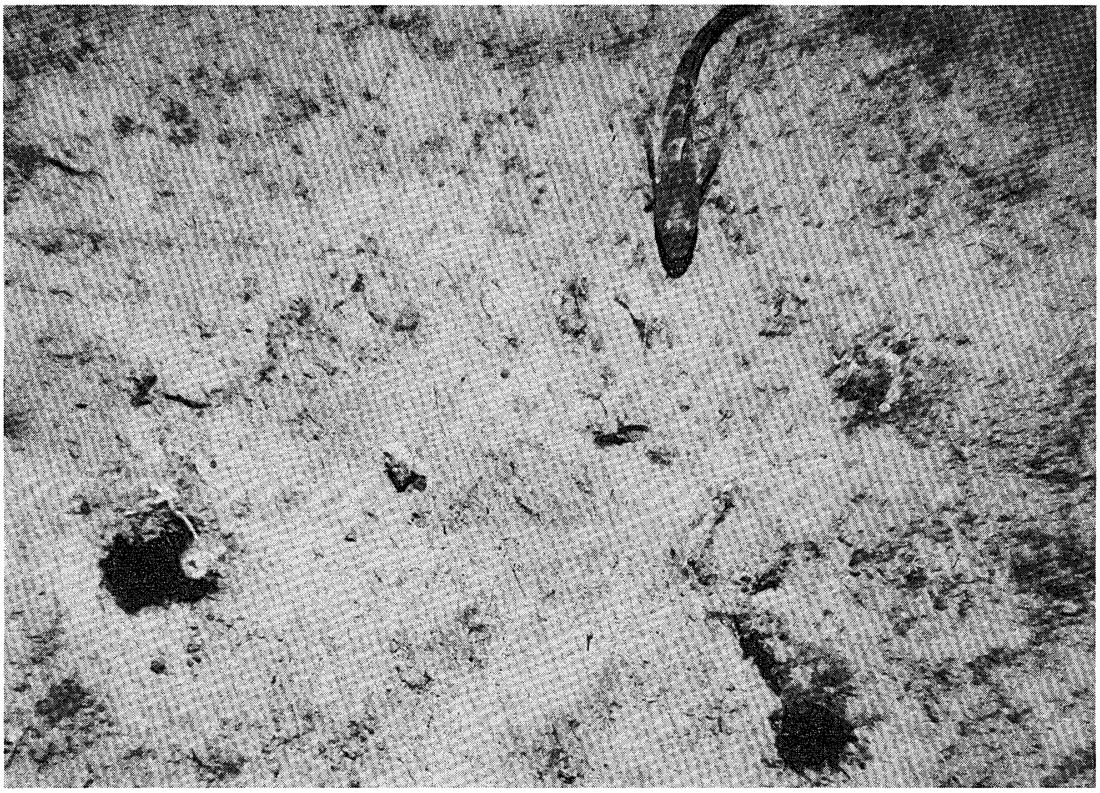

*Fig. 4.* Trematomus loennbergii, *resting directly on the sediment. Photograph taken at station ANT VI-384, water depth 525 m.*

*Fig. 5.* Pogonophryne sp. *resting on the bottom. The tracks behind the fish, caused by creeping on the ventral fins, are clearly visible. Photograph taken at station ANT III-307, water depth 1175 m.*

## 4. Discussion

A relevant prediction for the quantitative analysis of underwater photography is the comparability with findings received with other gears. So one aim of the study was to validate the quantitative species composition on the underwater photographs and videos for further investigations.

Qualitative and quantitative species compositions resulting from the direct observations are similar to the results from net catches (EKAU, 1990). No new species were observed on video images or photographs and the dominant species were found to be the same. Slight variation was probably due to different investigation efforts with the different gear used. Furthermore, some of the specimens could not be identified to species level, so many of the small species known from the net catches are hidden within the higher taxonomical levels. Rare species were probably not found because of the big difference in the investigated area: $1.25 \times 10^6\,m^2$ by trawling, $15 \times 10^3\,m^2$ with cameras.

The dominance of species like *Chionodraco myersi* off Halley, *Trematomus loennbergii* in Vahsel Bay or the *Trematomus* species of Kapp Norvegia is similar to the results obtained with bottom trawls. Although identification of the fishes to species level was not possible for all pictures, high species diversity on the eastern continental shelf from the north down to the Halley area and the poor fish fauna in the south are reflected in both photographs/video tapes and net catches. The differences in species

*Fig. 6.* Cygnodraco mawsoni. *The bottom is covered by biogenic substratum. The S-shaped body-form may be caused by the approach of the vehicle. Photograph taken at station ANT VII-275, water depth 301 m.*

richness and abundance can be partly explained by the hydrographical conditions. Moderate temperatures (around 0°C) are found on the eastern shelf in contrast to lower temperatures (around $-1.8$°C) in Vahsel Bay. Another important factor is the biotic environment: better availability of food, more diverse biogenic substratum and/or presence of multistoried benthic habitat allow a more diverse fish fauna than the poorly populated Vahsel Bay.

We selected "typical" pictures to demonstrate the substratum in the three areas investigated. It should be considered, however, that the distribution of the substratum is very patchy in the northern areas, changing from dense populated sponge and bryozoan associations to flat and sandy areas without sessile benthic organisms (see GUTT, 1988). This can also be seen in the relation of fish abundance on photographs and video images. Relationships in fish per 1000 $m^2$ on photos and videos of 5.3 : 1 for Kapp Norvegia, 1 : 2.4, off Halley and 1 : 1 in Vahsel Bay demonstrate a high patchiness in the northern areas, while a constant and poor distribution is found in Vahsel Bay.

Another factor influencing species composition is the benthic fauna. Benthic animals such as sponges, bryozoans, polychaets or ophiurids offer protection, food and place for breeding. The video images especially give information on the behavior of the fishes and allow conclusions about food relationships and feeding behavior.

*Trematomus eulepidotus*, a bentho-pelagic species in terms of its morphology, was mainly observed swimming above the substratum (Fig. 3) as was expected from former morphological work (ANDRIASHEV, 1987; EKAU, 1988). Some specimens were resting on the bottom, but not as close to the substratum as *T. centronotus* or *T. loennbergii*, which are demersal species. Surprisingly, *T. eulepidotus* was found hiding inside a sponge (Fig. 7)! It is not unlikely that this species uses sponges to spawn. *T. eulepidotus* eggs were found in a bottom trawl catch, which consisted mainly of sponges (5 metric tons of sponges; EKAU, 1989).

Small *T. lepidorhinus* were found off Kapp Norvegia between dense populations of sponges and bryozoans. Certainly they use this to hide against predators. In addition, this habitat should offer a lot of small crustaceans, the food of small *T. lepidorhinus* (HUBOLD and EKAU, 1990). On the other hand, they prefer small free places within the sponge/bryozoan associations for resting, which may provide them with a better overview.

By resting on the tip of an ascidian about 20 cm above the bottom, *T. scotti* may have a better opportunity to localize and catch food organisms passing by (Fig. 7).

The long and strong pelvic fins of *Cryodraco antarcticus* were thought to be used as a tripod together with the tail, to enable the fish to rest on the substratum without touching it or to keep its head off the bottom to hunt prey more effectively (IWAMI, 1985). This kind of behavior was confirmed on the video images in many specimens of channichthyids. Figure 7 shows a different use of the fins! The tripod is built by the pelvics and the snout and the fish can hide itself behind a sea fan.

The video tapes show that the disturbances of the fish by the vehicle are not as drastic as expected. This is also supported by the good agreement of the species compositions on photographs and in the net catches. Thus the opportunity to observe the specimens in their natural environment makes these videos more useful for behavioral studies than most aquarium experiments, where stress is already implicated on the fish by sub-optimal culture conditions.

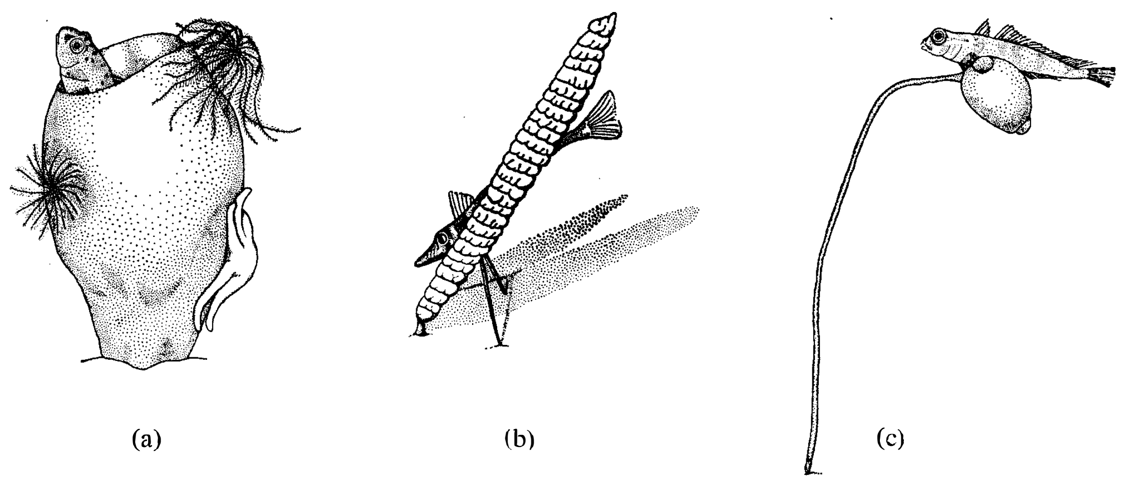

*Fig. 7. Line-drawings of different peculiarities of the behavior of some species. a)* Trematomus eulepidotus, *hiding inside a sponge. b)* Cryodraco antarcticus, *hiding behind a sea fan. c)* T. scotti, *resting on the tip of a sponge.*

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## References


ANDRIASHEV, A. P. (1987): A general review of the Antarctic bottom fish fauna. Proc. V. Congr. Europ. Ichthyol., Stockholm 1985, ed. by S. O. KULLANDER and B. FERNHOLM, 357–372.

ARNTZ, W. E., ERNST, W. and HEMPEL, I. (1990): The expedition ANTARKTIS VII/4 (EPOS leg 3) and VII/5 of RV "POLARSTERN" in 1989. Ber. Polarforsch., **68**, 214 p.

BULLIVANT, J. S. (1959): Photographs of the bottom fauna in the Ross Sea. N. Z. J. Sci., **2**, 485–497.

DYER, M. F., FRY, W. G., FRY, P. D. and CRANMER, G. J. (1982): A series of North Sea benthos surveys with trawl and headline camera. J. Mar. Biol. Assoc. U.K., **62**, 297–313.

EASTMAN, J.T. and DEVRIES, A.L. (1982): Buoyancy studies of notothenioid fishes in McMurdo Sound, Antarctica. Copeia, **2**, 385–393.

EASTMAN, J. T. and DEVRIES, A. L. (1985): Adaptations for cryo-pelagic life in the Antarctic notothenioid fish *Pagothenia borchgrevinki*. Polar Biol., **4**, 45–52.

EKAU, W. (1988): Ökomorphologie nototheniider Fische aus dem Weddellmeer, Antarktis. Ber. Polarforsch., **51**, 140 p.

EKAU, W. (1989): Egg development of *Trematomus eulepidotus* (Nototheniidae, Pisces) from the Weddell Sea, Antarctica. Cybium, **13**, 213–219.

EKAU, W. (1990): Demersal fish fauna of the Weddell Sea, Antarctica. Antarct. Sci., **2**, 129–137.

FÜTTERER, D. K. (1988): Die Expedition ANTARKTIS VI mit FS "POLARSTERN" 1987/1988. Ber. Polarforsch., **58**, 267 p.

GUTT, J. (1988): Zur Verbreitung und Ökologie der Seegurken (Holothuroidea, Echinodermata) im Weddellmeer (Antarktis). Ber. Polarforsch., **41**, 87 p.

HEMPEL, G. (1985): Die Expedition ANTARKTIS III mit FS "POLARSTERN" 1984/85. Ber. Polarforsch., **25**, 209 p.

HUBOLD, G. and EKAU, W. (1990): Feeding patterns of post-larval and juvenile notothenioids in the southern Weddell Sea (Antarctica). Polar Biol., **10**, 255–260.

HUGHES, T. J. (1981): Numerical reconstruction of palaeo ice sheets. The Last Great Ice Sheets, ed. by G. H. DENTON and T. J. HUGHES. New York, J. Wiley, 221-261.

IWAMI, T. (1985): Osteology and relationships of the family Channichthyidae. Mem. Natl Inst. Polar Res., Ser. E (Biol. Med. Sci.), **36**, 69 p.

KOCK, K.-H., SCHNEPPENHEIM, R. and SIEGEL, V. (1984): A contribution to the fish fauna of the Weddell Sea. Arch. Fischwiss., **34**, 103–120.

LEMCHE, H., HANSEN, B., MADSON, F. J., TENDAL, O. S. and WOLFF, T. (1976): Hadal life as analyzed from photographs. Vidensk. Medd. Dansk Naturhist. Foren., **139**, 263–336.

MARSCHALL, H.-P. (1988): The overwintering strategy of Antarctic krill under the pack-ice of the Weddell Sea. Polar Biol., **9**, 129–135.

MILLER, R. G. (1987): Origins and pathways possible for fishes of the Antarctic Ocean. Proc. V. Congr. Europ. Ichthyol., Stockholm 1985, ed. by S. O. KULLANDER and B. FERNHOLM, 373–380.

NUMANAMI, H., HAMADA, E., NAITO, Y. and TANIGUCHI, A. (1986): A biomass estimation of epifaunal megabenthos by stereo-photography around Syowa Station, Antarctica. Mem. Natl Inst. Polar Res., Spec. Issue, **44**, 145–150.

OHTA, S. (1983): Photographic census of large-sized benthic organisms in the bathyal zone of Suruga Bay, Central Japan. Bull. Ocean Res. Inst., Univ. Tokyo, **15**, 244 p.

ORTNER, P. B., HILL, L. C. and EDGERTON, H. E. (1981): *In-situ* shilhouette photography of Gulf Stream zooplankton. Deep-Sea Res., **28A**, 1569–1576.

PERMITTIN, Y. E. and TAVERDIEVA, M. I. (1978): Feeding of fishes of the families Nototheniidae and Channichthyidae in the South Orkney Islands. Sov. J. Mar. Biol., **4**, 619–622.

SCHWARZBACH, W. (1988): Die Fischfauna der östlichen und südlichen Weddell-See; Geographische Verbreitung, Nahrung und trophische Stellung der Fischarten. Ber. Polarforsch., **54**, 93 p.

SHIPEK, C. J. (1967): Deep-sea photography in support of underwater acoustic research. Deep-sea Photography, ed. by J.B. HERSEY. Baltimore, John Hopkins Press, 89–94.

TARGETT, T. E. (1981): Trophic ecology and structure of coastal Antarctic fish communities. Mar. Ecol. Progr. Ser., **4**, 243–263.

THIEL, H. and RUMOHR, H. (1979): Photostudio am Meersboden. Umsch. Wiss. Tech., **79**, 469–472.

VEVERS, H. G. (1951): Photography of the sea floor. J. Mar. Biol. Assoc. U.K., **30**, 101–111.

VOSKOBOINIKOVA, O. S. (1980): Visceral skeleton changes in the process of turning to pelagic mode of life in fishes of the family Nototheniidae. Akad. Nauk SSSR, Zool. Inst. Trudy, **114**, 67–76 (russ.).

VOSKOBOINIKOVA, O. S. (1982): Reduction of the pterygoid bones of the visceral skeleton during evolution of the suborder Notothenioidei (Perciformes). J. Ichthyol., **22**, 105–111.

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