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Larval fish community in the Bay of Whales (eastern Ross sea): Species composition, relative abundance and spatial distribution

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A R T I C L E I N F O

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A B S T R A C T

Early life stages of fish represent a key component in the food chain of the pelagic ecosystem of the Southern Ocean, connecting producer trophic levels to those of higher predators. Pelagic larvae and early juveniles of notothenioid fishes overwhelmingly dominate the ichthyoplankton community living on the continental shelf. Scientific research surveys targeting early life stages of fish in the pelagic realm have been mainly carried out in the western Ross Sea, whereas the eastern side can be considered unexplored. As source of high primary production, the presence and timing of formation of wide ice-free areas throughout the year in the Ross Sea play a fundamental role in structuring larval fish community. The Ross Ice Shelf Polynya (RISP) is a large coastal polynya, which is driven and maintained by local prevailing winds and oceanic currents. In the present study, we report the first data on species composition, relative abundance and spatial distribution of larval fish community found off the Bay of Whales in the eastern Ross Sea. As reported for other areas of the Ross Sea, the Antarctic silverfish *Pleuragramma antarcticum* was by far the most abundant species, followed by other nototheniids and channichthyids in smaller amounts. The huge abundance of *P. antarcticum* early larvae supports the hypothesis of a potential nursery area near the Bay of Whales. Present results strongly advocate for future investigations in these poorly known and remote areas.

1. Introduction

The eastern Ross Sea encompasses a large rift basin, bounded to the west side by the Glomar Challenger Basin and to the east side by the Little America Basin (Halberstadt et al., 2016). A relatively broad trough, the Whales Deep Basin, occupies the central eastern Ross Sea and is separated by the relatively low-relief ridges (Hayee and Outz Banks) (e.g., Danielson and Bart, 2019). To the south, the eastern Ross Sea is delimited by the Ross Ice Shelf, a nearly vertical ice barrier between 15 and 50 m high above the water surface (Fig. 1). The edge of the Ross Ice Shelf is characterized by a wide ice-free coastal area extending eastwards from Ross to Roosevelt Islands, i.e., the Ross Sea Polynya (RISP), whose formation and maintenance are influenced by various forcing mechanisms such as prevailing winds and oceanic currents (e.g. Park et al., 2018; Cheng et al., 2019). The currents on the Ross Sea continental shelf are characterized by a gyre-like circulation with substantial seasonal variability, and two wide anticyclonic gyres under the Ross Ice Shelf cavity (Dinniman et al., 2003; Smith et al., 2007).

From a zoogeographic point of view, Antarctic fishes were assigned to East Antarctic and West Antarctic Provinces based on the composition and distribution of coastal fish fauna (Andriashev, 1965, 1987; DeWitt, 1971). More recently, considering both the oceanic and coastal fish

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fauna, Kock (1992) described the Seasonal Pack-Ice Zone and the High-Antarctic Zone, corresponding to the former West Antarctic and East Antarctic Provinces. The demersal fish assemblage inhabiting the continental shelf is largely dominated by the notothenioids, a primarily benthic group as adults with few species becoming pelagic at various extent (Eastman, 1993; Klingenberg and Ekau, 1996). On the other hand, larval and juvenile stages of notothenioids are components of the coastal pelagic ecosystem of the Southern Ocean and play a fundamental role in promoting connectivity and gene flow among adult populations (Loeb et al., 1993; Koubbi et al., 2009).

Compared to their western counterparts in the Ross Sea (Dewitt and Tyler, 1960; Iwami and Abe, 1981; Eastman and Hubold, 1999; Vacchi et al., 2000; La Mesa et al., 2004, 2006; Clark et al., 2010; Buckley, 2013; Hanchet et al., 2013), the pelagic and demersal fish assemblages of the eastern Ross Sea are poorly known, due to relative remoteness of this area from any scientific research station and to the almost permanent ice-cover throughout the year (Donnelly et al., 2004). The few studies carried out in this area reported that the pelagic oceanic assemblage of the eastern Ross Sea mainly consisted of non-notothenioid fish families (Bathylagidae, Gonostomatidae, Myctophidae and Paralepididae), as well as adults of the notothenіid silverfish *Pleuragramma antarcticum* (Donnelly et al., 2004). The demersal assemblage was characteristic of the East Antarctic Province, being composed of seven species each of Artedidraconidae, Bathydraconidae and Channichthyidae, ten species of Nototheniidae, and three species each of Rajidae and Zoarcidae (Donnelly et al., 2004).

The same disparity in knowledge between different areas of the Ross Sea occurs for the ichthyoplanktonic component of the pelagic community. Previous studies on larval and juvenile fish assemblages have been focused almost exclusively on the western Ross Sea, primarily in proximity to the scientific research stations of Terra Nova Bay (Guglielmo et al., 1998; Vacchi et al., 1999; Granata et al., 2000, 2002, 2009) and McMurdo Sound (Murphy et al., 2017). As a result of four ichthyoplankton surveys carried out in the western Ross Sea and, in particular, in Terra Nova Bay, a species inventory including the notothenioid families Nototheniidae (8 species), Channichthyidae (8 species), Bathydraconidae (7 species) and Artedidraconidae (3 species), as well as Macrouridae (1 species), Muraenolepididae (1 species), Myctophidae (2 species), Bathylagidae (1 species) and Paralepididae (2 species) has been recorded (reviewed in Granata et al., 2002). A recent study conducted over a ten-years long sampling period from various locations off McMurdo Sound provided early life stages of Nototheniidae (6 species), Channichthyidae (4 species), Bathydraconidae (1 species) and Artedidraconidae (1 species) (Murphy et al., 2017).

Despite the considerable sampling effort exerted during the previous surveys, early life stages of only 50% of demersal species known from the western Ross Sea have been recorded so far (Granata et al., 2002; Clark et al., 2010). It was therefore concluded that further studies needed to be implemented to provide a more complete overview of the ichthyoplankton community (Vacchi et al., 1999). This is particularly true for the larval fish community inhabiting the coastal waters of the eastern Ross Sea, which is still virtually unknown. A single tow carried out by a Tucker trawl in the Bay of Whales yielded early larvae of *Pleuragramma antarcticum* and the channichthyid *Dacodraco hunteri* (Brooks et al., 2018). To fill this gap of knowledge, an ichthyoplankton survey was conducted in the austral summer 2023 in proximity to the Bay of Whales (eastern Ross Sea), in the framework of a multidisciplinary research project aimed to investigate the biophysical coupling

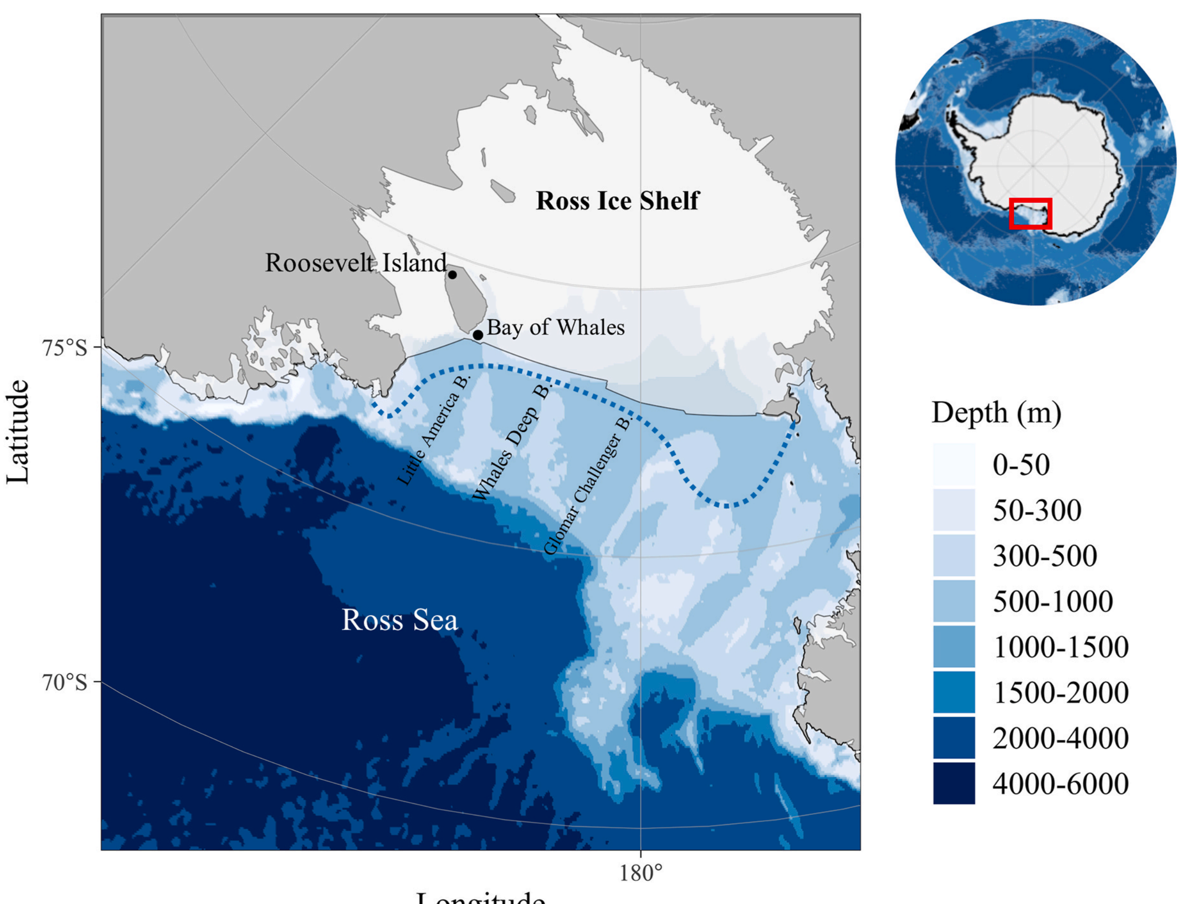

Fig. 1. The eastern Ross Sea, showing the main topographic features including the Ross Ice Shelf and the glacial troughs/banks systems characterizing the sea floor. The Ross Ice Shelf Polynya (RISP) is represented by the dotted line.

structuring the larval and juvenile fish community of the Ross Sea continental shelf (project acronym BIOCLEVER).

The main objectives of the present study are to provide, for the first time, data on species composition, relative abundance and spatial distribution of the ichthyoplankton community living in the Bay of Whales coastal area, just in front of the Ross Sea Ice Shelf. Based on the larval distribution, density and size, we could infer presence and location of hatching and/or nursery areas and confirm what previously hypothesized by other authors on the basis of few isolated samplings (Brooks et al., 2018). Patterns of horizontal and vertical distribution across the surveyed area were discussed in relation to hydrological characteristics and local water masses. Finally, present data on species diversity and relative abundances of larval assemblage recorded in the Bay of Whales were compared with their counterpart previously described in the western Ross Sea by other studies, as well as adult populations recorded in the same area.

2. Materials and methods

2.1. Sampling at sea

During the XXXVIII Italian Antarctic Expedition, an ichthyoplanktonic survey was carried out aboard the RV *Laura Bassi*. A total of 8 stations, located in the Bay of Whales in front of the Ross Sea Ice Shelf (Fig. 2, Table 1), were sampled between 28 and 29 January 2023 during daylight using an opening-closing Tucker trawl equipped with two nets of 1 m^2 mouth and mesh size 500 μm. For each station, the nets were towed in succession off the stern of the vessel through the water column, targeting the depth strata comprised between 300-150 m and 150-0 m, respectively. A SIMRAD trawl positioning and monitoring system was mounted on the fixed frame of the net to acquire data about net operating depth. Towing time for each net was approximately 25 min, and the volume of water sampled was measured using mechanical flowmeters (General Oceanics, Model CC5100 series). Potential temperature (θ, °C), salinity (S, PSU) and oxygen (mg/l) profiles were collected across the entire sampling strata at four stations positioned in the eastern, central and western biological sampling areas, using CTD (Sea Bird Electronics SBE9/11plus) casts.

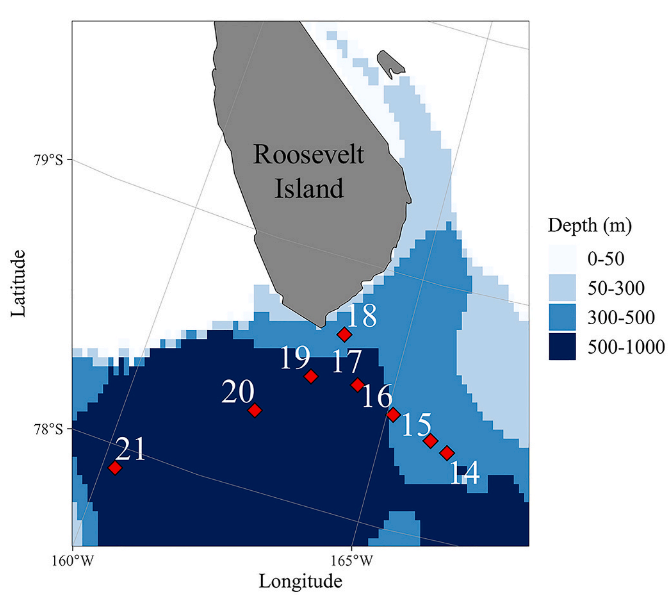

Fig. 2. Map of the study area in the Bay of Whales, showing the location of sampling stations. Numbers refer to the stations code.

Table 1
Sampling station data in the coastal area off the Bay of Whales.

Stations	Date	Lat (S)	Long (W)	Distance (nm)	Bottom depth (m)
14	28/01/2023	−78.38093	−166.39922	3.25	515
15	28/01/2023	−78.41025	−165.92116	2.98	498
16	28/01/2023	−78.46943	−165.04503	2.85	498
17	28/01/2023	−78.53238	−164.40363	3.06	599
18	29/01/2023	−78.73292	−163.76463	3.07	290
19	29/01/2023	−78.53271	−163.27592	3.03	580
20	29/01/2023	−78.32135	−162.57268	2.88	686
21	29/01/2023	−77.94273	−160.25465	2.91	665

2.2. Laboratory activities

A preliminary sorting was devoted to separate early life stages of fishes from other zooplankton taxa directly on board and stored in 95% ethanol. Taxonomic identification of fishes was done according to the key and catalogue of larval Antarctic fish (North and Kellermann, 1990; Kellermann, 1990). Larvae belonging to the genus *Chionodraco* were provisionally identified as *C. hamatus*, being the most abundant in the area (Donnelly et al., 2004). For each specimen, the standard length (SL) was measured to the nearest mm below and the larval stage of development was assigned to a four-point scale (Koubbi et al., 1990), defining yolk-sac larvae, pre-flexion larvae, post-flexion larvae and juveniles after metamorphosis. In case of large catches, as for *P. antarcticum*, a subsample representing at least 20% of total fish collected was measured. All specimens were then stored in 70% ethanol solution for further analyses.

2.3. Data analyses

To describe the larval fish assemblage, diversity (expressed in terms of species richness (S) and the Shannon-Wiener index (H')) and standardized abundance (expressed as the number of specimens per 1000 m^3) have been calculated for each sampling station and depth strata. To describe the spatial distribution of *P. antarcticum* in the investigated area, its standardized abundance was calculated for each station, depth strata and stage of development. The length-frequency distributions of *P. antarcticum* were computed for each station and compared using the Mann-Whitney pairwise test.

In the context of analysing larval abundance data, Generalized Linear Models (GLMs) were employed to assess potential variability in density of individuals among the two sampling depth ranges, and among the two early life stages (i.e., larvae and post-larvae, see Results). The models were constructed using the Gamma family, on sqrt-number of larvae per 1000 m^3, and considering sampling depth and life stage as two factors, fixed and crossed. To test the homogeneity of variances in abundance data, between groups of stage and depth, the Levene test based on absolute deviation from the mean was performed (Gastwirth et al., 2023). All statistical analyses were performed using the R version 4.2.3 software (R Core Team, 2023; James et al., 2013).

3. Results

3.1. Fish assemblage overview

Overall species composition of the larval fish assemblage sampled in the Bay of Whales is summarized in Table 2. The assemblage was

Table 2
Species composition, number of larvae (postlarvae in brackets), size range, frequency of occurrence and standardized abundance (considering only positive stations for each species) of the larval fish assemblage sampled in the Bay of Whales.

Species	Specimens (n)	Occurrence (%)	Abundance (n/1000m^3)	Size range (mm)
Bathydraconidae				
Racovitzia glacialis	(1)	12.5	0.4	16
Channichthyidae				
Chionobathyscus dewitti	(1)	12.5	0.3	32
Chionodraco hamatus	2 (4)	37.5	0.5	22–32
Dacodraco hunteri	23	62.5	1.1	15–20
Pagetopsis maculatus	9	75.0	0.4	15–18
Nototheniidae				
Aethotaxis mitopteryx	9	12.5	2.7	22–24
Pleuragramma antarcticum	4440 (4458)	100.0	275	7–18
Trematomus lepidorhinus	1 (2)	37.5	0.3	16–17
Trematomus scotti	1	12.5	0.2	10

composed exclusively by notothenioid families, such as Bathydraconidae (*Racovitzia glacialis*), Channichthyidae (*Chionobathyscus dewitti*, *Chionodraco hamatus*, *Dacodraco hunteri*, *Pagetopsis maculatus*) and Nototheniidae (*Aethotaxis mitopteryx*, *Pleuragramma antarcticum*, *Trematomus lepidorhinus*, *Trematomus scotti*). A total of 4485 larvae and 4466 postlarvae have been collected in the sampled area, with overwhelming dominance of *P. antarcticum* accounting for 98.9 % and 99.8 % of larvae and postlarvae, respectively (Table 2). Frequency of occurrence, as number of positive stations on the total number of stations performed, was at the lower end in some species (*A. mitopteryx*, *R. glacialis*, *C. dewitti*, *T. scotti*), increasing progressively in more abundant species. As expected, *P. antarcticum* was collected in all stations (Table 2). The standardized abundance was generally less than one specimen per 1000 m^3, except for *D. hunteri* and *A. mitopteryx*, while *P. antarcticum* was three orders of magnitude higher than other species (Table 2). Size range was relatively narrow in those species with few individuals (*R. glacialis*, *C. dewitti*, *T. lepidorhinus*, *T. scotti*), or with single stages of development (larvae of *D. hunteri*, *P. maculatus* and *A. mitopteryx*). On the other hand, *P. antarcticum*, for which a large number of specimens were collected of both larvae and postlarvae, was associated with a wide size range (Table 2). Interestingly, no juveniles at all were caught in the entire area of Bay of Whales.

3.2. Spatial patterns of distribution

Considering the overall spatial distribution of catches in the Bay of Whales, there was a clear longitudinal trend, as total abundance and number of species increased from eastern to western stations (Fig. 3a). Total abundance of larvae and postlarvae across the investigated area had a similar pattern, increasing from east to west (Fig. 3b and c). Conversely, the Shannon-Wiener index exhibits an opposite trend, increasing from west to east, due to the overwhelming dominance of a single species (*P. antarcticum*) compared to the other ones in the westernmost stations (i.e., 14 and 15) (Fig. 3d). The horizontal spatial distributions of the most representative species (excluding *P. antarcticum*) showed that *A. mitopteryx* and *C. hamatus* were collected in the westernmost station (Fig. 4a and b), whereas catches of *D. hunteri* occurred in the central stations (Fig. 4c). Larvae of *P. maculatus* were distributed in the whole sampled area, although mainly in the central stations (Fig. 4d). The vertical distribution of larvae and postlarvae of all species pooled together (excluding *P. antarcticum*) indicated that larval stages were evenly distributed in the entire water column surveyed (Fig. 5). The GLM for the abundance response variable showed no significance between the dependent variable and any combination of the independent variables. Moreover, Levene's test for variance showed that there is no significant difference in the variances of the abundance distributions along the water column and by stage.

3.3. *Pleuragramma antarcticum*

The early life stages of *P. antarcticum* included a similar number of

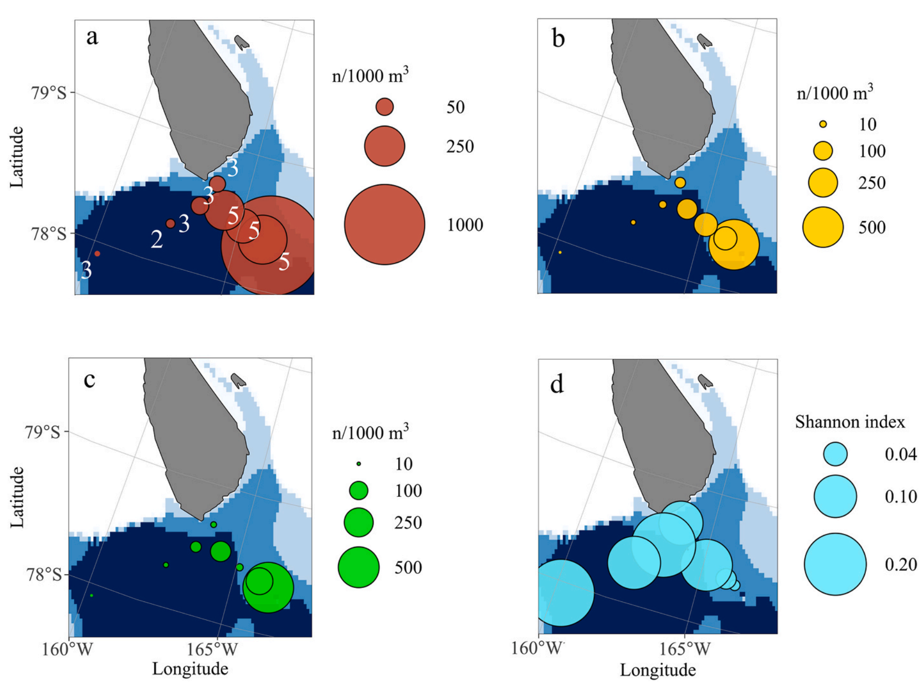

Fig. 3. Spatial distribution of standardized abundances and fish biodiversity across the sampling stations in the Bay of Whales. Overall abundances and species richness (i.e. total number of species, shown inside the circles) (a), overall abundance of larval (b) and post-larval stages (c) and species diversity (d).

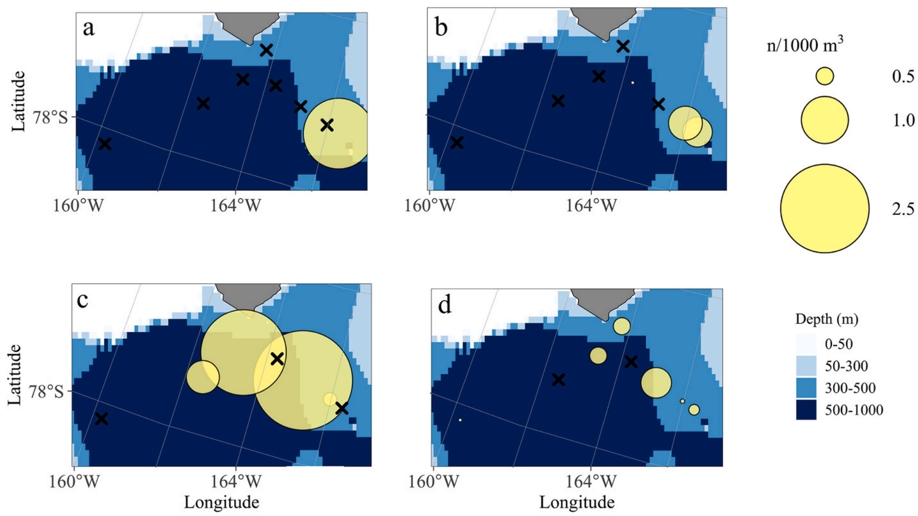

Fig. 4. Spatial distribution of standardized abundances of the most representative species collected in the Bay of Whales (excluding *Pleuragramma antarcticum*). *Aethotaxis mitopteryx* (a), *Chionodraco hamatus* (b), *Dacodraco hunteri* (c) and *Pagetopsis maculatus* (d). Crosses indicate negative stations.

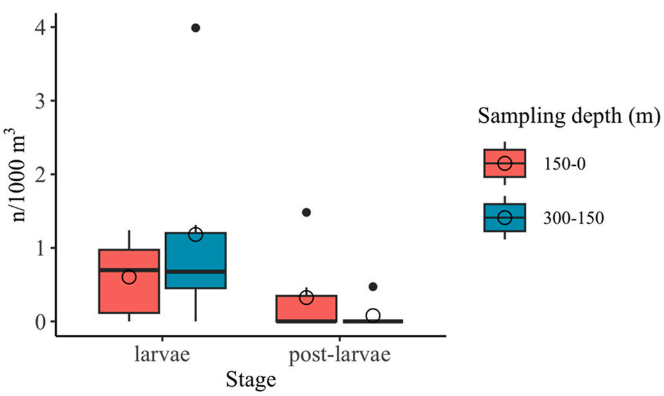

Fig. 5. Overall standardized abundances cumulated for all the species collected in the Bay of Whales (excluding *Pleuragramma antarcticum*) in relation to stage of development and sampling depth strata. Boxplots indicate the quartiles, the median (black line inside the boxplot) and the mean (empty circle) values.

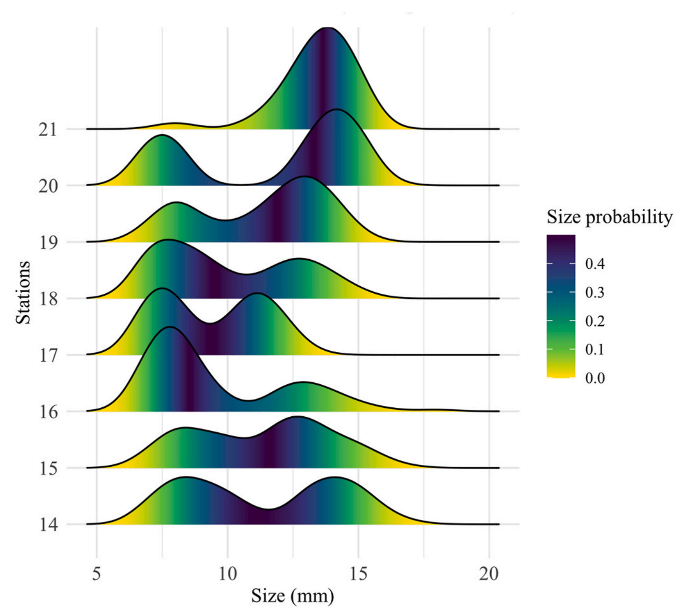

Fig. 6. Density curves by probabilities of *Pleuragramma antarcticum* sizes (SL, mm). Each curve is representative of each sampled station.

larvae (4440) and postlarvae (4458), yielding an overall standardized abundance of 275 specimens/1000 m^3 (Table 2). The length-frequency distributions (LFDs) obtained for each sampling station consisted of two discrete modes, representing larval and postlarval stages roughly separated by the 10–12 mm size classes (Fig. 6). The LFDs were significantly different across the surveyed area, especially those recorded in stations 15 and 21 (Table 3), with an evident shift of modes from east to west direction (Fig. 6). On the other hand, the small size of early larvae (7–8 mm SL) proved the closeness of both hatching period and location somewhere in the surveyed area of Bay of Whales. The horizontal distribution of catches was similar for larvae and postlarvae, with an increase of abundance towards the westernmost stations (Fig. 7a and b). Even the vertical distribution of larvae and postlarvae were similar to each other, as the overall abundance of both early stages of development was significantly more variable in the deeper stratum at 150–300 m (Fig. 8). In this case, although the GLM did not show significant differences in the distribution of abundances along the water column, in combination with stage, the Levene's test showed heterogeneity of variances (p-value <0.05) between groups defined by the combination of stage and depth with the dependent variable abundance. However, observing the variability within each life stage related to depth alone, the test showed that the variability is significant only for the larval stages (p-value: 0.0003).

3.4. Oceanographic data

Potential temperature (θ), salinity (S) and dissolved oxygen vertical profiles showed a highly oxygenated Antarctic Surface Water (AASW, Orsi and Wiederwohl, 2009; Budillon et al., 2011) layer of about 150 m in all stations (Fig. 9). In the eastern CTD stations (#20 and #21), a shallower and fresher mixed layer of about 10 m is observed, likely related to summer sea ice melting. In the western CTD stations, a deeper mixed layer of about 50 m was recorded at station #14, and approximately 130 m at station #18 within the Bay of Whales. In all stations, below the mixed layer, a strong thermocline was observed, associated with an increase in salinity and a decrease in dissolved oxygen.

The layer below 150 m had similar thermohaline properties in all stations, with salinity higher than 34.10 psμ, potential temperature colder than −1.78 °C and dissolved oxygen below 14.5 mg/l. At around 200 m depth, all profiles show a water mass with characteristics similar to the Amundsen Sea Water (ASW, θ ≈ −1.81 °C and S = 34.13 psμ;

Table 3
Results of the Mann-Whitney pairwise test applied to the length-frequency distributions of *Pleuragramma antarcticum* recorded from each sampling station. Statistically significant values U at $p < 0.05$ are in bold.

Stations	15	16	17	18	19	20	21
14	0.2001	**0.0264**	0.4683	0.2868	0.1828	0.0627	**0.0088**
15		**0.0043**	0.5867	**0.0366**	**0.0250**	**0.0089**	**0.0042**
16			**0.0452**	0.0788	0.1770	0.6229	0.2985
17				0.2888	0.2657	0.1325	**0.0217**
18					0.7234	0.1113	**0.0094**
19						0.4787	**0.0214**
20							0.0881

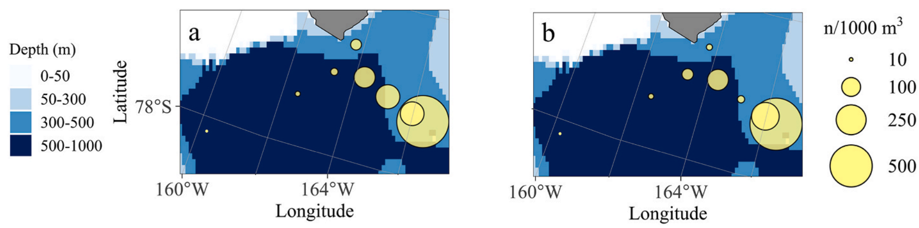

Fig. 7. Spatial distribution of standardized abundances of *Pleuragramma antarcticum* larvae (a) and postlarvae (b) collected in the Bay of Whales.

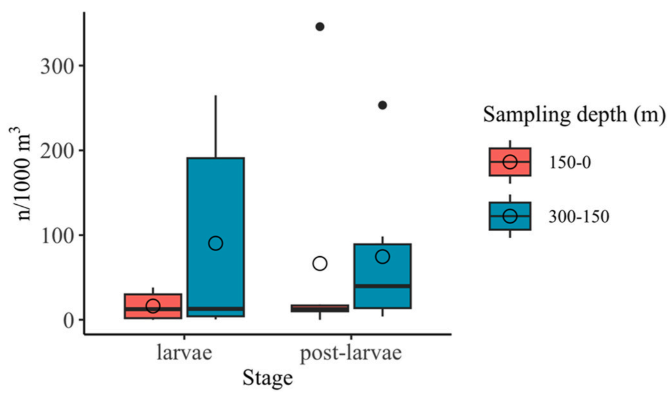

Fig. 8. Overall standardized abundances of *Pleuragramma antarcticum* collected in the Bay of Whales in relation to stage of development and sampling depth strata. Boxplots indicate the quartiles, the median (black line inside the boxplot) and the mean (empty circle) values.

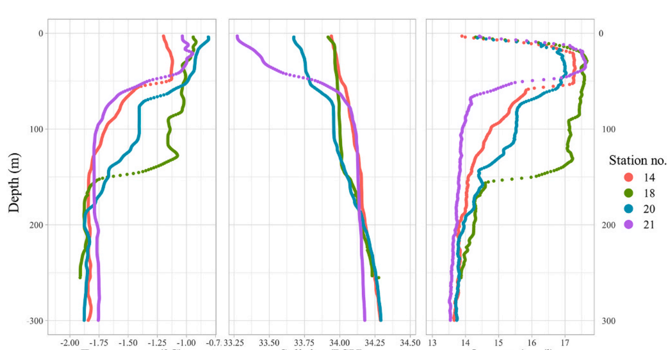

Fig. 9. Vertical profiles of potential temperature (°C), salinity (PSU) and dissolved oxygen (mg/l) in four stations located in the Bay of Whales.

Randall-Goodwin et al., 2015), which has already been found in the Ross Sea at the same depth (Rivaro et al., 2022). The Amundsen Sea Water is formed in the Amundsen Sea polynya during winter and transported by the Antarctic Slope Current into the Ross Sea (Thompson et al., 2018).

4. Discussion

The larval fish assemblage of the coastal area of the Bay of Whales consisted exclusively of notothenioid fishes, as early life stages of mesopelagic fish such as bathylagids, myctophids and paralepidids are confined offshore in oceanic waters beyond the shelf break (Hoddell et al., 2000; Koubbi et al., 2009). Despite the relatively small number of sampling stations surveyed over a short time, species diversity was comparable with those recorded elsewhere in the western Ross Sea, such as in Terra Nova Bay (Vacchi et al., 1999; Granata et al., 2002) and McMurdo Sound (Murphy et al., 2017). Considering the temporal limitation of sampling, the species diversity in the Bay of Whales was likely underestimated, as we were not able to catch larval and juvenile fishes hatched in different periods or already migrated into deeper waters. In contrast, as reported for larval fishes from South Georgia (e.g., North and Murray, 1992), net avoidance during daylight in summer could negatively affect the number of species caught.

As far as the species composition is concerned, larvae of *A. mitopteryx*, *P. maculatus* and *D. hunteri* were recorded in large numbers, considering their rare occurrence as adults either in pelagic or bottom trawl catches in the eastern and western Ross Sea (Eastman and Hubold, 1999; Donnelly et al., 2004; Hanchet et al., 2013). Interestingly, larval stages of the pelagic *A. mitopteryx* have never been recorded in the Ross Sea, whereas they commonly occurred in the larval fish assemblages from the Weddell Sea and, less frequently, off the Antarctic Peninsula (Efremenko, 1983, 1984; Kellermann, 1990; Loeb et al., 1993). The size range of *A. mitopteryx* larvae recorded off the Bay of Whales in January closely resembles that found in the same period from the Weddell Sea (Hubold, 1990). We can therefore hypothesize that in the Ross Sea this species hatches in spring as in the Weddell Sea, where yolk-sac larvae were collected in November (Kellermann, 1990). Differently from Hureau (1985), who stated that the Ross Sea population of *A. mitopteryx* might represent a subspecies, we hypothesize a panmictic population around the Antarctic Continent based on its pelagic habits and spawning season resemblance.

Early larvae of *P. maculatus*, a demersal species as adult, were evenly distributed in most sampled stations of the Bay of Whales, whereas they were occasionally sampled in the western Ross Sea (Granata et al., 2000). The small size of larvae sampled in the Bay of Whales may suggest a late spring-early summer hatching, as reported from the Weddell Sea (Hubold, 1990). The channichthyid *Dacodraco hunteri* is a semi-pelagic species, only recently documented in the Ross Sea (Eastman, 1999, 2020). Although adults have not yet been recorded in the eastern Ross Sea, likely because they occur in deep waters (Donnelly et al., 2004), larvae of *D. hunteri* were the most abundant channichthyid sampled in the Bay of Whales, indicating this site as a potential nursery area for this species. Similarly, early life stages of *D. hunteri* are among the major components of the larval fish assemblages all around the Antarctic Continent, being reported from the western sector of the Ross Sea, Weddell Sea and Cooperation Sea (Efremenko, 1989; Hubold, 1990; Granata et al., 2000; Brooks et al., 2018). The size range of early larvae of *D. hunteri* recorded in the Bay of Whales was similar to that recorded off Terra Nova Bay (La Mesa et al., 2012), suggesting the presence of two discrete hatching areas in both sectors of the Ross Sea, probably connected by prevalent coastal currents flowing along the Ross Ice Shelf (see below).

As expected, early life stages of *Pleuragramma antarcticum* overwhelmingly dominated the coastal fish assemblage of the Bay of Whales, as reported over the continental shelf from several other areas in the High-Antarctic Zone, where it accounted for more than 90–95% of total catches (e.g. Hubold, 1990; Koubbi et al., 1997; Hoddell et al., 2000; Granata et al., 2002). Although with large interannual variability, the mean standardized abundances of *P. antarcticum* larvae in the western Ross Sea were comparable to that observed in the Bay of Whales (275 specimens/1000 m^3), ranging from 80 to 600 specimens/1000 m^3 (Granata et al., 2002). On the other hand, the mean standardized abundance recorded in Terra Nova Bay was one order of magnitude higher, accounting for more than 2700 specimens/1000 m^3 (Granata et al., 2002).

Before our survey, the presence of early larvae of *P. antarcticum* in the Bay of Whales was documented for the first time in two occasions through single tows (Biggs, 1982; Brooks et al., 2018). Biggs (1982) found a remarkable concentration of larvae of about 10 mm SL in mid-December-mid January, whereas more recently larvae measuring 8–11 mm SL were sampled in mid-March (Brooks et al., 2018). The small size of larvae, close to the hatching size of 9 mm SL reported from Terra Nova Bay (Vacchi et al., 2004), led authors to hypothesize the presence of a spawning/hatching area in the vicinity of the Bay of Whales (Ghigliotti et al., 2017; Brooks et al., 2018). Present results strongly support this hypothesis, considering the large amount of recently hatched larvae of *P. antarcticum* collected during the survey. As described for the inshore waters of Terra Nova Bay, fast ice somewhere in the Bay of Whales likely provides suitable environmental conditions for spawning and embryonic development of *P. antarcticum*. Combining previous and present data, the timing of occurrence of early larvae of *P. antarcticum* in the Bay of Whales is spread over a relatively long period, reflecting remarkable interannual variability and/or multiple hatching events within the same spawning season, as reported elsewhere (Granata et al., 2002; Keller, 1983).

The ubiquitous presence of *P. antarcticum* in the entire surveyed area of the Bay of Whales allowed us to make some inferences on the environmental factors structuring its spatial distribution. Both the horizontal and vertical distribution patterns of this species were strictly correlated to hydrography and different water masses. The horizontal distribution indicated an evident westward increase of abundance of both larvae and postlarvae. The apparent advection of early life stages was likely driven by the main coastal currents flowing in the westward direction along the front of the Ross Ice Shelf (Pillsbury and Jacobs, 1985; Dinniman et al., 2003; Orsi and Wiederwohl, 2009). Such a westward transport during the ontogeny would allow early life stages of *P. antarcticum* to reach the RISP, which is centred east of Ross Island, an area particularly suitable for larval feeding of this species (Guglielmo et al., 1998; La Mesa et al., 2010). In addition, the cross-shelf inflow and outflow regimes of currents located respectively in the western and eastern sides of the eastern troughs (i.e., Glomar Challenger, Whales, and Little America) can promote movement between the nursery area in the Bay of Whales and feeding grounds offshore (Brooks et al., 2018).

Differently from late summer-early autumn (March), when the inshore waters showed a weak stratification and freshening consistent with upwelling from deeper melting processes along the front of the ice shelf (Brooks et al., 2018), all stations surveyed in January 2023 were characterized by a marked vertical gradient of temperature, salinity and oxygen positioned between 50 and 150 m depth. The vertical distributions of larvae and postlarvae of *P. antarcticum* were similar to each other, indicating no spatial structuring during the ontogeny as reported off the western Antarctic Peninsula (Morales-Nin, 1993). On the other hand, peaks of abundance of this species were recorded in the deeper stratum at 150–300 m, within a water layer evenly characterized by temperature lower than −1.7 °C and salinity higher than 34.10 psμ.

In conclusion, this study represents a novel overview of the ichthyoplankton community of the Bay of Whales in the Eastern Ross Sea. Along with the original data on species composition, relative abundance and spatial distribution of the larval community, present results highlight the significant role of this remote area has as potential spawning and nursery grounds for key Antarctic notothenioid species, such as the Antarctic silverfish.

CRediT authorship contribution statement

Mario La Mesa: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Data curation, Conceptualization. **Federico Calì:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Antonio Di Franco:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Emilio Riginella:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Fortunata Donato:** Writing – review & editing, Methodology, Investigation, Data curation. **Stefania Russo:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation. **Chiara Papetti:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Pasquale Castagno:** Writing – review & editing, Methodology, Investigation, Data curation. **Francesco Memmola:** Writing – review & editing, Methodology, Investigation. **Enrico Zambianchi:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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