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Summer distribution and abundance of larval and juvenile fishes in the western Ross Sea

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Abstract: Ichthyoplankton samples were collected during the November–December 1994 Italian Antarctic Oceanographic Cruise carried out to the western Ross Sea. A midwater trawl (Hamburg Plankton Net) was used to collect samples at 26 stations. Larval and juvenile specimens of 21 species belonging to six families (Artedidraconidae, Bathydraconidae, Channichthyidae, Macrouridae, Nototheniidae and Paralepididae) were caught from surface to 380 m depth. Mean relative abundance of larval fish in the whole area was about 2.7 specimens 1000 m^{-3} of filtered water. *Pleuragramma antarcticum* were the most abundant as postlarvae and juveniles. Larval and postlarval specimens of *Chionodraco myersi* were also abundant and widespread. The high number of *Trematomus lepidorhinus* (570 larvae) found in a single station off Terra Nova Bay (74°48'75"S, 164°36'90"E) was noteworthy. Our data demonstrate that the species diversity of the larval fish community in the western Ross Sea is much as found elsewhere in the Antarctic and show a greater abundance of fish larvae in inshore than in offshore waters.

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Introduction

The first studies that provided some information on early life history stages of Antarctic fish date from the early this century (Pappenheim 1912, Regan 1916). In the following sixty years, only a few more data were added on this topic (Nybelin 1947, Everson 1968). With the establishment of the Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) programme in 1972, a considerable number of studies on several aspects of the early life history stages of the Antarctic ichthyofauna were undertaken (Loeb *et al.* 1993). Most of the data on composition, distribution and abundance of larval and juvenile stages were from the Antarctic Peninsula region (Kellermann & Kock 1984, 1988, Ascencio & Mujica 1986, Kellermann 1986, 1989a, Slósarczyk 1986, 1987, White & North 1987, Kellermann & Schadwinkel 1991, Loeb 1991, Morales-Nin *et al.* 1995), but there were also studies in the Weddell Sea (Hubold 1990, White & Piatkowski 1993), Prydz Bay (Williams 1985, Gon 1988), off Adélie Land (Koubbi *et al.* 1997), South Georgia (North 1988, North & Murray 1992), the Crozet basin (Koubbi 1993) and Iles Kerguelen (Koubbi *et al.* 1990, 1991).

Data on the early life history stages of fish from the Ross Sea have been very few to date. The "*Terra Nova*" and "*Discovery*" collections include young stages of six species of the notothenniform fish from the Ross Sea and McMurdo Sound (Regan 1916). During Cruise 27 of the USNS *Eltanin*, 21 tows were made over the continental shelf of the Ross Sea, providing data on the composition and distribution of the local midwater fish fauna (De Witt 1970). More recently, from samples collected to the north of the Ross Sea, larvae of six mesopelagic fishes belonging to three families were identified (Efremenko 1987).

The purpose of this paper is to contribute to the limited knowledge of the species composition, abundance and spatial distribution of the ichthyoplankton community of the western Ross Sea.

Material and methods

The Italian Antarctic Oceanographic Cruise "ROSSMIZE" (Ross Sea Marginal Ice Zone Ecology) on board the RV *Italica* was undertaken in the western Ross Sea from 2 November 1994 to 3 January 1995.

Larval and juvenile fish were collected from 18 stations over the continental shelf between 67°50'–75°20'S and 164°40'E–179°20'W, in the period 21 November–27 December 1994 (Fig. 1). The original sampling strategy of a latitudinal cross section across the Ross Sea and a longitudinal transect along the coastal area off Terra Nova Bay could not be followed due to the presence of pack ice. The stations undertaken (Fig. 1) do, however, provide examples of stations within the Ross Sea and beyond it. The sampling gear was the Hamburg Plankton Net (a modification of the Isaacs-Kidd-Midwater-trawl, Hydro-Bios, Kiel, West Germany) with 5 m^2 mouth area and mesh size of 500 mm. The volume of filtered water was measured by a flowmeter at the mouth of the net.

For each station, the time and depth of the tow were recorded by means of a Time Depth Recorder. Towing speed was 1.5–2.5 knots and the fishing time was from 45–60 minutes. The net deployment was normally as a double oblique haul and only in the upper mesopelagic layer. The fishing depth usually ranged from surface to 120 m, except in station 11C where the net was hauled at 380 m depth. Table I summarizes the details for each station.

Larval and juvenile fish were separated from the other zooplanktonic groups. A stereo microscope was used for the taxonomic identification and standard length (SL) of each fish to the nearest millimetre . Larval and postlarval stages are referred to preflexion and postflexion larvae, i.e. before and after upward flexion of urostyle, respectively. The material was then fixed and stored in buffered 4% formaldehyde. The mean relative abundance of each species identified was expressed as number of individuals per 1000 m^3 of filtered water. As a measure of spatial distribution, the frequency of occurrence was also calculated.

Larval and juvenile fish were identified according to the BIOMASS identification keys (Kellermann 1989a, North & Kellermann 1989) and to the illustrated guide to the fish larvae of the Southern Ocean (Efremenko 1985). Postlarval specimens of *Cygnodraco mawsoni* and all the specimens of *Chionodraco myersi* were identified according to Gon (1987). The two postlarval specimens of Macrouridae have been provisionally identified as *Macrourus whitsoni*, on the basis of their number of pelvic fin rays (nine) and the present knowledge about distribution in the Southern Ocean of the other species belonging to the same family (Iwamoto 1990).

Results

Species composition

Twentyone species of larval, postlarval and juvenile fishes were identified (Table II). The nototheniids were the most diverse group (six species), followed by the bathydraconids and channichthyids (five species each). Although not recognized at species level, the artedidraconids occurred in three different morphological types. The other two groups were non-notothenioid fishes, such as the paralepidids and macrourids, each represented by only one species. Most of the specimens collected were at larval and postlarval development stage (Table III). Juvenile stages have been only found in three species, namely *Pleuragramma antarcticum*, *Notothenia kempi* (*Lepidonotothen kempi* in DeWitt *et al.* 1990) and *Trematomus scotti*, which represented all the specimens in the last two species. The mean value, the standard deviation and the range of size of each species is shown in Table II. The SL of early life stages ranged between 8 mm (Artedidraconidae sp. 2) and 73 mm (*Notolepis coatsi*).

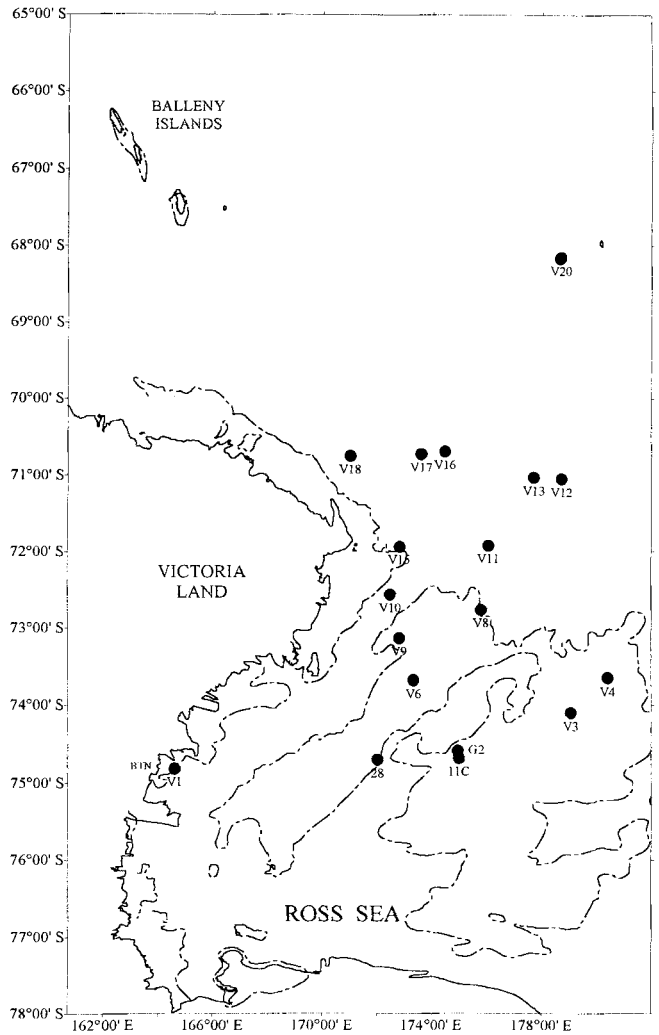

Fig. 1. Study area of the western Ross Sea showing the ichthyoplankton sampling stations carried out during the Italian Antarctic Oceanographic Cruise "ROSSMIZE" (Nov–Dec 1994). The dotted line shows the bathymetry of 500 m depth.

Abundance

A total of 849 specimens of larval, postlarval and juvenile stages of fish were collected at 18 out of the 26 stations. The total volume of filtered sea-water was 412 544 m^3, with a mean of 15 867 ± 4640 m^3 per station. The mean relative abundance value standardized to 1000 m^3 of filtered sea-water and referred to the whole area was 2.7 ± 8.0 specimens. Values estimated separately for each species ranged from 0.05 specimens/1000 m^3 (Artedidraconidae type 1) to 47.65 specimens/1000 m^3 (*Trematomus lepidorhinus*) (Table II).

The nototheniids were the most abundant group of fish, representing 94.3% of all the individuals caught. *Trematomus lepidorhinus* was the most abundant species mainly due to numbers at one station, followed by the Antarctic silverfish *Pleuragramma antarcticum* (26%). In decreasing order of abundance, we found channichthyids (mainly *Chionodraco*

Table I. Sampling data recorded during the Italian Antarctic Oceanographic Cruise "ROSSMIZE" in the western Ross Sea (Nov–Dec 1994).

Station	Date (1994)	Hour	Latitude S	Longitude	Bottom depth (m)	Station depth (m)	Volume filtered (m^3)	No of larvae collected
G2	23.11	16.02	74°34'80	174°57'56"E	448	30	17 205	2
11C	14.12	03.28	74°40'55	174°59'83"E	439	380	25 474	6
28	15.12	00.09	74°42'11	172°00'74"E	522	30	18 471	183
V1	17.12	14.57	74°48'75	164°36'90"E	320	30	11 961	574
V3	18.12	00.41	74°05'73	179°04'08"E	262	120	15 172	4
V4	19.12	10.44	73°38'92	179°35'67"W	383	50	13 383	4
V6	20.12	09.41	73°40'68	173°20'40"E	318	20	16 348	47
V8	21.12	17.58	72°45'66	175°47'91"E	555	25	12 832	1
V9	22.12	00.56	73°07'81	172°49'58"E	488	60	11 710	1
V10	22.12	09.17	72°33'70	172°29'39"E	542	20	16 294	2
V11	23.12	01.16	71°55'16	176°03'52"E	1952	70	7053	1
V12	23.12	17.38	71°02'64	178°43'03"E	1797	45	10 261	1
V13	23.12	00.39	71°01'68	177°41'81"E	2517	25	14 970	4
V15	24.12	17.35	71°55'94	172°49'57"E	1650	80	22 599	8
V16	25.12	15.05	70°41'27	174°28'51"E	2410	100	18 963	3
V17	25.12	18.32	70°43'09	173°36'18"E	1983	90	14 106	2
V18	26.12	00.52	70°44'83	171°00'47"E	2285	60	16 203	4
V20	27.12	15.28	68°09'00	178°41'10"E	3145	90	14 385	2

myersi), bathydraconids (*Gymnodraco acuticeps*) and artedidraconids (type 1), which made up 2.4%, 1.5% and 1.1% of the total specimens, respectively. *Notolepis coatsi* and *Macourus whitsoni* were among the least abundant species, being 0.6% and 0.2% of the total fish caught, respectively.

Spatial distribution

The frequency of occurrence (F) of all the sampled species is shown in Table II. Both artedidraconids and bathydraconids occurred at seven stations (F = 38.9%). The three morphological types of artedidraconids mentioned above

Table II. Larval fish abundance in the western Ross Sea (Nov–Dec 1994) expressed as total numbers (N), relative abundance (N/1000 m^3) and frequency of occurrence (F). The size range, as well as the mean length (SL) and the standard deviation (s d) of each species is included.

Species	N	F (%)	Mean abundance (N°/1000 m^3)	Mean length (mm)	s d (mm)	Range (mm)
Paralepididae						
Notolepis coatsi Dollo, 1908	5	16.7	0.12	46.4	23.1	25–73
Macrouridae						
Macrourus whitsoni (Regan, 1913)	2	11.1	0.06	21.0	2.8	19–23
Notothenidae						
Notothenia kempi Norman, 1937	2	5.5	0.14	43.5	0.7	43–44
Pleuragramma antarcticum Boulenger, 1902	222	27.8	2.45	36.5	4.4	26–56
Trematomus lepidorhinus (Pappenheim, 1911)	570	5.5	47.65	12.2	0.7	10–14
Trematomus loennbergi Regan, 1913	3	5.5	0.20	22.0	1.7	20–23
Trematomus newnesi Boulenger, 1902	1	5.5	0.08	15.0		15
Trematomus scotti (Boulenger, 1907)	3	11.1	0.09	36.0	2.6	33–38
Artedidraconidae						
Species 1	4	22.2	0.05	14.2	3.6	9–17
Species 2	1	5.5	0.08	8.0		8
Species 3	3	16.7	0.07	16.7	1.1	16–18
Bathydraconidae						
Akarotaxis nudiceps (Waite, 1916)	1	5.5	0.08	14.0		14
Cygnodraco mawsoni Waite, 1916	3	11.1	0.07	47.3	5.0	42–52
Gerlachea australis Dollo, 1900	3	11.1	0.08	33.0	1.7	31–34
Gymnodraco acuticeps Boulenger, 1902	4	16.7	0.08	21.5	0.6	21–22
Prionodraco evansii Regan, 1914	2	5.5	0.08	14.5	0.7	14–15
Channichthyidae						
Chaenodraco wilsoni Regan, 1914	1	5.5	0.07	43.0		43
Chionobathyscus dewitti Andriashev & Neelov, 1978	1	5.5	0.06	31.0		31
Chionodraco myersi DeWitt & Tyler, 1960	14	22.2	0.21	37.6	13.8	14–50
Cryodraco antarcticus Dollo, 1900	2	11.1	0.06	33.0	7.1	28–38
Pagetopsis macropterus (Boulenger, 1907)	2	11.1	0.06	29.0	24.0	12–46

were mostly found at the more inshore stations: types 1 and 3 were the most widely distributed (22.2%, stations V1-28-11C-V15 and 16.7%, stations V9-V10-V18 respectively), compared with type 2, which was the least frequent (5.5%, station V1). The bathydraconids showed the following pattern of spatial distribution: *Gymnodraco acuticeps* was the most common species (16.7%, stations V8-V15-V18), followed by *Cygnodraco mawsoni* (11.1%, stations V15-V16) and *Gerlachea australis* (11.1%, stations V3-V15). The other bathydraconids, namely *Akarotaxis nudiceps* and *Prionodraco evansii*, were found in only one station (5.5%, stations V1 and 11C, respectively). The channichthyids and the nototheniids were the most widely distributed groups, both in inshore and in offshore waters. These groups were caught at eight of the 18 stations (F = 44.4%). *Chionodraco myersi* was the most commonly occurring icefish (22.2%, Fig. 2a), followed in decreasing order by *Cryodraco antarcticus* and *Pagetopsis macropterus* (11.1%, stations V16-V17 and 28-V4, respectively). *Chaenodraco wilsoni* and *Chionobathyscus dewitti* were caught once (5.5%, station V3 and V10, respectively). Among nototheniids, *Pleuragramma antarcticum* ranked first in frequency of occurrence (27.8%, Fig. 2b), followed by *Trematomus scotti* (11.1%, stations G2-V6). The other species were caught only once (5.5%, station V20, V1, V13 and V1 for *Notothenia kempi*, *Trematomus lepidorhinus*, *T. loenbergii* and *T. newnesi*, respectively). Finally, the paralepidid *Notolepis coatsi* occurred at three stations mainly offshore (16.7%, stations 11C-V11-V12), whereas the macrourid *Macrourus whitsoni* was captured at two sites off Cape Adare (11.1%, stations V16-V17).

Table III. Early life stages of development of each species collected in the Ross Sea during Nov–Dec 1994.

Species	Larvae	Postlarvae	Juveniles
Notolepis coatsi	+	+	
Macrourus whitsoni		+	
Notothenia kempi			+
Pleuragramma antarcticum		+	+
Trematomus lepidorhinus	+		
Trematomus loennbergii		+	
Trematomus newnesi	+		
Trematomus scotti			+
Artedidraconidae sp. 1	+	+	
Artedidraconidae sp. 2	+		
Artedidraconidae sp. 3		+	
Akarotaxis nudiceps	+		
Cygnodraco mawsoni		+	
Gerlachea australis		+	
Gymnodraco acuticeps		+	
Prionodraco evansii	+		
Chaenodraco wilsoni		+	
Chionobathyscus dewitti		+	
Chionodraco myersi	+	+	
Cryodraco antarcticus	+	+	
Pagetopsis macropterus	+	+	

Discussion and conclusion

The ichthyoplankton community of the Ross Sea was described for the first time by Regan (1916), who pointed out the presence of a small number of species, most of which have been recently revised (North & Kellermann 1989, Loeb *et al.* 1993). They were *Artedidraco skottsbergi*, *Gymnodraco acuticeps* (now *Bathydraco* sp.), *Chionodraco kathleenae* and *Cryodraco* sp. (now *Chionodraco hamatus* and *Dacodraco hunteri*, respectively), *Pagetopsis macropterus*, *Pleuragramma antarcticum* and *Electrona* sp. The species *A. skottsbergi* and *Bathydraco* sp., which Regan (1916) reported in the area of Ross Island did not occur in our samples. Conversely, we found larvae of *D. hunteri* larvae in the stomach of *Trematomus newnesi* off Terra Nova Bay (74°41'20"S, 164°04'00"E) (Vacchi & La Mesa 1995).

The character of the midwater fish fauna inhabiting the continental shelf of the Ross Sea has been investigated by DeWitt (1970), in terms of distribution and abundance of the most representative families. As a consequence of the striking decrease in temperature of deep water (from 0.5 to -1.8°C) in the northern area of the Ross Sea (DeWitt 1970), a very sudden change in species composition was observed in the midwater fish fauna of the Ross Sea, compared with that observed in the Southern Ocean farther north. Some families, such as Myctophidae, Gonostomatidae, Bathylagidae and Paralepididae, are almost entirely excluded from the Ross Sea except for the last family, which extends south only to the edge of the continental shelf. Thus, the midwater fish fauna of the continental shelf of the Ross Sea is almost exclusively composed of diverse notothenioids species (DeWitt 1970). On the other hand, the true mesopelagic community represented by Myctophidae, Bathylagidae and Paralepididae characterizes the northern area adjacent to the Ross Sea (Efremenko 1987). The mesopelagic fish show notal Antarctic (*Krefftichthys anderssoni, Protomyctophum bolini* and *Gymnoscopelus braueri*) and Antarctic (*Bathylagus antarcticus, Notolepis coatsi* and *Electrona antarctica*) types of range. Eggs and larvae of the notal Antarctic species are confined to the Antarctic Circumpolar Current (ACC), whereas those of the Antarctic species have been found both in the ACC and in the higher latitudes (Efremenko 1987).

Our results are in agreement with DeWitt 's findings but the relatively low number of stations in the northern area beyond the Ross Sea shelf, the sampling period and the shallow depth range investigated probably introduced a bias in our samples, which contain only one mesopelagic fish, *N. coatsi*. In late summer (January and February), the mesopelagic fish such as the bathylagids, myctophids and paralepidids, were most common in samples from the offshore and deeper stations in the Weddell Sea, characterizing the oceanic waters beyond the shelf-break front (Hubold 1990, White & Piatkowski 1993).

As the greater part of the suborder Notothenioidei are mostly benthic as adults, the midwater fish fauna of the continental shelf of the Ross Sea is only constituted by

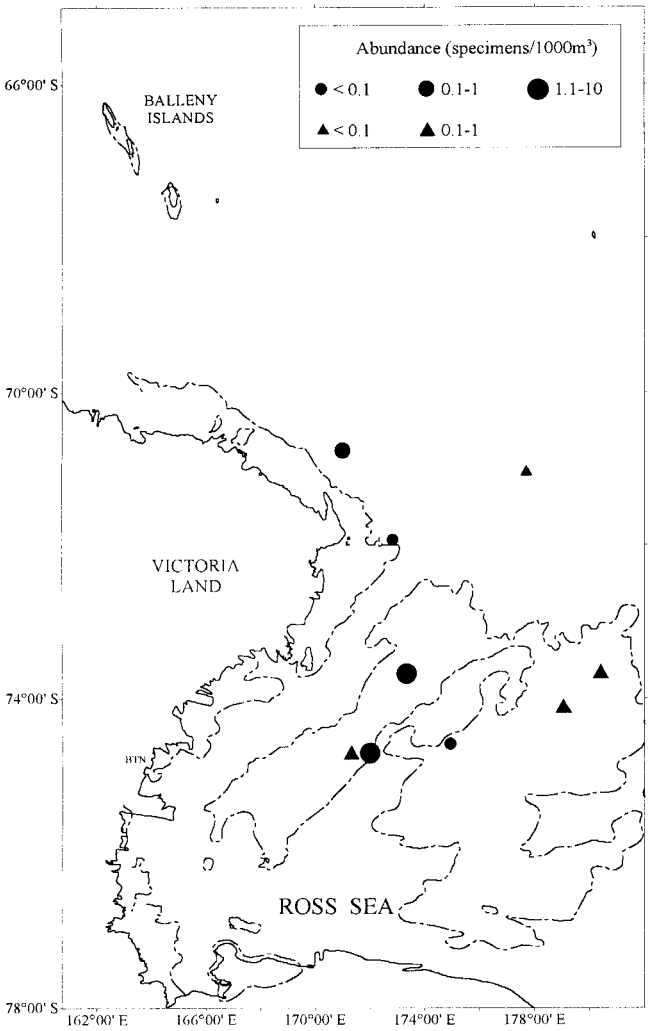

Fig. 2. Spatial distribution and abundance of *Chionodraco myersi* (●) and *Pleuragramma antarcticum* (▲) sampled in the western Ross Sea during Nov–Dec 1994. Abundance values are standardized as number of specimens 1000 m^{-3} of filtered water.

juveniles or larvae, except for the over shelf pelagic species *P. antarcticum*. This fish is one the few notothenioid pelagic species in the high Antarctic waters also present in the adult stage, and it represents the dominant component of the midwater fish fauna of the Ross Sea (DeWitt 1970, present results). Similarly, *P. antarcticum* overwhelmingly dominated the ichthyoplankton samples in the Weddell Sea, representing from 85% to 98% of the total catches (Hubold 1990, White & Piatkowski 1993).

The size ranges of the species collected in the Ross Sea was very similar to those observed at other Antarctic sites during the same period of the year. Similarly to our results on bathydraconids in the Ross Sea (see Table II), Kellermann (1989) reported postlarvae of *Gerlachea australis* (34 mm SL) and of *Gymnodraco acuticeps* (16–27 mm SL) as well as larvae of *P. evansii* (12–14 mm SL) with yolk remains in the Antarctic Peninsula region in the period mid-November and mid-December.

Among channichthyids, postlarvae of *Chaenodraco wilsoni* (30–37 mm SL), *Cryodraco antarcticus* (32–44 mm SL) as well as *P. macropterus* (23–36 mm SL) were found in the Antarctic Peninsula region in late November–early December (Kellermann 1989). Similarly, we sampled a postlarva of *C. wilsoni* of 43 m SL and larval and postlarval stages of *C. antarcticus* (28–38 mm SL) and *P. macropterus* (12–46 mm SL) in the Ross Sea in December.

Our data for nototheniids also closely resemble the size range reported for *T. lepidorhinus* (8.7–11 mm SL), *T. newnesi* (11–22 mm SL) and *T. scotti* (27–36 mm SL) from the Antarctic Peninsula in mid-November (Kellermann 1989a) and mid-November to mid-December (Kellermann 1989), (see Table II). On the other hand, early juvenile stages of *N. kempi* of 37–41 mm SL were collected in the Antarctic Peninsula region in February (Kellermann 1986), about two months later than our individuals (43–44 mm SL) caught in December. Our *N. kempi* were collected only close to the Scott Islands at station V20, which agrees with previous data on distribution (DeWitt *et al.* 1990). It is interesting to note that juvenile fishes similar to the above specimens of *N. kempi*, as well as to the description of Kellermann (1989a), were identified as *Trematomus bernacchii* by Slósarczyk (1983) off the Balleny Islands. These data partially agree with those concerning nototheniids reported by DeWitt (1970), who pointed out that the genus *Notothenia* (subsequently subdivided into several genera) represented the dominant benthic group at Scott and Balleny Islands, whereas the genus *Trematomus* dominated the continental shelf of the Ross Sea.

The high number of larvae of *T. lepidorhinus* caught off Terra Nova Bay is noteworthy (station V1, Fig. 1). The abundance of this species in Terra Nova Bay might be due to the presence of a polynya, which influences sea ice dynamics and physical oceanography in this area (Kurtz & Bromwich 1985). In addition, the same data suggest that in the Ross Sea this species hatches in spring, as observed in the Antarctic Peninsula (Kellermann 1989a, 1989b).

Finally, another interesting result is the wide size range of *P. antarcticum* found in our samples. The majority of *P. antarcticum* specimens were sampled at station 28 in a marginal ice zone where a high value of fluorescence was detected (Russo in press). According to present information on hatching and life history of this species (Kellermann 1986, Hubold 1985), our specimens belong to the age class 1 (several postlarvae of 27–48 mm SL caught in December) and 2 (one juvenile of 58 mm SL caught in November).

Taking into account the species described in this paper, a total of 31 different fish species have been thus far identified as living and reproducing in the Ross Sea. However, this is only *c.* 40% of the more than 70 coastal and mesopelagic species reported from the Ross Sea (DeWitt & Tyler 1960, Iwami & Abe 1981, Wyanski & Targett 1981, Takahashi & Nemoto 1984, Gon & Heemstra 1990, Vacchi *et al.* 1991,

1992, Balushkin 1994). In better studied Antarctic sectors, such as the Weddell Sea and the Antarctic Peninsula, more than 50% of the coastal and mesopelagic species have been identified from ichthyplankton collections (Kellermann & Kock 1988, White & Piatkowski 1993). This indicates that further studies are needed to complete the survey of larval and juvenile fishes in the Ross Sea.

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