1	Spring-time dynamics of diatom communities across landfast and underlying platelet-ice in
2	Terra Nova Bay, Ross Sea, Antarctica
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27	
28	Abstract
29	Landfast ice is one of the largest ecosystems on the earth and is considered to be an extreme and highly
30	variable environment. It is typically inhabited by diatoms that grow both within and underneath the sea
31	ice thickness. While the major contribution of diatoms to the Antarctic primary production is well
32	known, floristic studies on ice-associated diatoms are scarce. We investigated the

33 composition of diatom communities across annual fast ice and their variations over time during the 34 1999 austral spring in Terra Nova Bay (Ross Sea, Antarctica). To this aim, two complete ice cores were 35 sampled on 7 and 27 November 1999, whereas additional bottom- and platelet-ice samples were 36 collected on four occasions between these dates. Cell counts were performed in light microscopy, while 37 identifications were in most cases confirmed using scanning and transmission electron microscopy. 38 Diatoms varied along the ice core in both cell abundance and species composition, with a minimum in 39 the lower 165-220 cm-layer and a peak in the platelet ice. Planktonic species constituted in total, about 40 98% of the diatom assemblage in the surface layers of the ice core down to the thickness of 220 cm. 41 their distribution most likely reflecting their seasonal occurrence in the sea during the freezing process. 42 In the bottom ice (221-240 cm) and the underlying platelet-ice layer, the contribution of planktonic 43 diatoms was lower (60% and 65%, respectively) at the beginning of the sampling period, and then 44 decreased further to reach 30% in the bottom ice, where a remarkable biomass increase over time was 45 mainly caused by in situ growth and migration of sympagic species. By contrast in the platelet-ice 46 layer, despite a comparably high biomass increase, only small changes were recorded in the 47 composition of the diatom assemblage, which was mainly constituted by planktonic species and was 48 dominated by the bloom of the tiny pennate species *Fragilariopsis nana*. While the high biomass 49 produced in the bottom ice probably settles onto the sea floor, constituting an important food source for 50 both pelagic and benthic food webs, the bloom in the platelet-ice layer constitutes the seed for the 51 initial plankton bloom during the ice-free periods in Terra Nova Bay.

## 53 **1 Introduction**

54 Annually formed sea ice is the main feature of the polar regions and plays a fundamental role in 55 structuring marine ecosystems at high latitudes, thus affecting the interactions between the ocean and 56 the atmosphere as well as influencing global climate (Eichen, 1992; Thomas and Dieckmann, 2002; 57 Smetacek and Nicol, 2005). Sea ice is a complex matrix containing channels, capillaries and pores, 58 intimately connected with the underlying water column, and represents a harsh physico-chemical 59 environment characterized by steep gradients in temperature, salinity, light and nutrient concentrations 60 (Eicken, 1992; McMinn et al., 1999; Thomas and Dieckmann, 2002). Nevertheless, diverse microbial communities, known as the sympagic biota, are able to survive in the brine inclusions and interstices of 61 62 the sea ice habitat (e.g. Arrigo, 2014).

63 The most conspicuous members of the sea ice microbial communities are the microalgae that 64 are adapted to live in extreme conditions and flourish within the distinct micro-habitats that are created 65 when the sea ice forms and develops (Lizotte, 2003; Arrigo and Thomas, 2004; Lavoie et al., 2005; 66 Mock and Thomas, 2005; Matsuoka et al., 2009). The microalgae living in the annual pack ice may contribute ca. 10–30% of the annual primary production in the Antarctic regions (Arrigo et al., 1998) 67 68 and up to 57% in the central Arctic Ocean (Gosselin et al., 1997). Although landfast ice occupies only 69 1 to 5 % of the total ice cover around Antarctica, standing crops of microalgae are three orders of 70 magnitude greater than those reported for the pluriannual pack ice autotrophic communities (Ackley 71 and Sullivan, 1994; Archer et al., 1996; Guglielmo et al., 2000).

In landfast ice, microalgae form distinct surface, interior and bottom communities that originate and develop over time under the influence of different environmental variables (e.g. Horner, 1985; Horner et al., 1992; Arrigo, 2014). Surface communities occurring at the snow-ice interface mainly result from seawater infiltration (Meguro, 1962). The internal horizons are probably the most inhospitable habitats for microalgal life, because they are constituted by relatively solid, columnar ice.

77 Although these horizons can receive sufficient light for photosynthesis, they are characterized by brine 78 salinities that are too high to allow microalgal growth (Arrigo and Sullivan, 1992), while the low brine 79 volumes in the interior ice layers restrict nutrient exchange with the water column underneath (Golden 80 et al., 1998, 2007). Following temperature increase in springtime, the decline of brine salinities and the 81 nutrient exchange promoted by the increase of brine volumes make net microalgal growth possible in 82 these layers (Garrison et al., 2003; Mundy et al., 2011; Arrigo, 2014). The microbial communities 83 inhabiting the bottom few centimeters of landfast ice and the underlying platelet-ice layer differ 84 markedly from the interior communities in taxonomic composition and biomass, and in the timing and 85 fate of production (Bunt, 1963; Horner et al., 1992; Günther and Dieckmann, 2001; Arrigo and 86 Thomas, 2004; Fiala et al., 2006; Lazzara et al., 2007). The platelet ice is a semi-consolidated layer of 87 disk-shaped ice crystals mixed with seawater, ranging from a few centimetres to several meters in 88 thickness, which develops under the landfast ice in several Antarctic coastal areas (Garrison et al., 89 1986; Smetacek et al., 1992; Mangoni et al., 2009a). The bottom- and platelet-ice microhabitats are 90 frequently the most biologically productive sea ice habitat owing to their ubiquity, proximity to 91 seawater nutrients, and mild temperature and salinity gradients (Archer et al., 1996; Arrigo, 2014). The 92 ice-associated microalgae in these layers are well adapted to low irradiances and variations in the light 93 regime during the winter-spring transition (Lizotte and Sullivan, 1991; Lazzara et al., 2007; Mangoni 94 et al. 2009a, b; Różańska et al., 2009). In the Ross Sea during the spring bloom, in the bottom- and 95 platelet-ice microhabitats the chlorophyll a biomass showed an increase up to three orders of 96 magnitude higher than the one in the upper ice horizons, while the microalgal communities occurring 97 throughout the ice thickness were always characterized by a relatively low biomass increase (Arrigo, 98 2003; Guglielmo et al., 2000; Lazzara et al., 2007; Mangoni et al, 2009a).

99 The most abundant microalgal taxa in sea ice, in both the Arctic and the Antarctic, are the
100 diatoms (Bacillariophyceae) (Medlin and Priddle, 1990; Palmisano and Garrison, 1993; Ikävalko and

101 Thomsen, 1997; Tuschling et al., 2000; Thomas and Dieckmann, 2002; McMinn et al., 2007; Riaux-102 Gobin et al., 2011). In Antarctic landfast ice, planktonic diatoms, such as *Chaetoceros* Ehrenberg and 103 Fragilariopsis Hustedt species, are usually observed in the surface-ice horizon, whereas benthic taxa, 104 belonging to the genera Berkeleva Greville, Entomoneis Ehrenberg, Nitzschia Hassall and Pleurosigma 105 W. Smith, dominate the bottom ice and the platelet-ice layer communities (Palmisano and Sullivan, 106 1983, 1985; Lazzara et al., 1995, 2007; Arrigo et al., 1998; Dieckmann et al., 1998; Guglielmo et al., 107 2000). Pennate diatom taxa, namely of the genera Nitzschia, Fragilariopsis, Entomoneis, and Navicula 108 Bory, are common in the bottom ice (Ratkova and Wassmann, 2005; Fiala et al., 2006), but have also 109 been noted in surface ice (Whitaker and Richardson, 1980; Lizotte and Sullivan, 1992; Ryan et al., 110 2006), interior ice (Garrison, 1991), and in the platelet-ice layer (Arrigo et al., 1995). Centric diatoms 111 (e.g., Thalassiosira Cleve, Porosira Jørgensen and Chaetoceros Ehrenberg) are also found in the ice 112 habitats in the Antarctic but generally dominate in recently formed ice or in the platelet-ice layer 113 (Lizotte and Sullivan, 1992; Smetacek et al., 1992; Riaux-Gobin et al., 2003). The benthic diatoms, 114 namely Amphiprora kufferathii Manguin, Berkeleya adeliensis Medlin and Navicula glaciei Van 115 Heurck, which cannot survive in ice-free pelagic waters, may be considered a sea ice signature 116 (Mangoni et al., 2009b; Riaux-Gobin et al., 2011).

117 The Ross Sea is an interesting site for the study of the role of sea ice habitats in polar regions 118 for the high seasonal variability, the presence of several distinctive polynya systems and the 119 conspicuous biological processes linked to sea ice (Zwally et al., 1983; Arrigo et al., 1998). Landfast 120 ice in the Ross Sea shows an underlying layer of semi-consolidated platelet-ice that can range up to 121 several meters (Arrigo et al., 1998). In Terra Nova Bay (TNB), a thick landfast ice (100–250 cm) is 122 often associated in springtime with a highly dynamic platelet-ice layer, which has served several 123 studies on ice-associated microalgae (Guglielmo et al., 2000; Lazzara et al., 2007, Mangoni et al., 124 2009a, b). In this area, microalgal biomass reaches its maximum value in the ice, being even higher than the whole water column biomass during the summer bloom (Guglielmo et al., 2000; Lazzara et al., 2007). However, no information is available on the microalgae communities inhabiting the different sea ice horizons, nor on the spring dynamics of diatoms in the bottom- and platelet-ice layers, while their implications in bloom-seeding processes remain unclear.

The aim of this study was to investigate the vertical distribution of the diatom communities throughout the entire annual landfast ice and its changes over time through the analysis of two complete ice cores collected during the austral spring in TNB. Additional samples were collected to assess the temporal dynamics of diatom communities in bottom- and platelet-ice layers.

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## 134 **2 Materials and methods**

## 135 2.1 Sampling

136 The sampling area is located on the landfast ice in Gerlache Inlet at TNB, , Ross Sea, Antarctica 137 (74°41.20' S, 164°10.73' E) at about 4 km from the Italian 'Mario Zucchelli Station'. Sea ice cores were collected within a 100  $\text{m}^2$  surface area on six occasions from 7 to 27 November 1999, using an 138 139 aluminum ice corer (10 cm internal diameter). Sea ice thickness was about 240 cm and remained 140 almost constant during the sampling period. Two complete ice cores were collected on 7 and 27 141 November corresponding to the beginning and the end of the sampling period, and cut with a carpenter 142 saw. The first core was cut in five sections: 0-55 cm (top), 56-110 cm, 111-165 cm, 166-220 cm and 143 221-240 cm (bottom), while the last core was cut in three sections: top (0-55 cm), middle (111-165 144 cm) and bottom (221–240 cm). Four additional bottom-ice cores (221–240 cm) were collected on 13, 145 19, 21 and 22 November. Ice-core sections were kept in plastic vessels at low light intensity, and 146 slowly melting in a thermostatic bath at 2–4°C for 4–6 h. The semi-consolidated ice crystals forming 147 the underlying platelet-ice layer (about 140 cm by visual scuba-diver inspection) were collected 148 through the core holes with a plastic ladle on each sampling occasion.

Information on the main environmental features, such as air/water/ice temperatures, water/ice salinities
and irradiances above-inside-below the ice column during the study period, is reported in Lazzara et al.,
(2007).

152 2.2 Analyses

In the laboratory, melted ice subsamples were filtered through Whatman GF/F glass fiber filters for chlorophyll *a* (chl *a*) determination. Filters were grinded and extracted in 90% acetone at  $-20^{\circ}$ C for at least 12 h in the dark. Chl *a* concentration was measured with a PerkinElmer LS 50 spectrofluorometer (Holm-Hansen et al., 1965).

157 For the identification and enumeration of diatoms, melted ice subsamples from each ice core 158 section and platelet-ice layer were preserved in 4% formaldehyde final concentration. Diatom cells 159 were identified to the lowest possible taxonomic rank (Medlin and Priddle, 1990; Hasle and Syvertsen, 160 1997; Scott and Thomas, 2005). In case of doubtful identifications, specimens were classified at a higher taxonomic rank. Cells were counted using a Zeiss Axiophot inverted microscope (Carl Zeiss, 161 162 Oberkochen, Germany) at 400× magnification, operating with phase contrast optics (Lund et al., 1958; 163 Zingone et al., 2011). Empty diatom frustules were counted separately from those containing 164 cytoplasm.

For electron microscopy examination, subsamples were oxidized with 70% nitric acid at 60°C for 1 h, washed several times with distilled water, oxidized again with concentrated sulphuric acid and washed again. A few drops of cleaned diatom material were air-dried onto aluminum stubs and coated with platinum for scanning electron microscopy (SEM) (JEOL JSM-6700F, Peabody, USA) or put on formvar-coated grids for transmission electron microscopy (TEM) (LEO 912AB, Carl Zeiss, Oberkochen, Germany).

171 The Shannon diversity index (H') (ln) was calculated to characterize the species diversity of 172 sea-ice diatom communities (Magurran, 1988). A non-metric multidimensional scaling (MDS) ordination of a Bray-Curtis similarity matrix, with a group-average cluster analysis, was performed to identify groups of samples with similar taxonomic composition (Clarke and Warwick, 2001). Before calculating the similarity matrix, the abundance data were standardized (i.e., relative abundance data) and log (x+1) transformed to reduce the influence of the most dominant taxa. All these analyses used the PRIMER v5 software (Clarke and Gorley, 2001)

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# 179 **3 Results**

There was a great variability among the different ice horizons of the landfast ice in TNB. At the beginning of the sampling, chl *a* concentrations showed a marked gradient throughout the ice thickness, ranging from 0.10  $\mu$ g l<sup>-1</sup> in top-ice horizon to 8.20  $\mu$ g l<sup>-1</sup> in the bottom ice (Fig. 1A). In the platelet-ice layer, the chl *a* biomass reached a maximum concentration of 105  $\mu$ g l<sup>-1</sup>, giving an intense bright brown coloration to this semi-consolidated ice layer (Fig. 1a). At the end of the sampling season, chl *a* concentrations along the ice core had increased to 4.84  $\mu$ g l<sup>-1</sup> in the top-ice horizon and 410  $\mu$ g l<sup>-1</sup> in the bottom ice, with 360  $\mu$ g chl *a* l<sup>-1</sup> recorded in the platelet-ice layer (Fig. 1B).

The abundance of diatoms along the ice core sampled early in the springtime varied considerably 187 among the various ice horizons and the platelet-ice layer (Fig. 1). Diatom abundances reached  $3.9 \times 10^6$ 188 cells  $l^{-1}$  in the surface-ice horizon (0–55 cm) and  $3.6 \times 10^6$  cells  $l^{-1}$  in the immediate next ice horizon 189 (56–110 cm). A sharp and steady decline in diatom abundances with  $1.4 \times 10^6$  cells  $l^{-1}$  and  $0.30 \times 10^6$ 190 cells l<sup>-1</sup> were recorded in the 111–165 cm and 166–220 cm ice horizons, respectively. In the lowest 191 bottom-ice horizon (221–240 cm), diatom abundance increased to  $2.1 \times 10^6$  cells l<sup>-1</sup>, while reaching 192  $11.6 \times 10^6$  cells l<sup>-1</sup> in the 140-cm thick platelet-ice layer (Fig. 1A). In the late springtime sampling, the 193 abundance of diatoms increased to  $10.4 \times 10^6$  cells l<sup>-1</sup> in the top-ice horizon (0–55 cm) and to  $2.6 \times 10^6$ 194 cells  $l^{-1}$  in the middle horizon (111–165 cm) (Fig. 1B). In the bottom-ice horizon (221–240 cm), cell 195 abundance increased to  $77 \times 10^6$  cells l<sup>-1</sup> while the maximum diatom abundance was recorded in the 196

platelet-ice layer with  $106 \times 10^6$  cells I<sup>-1</sup> (Fig. 1B). On 7 November, the number of empty diatom frustules gradually decreased throughout the ice matrix from top to bottom, dropping from  $4.0 \times 10^6$ cells I<sup>-1</sup> in the 0–55 cm ice layer to  $0.33 \times 10^6$  cells I<sup>-1</sup> in 166–220 cm ice horizon, where no empty frustules were recorded in either the bottom ice (221–240 cm) and the platelet-ice layer (Fig. 1A). A similar trend was observed on 27 November, except that the numbers of empty frustules were higher, with  $11.3 \times 10^6$  empty cells I<sup>-1</sup> in the surface ice and  $2.6 \times 10^6$  empty cells I<sup>-1</sup> in the 166–220 cm ice horizon (Fig. 1B). No empty cells were observed in the bottom ice and the platelet-ice layer.

The diatom recorded from the various ice horizons and the platelet-ice layer in TNB included 39 taxa belonging to 23 genera, of which 39 were identified at the species level (Table 1). In both ice cores, more than 90% of the surface (0–55 cm) and interior (56–165 cm) diatom communities were represented by 20 planktonic taxa (Fig. 2). Several planktonic taxa were present along the entire ice thickness, such as *Chaetoceros* spp. (Fig. 5F), *Cylindrotheca closterium* (Fig. 5E) and *Fragilariopsis curta* (Fig. 5D), while others, like *Thalassiosira* spp., were only recorded in the bottom ice and the platelet-ice layer (Fig. 2).

In the surface (0-55 cm) layers, initially the most abundant species were represented by the 211 weakly silicified *Dactyliosolen tenuijunctus* (Fig. 5A) with  $2.3 \times 10^6$  cells  $1^{-1}$  and the ice-associated 212 species *Fragilariopsis curta* with  $0.82 \times 10^6$  cells  $1^{-1}$ , accounting for 57% and 21% of the total diatom 213 214 community, respectively (Table 1, Fig. 2a). At the end of the sampling period, both species dramatically dropped in numbers to  $0.07 \times 10^6$  cells l<sup>-1</sup> and  $0.60 \times 10^6$  cells l<sup>-1</sup>, contributing 1% and 215 6% of the entire diatom community, respectively (Table 1, Fig. 2B). These taxa were replaced by F. 216 *nana* (Fig. 5B and C), which became the predominant planktonic species increasing from  $0.16 \times 10^6$ 217 cells  $l^{-1}$  (4% of the diatom community) on 7 November to  $65 \times 10^6$  cells  $l^{-1}$  (62% of the diatom 218 219 community) on 27 November. Other species in this top-ice horizon were unidentified Chaetoceros in 220 the 7 November core and Nitzschia spp. in the 27 November core. Due to the predominance of D.

*tenuijunctus* and *F. curta* in early spring and of *F. nana* and *Nitzschia* spp. in late spring, the Shannon diversity index in both top-ice layers was relatively low  $(H^2 = 1.3)$ .

223 On 7 November, the interior diatom community of the three ice horizons, from 56 to 220 cm, was scarcely diversified and mainly characterized by high cell abundances of *Fragilariopsis curta* and 224 *Cvlindrotheca closterium*, which varied from 0.16 to  $1.8 \times 10^6$  cells l<sup>-1</sup> and from 0.09 to  $1.1 \times 10^6$  cells 225  $1^{-1}$ . accounting for 48–50 % and 27–46 % of the total diatom community, respectively (Table 1, Fig. 226 227 2A) and with a diversity index (H') varying between 1.3 and 0.9, respectively. Several sympagic 228 species were recorded in the 166-220 cm horizon, such as Amphiprora kufferathii (Fig. 5J), Navicula 229 perminuta (Fig. 5M), Berkeleya adeliensis (Fig. 5L), Entomoneis spp., Nitzschia lecointei (Fig. 5H) and 230 N. taeniiformis (Fig. 5I) (Table 1, Fig. 2A), although they were scarcely represented and only 231 contributed only 2% of the total diatom community. The middle horizon of the 27 November ice core was characterized by the dominance of F. curta, with  $2.0 \times 10^6$  cells  $l^{-1}$  accounting for 86% of the total 232 233 diatom community (Table 1, Fig. 2B), and a still lower diversity index (H'=0.6).

234 In the early sampling dates, compared to the overlying layers the bottom ice (221–240 cm) and the platelet-ice layer showed more diverse diatom assemblages (H' = 2.1 and 1.9, respectively), which 235 236 were very similar in species composition despite a remarkably higher cell abundance in the platelet-ice 237 layer (Table 1, Fig. 2A). In both the bottom ice and the semi-consolidated ice crystal layers, 238 Fragilariopsis nana and Nitzschia stellata (Fig. 5G) were predominant, along with other sympagic and 239 ice-related species, e.g., Amphiprora kufferathii, Berkeleya adeliensis, Nitzschia lecointei and Synedropsis recta (Fig. 5K) (Table 1, Fig. 2A). In the bottom ice, F. nana, Navicula perminuta and 240 Synedropsis recta attained  $0.40 \times 10^6$  cells  $l^{-1}$ ,  $0.03 \times 10^6$  cells  $l^{-1}$  and  $0.38 \times 10^6$  cells  $l^{-1}$ , respectively, 241 242 the three species representing together 55% of the total diatom community (Table 1, Fig. 2A). The 243 predominance of F. nana was maximum in the platelet-ice layer, where they contributed 61% of the total diatom community, both initially with  $4.6 \times 10^6$  cells l<sup>-1</sup> and at the end of the sampling period with 244

64.8 × 10<sup>6</sup> cells l<sup>-1</sup> (Table 1, Fig. 2A). In both the bottom- and platelet-ice layers, specimens of *F. nana* always showed a reduced cell size (apical axis <5  $\mu$ m, antapical axis <2.5  $\mu$ m) and were recorded as solitary cells or in pairs.

248 In the bottom ice, the abundance of diatom cells notably increased from the initial to the final 249 spring sampling, where the contribution of benthic diatoms increased from 40% to 72% and 250 Amphiprora kufferathii, Berkeleya adeliensis and Nitzschia stellata became the dominant benthic species with  $26 \times 10^6$  cells  $l^{-1}$ ,  $4.5 \times 10^6$  cells  $l^{-1}$  and  $18.7 \times 10^6$  cells  $l^{-1}$ , respectively. Among the 251 252 planktonic species, cell abundance of Synedropsis recta and Fragilariopsis nana also increased notably, up to  $9.4 \times 10^6$  cells l<sup>-1</sup> and  $6.6 \times 10^6$  cells l<sup>-1</sup>, respectively (Fig. 3A). In the platelet-ice layer. 253 254 cell abundance increased between the 7 and 27 November, but only small changes were observed in the 255 relative importance of the dominant taxa (Fig. 3B).

Some planktonic species (e.g., *Fragilariopsis curta, Cylindrotheca closterium* and *Dactyliosolen tenuijunctus*) were found with relatively high cell numbers in the different ice horizons and platelet-ice layer, but they were more abundant and with a higher proportion of dead cells in the upper ice horizons, representing only a minor part of the total community in the bottom ice and the platelet-ice layer. Some benthic and planktonic species, however, were almost or completely absent from the upper ice horizons (e.g. *Entomoneis* spp., some *Thalassiosira* species) while they reached high cell abundances in the bottom ice and the platelet-ice layer.

The cluster analysis based on the similarity matrix identified five groups of taxonomically similar diatoms in landfast ice and platelet-ice layer of TNB (Fig. 4). MDS analyses, based on the taxonomic composition across the entire thickness of the ice cores and over time, showed that the two surface samples of 7 and 27 November (IV and I) differed between them and from all the other samples. The samples from the interior core horizons (V) grouped together. All platelet samples also grouped together, along with the bottom samples collected on the first two sampling dates (II), which had essentially the same taxonomic composition as the platelet-ice layer. The last group (III) wasformed by the remnant bottom samples.

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## 272 **4 Discussion**

In this first recognition of diatom communities in Terra Nova Bay (TNB) landfast ice, diatoms showed a clearly distinct distribution throughout the ice thickness and marked temporal variations in the bottom horizon and the platelet-ice layer, with patterns often similar to those previously reported from other Antarctic areas.

Low diatom abundances were recorded in the interior ice horizons as opposed to high cell numbers at the top and mainly in the bottom-ice horizons, displaying the typical C-shaped vertical pattern throughout the ice thickness, similar to the results previously reported in the Weddell Sea by Günther and Dieckmann (2001), who found also high cell abundances in the platelet-ice microhabitat.

281 Chlorophyll *a* biomass in the entire ice thickness increased over time, especially in the bottom 282 horizon and the platelet-ice layer (Lazzara et al., 2007). In these horizons, the spring increase of the chl 283 a biomass was up to three orders of magnitude higher than the one in the upper ice horizons, while 284 remaining more or less constant in the upper ice horizons, a pattern shared with many other areas (for 285 example in the vicinity of the Australian Antarctic station of Davis, Archer et al., 1996). The higher 286 microalgal abundances in landfast ice (Fiala et al., 2006), bottom ice (Garrison et al., 2003) and 287 platelet-ice layer (Arrigo et al., 1993) can be explained by the enhanced nutrient availability in these 288 regions (Melnikov et al., 2002, Michel et al., 2003). By contrast, the internal ice horizons, although 289 receiving sufficient light for photosynthesis, are the most inhospitable habitat for microalgal life 290 because they are relatively solid and, in addition, they are characterized by low brine volumes and 291 salinities too high to support microalgal growth (Arrigo and Sullivan, 1992).

292 In TNB, five species, namely Dactyliosolen tenuijunctus, Cylindrotheca closterium, 293 Fragilariopsis curta, F. nana and Navicula perminuta, made up between 20% and 50% of the total 294 diatom abundance of the top to interior ice horizons (down to 220 cm) in both early and late spring. 295 Such high contribution from these species does not find a match in any other reports from Antarctica. 296 Gleitz et al. (1998) and Günther and Dieckmann (2001) did record these speciesì but with much lower 297 abundances in the Weddel Sea, where large *Chaetoceros* spp. and flagellates predominated. The five 298 dominant species mentioned above have also been recorded in seawater in the first phases of ice 299 formation in subsequent years (M. Saggiomo, unpubl. data), supporting the idea that TNB hosts a 300 phytoplankton community which differs from other Antarctic areas.

301 Two non-mutually exclusive hypotheses have been formulated regarding planktonic diatoms 302 recorded in high numbers in ice cores (Hoshiai, 1977; Grossi and Sullivan, 1985). These pelagic taxa 303 may have been already present in high abundance in the water column at the time the ice was forming 304 in autumn, or they may eventually have grown better than other entrapped diatom species. In the case 305 of Dactyliosolen tenuijunctus, the species was already reported in ice-free waters of TNB during the 306 second half of February 1999, which corresponded to the first freezing steps of the surface waters, and 307 in a later fall bloom (Nuccio et al., 2000). In our study, the low chl a biomass in the top-ice horizon and 308 the high number of empty frustules of *D. tenuijunctus* indicate that the cells were either already dead at 309 the moment of their entrapment or died right after their incorporation into the ice. This is also 310 supported by the fact that *D. tenuijunctus* almost disappeared in the landfast ice in the second ice core 311 sampled three weeks later. Indeed, in the upper ice horizon, total cell abundance more than doubled but 312 the species composition changed completely compared to 20 days before, highlighting that most of the 313 species dominating at the beginning of the sampling period were unable to grow in the ice.

*Cylindrotheca closterium*, another common planktonic diatom , that was among the dominant ones in
the interior-ice community, was also observed previously in TNB (Innamorati et al., 1990; Nuccio et

al., 1992; Andreoli et al., 1995). An increase of this species over time occurred only in the surface layer
of the core, matching the observations from Adélie Land, where it was found only in the upper ice
horizon and supporting the hypothesis that *C*. *closterium* requires high light levels for its growth (Fiala
et al., 2006). The distribution of *C. closterium* in Antarctica varies markedly through time and space
(Sung Ho and Fryxell, 1992; Günther and Dieckmann, 2001), but the species has never been reported
to attain such high abundances as those reported here in TNB.

322 Fragilariopsis curta was relatively abundant across the entire ice sheet in TNB, and was hence 323 presumably present in the water column during the whole period of ice formation. This species also 324 was probably trapped in the ice during its formation, and apparently did not grow well in the ice, not 325 even in the upper layer, where it was substituted over time by F. nana. In fact F. curta is predominant 326 in ice-free waters in TNB in the austral spring (Saggiomo et al., 2000) as well as in austral summer 327 (Innamorati et al., 1990; Nuccio et al., 1992; Andreoli et al., 1995; Nuccio et al., 2000). Fragilariopsis 328 *curta* was also abundant among the diatoms in the faecal pellets from the inshore waters of TNB 329 (Marino et al., 1994) and in yearly moored sediment traps from the southwest Ross Sea (Leventer and 330 Dunbar, 1996). Along with F. cylindrus, F. curta is considered the most abundant species in the coastal 331 polynya of Victoria Land (Garrison et al., 2003). The latter species also is the most abundant species 332 of ice edge environment (Smith and Nelson, 1985; Wilson et al., 1986), pack ice (Leventer et al., 1993) 333 and landfast ice (Fiala et al., 2006; Günther and Dieckmann, 2001) in several polar areas. Hence, 334 considering its abundance and widespread distribution, F. curta can be considered typical not only of 335 the Ross Sea but the whole Antarctic coastal areas. Fragilariopsis nana, already abundant in the bottom 336 ice and the platelet-ice layer on the first sampling date, by the end of November dominated both the platelet and the surface communities in TNB, reaching the highest specific abundances (> $60 \times 10^6$  cells 337  $1^{-1}$ ). The distinction of the species from F. cylindrus is not obvious, but the width of the valve and the 338 339 poroid density of our specimens matched F. nana (Lundholm and Hasle, 2008) although the rows of 340 poroids were two or three, and never four, as at times reported for F. nana. Records of F. nana have 341 certainly been included in those of F. cylindrus (Lundholm and Hasle, 2008), which is commonly 342 reported in sea-ice algal communities from both the Arctic (Horner and Schrader, 1982; Poulin et al., 343 1983; von Ouillfeldt et al., 2003; Różańska et al., 2009) and the Antarctic (Garrison and Buck, 1985; 344 Gleitz et al., 1996, 1998; Lizotte, 2001), and is considered typical for the plankton of the Southern 345 Ocean (Clarke and Ackley, 1984; Ackley, 1985; Sung Ho and Fryxell, 1992). Fragilariopsis nana is 346 the first species to bloom as the ice melt and, under experimental conditions showed sustained growth 347 at both high and low irradiance, and in nutrient-depleted as well as nutrient-repleted conditions, which 348 demonstrates the versatile physiology of this species (as F. cylindrus, Mangoni et al., 2009a) and 349 explains its increase over time in both the upper ice horizon and in the platelet-ice layer.

350 Benthic species were restricted to the lower ice horizon and consisted of taxa (e.g., Amphiprora 351 kufferathii, Synedropis recta and several Nitzschia species) already known to be part of the ice-352 associated diatom community in several polar areas (von Quillfeldt et al., 2003; Guglielmo et al., 2004; 353 Lazzara et al., 2007; Różańska et al., 2009). Some species of the genus Navicula are also commonly 354 found in the sea ice but, notably, the small *Navicula perminuta* is here reported for the first time in this 355 environment. However, the identification of small specimens of *Navicula* to the species level may be 356 difficult with light microscopy and, therefore, N. perminuta may have perhaps been misidentified as N. 357 glaciei Van Heurck (Kang et al., 2002).

A peculiarity of the landfast ice emerging from our results was the relatively high abundance of planktonic species in the bottom-ice horizon, which were not reported previously for TNB. Over the spring period, these species increased in numbers, but benthic species showed a much higher increase passing from 30% in early spring to 70% of the whole diatom population at the end of the sampling, resulting in a shift in the diatom community composition, which became more similar to the typical sympagic community reported for the same area (Guglielmo et al., 2000). Such a growth supports the 364 idea that the bottom-ice microalgal species are amongst the most shade-adapted photosynthetic 365 organisms on earth (Thomas and Dieckmann, 2002) and grow well at low irradiance, where they are 366 acclimated to normal salinity sea water with a regular supply of nutrients from the underlying seawater 367 (Garrison, 1991). During ice melting, salinities in the water surrounding bottom-ice algae decreases 368 (Meguro et al., 1967; Gleitz and Thomas, 1992). Different ice microalgal species respond in different 369 ways to low salinity values, some species being quite halotolerant while other species may be more 370 sensitive to reduced salinities (Ryan et al., 2004). Some species of bottom-ice microalgae may also 371 undergo considerable photosynthetic stress during the process of melting, being exposed to much higher light intensities (Mangoni et al., 2009a). In addition the change in the physical structure of the 372 373 ice is also due to the *in situ* growth, and favors the migration of benthic species, thus contributing to the 374 remarkable biomass accumulation also reported in previous above-mentioned studies.

Interestingly, a different bottom-ice algal community was reported from Woods Bay, 80 km north of TNB, where the xanthophyte *Pseudopleurochloris antarctica* Andreoli, Moro, La Rocca, Rigoni, Dalla Valle & Bargelloni, represented 50% of the total algal community, and most common diatoms were *Amphiprora kufferathii*, *Chaetoceros dichaeta* Ehrenberg, *Fragilariopsis curta* and *F. cylindrus* (Moro et al., 2000). This difference is likely due to hydrological factors which, in Woods Bay, prevent the development of a platelet-ice layer (Moro et al., 2000).

In contrast to the shift in the species composition of the bottom ice, the semi-consolidated platelet-ice layer showed a considerable biomass increase with a continued dominance of planktonic species, mainly with *F. nana*, throughout the sampling period. High cell abundances in these layers were comparable to the ones reported from other Antarctic regions (Arrigo et al., 1995; Dieckmann et al., 1998; Guglielmo et al., 2000; Arrigo, 2003; Lazzara et al., 2007), which is remarkable considering that the under-ice irradiance is typically less than 1%, and often less than 0.1%, of the surface downwelling irradiance during the ice microalgal bloom in spring (Sullivan et al., 1983; Lazzara et al., 2007). Similar to what observed for bottom ice communities, the taxonomic composition of the platelet-ice community in TNB was quite different from the one reported in other areas. For example, centric diatoms were the most abundant algae in the platelet-ice layer from the Weddell Sea (Smetacek et al., 1992), whereas the dinoflagellates, *Amphidinium* Hulburt and *Gymnodinium* (Bergh) Lankester, dominated off Elephant Island, with diatoms representing only a minor fraction of the sea-ice algal community (Helbling et al., 1993).

394 Overall, a quite similar dynamics of the different ice horizons over the spring season across the 395 Antarctic region, with a conspicuous biomass increase characterizing the bottom ice and the platelet-ice 396 layer, when present. However, remarkable variations among the species responsible for this increase 397 emerge from the observations in the different areas. Differences could partly depend on the interannual 398 and/or seasonal variability, considering that the studies were conducted in different years or different 399 stages of the ice melting process. However, the large variability in species composition or dominance 400 observed among Antarctic areas could well be the reflection of local physical and biological 401 characteristics, including the interplay of light and salinity variations and possibly different predator communities, whose specific effects on microalgal communites would deserve deeper investigations. 402

403 As to the origin of the different populations, the truly planktonic species of the upper ice layers 404 may have been trapped in late autumn-early winter during the first steps of sea-ice formation. 405 Considering the different phases of ice formation, a bloom of *Dactyliosolen tenuijunctus* dominating 406 the upper ice horizon was probably trapped as first, whereas planktonic species such as Fragilariopsis 407 *curta* and *Cylindrotheca closterium*, found in the interior-ice horizons, may have been trapped also or 408 only in subsequent phases of the ice formation, thus showing to belong to a later stage of the succession 409 in the area. The planktonic species *Fragilariopsis nana*, along with *Navicula perminuta* and other 410 benthic species such as A. kufferathii, probably colonized the bottom ice and the platelet-ice layer over 411 the winter and early spring. The benthic species were most likely transported by the small ice crystals forming on the sea floor and then floating freely upwards (Gough et al., 2012), thus forming theplatelet-ice layer.

414 The different assemblages evolved differently during the spring sympagic algae bloom, which in 415 TNB is characterized by different processes. The upper layers showed only a modest increase produced 416 by species that are able to grow/survive in the ice with its associated environmental features, such as 417 high fluctuations of irradiance and salinity. In the bottom ice, the change in the physical structure 418 favored both the migration and *in situ* growth of benthic species. In the platelet-ice layer, the 419 abundance increase was rather due to a bloom of planktonic species, dominated by Fragilariopsis 420 nana, together with the benthic species A. kufferathii and Nitzschia spp. These benthic species were 421 only present in the bottom ice and the platelet-ice layer where they grow in low light conditions in 422 spring, while they were unable to grow in the planktonic habitat under experimental conditions 423 (Mangoni et al., 2009b). Indeed these species, have never been reported in ice-free waters of Terra 424 Nova Bay. These are the species that apparently better cope with growth in the ice, as shown by quite 425 high chlorophyll a biomass recorded in these layers. Whilst platelet-ice communities evolved 426 maintaining an almost constant dominance of species with planktonic traits, bottom-ice communities 427 were increasingly dominated by benthic diatoms.

Finally, diatoms accumulating in the bottom horizon of the landfast ice also undergo different fate in the subsequent phases of the system. The benthic species do not contribute to the late spring phytoplankton blooms, and the high biomass they produce in the bottom ice probably settles back onto the sea floor, constituting an important food source for both pelagic and benthic food webs. By contrast, the planktonic species of the platelet-ice layer are the first to be found in high concentrations in open waters (Mangoni, 2009), showing that this peculiar ice form constitutes an incubator for the late spring bloom of TNB.

The schematic representation of the origin and fate of different microalgal communities given above finds some confirmations in data collected in other years in the area. However, due to the significant spatial variability which is found in the landfast ice, additional studies are warranted to ascertain to what extent our data are representative with respect to other areas and other phases of ice development and to further delineate diatom taxonomy of ice assemblages in TNB.

440 Overall, a quite similar dynamics of the different ice horizons over the spring season across the 441 Antarctic region, with a conspicuous biomass increase characterizing the bottom ice and the platelet-ice 442 layer, when present. However, remarkable variations among the species responsible for this increase 443 emerge from the observations in the different areas. Differences could partly depend on the interannual 444 and/or seasonal variability, considering that the studies were conducted in different years or different 445 stages of the ice melting process. However, the large variability in species composition or dominance 446 observed among Antarctic areas could well be the reflection of local physical and biological 447 characteristics, including the interplay of light and salinity variations and possibly different predator 448 communities, whose specific effects on microalgal communites would deserve deeper investigations.

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460 **References** 

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793 Figure captions

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Figure 1: Vertical distribution of chlorophyll *a* (chl *a*) concentration and diatom cell abundance of planktonic and sympagic
species, and empty cells from various landfast ice horizons and the platelet-ice layer in Terra Nova Bay, Antarctica on (a) 7
November and (b) 27 November 1999.

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Figure 2: Relative abundance (%) of diatom taxa from various landfast ice horizons and the platelet-ice layer in Terra
Nova Bay, Antarctica on 7 and 27 November 1999. Other species include taxa with a relative abundance < 3% in each</li>
horizon. Sympagic species include *Amphiprora kufferathii*, *Nitzschia* spp. and *Synedropsis recta*.

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Figure 3: Temporal variation of diatom cell abundance and chlorophyll (chl) *a* concentration in (a) the bottom ice and (b)
the platelet-ice layer in Terra Nova Bay, Antarctica in November 1999.

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Figure 4: Two-dimensional non-metric multidimensional scaling (MDS) of 18 diatom samples collected from landfast ice horizons and platelet-ice layer in Terra Nova Bay, Antarctica. The five groups of samples with taxonomically similar diatoms assessed with a group-average clustering are superposed to the MDS. The similarity matrix was created on the log (x+1) transformed relative abundance of diatoms. Each sample is identified by the ice thickness horizon or a letter (B: bottom ice, P: platelet-ice layer) followed by the sampling date.

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812 Figure 5: Scanning (A, B, D-M) and transmission (C) electron micrographs of the most representative diatom species in the 813 landfast ice and the underlying platelet-ice layer in Terra Nova Bay, Antarctica in November 1999. (A) Dactyliosolen 814 tenuijunctus, entire frustule in pervalvar view, scale bar: 5 µm. (B) Fragilariopsis nana, internal valve view, scale bar: 1 815 μm. (C) Fragilariopsis nana, valve, scale bar: 5 μm. (D) Fragilariopsis curta, internal valve view, scale bar: 5 μm. (E) 816 Cylindrotheca closterium, entire frustule, scale bar: 20 µm. (F) Chaetoceros sp., single cell in pervalvar view, scale bar: 10 817 μm. (G) Nitzschia stellata, internal valve view, scale bar: 10 μm. (H) Nitzschia lecointei, internal valve view, scale bar: 10 818 μm. (I) Nitzschia taeniiformis, entire frustule in valve view, scale bar: 20 μm. (J) Amphiprora kufferathii, valve in girdle 819 view, scale bar: 10 µm. (K) Synedropsis recta, external valve view, scale bar: 2 µm. (L) Berkeleya adeliensis, internal valve 820 view, scale bar: 10 µm. (M) Navicula perminuta, internal valve view, scale bar: 2 µm.

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# Table 1 Click here to download Table(s): TABLE 1.docx

Table 1. Temporal variations in abundance  $(10^3 \text{ cells I}^{-1})$  of diatom species recorded across landfast ice horizons and the underlying platelet-ice layer in Terra Nova Bay, Antarctica in November 1999. The last two columns identify the habit of the species as reported from the literature. S: sympagic, P: planktonic. na: taxon present but not counted. -: taxon not detected. \*: species only recorded in electron microscopy.

Taxon	0–55 cm		56–110 cm	111–165 166–220 cm cm			221–240 cm Bottom ice							Platelet-ice layer						
Date	7	27	7	7	27	7	7	13	19	21	22	27	7	13	19	21	22	27		
Asteromphalus hyalinus Karsten	-	-	-	6585	-	-	-	-	-	-	-	-	-	-	-	-	-	-		Х
Chaetoceros bulbosus (Ehrenberg) Heiden	13.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		X
Chaetoceros spp.	148	-	9.9	9.9	-	5.3	44	310	-	3129	-	-	99	-	-	132	395	-		Х
Dactyliosolen tenuijunctus (Manguin) Hasle	2263	70	115	13	-	1.3	-	-	-	-	-	-	-	-	399	-	-	-		x
<i>Odontella</i> <i>litigiosa</i> (Van Heurck) Hoban	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-		х
O. weissflogii (Grunow) Grunow	-	-	-	-	-	-	-	-	-	-	-	-	-	33	22	-	-	66		х
Porosira pseudodenticulata (Hustedt) Jousé	9.9	-	6.6	-	-	2.6	-	-	-	-	-	-	-	-	-	-	-	-		х
Rhizosolenia spp.	3.3	-	3.3	-	-	<1	11	-	-	-	-	-	-	-	-	-	-	198		Х
Stellarima microtrias (Ehrenberg) Hasle et Sims	-	-	-	-	-	<1	11	-	198	-	484	198	198	428	66	329	329	132		х
<i>Thalassiosira</i> gracilis (Karsten) Hustedt <sup>*</sup>	na	-	-	na	-	na	na	na	-	na	na	na	na	-	na	na	na	na		х
<i>T. gravida</i> Cleve <sup>*</sup>	na	-	-	na	-	na	na	na	-	na	na	na	na	-	na	na	na	na		Х
<i>T. lentiginosa</i> (Janisch) Fryxell <sup>*</sup>	na	-	-	na	-	na	na	na	-	na	na	na	na	-	na	na	na	na		Х
<i>T. maculata</i> Fryxell et	na	-	-	na	-	na	na	na	-	na	na	na	na	-	na	na	na	na		Х

Johansen*																				
<i>T. oestrupii</i> (Ostenfeld) Hasle*	na	-	-	na	-	na	na	na	-	na	na	na	na	-	na	na	na	na		х
<i>T. antarctica</i> Comber*	na	-	-	na	-	na	na	na	-	na	na	na	na	I	na	na	na	na		Х
<i>Thalassiosira</i> spp.*	56	-	-	13	-	9.9	11	78	-	198	77	132	66	-	66	132	264	527		Х
Unidentified centric diatoms	-	-	20	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-		
Empty centrics	1278	421	86	26	-	14	-	-	-	-	-	-	-	-	-	-	-	-		
<i>Amphiprora</i> <i>kufferathii</i> Manguin	-	-	-	3.3	5.8	6.6	177	659	2836	18193	21935	25954	725	823	443	2240	2833	9486	х	
Berkeleya adeliensis Medlin	3.3	-	6.6	3.3	-	2.0	66	67	155	1647	2240	4508	-	66	709	725	-	132	Х	
Cylindrotheca closterium (Ehrenberg) Reimann et Lewin	53	654	1110	672	543	92	-	22	-	33	-	-	-	-	111	-	132	-		X
<i>Entomoneis</i> cf. <i>oestrupii</i> (Van Heurck) Cremer*	-	-	-	_	-	na	na	na	-	na	na	na	na	-	na	na	na	na	Х	
<i>E</i> . cf. <i>kjellmanii</i> (Cleve) Poulin et Cardinal*	-	-	-	-	-	na	na	na	-	na	na	na	na	-	na	na	na	na	х	
Entomoneis spp.*	-	-	-	-	-	2.6	22	33	-	198	527	593	165	-	155	198	263	461	Х	
Fragilariopsis curta (Van Heurck) Hustedt	823	608	1798	725	3810	160	255	188	-	-	263	70	659	1350	421	593	461	988		х
<i>F. nana</i> (Steemann Nielsen) Paasche	158	6451	33	-	-	11	399	1152	1252	4512	6825	6587	4677	3359	12256	15743	23451	64884		х
<i>F. obliquecostata</i> (Van Heurck) Heiden and Kolbe	6.6	-	-	-	-	-	-	55	66	33	22	-	33	296	288	132	988	-		х
<i>F. rhombica</i> (O'Meara) Hustedt	-	210	-	3.3	-	9.2	-	-	-	-	-	-	-	-	-	-	-	-		Х

<i>F. sublinearis</i> (Van Heurck) Heiden and Kolbe	13	-	-	-	-	14	100	22	659	296	617	395	362	955	620	4616	1186	3294		Х
Haslea trompii (Cleve) Simonsen	16	-	13	20	_	_	11	11	263	33	132	329	-	-	22	-	-	66		х
<i>Kurpiszia</i> <i>kryokonites</i> (Cleve) Witkowski, Lange-Bertalot et Metzeltin	3.3	-	-	_	_	-	-	-	362	593	1054	1759	132	66	-	-	-	66	x	
Navicula glaciei Van Heurck**	na	na	-	-	-	na	na	na	na	-	-	na	na	na	na	na	na	na	X	
<i>N. jejunoides</i> Van Heurck	-	-	3.3	-	5.6	_	22	89	165	-	-	418	692	593	66	527	1844	2371	Х	
<i>N. perminuta</i> Grunow**	6.6	351	-	-	-	9881	33	3656	494	-	-	872	66	560	3634	1713	1252	1515	X	
<i>Nitzschia lecointei</i> Van Heurck	-	70	-	-	5.8	2.0	66	76	231	320	329	395	1350	362	1108	329	2174	3821	x	
<i>N. stellata</i> Manguin	-	-	-	-	_	_	432	44	1383	6390	14294	18654	33	362	89	593	1120	1449	Х	
<i>N. taeniiformis</i> Simonsen	-	70	-	3.3	_	1.3	33	199	1252	66	527	1418	428	922	89	1383	1910	1976	X	
Pinnularia quadratarea var. constricta (Østrup) Gran	6.6	-	-	3.3	-	-	-	-	-	-	-	-	-	-	-	66	263	66	x	
Pleurosigma stuxbergii Cleve et Grunow	-	-	-	-	-	-	-	44	66	605	-	790	33	269	22	725	395	527	x	
Pseudogomphone ma kamtschaticum (Grunow) Medlin	-	-	-	-	-	-	11	-	66	66	132	395	99	-	66	132	132	132	x	
Pseudo-nitzschia cf. delicatissima (Cleve) Heiden	49	-	-	-	-	_	-	-	-	-	-	-	-	-	-	988	2240	1581		х
<i>P. lineola</i> (Cleve) Hasle	56	1356	138	-	47	<1	-	100	66	395	-	263	165	33	66	-	132	922		Х

P. subcurvata (Hasle) Fryxell	56	514	283	-	-	1.3	11	44	461	263	395	3557	99	-	487	132	725	4612	Х
<i>P. turgiduloides</i> (Hasle) Hasle	40	-	72	-	-	2.0	89	-	66	66	418	461	263	1482	310	2833	1317	2240	х
<i>Synedropsis recta</i> Hasle, Medlin et Syvertsen	-	94	-	-	23	1.3	377	343	6192	1581	4954	9354	922	263	1241	2306	2240	4085	x
<i>Thalassiothrix</i> spp.	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	х
Unidentified pennate diatoms	191	-	-	-	-	-	-	-	-	-	-	-	329	263	-	856	-	66	
Empty pennates	1120	-	1334	830	321	269	-	-	-	-	-	-	-	-	-	-	-	-	
Shannon index (H')	1.3	1.3	1.3	0.9	0.5	1.6	2.1	2.1	1.8	1.7	1.6	1.8	1.8	2.1	1.7	1.9	1.6	1.4	

\* *Thalassiosira* and *Entomoneis* species were identified in electron microscopy and grouped in the cell counts.

\*\* Counts for *N. perminuta* may also include some *N. glaciei* cells, as the latter species was rarely identified in electron microscopy.

Dear Editor,

I send you my manuscript entitled: 'Spring-time dynamics of diatom communities across landfast and underlying platelet-ice in Terra Nova Bay, Ross Sea, Antarctica '.

I would like submit it in the special issue "SI: Ross Sea."

Best regards

Dr. Maria Saggiomo, PhD

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