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Diatoms in Water Column and Sea-ice in Lützow-Holm Bay, Antarctica, and their Preservation in the Underlying Sediments

By

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Abstract Quantitative floral analyses have been performed on sea water and sea-ice samples collected from two sites near East Ongul Island in Lützow-Holm Bay, Antarctica. Fifty-nine diatom species and varieties belonging to 28 genera were identified in the samples. Nine species dominate the sea water assemblage; *Chaetoceros neglectum*, *Chaetoceros tortissimus*, *Fragilaria* (?) sp. a, *Nitzschia curta*, *Nitzschia cylindrus*, *Nitzschia lecointei*, *Nitzschia turgiduloides*, *Nitzschia vanheurckii* and *Porosira pseudodenticulata*. High abundance of the following 10 species characterize the sea-ice assemblage; *Berkeleya* sp. a, *Eucampia balaustium*, *Nitzschia closterium*, *Nitzschia curta*, *Nitzschia cylindrus*, *Nitzschia lecointei*, *Nitzschia stellata*, *Nitzschia turgiduloides*, *Pinnularia quadratarea*, *Pleurosigma* sp. a, *Rhizosolenia alata* and *Tropidoneis* sp. a. Floral composition of the sea water and sea-ice samples are reflected in those of the underlying surface sediments of the bay, while diatoms with poorly silicified valves are less common in the sediment flora compared to the water column and/or sea-ice floras. Two important species associated with sea-ice and the underlying water, *N. curta* and *N. cylindrus*, occur commonly in the sediments after allowing for dissolution, and the predominance of these two forms may be a good indicator of the environment covered and/or strongly influenced by sea-ice. Other corrosion resistant ice forms, resting spore of *Eucampia balaustium* and *Pinnularia quadratarea*, have also been discriminated as supplementray guide taxa for near ice environment.

Introduction

Austral summer diatoms from sea water and the overlying sea-ice collected by the biological investigation members of the 23rd and 24th Japanese Antarctic Research Expeditions (JARE) in 1982 and 1983 were examined. This study is supplementary to the diatom distribution analysis done on the sediments of Lützow-Holm Bay, Antarctica (TANIMURA, 1990). The bay is covered with coastal fast ice, and hence diatoms in the sediments consist of sea-ice and sea water floras. The composition and distribution of these floras and their relationships to modern oceanographical and sea-ice conditions provide information to interpret the sediment flora and to reconstruct the paleoceanographic history of the bay. In this paper we describe the diatom floras in 16 sea water and 4 sea-ice samples obtained from two stations near East

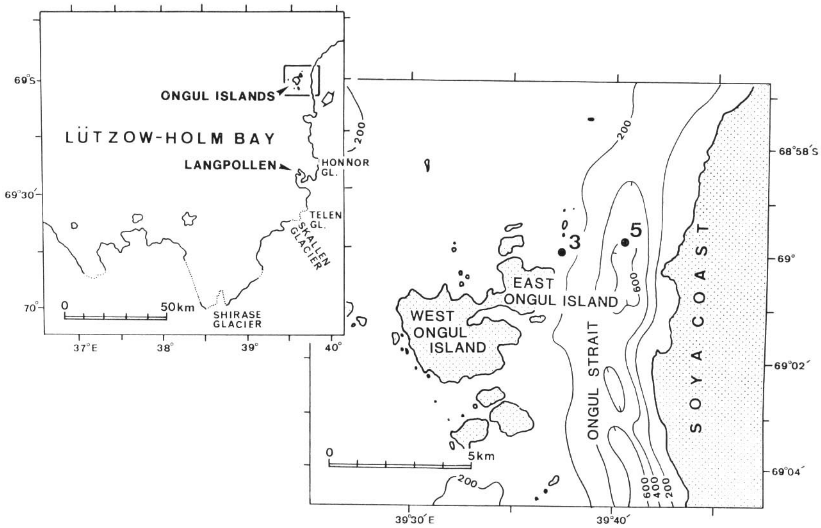


Fig. 1. Location of stations (bathymetry by MORIWAKI and YOSHIDA, 1983). Bathymetric contours are shown in meters. The information of sea-ice conditions at and around the stations is available in KUSUNOKI (1975, 1981) and WATANABE and SATOH (1987).

Ongul Island, and compare them with the diatom flora found in the underlying sediments.

Location of sea water and sea-ice samples are shown in Fig. 1, and other *in situ* physical, chemical and biological data are given in FUKUCHI *et al.* (1885) and WATANABE *et al.* (1986).

Material and Methods

The material used was obtained at the stations during March 1982 through December 1983. Water column samples were collected with 5-liter Van Dorn bottles at 5-25 m intervals from the upper 50 m water column. These samples were fixed with 1–2% borex-buffered formalin. Sea-ice cores were obtained using a SIPRE coring auger. Each sea-ice sample was returned to a laboratory, melted at room temperature and preserved with a mixture of acetic acid and formalin (1 : 1). Prior to the counts of diatoms, taxonomic examination was carried out on a light microscope at ×1250 magnification with direct transmitted light and Nomarskii differential interference contrast, and on a scanning electron microscope for several sea water and sea-ice samples. For permanent slide preparation, 10 to 20 m*l* of sea water or 1 to 2 m*l* of ice water samples were filtrated with 0.8 μm Millipore filters (type AA) for desalting. These filters were gently washed with distilled water to remove any adhering diatom cells, and permanent slides were made after the methods of TANIMURA

(1990). For scanning electron microscopic observation, diatom valves were collected by filtration of the same water samples within 0.8 μm Millipore filter.

Counts of both relative diatom species abundance and absolute diatom cell number were performed on the sea water samples. With the exception of several sea water samples containing poorly preserved diatom valves, relative abundance of each diatom species in a flora was estimated by counting over 1000 diatom valves while traversing a Fuchs-Rosenthal ruling blood-counting chamber under a light microscope at 600 x. Cell number in each sea water sample was estimated by scanning and counting the entire field of combined plate chamber (Wild, 50 m*l*) with an inverted-microscope at 400 x. For the sea-ice samples only relative species abundaces were estimated with Pleurux-mounted slides.

Results

Sixteen samples from three water columns were analyzed in this study; one taken on December 3, 1982 from the central part of the Ongul Strait (St. 5) and the rest taken on March 2, 1982 and January 27, 1983 from the northwestern off East Ongul Island (St. 3). Seven samples (St. 3, Jan. 27, 1983=0 m, 5 m, 10 m, 15 m, 20 m, 30 m; St. 3, Dec. 3, 1982=10 m) contain a large number of poorly preserved *Chaetoceros* species. In the water samples, it is probable that the proportion of species with rather heavily silicified valves are more common compared to the water column at each sampling site.

Thirty-nine marine taxa were identified in three water columns (Table 1). All sea water samples are dominated by large to very large numbers of *Chaetoceros* and/or *Nitzschia* species. The floral composition of six water samples taken from St. 3 on March 1982 is more or less uniform throughout the water column except for changes in the abundance pattern of diatom cells (Fig. 2). Several species of the genus *Chaetoceros* are the dominant constituents of the samples, over 80% and up to 90%, and those of the genus *Nitzschia* are also common in almost all samples, 8–19%. Four species belonging to these two genera, *Chaetoceros neglectum*, *Chaetoceros tortissimus*, *Nitzschia cylindrus* and *Nitzschia turgiduloides*, together comprise over 84% of the flora in the quantitative analysis. *Navicula glaciei*, *Nitzschia closterium*, *Nitzschia curta*, *Nitzschia lecointei* and *Thalassiosira gracilis* are also present nearly uniformly throughout the water column. None of these forms, however, reach 2% in the flora.

In contrast to these samples, the spectrum of diatom species found in six water samples obtained from the same station on January 1983 is somewhat variable within the water column. High abundance or common occurrence of *Gomphonema* sp. a, *Navicula glaciei* and *Nitzschia cylindrus* in the uppermost portion of the water column and those of *Chaetoceros* species, *Nitzschia curta*, *N. turgiduloides* and *N. vanheurckii* in the lower to middle part of the water column are the characteristics of this spectrum. *Nitzschia stellata*, *Pinnularia quadratarea* and *Thalassiosira gracilis* are

Table 1. Diatoms found in water column and sea-ice. G.I.L.=consolidated grease ice layer, with asterisks represent

DIATOM TAXA	WATER COLUMN								
	Station 3								
	March 2, 1982						January 27, 1983		
	0(m)	5(m)	10(m)	20(m)	30(m)	45(m)	0(m)	5(m)	10(m)
Actinocyclus actinochilus									
Amphiprora kjellmanii									1
A. kufferathii		3	1	1					
A. oestrupii	1			2	1		1		
A. spp.									
Amphora sp.									
Asteromphalus hyalinus									
Berkeleya sp. a							2		
Chaetoceros bulbosum									
C. criophilum									
C. dichaeta									
C. neglectum	818	693	824	700	789	796		6	22
C. trotissimus	95	65	71	60	68	60			
C. spp.	8	65	68	119	47	52	13*	1076*	1978*
Cocconeis sp.			1						
Corethron criophilum				1	1				
Coscinodiscus bouvet		1							
C. sp.									
Dactyliosolen antarcticus									
Diploneis sp.									
Eucampia balaustium			1	1					
Fragilaria (?) sp. a									
Fragilaria sp.									
Gomphonema sp. a							39	8	12
Grammatophora gaussii							1		
Haslea trompii+ *H. trompii* var. *major*								2	
Navicula directa									
N. glaciel	2	1	2	2	1		40	2	10
N. jejunoides							1		
N. spp.		2		1		3	3	1	
Nitzschia angulata									
N. closterium	22	4	5	3	1			2	3
N. curta	3	19	4	12		4	2	72	99
N. cylindrus (A)	2	38	10		4	17	201	20	21
N. cylindrus (B)		38	4	46	23	16			
N. kerguelensis									
N. lecointei	8	5	1	4		2	2		
N. obliquecostata		8							
N. ritscheri				1					

S.L. = consolidated snow layer and M.P. = melt pool. Valve number of *Chaetoceros* species poorly preserved specimens.

WATER COLUMN							SEA–ICE			
Station 3			Station 5				St. 3			St. 5
January 27, 1983			December 3, 1982				Mar. 5, 1983	Oct. 13, 1983	Dec. 3, 1983	Nov. 10, 1983
15(m)	20(m)	30(m)	0(m)	10(m)	25(m)	50(m)	G.I.L.	G.I.L.	S.L.	M.P.
								15		
		1	1						1	
							9	16	4	
		1	1						1	
1	1									
								1		
			5					4		186
								2		
								2		
								42		
10		7								
372*	535*	192*		12*			11	24		
								4		
								15		
								1		
								16		
1								1		
								113		
			111	48	71					
								3		
		1	6				27	5		3
1				1	2					1
								29		
						1			7	2
							12			1
	2		12	5	1		88	8		9
								14		
2	1		7						19	148
192	160	103	27	47	7	2	7	110		61
18	20	14	9				41		790	5
							697	6		19
								17		
			96	9	6	2	72	78		181
								37		4
								44		4

Table 1.

DIATOM TAXA	WATER COLUMN								
	Station 3								
	Mach 2, 1982						January 27, 1983		
	0(m)	5(m)	10(m)	20(m)	30(m)	45(m)	0(m)	5(m)	10(m)
Nitzschia separanda									
N. stellata							1	11	11
N. subcurvata		4			2	5	3		1
N. sublineata									
N. taenia	3	1		2			4	6	16
N. turgiduloides	151	71	75	76	82	36		2	17
N. vanheurckii				6				3	7
N. spp.	9	2	7	4		3		23	18
Odontella weissflogii			1	3					
Pinnularia quadratarea+ *P. quadratarea* var. *constricta*		1	1	1			2	18	18
Pleurosigma sp. a									
Pleurosigma spp.								2	5
Porosira pseudodenticulata+ *Porosira* spp.				2	3	2			
Rhizosolenia alata+ *R. alata* f. *inermis*									
Stellarima furcatus									
Synedra sp.				1				4	30
Thalassiosira gracilis	8	2	2	4	2	1		13	3
T. ritscheri									
T. spp.									5
Thalassiothrix longissima									
T. sp.									
Tropidoneis belgicae				1			2		
T. gaussii		1						2	1
T. sp. a					1				
T. sp.									
Others			1			2	13		10
Total number of diatom valves counted	1130	1023	1079	1055	1025	1000	328	1273	2288

also observed regularly in the same water column, but they are never common.

The floral composition in four water samples taken on December 1982 from St. 5 differs markedly from that found in the water columns at St. 3; *Chaetoceros* species are rare in the samples from St. 5. In addition, *Fragilaria* sp. a, *Porosira pseudodenticulata* and *Porosira* species are abundant in the upper water column of this site, while these forms have not been seen in significant numbers in the water column at St. 3. *Nitzschia curta*, *N. lecointei* and *N. vanheurckii* are, however, common representatives of this flora as observed at St. 3.

(Continued)

WATER COLUMN							SEA–ICE			
Station 3			Station 5				St. 3			St. 5
January 27, 1983			December 3, 1982				Mar. 5, 1983	Oct. 13. 1983	Dec. 3, 1983	Nov. 10, 1983
15(m)	20(m)	30(m)	0(m)	10(m)	25(m)	50(m)	G.I.L.	G.I.L.	S.L.	M.P.
								2		
4	3	3								114
5	3	2								
								1		
			10				77		1	96
15	42	6	18	2	13	1	153			5
56	53	31	65	15	111	21	35			8
3	7		9	6	3	3	2	9		
								21		
14	14	4	1	3			93	2		12
							3	4	3	160
2	1	2	4							
			39	524	94	8		15		
								181		1
								1		
	3		17	4	2					
	1							5		
							6			
								32		
								6		
									1	
		1							8	
								5	415	9
								4		
1	3	3	14		1		3	9	1	34
688	849	371	447	676	311	38	1142	1098	1251	1075

Four sea-ice samples were analyzed, one taken on November 10, 1983 from St. 5 and the rest taken on March 5, October 13 and December 3, 1983 from St. 3. Of these, two are obtained from consolidated grease ice layers in fast ice (Table 1; G. I.L.) and the rest are taken from a consolidated snow layer (Table 1; S. L.) and a melt pool (Table 1; M. P.) on fast ice, respectively. Two consolidated grease ice samples are collected from different sea-ice, because multi-year sea-ice flowed away from Lützow-Holm Bay on May 5, 1883.

All samples contain abundant well-preserved diatoms. Forty-six different

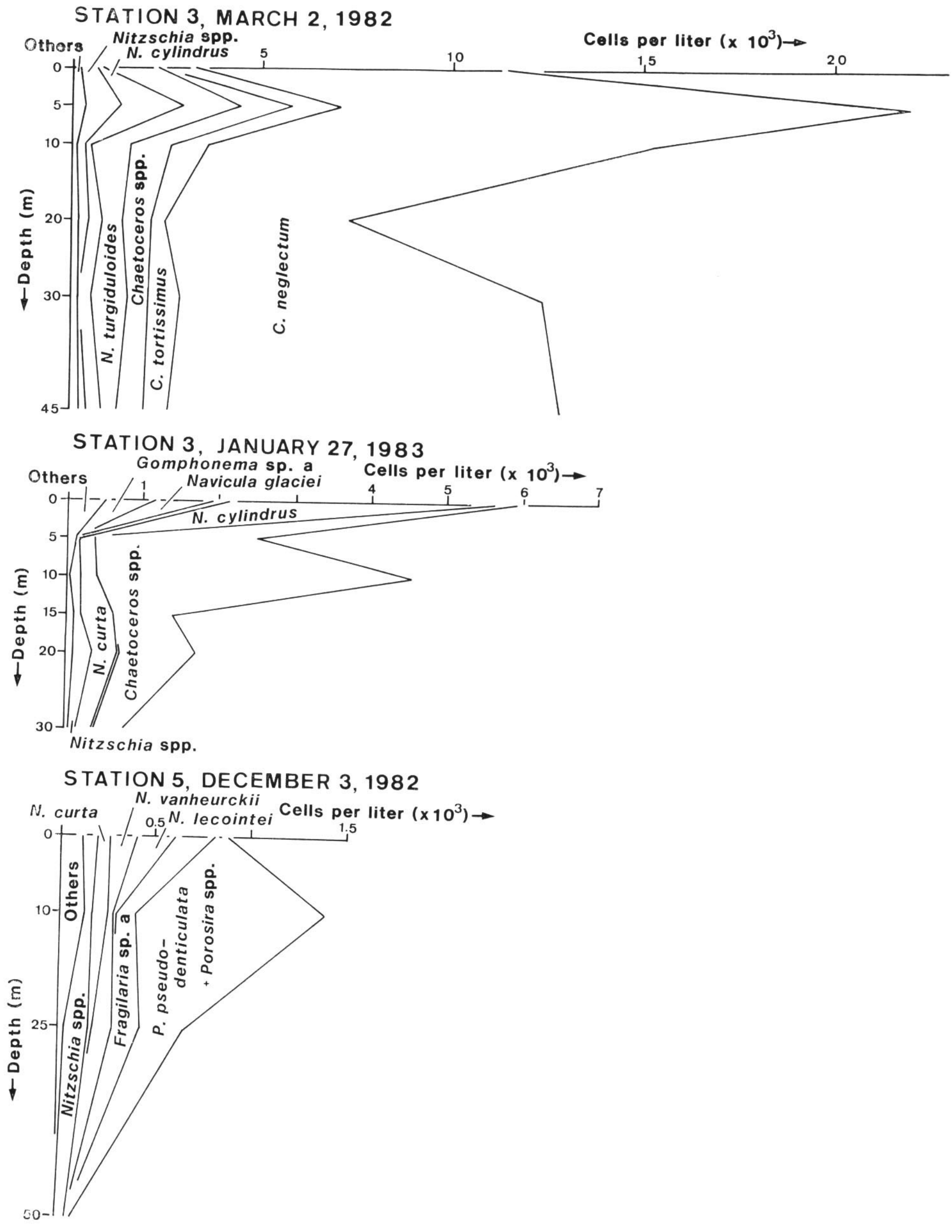


Fig. 2. Cell concentrations of dominant diatoms versus water depth for three water columns.

diatom species and varieties belonging to 22 genera were identified in four sea-ice samples (Table 1). *Nitzschia cylindrus* comprises about 65% of the flora in the consolidated grease ice sample taken from St. 3 on March 5, 1983. *Nitzschia lecointei*, *N. taenia*, *N. turgiduloides* and *Pinnularia quadratarea* are also abundant to common in the sample. These five forms together comprise about 95% of the flora. In contrast to this sample, the consolidated grease ice sample obtained from the same station on October 13, 1983, has a more diverse assemblage containing other antarctic diatoms such as *Chaetoceros dichaeta*, *Eucampia balaustium*, *Navicula directa*, *Nitzschia curta*, *N. lecointei*, *N. obliquecostata*, *N. ritscheri*, *Rhizosolenia alata* and *Odontella weissflogii*. Among them, *E. balaustium*, *N. curta* and *R. alata* are found in the sample as dominant species. The predominance of two antarctic diatoms, *Nitzschia cylindrus* (about 63%) and *Tropidoneis* sp. a (about 33%), is a characteristic of the flora representing a consolidated snow ice sample. Several other forms are the minor components of the flora, reaching maximum abundance of <1.5%.

More than 50% of the diatoms obtained from a melt pool on fast ice are composed of the species being not abundant in other three sea-ice samples. These species include; *Berkeleya* sp. a, *Nitzschia closterium*, *N. stellata* and *Pleurosigma* sp. a. First three of these forms have been known as "tube-dwelling diatoms", which make microalgal strands on the under surface of sea-ice.

Discussion

Most of diatom species identified have been recorded from modern antarctic waters and/or sea-ice (FUKASE, 1962; BUNT and WOOD, 1963; KOZLOVA, 1964; HASLE, 1969; FENNER *et al.*, 1976; KREBS, 1983; MCCONVILLE and WETHERBEE, 1983; GERSONDE, 1984; BURCKLE *et al.*, 1987). Probably, all of the sea water sampes contain a large number of the diatom valves released from sea-ice and/or microalgal strands hanging from the under surface of fast ice. Close similarity of the species association of common *Nitzschia* species in the water flora to that of the sea-ice is a support for this inference. In addition, two grease ice samples may partly contain the phytoplankton which are physically frozen onto the underside of sea-ice as GARRISON *et al.* (1983) proposed. Significant differences between two grease ice floras support this assumption. These two floras represent different multi-year sea-ice, and the floral difference is likely due to the difference of water column assemblages physically concentrated during ice formation. It may hence be usually difficult to distinguish phytoplankton forms from the epontic species released into water column and mixed with sea water forms. In the present material *Chaetoceros neglectum*, *C. tortissimus* and *Fragilaria* (?) sp. a appear to be the common forms that are restricted to the water column, and *Fragilaria* (?) sp. a is also commonly found in the underlying sediments (TANIMURA, 1990). The two *Chaetoceros* species are phytoplankton forms. Modern habitat of *Fragilaria* (?) sp. a is, however, unknown. This species occurs abundantly in the uppermost layer of water column at St. 5 with an occurrence of about 30%. In the Lützow-Holm Bay sediments this species is commonly found in two small areas; one is the central to eastern part of the Ongul Strait near St. 5 and the other is in Langpollen, a cove which is shallow and covered with coastal fast ice almost all the year-round. The fact suggests that sea-ice could also provide a habitat for *in situ* growth of this species. More detailed investigation is needed for the proper evaluation of these alternatives.

A comparison of the floral composition found in the water column or sea-ice with that in the surface sediments obtained from the sea floor at and around the Ongul Strait (TANIMURA, 1990; sites=A, B, C, D, E and F) is made. Since the water and sea-ice floras at two stations represent only a short period, a strict comparison between the sediment and water column or sea-ice floras is difficult. The available data, however, show that the species associations in the water column and sea-ice samples are reflected in those of diatoms in the upper-most layer of underlying sediments, while the individual species abundances show larger differences between them. Two small *Nitzschia* species, *N. curta* and *N. cylindrus*, predominate in the water column and sea-ice assemblages, and are considered to be the most important forms associated with sea-ice in Lützow-Holm Bay as previously reported by several workers; they increase in abundance to Antarctic Continent (HASLE, 1965b), and have been found in abundance on and/or in sea-ice (Van HEURCK, 1909; HEIDEN and KOLBE, 1928; HENDEY, 1937; GERSONDE, 1984). These two forms are also abundant or common in the sediments, and may hence be a good tracer of the environment strongly influenced by sea-ice, although each species abundance has not been preserved in the sediment flora for a silica dissolution. *Nitzschia cylindrus* is less common in the sediments compared with the water column and sea-ice. There are two forms in the present *N. cylindrus*; one smaller and weakly silicified and the other larger and rather heavily silicified forms. The smaller form is scarce in the sediment core tops, and the relatively low abundance of *N. cylindrus* in the sediments could be caused by the selective dissolution of weakly silicified smaller valves.

The sea water and sea-ice floras contain commonly *Eucampia balaustium*, *Gomphonema* sp. a, *Nitzschia turgiduloides*, *N. vanheurckii* and *Pinnularia quadratarea*. These species are also observed regularly in the upper most layer of the sediments, but it is never common. With the exception of vegetative cell of *E. balaustium*, these five species have well silicified valves. In particular, resting spore of *E. balaustium* and *P. quadratarea* have heavily silicified valves being corrosion resistant. *Eucampia balaustium* has been exclusively observed in the Southern Ocean (HASLE, 1969), and is also found as a member of ice flora (e. g. BUNT and WOOD, 1963; GERSONDE, 1984). In contrast to this species, *P. quadratarea* is a bipolar species (SCHMIDT *et al.*, 1874-; HENDEY, 1964). In the present material we judged this species as an important species associated with sea-ice because of the high abundance of the species in the sea-ice. HOSHIAI *et al.* (1987) reported this species to be a component of the gut remain in ice-associated copepod *Paralobidocera antarctica* (I. C. THOMPSON) from Lützow-Holm Bay, which fact supports the judgment. These two forms may hence be supplementary guide taxa for near ice environment. In the water and/or sea-ice floras *Berkeleya* sp. a, *Chaetoceros* species, *Navicula glaciei*, *Nitzschia closterium*, *N. lecointei*, *N. stellata*, *Pleurosigma* sp. a and *Tropidoneis* sp. a are extremely abundant, but these species have not been found in the sediment flora. All of these species are weakly silicified and are probably easily corroded by sea water in water column or sediment-water interface and/or in interstitial water in sediments. The sediment flora thus may lack these species. Resting spores of *Chaetoceros* species, however, occur abundantly from the sediment core tops of the bay, and specific identification of the spores will be needed for the reconstruction of paleoceanographic history, especially the distribution of water-masses in the bay, while most of the spores lack distinctive morphological charactreistics, making their identification difficult in almost all cases.

A relatively low abundance of weakly silicified valves in the uppermost layer of sediment core tops in comparison with the water column and sea-ice samples result in a relatively high abundance of the diatom with heavily silicified valves such as *Nitzschia kerguelensis*, *N. obliquecostata*, *N. separanda* and *N. sublineata*. *Nitzschia kerguelensis* is apparently more abundant in the sediments than it is in the overlying water column and sea-ice. This species is widely distributed in the Southern Ocean (HENDEY, 1937; HART, 1942; FUKASE, 1962; HASLE, 1969; FENNER *et al.*, 1976; FUKUCHI *et al.*, 1978; IORIYA and KATO, 1982; BURCKLE, 1987). High abundance of this species also has been reported from modern antarctic sediments (KOZLOVA, 1964; ABBOT, 1976; TRUESDALE and KELLOGG, 1979; DEFELICE and WISE, 1980; BURCKLE *et al.*, 1887; BURCKLE and CIRILLI, 1987). As discussed previously in TANIMURA (1990), the predominance of *N. kerguelensis* in the sediment flora is attributed to both its corrosion resistant valves and the penetration of open ocean currents with abundant *N. kerguelensis* beneath the coastal fast ice, and the latter process was considered to be more important role in the enrichment of the species in the sediment flora. *Nitzschia obliquecostata*, *N. separanda*, and *N. sublineata* are generally richer in the sediments than they are in the overlying water column and sea-ice like *N. kerguelensis* is. These species are found quite regularly, but not common, in the sediments while they are not seen in significant number in the water and sea-ice samples.

As noted previously, the high abundance of heavily silicified valves in the sediments is primary due to selective dissolution of weakly silicified forms. Diatoms which have rather lightly silicified valves are, however, found in the sediments flora. Probably, many of these forms deposited during high production conditions, and some of them reach sediment in fecal pellets, which help protect the diatoms during the decent and burial. In other words, surface sediment samples record complex oceanographical events having occurred during a fairly long period than water column and sea-ice samples do, because the latter samples only represent the oceanographical conditions during a short period of sampling on one day.

Concluding Remarks

Fifty-nine diatom taxa are identified in the water column and sea-ice from Lützow-Holm Bay. High abundance of *Chaetoceros*, *Fragilaraia*, *Nitzschia* and *Porosira* species characterize the diatoms in the water column, and *Berkeleya*, *Eucampia*, *Nitzschia*, *Pleurosigma*, *Rhizosolenia* and *Tropidoneis* species are the dominant constituents of sea-ice flora. Species associations in the water column and sea-ice samples are reflected in those of diatoms in the underlying sediments, while diatoms with weakly silicified valves are absent or less common in the sediment flora. Two important *Nitzschia* species, *N. curta* and *N. cylindrus*, occur abundantly in both the water column and sea-ice, and also found significant number in the underlying sediments. These two forms have been discriminated as useful guide taxa for reconstruction of paleoceanographic history, especially the distribution of sea-ice, of the bay.

Taxonomic Notes

Species occurred in the water column and sea-ice are listed in Table 1. Only those taxa which have been used for describing the floral composition in the water column and sea-ice samples are included in the following lines. Unidentified and significant forms are alphabetized and illustrated and will be published in a following work.

All permanent slides have been reposited in the micropaleontological reference collection of the National Science Museum, Tokyo, MPC 4910–4913.

Berkeleya sp. a

(Figs. 3–6, 6–3, 4)

Amphipleura/Berkeleya group, MCCONVILLE and WETHERBEE, 1983, figs. 5–7.

Berkeleya rutilans (TRENTEPHOL) CLEVE; WATANABE, 1988, figs. 8, 9.

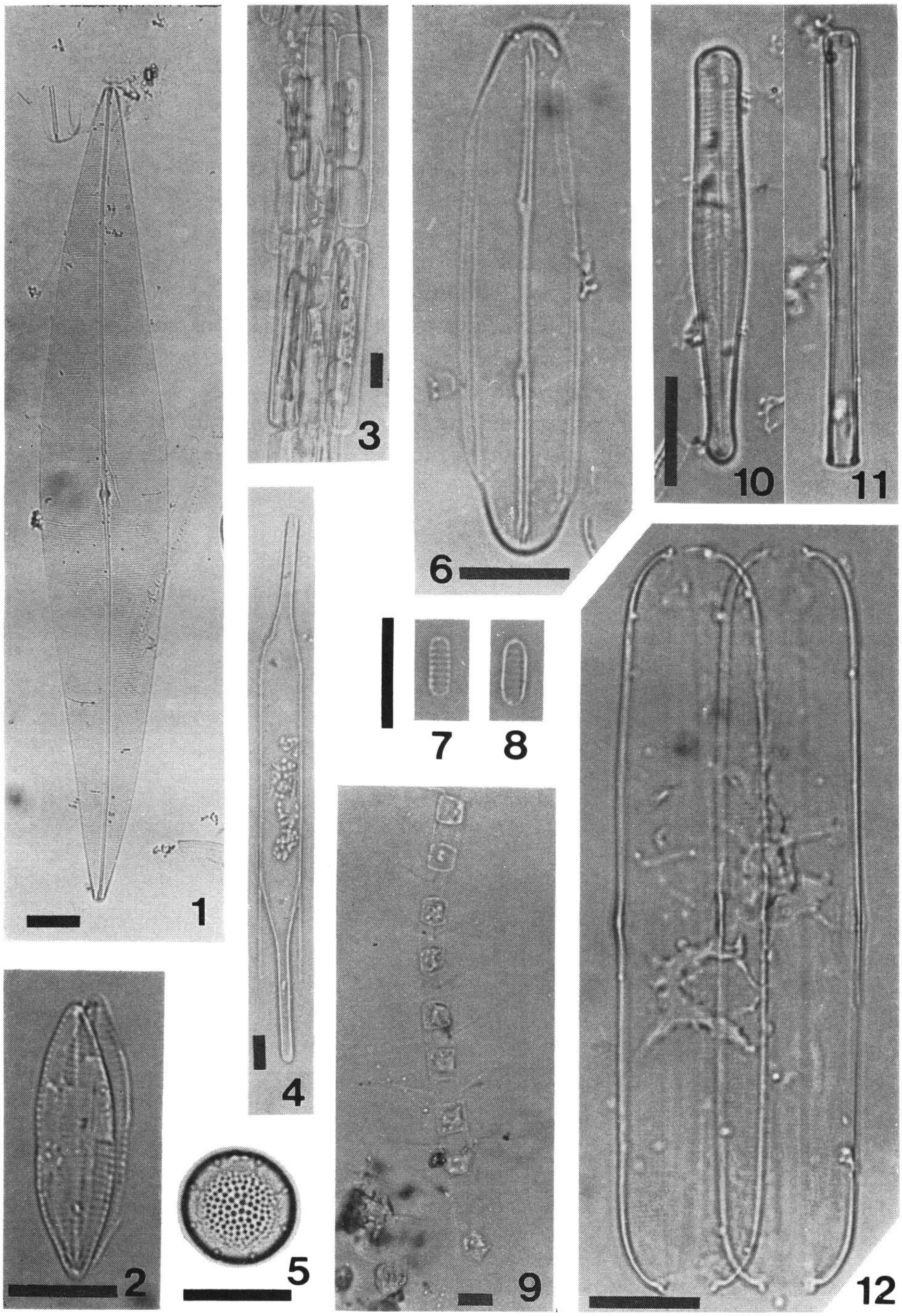
MCCONVILLE and WETHERBEE (1983) reported this weakly silicified taxon to be a member of the microalgal community collected from coastal fast ice near the Australian Antarctic Station of Casey as "*Amphipleura/Berkeleya*" group. WATANABE (1988) recently reported this form to be an abundant constituent of microalgal strands hanging from the coastal fast ice near East Ongul Island, Lützow-Holm Bay as *Berkeleya rutilans*. This species is differentiated from *B. rutilans* (COX, 1975, p. 11) by its more obtuse apices and finer structure. Valves have nearly parallel sides and broadly rounded apices, 45–60 μm long, 8–12 μm wide. There is a long and narrow central area between two straight raphes. Transapical striae composed of small pores, 5–6 in 10 μm, are parallel to radiate near the apices.

Chaetoceros dichaeta EHRENBERG

(Fig. 4–6)

Chaetoceros dichaeta EHRENBERG, 1884; Van HEURCK, 1909, p. 29, pl. 5, figs. 78–82; MANGIN, 1915, p. 37, fig. 17, pl. 1, figs. 2, 3; HENDEY, 1937, p. 291, pl. 6, figs. 9, 10; HENDEY, 1964, p. 119, pl. 13, fig. 1.

Fig. 3. 1, *Pleurosigma* sp. a, St. 5, Nov. 10, 1982. 2, *Navicula glaciei* Van HEURCK, St. 3, Dec. 3, 1983. 3, *Berkeleya* sp. a, St. 5, Nov. 10, 1983. 4, *Rhizosolenia alata* BRIGHTWELL, St. 3, Oct. 13, 1983. 5, *Thalassiosira gracilis* (KARSTEN) HUSTEDT, St. 3, Oct. 13, 1983. 6, *Berkeleya* sp. a, St. 5, Nov. 10, 1983. 7 and 8, *Nitzschia cylindrus* (GRUNOW) HASLE, smaller type, St. 3, Mar. 5, 1983. 9, *Chaetoceros neglectum* KARSTEN, St. 3, Mar. 2, 1982. 10 and 11, *Gomphonema* sp. a, St. 3, Mar. 5, 1983. 12, *Tropidoneis* sp. a, St. 3, Dec. 3, 1983. (Scale bar = 10 μm)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Chaetoceros neglectum KARSTEN
(Figs. 3–9, 6–6)
Chaetoceros neglectum KARSTEN, 1905, p. 119, pl. 16, fig. 5; MANGIN, 1915, p. 47, fig. 29.

Six water samples (St. 3, Mar. 2, 1982, 0–45 m) contained a large number of weakly silicified *Chaetoceros* species similar to *C. neglectum*. The morphological characteristics of the present *Chaetoceros* species slightly differ in valve outline from those of the original illustration and description of *C. neglectum* (*C. neglectus*): however, most of the specimens observed resemble the specimen illustrated by MANGIN (1915, fig. 29) of the species. More detailed examination will be necessary to obtain conclusive taxonomical information about this species, and we have tentatively assigned this form to *C. neglectum*. Cells united in straight or curved chains, sometimes twisted, are rectangular in girdle view. Valves are circular, 8–12 μm in diameter, not in contact with adjacent valves. Setae are long and very fine. Scanning electron microscopy shows that the costae radiating from a central field and a central process are present on valve face. The central process is a slit-like opening with thickening on the outside of valve.

Chaetoceros tortissimus GRAN
Chaetoceros tortissimus, 1900; MANGIN, 1915, p. 49, fig. 33; HENDEY, 1964, p. 135, pl. 11, fig. 2.

Eucampia balaustium CASTRACANE
(Figs. 4–1, 3, 5)
Moelleria antarctica CASTRACANE, 1886, p. 98, pl. 18, fig. 8; Van HEURCK, 1909, p. 38, pl. 18, fig. 114.
Eucampia balaustium var. *minor*, CASTRACANE, 1886, p. 98, pl. 18, fig. 6.
Eucampia balaustium CASTRACANE, 1886, p. 97, pl. 18, fig. 5; KARSTEN, 1905, p. 120, pl. 11, figs. 7, 7a; HENDEY, 1937, p. 285, pl. 13, figs. 8–10; FENNER *et al.*, 1976, p. 774, pl. 5, figs. 7–9; HOBAN *et al.*, 1980, p. 592, figs. 1–14.

Fragilaria (?) sp. a
(Figs. 5–4, 5, 7)
Fragilaria (?) sp. a TANIMURA, 1990, figs. 4–30—31, 5–7.

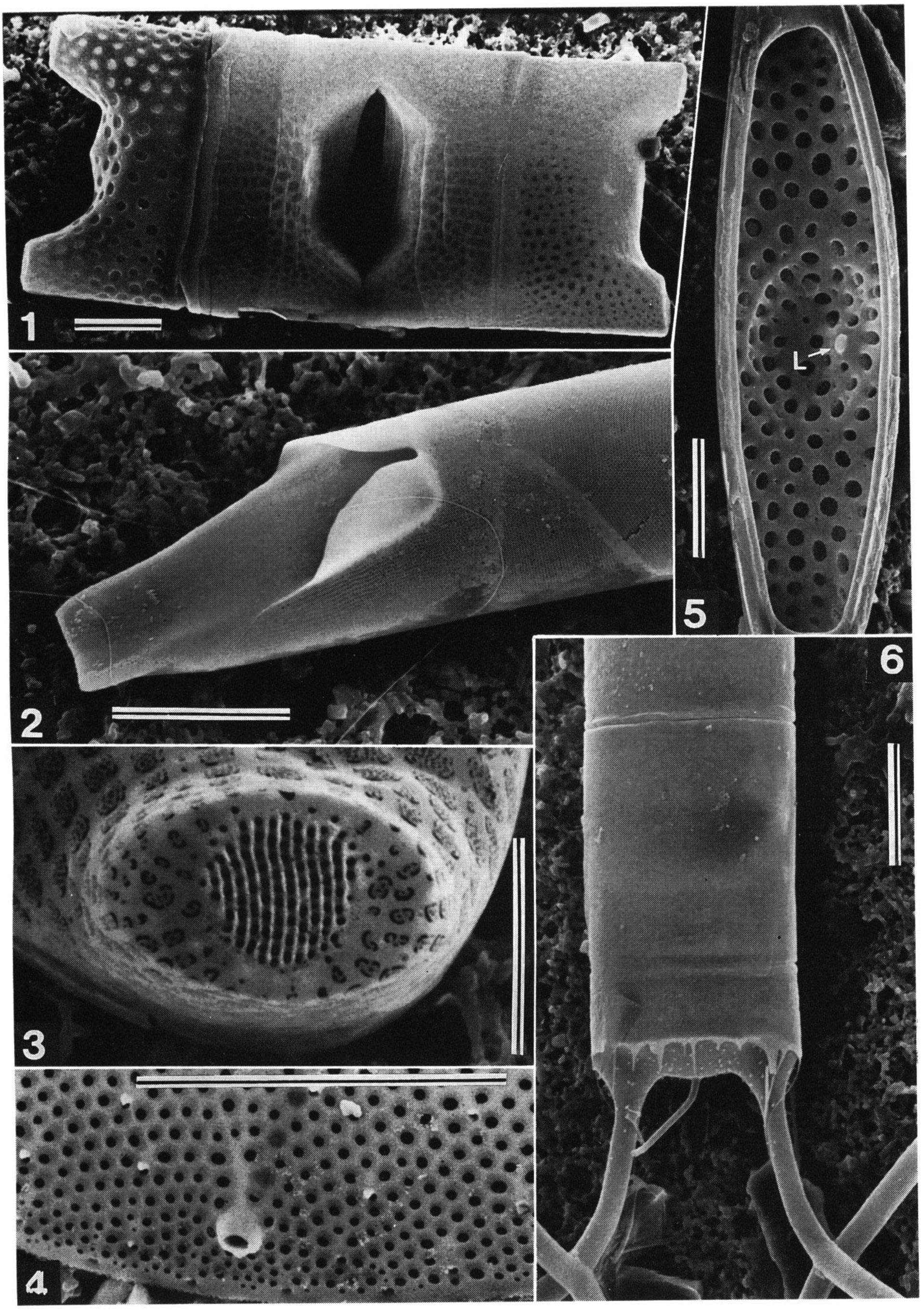
Gomphonema sp. a
(Figs. 3–10, 11)

Valves of this small *Gomphonema* species are club-shaped with broadly rounded upper apices and small rounded lower apices. The size of the specimens observed varies between 35 and 42 μm in length and 4 and 6 in width. Apical area is narrow, and raphe is straight. Transapical striae are slightly radial, 18–20 in 10 μm.

Navicula directa (W. SMITH) RALFS
Navicula directa (W. SMITH) RALFS in PRITCHARD, 1861; SCHMIDT *et al.*, 1874–, pl. 47, fig. 5; HENDEY, 1964, p. 202; KREBS, 1983, p. 285, pl. 3, fig. 7.

Navicula glaciei Van HEURCK

Fig. 4. 1, 3 and 5, *Eucampia balaustium* CASTRACANE, St. 3, Oct. 13, 1983; 1, resting spore and vegetative valves, scale bar=10 μm. 3, elevation of resting spore, scale bar=4 μm; 5, resting spore with labiate process (arrow), scale bar=10 μm. 2, *Rhizossolenia alata* f. *inermis* (CASTRACANE) HUSTEDT, St. 3, Oct. 13, 1983, scale bar=10 μm. 4, *Porosira pseudodenticulata* (HUSTEDT) JOUSÉ, valve with labiate process, St. 3, Oct. 13, 1983, scale bar=10 μm. 6, *Chaetoceros dichaeta* EHRENBERG, St. 3, Oct. 13, 1983, scale bar=10 μm.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(Fig. 3–2)

Navicula gelida var. *parvula* HEIDEN et KOLBE, 1928, p. 605, pl. 2, fig. 53.

Navicula glaciei Van HEURCK, 1909, p. 11, pl. 1, fig. 13; WHITAKER and RICHARDSON, 1980, p. 254, fig. 4; KREBS, 1983, p. 285, pl. 4, fig. 1; WATANABE, 1988, figs. 16, 17.

Nitzschia closterium (EHRENBERG) W. SMITH

Nitzschia closterium (EHRENBERG) W. SMITH; CUPP, 1943, p. 200, figs. 153 a–c; HASLE, 1964, p. 16, text-figs. 1–10; pl. 5, fig. 1; pl. 7, figs. 1–12; pl. 8, figs. 1–8; pl. 9, figs. 1–9; pl. 10, figs. 1–4.

Nitzschia curta (Van HEURCK) HASLE

(Fig. 5–1)

Fragilaria curta Van HEURCK, 1909, p. 24, pl. 3, fig. 37.

Fragilariopsis linearis var. *curta* (Van HEURCK) FRENGUELLI in FRENGUELLI et ORLANDO, 1958, p. 107, pl. 4, fig. 31.

Fragilariopsis curta (Van HEURCK) HUSTEDT, 1958, p. 160, pl. 11, figs, 140–144; pl. 12, fig. 159; HASLE, 1965 b, p. 32, pl. 6, fig. 6; pl. 12, figs. 2–5; pl. 13, figs, 1–6; pl. 16, fig. 6; pl. 17, fig. 5.

Nitzschia curta (Van HEURCK) HASLE, 1972, p. 115.

Nitzschia cylindrus (GRUNOW) HALSE

(Fig. 5–6)

Fragilaria cylindrus GRUNOW; HUSTEDT, 1930, p. 152, fig. 665; OKUNO, 1954, p. 24, pl. 1, fig. 4.

Fragilariopsis cylindrus (GRUNOW) KRIEGER; HASLE, 1965 b, p. 34, pl. 2, figs. 6–12; pl. 14, figs. 1–10; pl. 17, figs. 2–4.

Nitzschia curta (GRUNOW) HALSE, 1972, p. 115.

This species has two forms; one smaller (Table 1; *N. cylindrus* (A); Figs. 3–7, 8) and the other larger (Table 1; *N. cylindrus* (B); Fig. 5–1). The former has been found in abundance in the water column samples taken from St. 3 on March 2, 1982 and the sea-ice samples obtained from the same station on Dec. 3, 1983. A large number of *N. cylindrus* (A) in the sea water samples were attached to Cilita.

Nitzschia kerguelensis (O'MEARA) HASLE

Fragilaria antarctica CASTRACANE, 1886, p. 56, pl. 25, fig. 12; KARSTEN, 1905, p. 122, pl. 17, figs. 7, 7 a–d.

Fragilariopsis kerguelensis (O'MEARA) HUSTEDT, 1952, p. 294; HUSTEDT, 1958, p. 162, pl. 10, figs. 121–127; pl. 12, fig. 158; HASLE, 1965 b, p. 14, pl. 3, figs. 4, 5; pl. 4, figs. 11–18; pl. 5, figs. 1–11; pl. 6, figs. 2–4; pl. 7, fig. 9; pl. 8, fig. 10; pl. 16, figs. 3–5.

Nitzschia kerguelensis (O'MEARA) HASLE, 1972, p. 115.

Nitzschia lecointei Van HEURCK

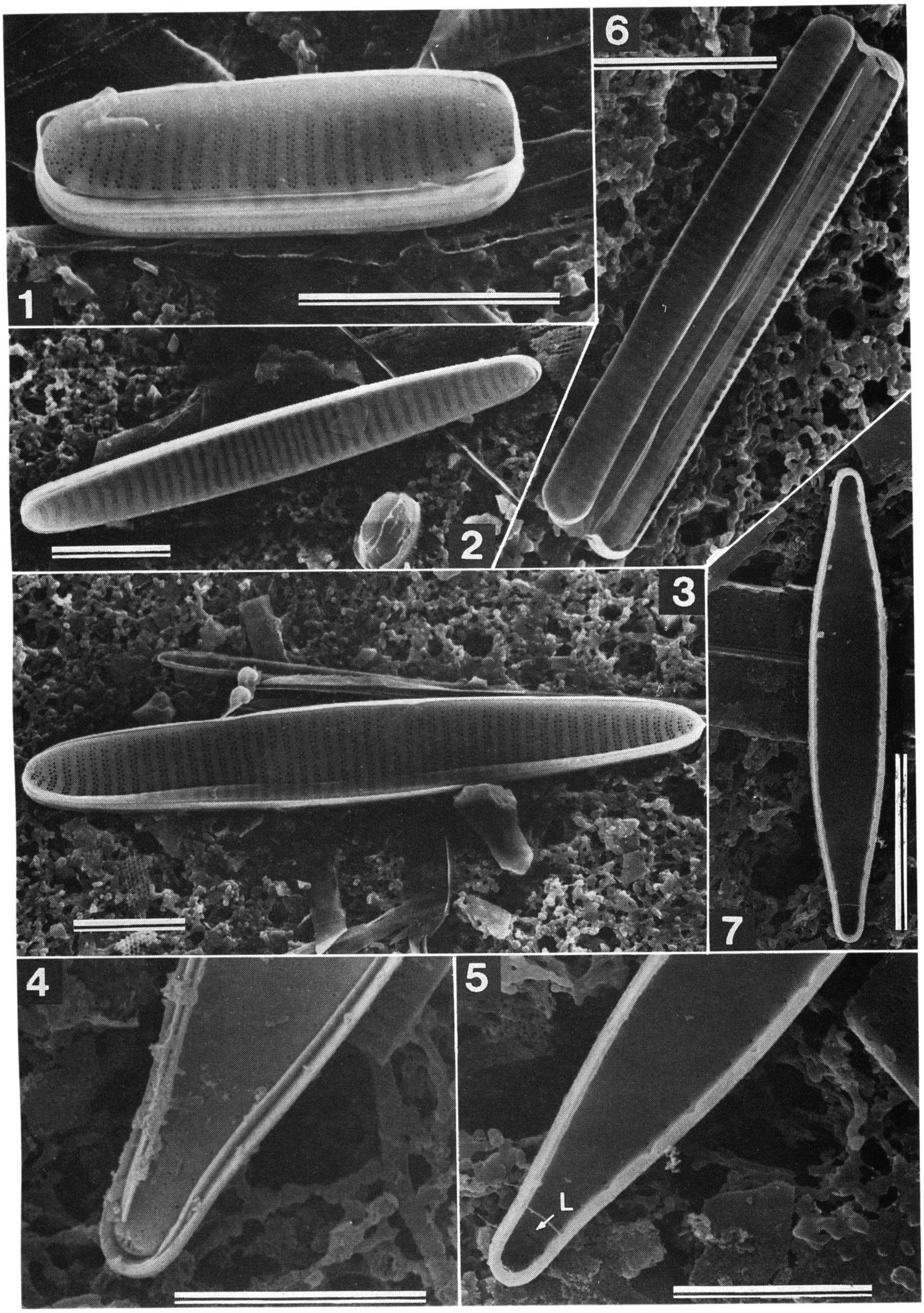
Nitzschia lecointei Van HEURCK, 1909, p. 21, pl. 3, fig. 57; HUSTEDT, 1958, p. 172, pl. 13, figs. 167–168; HASLE, 1964, p. 23, pl. 1, fig. 1; pl. 4, fig. 5; pl. 5, fig. 2; pl. 11, figs. 14, 15; pl. 12, figs. 9–13.

Nitzschia obliquecostata (Van HEURCK) HASLE

(Fig. 5–3)

Fragilariopsis obliquecostata (Van HEURCK) HEIDEN et KOLBE, p. 555; Hasle, 1965 b, p. 18, pl. 7, figs.

Fig. 5. 1, *Nitzschia curta* (Van HEURCK) HASLE, St. 5, Nov. 10. 1983, scale bar = 10 μm. 2, *Nitzschia sublineata* (Van HEURCK) HASLE, St. 3, Oct. 13, 1983, scale abr = 10 μm. 3, *Nitzschia obliquecostata* (Van HEURCK) HEIDEN et KOLBE, St. 3, Oct. 13, 1983, scale bar = 10 μm. 4, 5 and 7, *Fragilaria* (?) sp. a, St. 5, Dec. 3, 1982; 4, outside view of valve, scale bar = 5 μm; 5, valve with labiate process (arrow), scale bar = 10 μm; 7, inside view of whole valve, scale bar = 10 μm. 6, *Nitzschia cylindrus* (GRUNOW) HASLE, St. 3, Dec. 3, 1982, scale bar = 10 μm.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Nitzschia obliquecostata (Van HEURCK) HASLE, 1972, p. 115.

Nitzschia ritscheri (HUSTEDT) HASLE
Fragilariopsis ritscheri HUSTEDT, 1958, p. 164, pl. 11, figs. 133–136; pl. 12, fig. 153; HASLE 1965 b, p. 20, pl. 1, fig. 20; pl. 3, fig. 3; pl. 4, figs. 1–10; pl. 5, figs. 12, 13; pl. 6, fig. 1; pl. 7, fig. 8.
Nitzschia ritscheri (HUSTEDT) HASLE, 1972, p. 115.

Nitzschia separanda (HUSTEDT) HASLE
Fragilariopsis separanda HUSTEDT, 1958, p. 165, pl. 10, figs. 108–112; HASLE, 1965 b, p. 26, pl. 9, figs. 7–10; pl. 10, fig. 1.
Nitzschia separanda (HUSTEDT) HASLE, 1972, p. 115.

Nitzschia stellata MANGUIN
(Figs. 6–1, 2)
Nitzschia stellata MANGUIN, 1960, p. 335, pl. 19, figs. 234–236; pl. 31, figs. 379–380.

Nitzschia sublineata (Van HEURCK) HASLE
(Fig. 5–2)
Fragilaria sublinearis Van HEURCK, 1909, p. 25, pl. 3, fig. 39.
Fragilariopsis sublinearis (Van HEURCK) HEIDEN in HEIDEN et KOLBE, 1928, p. 554; HASLE, 1965 b, p. 21, pl. 7, fig. 1; pl. 11, figs. 1–10; pl. 12, fig. 1.
Nitzschia sublineata (Van HEURCK) HASLE, 1972, p. 115.

Nitzschia taenia HUSTEDT
Nitzschia taenia HUSTEDT, 1958, p. 180, pl. 13, fig. 195.

Nitzschia turgiduloides HASLE
Nitzschia turgiduloides HASLE, 1965 a, p. 28, pl. 12, figs. 9–14; pl. 13, figs. 3–6.

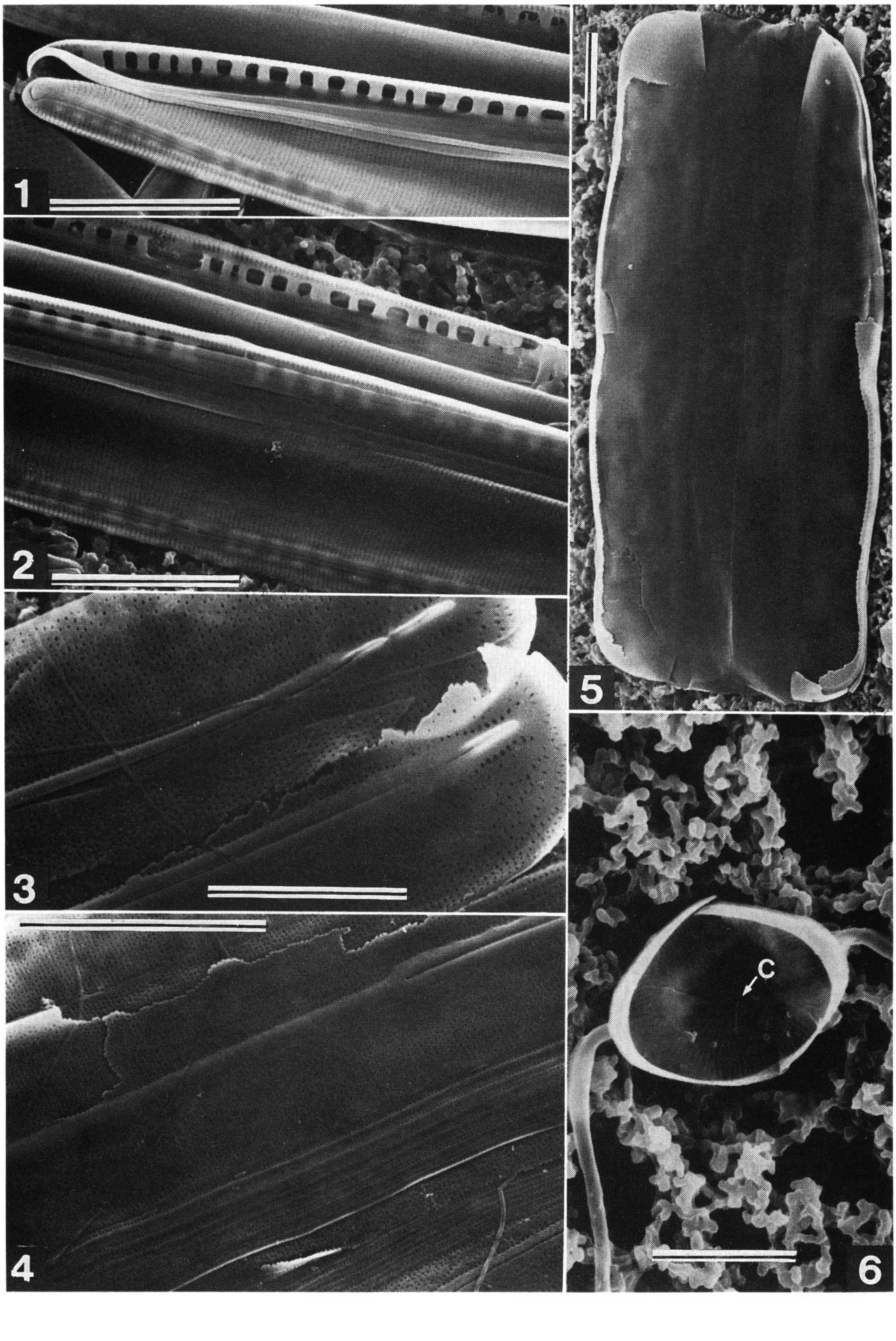
Nitzschia vanheurckii (PERAGALLO) HASLE
Fragilariopsis vanheurckii (PERAGALLO) HUSTEDT, 1958, p. 166, pl. 12, fig. 156; HASLE, 1965 b, p. 30, pl. 12, figs. 13–16; pl. 12, figs. 7, 8; pl. 15, fig. 8.
Nitzschia vanheurckii (PERAGALLO) HASLE, 1972, p. 115.

Odontella weissflogii (JANISCH) GRUNOW
Biddulphia weissflogii (JANISCH) GRUNOW in Van HEURCK, 1882, pl. 100, figs. 1, 2.
Biddulphia striata KARSTEN, 1905, p. 122, pl. 7, figs. 3 a, 3 b; Van HEURCK, 1909, p. 42, pl. 10, figs. 144, 147, 148; MANGIN, 1915, p. 22, fig. 1; HENDEY, 1937, p. 278, pl. 10, figs. 4, 5 (?); FRENGUELLI and ORLANDO, 1958, p. 131, pl. 9, figs. 4–7; pl. 12, figs. 2, 3.
Odontella weissflogii (JANISCH) GRUNOW, 1884; HOBAN *et al.*, 1980, p. 594, figs. 15–26.

Pinnularia quadratarea (SCHMIDT) CLEVE
(Figs. 7–1, 2)
Pinnularia quadratarea (SCHMIDT) CLEVE, 1895, p. 95; SCHMIDT *et al.*, 1874–, pl. 260, figs. 33–35; HENDEY, 1964, p. 232.

This heavily silicified and coarsely structured taxon has been reported from various area of the world ocean (e. g. SCHMIDT *et al.*, 1874-; BUNT and WOOD, 1963; HENDEY, 1964). This species is variable in valve outline (SCHMIDT *et al.*, 1874-). In the present material the wide variation of valve outline is also observed, and many specimens may be assigned to *P. quadratarea* var. *constricta* (OESTRUP) HEIDEN (1905

Fig. 6. 1 and 2, *Nitzschia stellata* MANGUIN, St. 5, Nov. 10, 1983, scale bar = 10 μm. 3 and 4, *Berkeleya* sp. a, St. 5, Nov. 10, 1983, scale bar = 5 μm. 5, *Tropidoneis belgicae* (Van HEURCK) HEIDEN, St. 3, Dec. 3, 1983, scale bar = 10 μm. 6, *Chaetoceros neglectum* KARSTEN, St. 3, Mar. 2, 1982, scale bar = 5 μm.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in SCHMIDT *et al.*, 1874-, pl. 260, figs. 3–8, 36). Intermediate forms between them also occur commonly in the samples.

Pleurosigma sp. a
(Figs. 3–1, 7–4, 6)

This weakly silicified taxon has some resemblance to *P. antarcticum* HEIDEN et KOLBE (1928, p. 648, pl. 4, fig. 94), a name which was illegitimate because it had already been used by GRUNOW (CLEVE and MOLLER, 1877-) for another form. The present species differs in an angle of two oblique striation system from *P. antarcticum*. Valves are slightly sigmoid in outline with subacute ends, about 150–200 μm long, 18–32 μm wide. Raphe is also sigmoid, axial area is very narrow and central area with central nodule is small. Oblique striae are composed of small pores, 18–20 in 10 μm, crossing each other at an angle of about 40°.

Porosira pseudodenticulata (HUSTEDT) JOUSÉ
(Fig. 4–4)

Coscinodiscus pseudodenticulatus HUSTEDT, 1958, p. 117, pl. 4, figs. 20, 21.
Porosira pseudodenticulata (HUSTEDT) JOUSÉ in KOZLOVA, 1962, p. 10, fig. 3, no. 2; HASLE, 1973, p. 10, pl. 5, figs. 30, 31; pl. 6, figs. 32–37, pl. 7, figs. 38–43; WATANABE, 1982, pl. 1, figs. 1–3.

This species is similar to *Porosira glacialis* (GRUNOW) JORGENSEN, (HUSTEDT, 1930, p. 315, fig. 153; HENDEY, 1964, p. 88, pl. 1, fig. 12; HASLE, 1973, pl. 3, figs. 13–18; pl. 4, figs. 19–25; pl. 5, figs. 26–29) in several morphological characteristics such as convex valve, radial arrangement of areolae, presence of strutted tubuli scattered over the whole valve and that of labiate process near the margin. We identified *P. pseudodenticulata* by its straight radial rows of areolae and larger areolae size in Pleurux mount. In water mount it is usually difficult to recognize these characteristics, which fact makes specific identification impossible in most cases. Many of these specimens have a finer structure, and are possibly assigned to other *Porosira* species such as *P. glacialis* and *P. antarctica*, which is regarded as conspecific with *P. glacialis* by HASLE (1973). These forms are bundled as spp. in Table 1. More detailed examination is necessary to obtain conclusive information about the *Porosira* species in the Lützow-Holm Bay water samples.

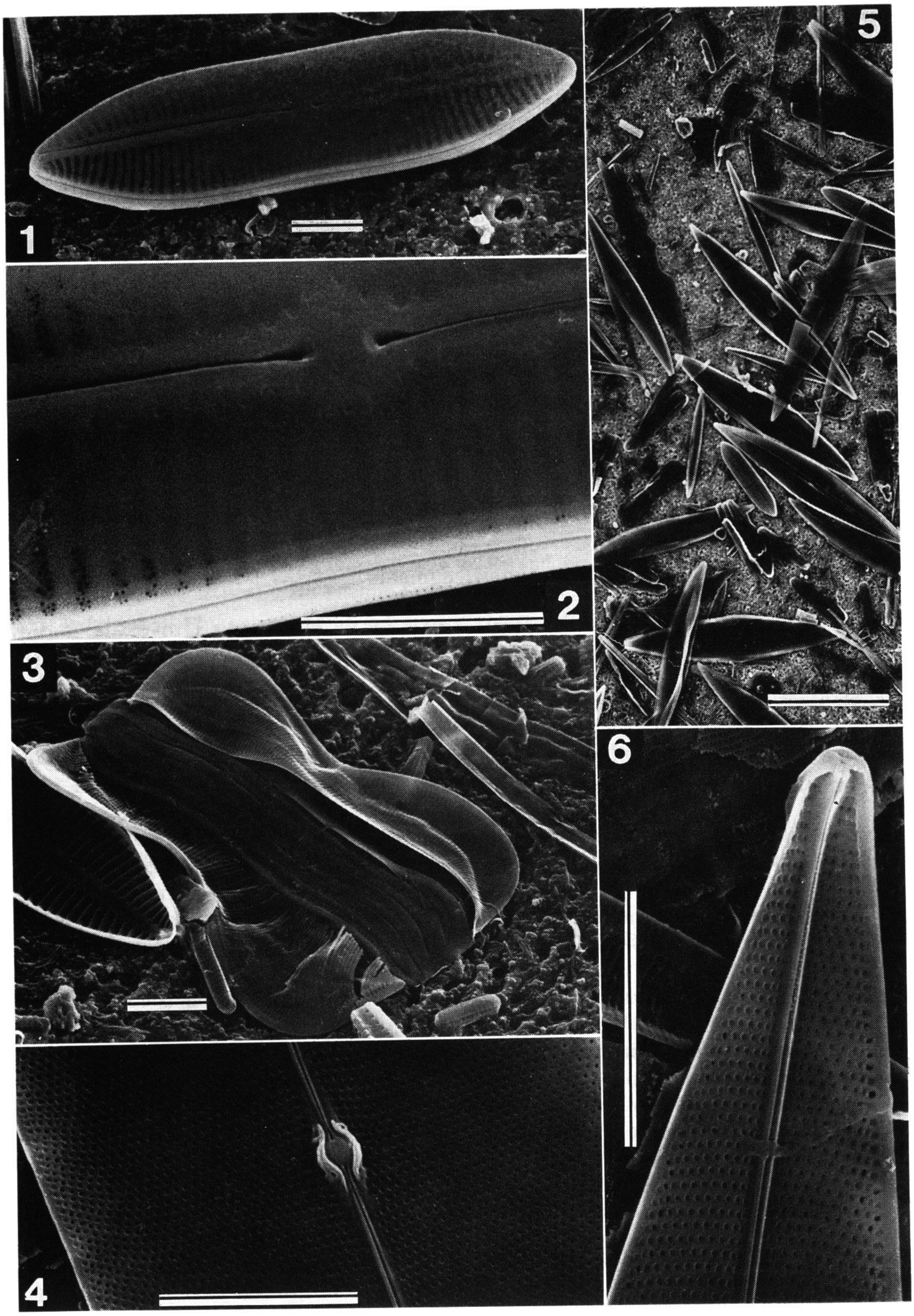
Rhizosolenia alata BRIGHTWELL
(Fig. 3–4)

Rhizosolenia alata BRIGHTWELL, 1858; HUSTEDT, 1930, p. 600, fig. 344; CUPP, 1943, p. 90, fig. 52 A; HENDEY, 1964, p. 140, pl. 2, fig. 2; FENNER *et al.*, 1976, p. 778, pl. 3, fig. 1.

Rhizosolenia alata f. ***inermis*** (CASTRACANE) HUSTEDT
(Fig. 4–2)

Rhizosolenia alata f. *inermis* (CASTRACANE) HUSTEDT, 1930, p. 602, fig. 348; CUPP, 1943, p. 94, fig. 52 E; FENNER *et al.*, 1976, p. 778, pl. 13, fig. 2.

Fig. 7. 1 and 2, *Pinnularia quadratarea* (SCHMIDT) CLEVE, St. 3, Mar. 5, 1983, scale bar = 10 μm. 3, *Amphiprora kufferathii* MANGUIN, St. 3, Mar. 5, 1983, scale bar = 10 μm. 4 and 6, *Pleurosigma* sp. a, St. 5, Nov. 10, 1983, scale bar = 10 μm. 5, Scanning electron micrograph of sea-ice sample taken from St. 5 on Nov. 10, 1983 with abundant *Pleurosigma* sp. a, scale bar = 100 μm.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Stellarima microtrias (KARSTEN) HASLE et SIMS

Coscinodiscus furcatus KARSTEN, 1905, p. 82, pl. 14, fig. 7; HUSTEDT, 1958, p. 113, pl. 3, figs. 18, 19; WATANABE, 1982, pl. 1, figs. 4–6.

Stellarima microtrias (KARSTEN) HASLE et SIMS, 1986, p. 111.

Thalassiosira gracilis (KARSTEN) HUSTEDT

Coscinodiscus gracilis KARSTEN, 1905, p. 78, pl. 3, fig. 4.

Thalassiosira gracilis (KARSTEN) HUSTEDT, 1958, p. 109, pl. 3, figs. 4–7; FENNER *et al.*, 1976, p. 780, pl. 9, figs. 11–22.

Tropidoneis sp. a
(Fig. 3–12)

This *Tropidoneis* species resembles *T. glacialis* described and illustrated by HEIDEN and KOLBE (1928, p. 656, pl. 5, fig. 100). The present species differs in its smaller size and finer structure from *T. glacialis*. Valves are nearly rectangular with rounded apices, not constricted, 70–90 μm long, 12–16 μm wide, and have parallel to slightly radiated transapical striae, about 30 in 10 μm. Scanning electron microscopy shows that transapical striae are composed of round or slit-like small pores, 3–4 in 10 μm, and the slit-like pores form the wavy line of apical striae, about 20 in 10 μm.

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