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1. *DATA REPORT:* INTRA-ANNUAL VARIABILITY OF THE DIATOM ASSEMBLAGES AT HOLE 1034B (SAANICH INLET) NEAR 9 KA[1]

Elisabeth Fourtanier[2] and John A. Barron[3]

INTRODUCTION

Ocean Drilling Program (ODP) Site 1034 (48°38.000′N, 123°30.000′W) was drilled at a water depth of 200 m in the Saanich Inlet, an anoxic fjord on the southeastern coast of Vancouver Island, British Columbia, to a depth of 118.2 meters below seafloor (mbsf). The uppermost 50 m consists of very well-laminated (triplet varves) diatomaceous muds deposited over the past 7000 yr. Below, sediments become progressively less distinctly laminated and reflect better oxygenated bottom-water conditions. The oldest sediments recovered at Site 1034 were dated as 14 to 15 ka (see Shipboard Scientific Party, 1998).

Varved sediments recovered during Leg 169S in the Saanich Inlet offer an excellent opportunity to compare the interannual variability of recent climatic elements (e.g., sea-surface temperature, salinity, precipitation) with those of late Quaternary periods that were characterized by climates appreciably different from those of today. A large amount of recent diatom data from Saanich Inlet exists, which can serve as a baseline for such comparisons: Sancetta (1989a, 1989b, 1990) investigated modern processes controlling the accumulation of diatoms and spacial and temporal trends of diatom flux in the Inlet; Sancetta and Calvert (1988) documented the annual cycle of sedimentation in the fjord. McQuoid (1995) and McQuoid and Hobson (1997) studied the modern pattern of diatom succession in the Saanich Inlet and analyzed the diatoms in laminae couplets in frozen sediment cores for the years 1900 to 1991 A.D.

During the hypsithermal warming of the early Holocene (~10–6 ka), climatic conditions throughout much of northern North America were warmer and drier than those of the present (Pielou, 1991; Hebda and Whitlock, 1997), largely as a result of increased solar insolation, which peaked between 10 and 9 ka at 65°N (Berger and Loutre, 1991). Temperatures are estimated to have been 2° to 4°C warmer than today for most of this interval, reaching a maximum between ~9 and 7 ka (Hebda and Whitlock, 1997). According to Heusser (1983) and Heusser (1985), rapid warming occurred at ~10 ka in southwestern British Columbia with summer conditions that were drier and as warm or warmer than today lasting until ~6 ka. Clague and Mathewes (1989) report that treeline elevation in the southeastern coast mountains of British Columbia reached elevations that were between 60 and 130 m higher than today between 9.1 and 8.2 ka. Thompson et al. (1993) argue that the driest conditions (period of maximum summer drought) of the Holocene were reached in western North America at 9 ka. The warmer and drier conditions of this Holocene thermal maximum were gradually replaced by cooler and wetter conditions (Hebda, 1995; Hebda and Whitlock, 1997).

This report describes the intra-annual variability of the diatom assemblages at Site 1034, during a 8-yr interval near 9 ka. Pollen and dinoflagellates are being studied from the same samples by R. Hebda and P. Mudie (unpubl. data).

MATERIAL AND METHODS

Although the sediments at Site 1034 are well laminated between the seafloor and ~50 mbsf, they are only intermittently laminated between 50 and 65 mbsf. The interval around 9 ka is located near the bottom of Core 169S-1034B-7H at Sample 169S-1034B-7H-4, 107 cm, dated as 8.469–8.891 ka (^{14}C-corrected calendar yr BP) and Sample 169S-1034B-7H-6, 129 cm, dated as 9.148–9.419 (^{14}C-corrected calendar yr BP) (Shipboard Scientific Party, 1998). The interval at 169S-1034B-7H-6, 9–22 cm (~62 mbsf), is well laminated with laminae consisting of varves ~1.2-cm thick on average (R. Hebda, pers. comm., 1998) and was consequently selected by Richard Hebda for our study. Sampling was performed by Richard Hebda.

Sampling Method

A quarter-section study segment, interval 169S-1034B-7H-6, 9–22 cm, was removed from the core and immediately frozen. For sampling, the segment was unwrapped and placed on a freezing stage. Using a sharp knife with a millimeter scale for reference, 1-mm-thick pieces of core were scraped off perpendicular to the core axis. It was assumed that the sediment layers were flat lying and that each 1-mm-thick piece represented the same time of the year. Although the laminae were clear when the core segment was removed from the main core, they were mostly obscure after the segment was frozen. The 1-mm-thick sediment samples were scraped onto a glass microscope slide and then washed into plastic vials. Distilled water was added to the vial, and the sample was shaken and then immediately divided into two, one part for diatom analysis and the other for pollen and dinoflagellate preparation. Two to three centimeters of core were sampled at a time, because the core began to soften and we wanted to avoid deformation of the sediment layers (R. Hebda, pers. comm., 1998).

Preparation of Material for Diatom Analyses

Samples were received from R. Hebda as wet residues. They were then processed for diatom analysis at the California Academy of Sciences (CAS). The samples were dried, weighed, and cleaned using H_2O_2. The residues were rinsed by diluting in distilled water and decanting after 24 hr (this process was repeated twice). The clean residues were then suspended in a known volume of water, and, for each sample, two subsamples of a known volume of the suspension were sampled and deposited on a cover glass. After the residues had dried overnight, they were mounted on glass slides using Naphrax. Thus, two slides per sample were prepared.

Diatoms were identified and counted under the light microscope at 1000×. A total of at least 300 valves was counted per sample, with about half of the counts done on one slide and the other half on the other slide.

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[2]Diatom Collection, Department of IZ&G, California Academy of Sciences, Golden Gate Park, San Francisco CA 94118, USA. efourtan@cas.calacademy.org
[3]U.S. Geological Survey, Menlo Park CA 94025, USA.

RESULTS OF QUANTITATIVE ANALYSES

Table 1 reports, in percentages, the relative abundance of the various diatom taxa counted in each samples. Intra-annual variations of selected taxa are plotted on Figures 1–5.

Percentages of *Chaetoceros* spp. and percentages of *Skeletonema costatum,* the two dominant taxa, are plotted on Figure 1. Given a sedimentation rate of ~1.2 cm/yr in this interval (R. Hebda, pers. comm., 1998), these two species do not show clear annual cycles. *Skeletonema costatum,* however, shows two peaks of abundance at ~13–14 cm and 18–19 cm. The peaks in *Skeletonema costatum* abundance appear to be about 5 yr apart, similar to the 4- to 7-yr cyclicity observed by McQuoid (1995) in modern sediments. McQuoid (1995) and McQuoid and Hobson (1997) have shown that the peaks were situated between ENSO years.

Annual cycles can be observed in the relative percentages of littoral and freshwater diatoms in the assemblages, with cycles repeating every 1.0–1.5 cm, approximating the average annual sedimentation rate at ~9 ka (see Fig. 2). The highest abundances of littoral taxa probably represented passive transport from the margins of the fjord (Sancetta, 1989b), and correspond to the winter deposition (McQuoid, 1995). Furthermore, McQuoid (1995) has suggested that the littoral taxa were most abundant in the sediments during times of heavy winter rains. McQuoid and Hobson (1997) observed highest concentrations of *Thalassionema nitzschioides* in the late spring/early summer sediment layers, although some of the sediments labeled as "summer" could also have included September and October deposition (M.R. McQuoid, pers. comm., 1999). Sancetta (1989b) reported greatest abundance in the fall (September and October). Reduced relative abundance of *T. nitzschioides* tends to correspond with intervals of reduced relative abundance of the littoral taxa (Fig. 3), suggesting a seasonal proximity of *T. nitzschioides* abundance with the wetter winter interval.

Thalassiosira species are characteristic of the early spring deposition in modern sediments (McQuoid, 1995). The section at 9 ka shows variation in the relative abundance of *Thalassiosira* spp., but yearly cycles are not clear (see Fig. 4). Relative abundance of *Cyclotella* spp. (represented mostly by *Cyclotella caspia*) does not show clear yearly cyclicity (see Fig. 5); however, it is interesting to note that many of the peaks of *Thalassiosira pacifica* (a species that blooms in the early spring, according to Sancetta, 1989b) immediately precede the peaks of *Cyclotella caspia* (blooming in the summer).

TAXONOMIC RESULTS

Selected Diatom Species Identified in Interval 169S-1034B-7H-6, 9–20 cm

Planktonic Diatoms

Actinocyclus curvatulus Janisch: rare (<1%)
Bacteriastrum sp.: rare (<1%)
Chaetoceros spp.

Both spores and vegetative cells of *Chaetoceros* spp. were abundant in the sediments examined, comprising generally 35% to 65% of the assemblages. Vegetative cells were usually not attached in chains, and identification to the species level was usually impossible. The vegetative cells of *Chaetoceros radicans* were recognizable only when the setae were still attached. All *Chaetoceros* species not identified at species level were counted as *Chaetoceros* spp. *Chaetoceros* spores were easier to identify; however, because of breakage or inadequate preservation, many were counted as *Chaetoceros* spp.

The following four species of *Chaetoceros* were observed:

C. radicans Schütt: relative percentage values up to 10% were reported. This number, however, was probably underestimated for the reasons explained above.

C. debilis Cleve: rare (<1%)

C. diadema (Ehrenberg) Gran: rare (<1%)

C. vanheurckii Gran: rare (<2%)

McQuoid (1995) and McQuoid and Hobson (1997) reported the *Chaetoceros* species to be most abundant during the early spring to early summer sediment layers, with *C. debilis, C. diadema, C. didymus,* and *C. vanheurckii* as the most abundant in the early spring layers and *C. radicans* and *C. compressus* as the most abundant in the late spring/early summer layers. Sancetta (1989b) reported high abundance of *Chaetoceros radicans* in late spring (May–June), and reported *C. concavicornis, C. debilis, C. vanheurckii,* and *C. didymus* to be most abundant in the fall bloom (September–October).

Coscinodiscus radiatus Ehrenberg: rare (<1%)

Cyclotella caspia Grunow (?) *sensu* Sancetta 1990: common (<10%)

Most of the *Cyclotella* species counted under *Cyclotella* spp. probably belong to this taxon. Sancetta (1989b) noted that this species was present and abundant in Saanich Inlet only during summer months (July–August).

Cyclotella litoralis Lange & Syvertsen: rare (<1%)

Present, but rare in Saanich Inlet during summer and early fall (July–September) (Sancetta, 1989b)

Ditylum sp.: rare (<1%)

Nitzschia pacifica Cupp: usually rare (<2%), although one peak of 10% was observed at 169S-7H-6, 15–16 cm.

Nitzschia pungens Grunow ex Cleve: rare (0–2%)

Most common from June to August (Sancetta, 1989b)

Proboscia alata (Brightwell) Sundtröm: rare (<1%)

Rhizosolenia sp. (R. *setigera* Brightwell?): rare (<1%)

This species blooms in late October in the Saanich Inlet (Sancetta, 1989b). McQuoid (1995) reported that it was found exclusively in the fall/winter sediment samples, and only after 1940 (M.R. McQuoid, pers. comm., 1999). This species was either absent or very rare in our samples.

Skeletonema costatum (Greville) Cleve

Composes 5%–75% of the assemblages.

McQuoid (1995) and Sancetta (1990) reported highest abundance in the water column in early spring to early summer. McQuoid and Hobson (1997) reported highest abundance in late spring/early summer sediment layers. McQuoid (1995) and McQuoid and Hobson (1997) noted a cyclic pattern of variation in *S. costatum* abundance, with a periodicity of 4 to 7 yr on average, and observed that the El Niño Southern Oscillation (ENSO) years usually occur between the periods of high *S. costatum* abundance.

"*Synedra*" sp.: rare (<1%)

Thalassionema nitzschioides (Grunow) Meresch.: common, usually making 5%–10% of the assemblages.

McQuoid and Hobson (1997) observed highest concentrations in the late spring/early summer sediment layers. Sancetta (1989b) reported greatest abundance in the fall (September to October).

Thalassionema spp.: rare (<1%)

Thalassiosira species

The assemblages comprised 10%–35% of *Thalassiosira* spp. including:

T. eccentrica (Ehrenberg) Cleve: rare (<1%)

According to Sancetta (1990), this species is present throughout the year in Saanich Inlet, ~1%, rising to 4%–8% in early spring (April and May). Large specimens (>50 µm) are confined to the early spring (Sancetta 1990).

T. lineata Jousé: rare (<1%)

T. nordenskioeldii Cleve: rare (<2%)

Occurs throughout the year, according to Sancetta (1990). Maxima up to 20% during early spring bloom (March and April).

T. oestrupii (Ostenfeld) Prosch.: rare (<2%)

T. pacifica Gran & Angst: rare to common (0%–10%)

According to Sancetta (1990), this species occurs throughout the year, with maxima (20%–30%) during early spring (April and May), also common (10%) in winter (December to March), otherwise usually 5%.

McQuoid and Hobson (1997) noted that *Thalassiosira* spp. (*T. pacifica, T. eccentrica, T. gravida,* and *T. nordesnkioeldii*) were characteristic of the early spring deposition.

Thalassiosira spp.

Table 1. Relative abundance of the various taxa found in the sediments of Section 169S-1034B-7H-6.

Depth (cm)	Preservation	*Actinocyclus curvatulus*	*Bacillaria* sp.	*Bacteriastrum* sp.	*Chaetoceros radicans*	*Chaetoceros* spp.	*Coscinodiscus radiatus*	*Coscinodiscus* sp.	*Cyclotella litoralis*	*Cyclotella* spp.	*Delphineis* spp.	*Ditylum* sp.	*Neodenticula seminae*	*Nitzschia pungens*	*Nitzschia pacifica*	*Proboscia alata*	*Rhizosolenia* sp. (*setigera*)	*Skeletonema costatum*	*Stephanopyxis* spp.	*Synedra* sp. (marine)	*Thalassionema nitzschioides*	*Thalassionema* sp.	*Thalassiosira eccentrica*	*Thalassiosira lineata*	*Thalassiosira nordenskioeldii*	*Thalassiosira oestrupii*	*Thalassiosira pacifica*	*Thalassiosira* spp.	*Thalassiothrix longissima*	Other planktic diatoms	*Actinoptychus senarius*	*Actinoptychus splendens*	*Paralia sulcata*	Benthic diatoms	Freshwater diatoms	Total counted
9.7-9.8	G		0.9		6.9	44.5		0.3		3.1				0.6	1.6	0.3		8.4	0.3		4.7	0.3	0.9	0.3		0.9	6.5	1		0.3		1.6	0.3	6.5	0.3	321
9.8-9.9	G	0.6		0.6	6.4	40.4				4.3	0.9		0.3	0.9	0.9	0.9		5.5		0.6	9.7	0.3	0.9			0.9	5.5	8.2	0.3			0.6		8.8	1.8	329
9.9-10.0	G		0.3	0.3	2.4	47.8				4.1				0.7	1	1		6.8		0.7	6.1		0.3			0.3	5.4	10.2						8.8	3.1	295
10.0-10.1	G		0.6		2.5	47.2				3.4				1.5	0.6	0.9		5.5		0.6	10.1		1.2		0.3	2.8	2.8	9.8				0.6	0.3	7.7	1.5	326
10.1-10.2	G				9.5	40.8				2.4	1.6			1.1	0.8	1.1		7.1		0.3	8.7		0.5			2.2	4.1	8.7					0.8	7.6	1.9	368
10.2-10.3	M			1	3	48.3				3.7				1.3	0.3	0.7		9.3		0.3	1	0.3	0.3	0.7		1	2.3	8					0.3	6.7	1.7	300
10.3-10.4	MG				2.6	45.2	0.3	0.3		4.1		0.3		0.9	0.6	0.3		11.1		0.6	8.2		0.3		0.9	2.1	3.2	9.7				0.3	0.6	8.2	0.3	341
10.4-10.5	M		0.3	0.3	7.9	40.1	0.3			5.6				2.3	0.3		0.6	7.9		0.6	7.3	0.6	0.3	0.3	1.5	1.8	3.8	8.8	0.3		0.3		0.6	6.1	1.8	342
10.5-10.6	M	0.3		0.6	4.7	41.2	0.3			3.5		0.3		0.9	0.9	0.9	0.3	12.1		0.3	8.8	0.3			0.3		2.9	8.8			0.3		0.3	7.9	2.6	340
10.6-10.7	MG	0.3		0.3	5.7	36.8	0.6			3.2				1.1	0.6	0.9		15.5		0.3	7.2		0.3	0.3		1.4	2.9	10.6	0.3		0.3		0.3	7.5	3.4	348
10.7-10.8	MG			0.3	0.9	47.3				1.5				1.2	0.6	0.3		23.7		0.6	5			0.6	0.3		2.7	7.4						6.5	0.6	338
10.8-10.9	G		0.6		3.3	46.5				1.2				1.2	1.2			18.8		0.3	9.1		0.3	0.3	0.6	0.6	2.1	8.8				0.6	0.3	3.3	0.6	329
10.9-11.0	MG		0.6	0.3	2.8	47.6				3.1				1.6		0.3		13.2		0.6	8.5				0.3		3.4	9.4					0.3	6.6	1.3	319
11.0-11.1	M			0.3	3.5	43.9				5.3					0.5	0.5	0.3	7.5		1.1	9.1		0.3			0.5	5.9	7.5			0.3	0.5		10.4	2.7	374
11.1-11.2	M		0.3		4.4	45.3				3.5				0.6	0.6	0.3	0.3	17.4	0.3	0.6	7.3	0.6	0.3	0.9		0.6	1.3	7.6						6.6	0.9	316
11.2-11.3	MG				1.7	43.7				3.1				0.7	0.3	1.7		9.5	0.3	1.4	8.5	0.7			0.7	0.3	5.4	8.8			0.3	0.3	1	10.2	1.4	295
11.3-11.4	GM				1.3	45				4.2	0.3	0.3		0.7		0.3		14		0.7	7.2		0.7	0.3	1.3	0.3	0.7	13				0.3	0.3	5.9	2.6	307
11.4-11.5	G	0.3		1.1	3.9	33.1	0.3			5.3				0.8	0.6	0.3	0.3	15		0.6	10.9		0.8	1.1		1.4	2.5	10.9					0.3	7.2	2.8	359
11.5-11.6	G			0.6	4	43.3	0.3			6.6			0.6	0.6	0.9	0.9		10.6	0.3	0.3	7.2	0.3	0.9	0.6	0.3	0.9	0.9	9.2						9.5	1.7	349
11.6-11.7	MG			0.3	8.2	42.3				4		0.3		0.6	0.3	0.3		10.8		0.6	7.1	0.6		0.3	0.3	1.4	1.7	10.8						7.7	2.6	352
11.7-11.8	G			0.3	8	50.5				3.3		0.3		1	0.7		0.7	5.3		0.7	6.6		1.7			0.3	1.7	9.3	0.3		0.3			7.6	0.7	301
11.8-11.9	MG				9.4	44.8	0.3			6.6				1.3	1.3			6.6			5.6		0.9	0.3		1.3	0.6	10.3	0.3					7.5	2.5	319
11.9-12.0	M			0.3	4.4	51.7				4.4				0.3	1.7	0.3	0.3	5.1		0.3	6.8	0.3	0.7	0.3		0.7	2.4	10.8		0.7				7.1	1.4	296
12.0-12.1	MG	0.3			3.5	54.1	0.3			2.9				0.6	0.6	0.6	0.3	8.2			5.8		0.9	0.6	0.3	1.2	2.3	11.4				0.3		4.7	1.2	342
12.1-12.2	M	0.6			5.5	53.8			0.3	2.3				0.9	0.6	0.6		4.7			8.7		0.6	0.3	0.3	0.3	4.1	11.3		0.6	0.3			3.8	0.6	344
12.2-12.3	MG	0.3		0.6	3.1	56.3				1.6				1.3	0.6	0.9	0.3	7.8			5.6	0.3	1.3			0.3	1.9	10.3		1.3			0.9	5	0.3	320
12.3-12.4	M			0.3	3.9	53.6	0.3		0.3	2.2				1.1	0.6	0.6	0.6	7.7		1.1	6.6	0.6	0.8		0.3		2.5	9.7	0.3				0.3	5.2	1.7	362
12.4-12.5	M		0.3	0.6	5.2	50.6			0.6	3.1				0.9	0.6		0.3	10.5		0.6	7.1			0.3			2.2	8		0.6	0.3		0.3	7.7		324
12.5-12.6	M	0.6		0.3	3.6	53.4			0.9	3.3				1.2	0.3	1.2		8.9			4.5		0.3	0.3		1.5	1.2	8.9		0.9	0.6			8.3		337
12.6-12.7	M	0.6		0.6	2.1	55.8			0.3	1.8				0.6	0.6			13.4			6.1		0.3	0.3		0.3	1.5	8.5		0.9	0.3			5.2	0.6	328
12.7-12.8	MG	0.3			3.6	52.2			0.6	1.9				1.1	0.6	0.6	0.3	18.2			7.2					0.6	2.2	4.7					0.6	4.7	0.8	362
12.8-12.9	G				3.4	53.3			0.3	2.2				1.2	0.3	0.6		18.1		0.3	6.2		0.6	0.6	0.6		0.3	8.7		0.3	0.9			1.9		321
12.9-13.0	MG	0.3		0.9	3.9	54.5			0.6	2.1				0.6	0.6			10.2		0.3	5.1		0.6		0.6		0.9	13					0.3	4.8	0.6	332
13.0-13.1	G				4.3	59			0.3	0.7				0.7	0.7	0.3		8.9			5.6		1		0.7	0.3		11.8	0.3				0.7	4.6	0.3	305
13.1-13.2	MG				0.3	55.3				2.8				0.3	1.2			12.1			3.4		0.6		1.9	0.6	0.6	9	0.3					6.2	5.3	322
13.2-13.3	G				3.1	47.2				0.6				0.3	1.2	0.3		16.8		0.6	5.3			0.3	2.5	1.6	1.9	10.6			0.6		0.3	6.2	0.6	322
13.3-13.4	G	0.3	0.6		0.6	35.8			0.6	1.2				0.3	0.9		0.3	37			4.6		0.6	0.3	1.4		0.9	7.5			0.6		0.3	5.8	0.6	346
13.4-13.5	GM	0.3	0.3		2.4	18.3				1.2				0.3				58.7			2.1					0.6	4.7	3.2		0.6			0.3	5	2.1	339
13.5-13.6	G				0.5	14.2				1.2			0.2	0.2	0.2			73.5			1.4		0.2	0.2	0.2	0.2	1.2	3.6		0.2			0.2	1.4	0.9	422
13.6-13.7	GM				1.6	28.4				1.1				0.3		0.3		53.1			3.2				0.3	0.5	1.9	3.4		0.3			0.5	3.7	1.6	377
13.7-13.8	G				5.7	34				0.8				0.3				44.2			2.3			0.3	0.8	0.6	0.6	5.7		0.6			0.8	1.4	2	353
13.8-13.9	GM				4	45.7			0.3	2.3				0.3	0.3	0.3		27.1			2.6	0.3			1.7	0.3	1.4	8		0.9				3.7	0.9	350
13.9-14.0	G		0.3		7.9	44.4				0.9		0.3						23.5		0.6	5		0.6		0.6	0.9	2.6	7.1		0.9	0.3			2.6	1.5	340
14.0-14.1	M	0.3			3.2	48.4				3.2				0.3	0.3		0.3	22.6		0.3	5.8				1.3	0.6	1.6	7.4						2.9	1.3	310
14.1-14.2	MG		0.3		9.1	45.3				1.8	0.3		0.3		0.3	0.3	0.3	19			3.6			0.3	1.8	0.3	3.9	9.1	0.3					2.7	0.9	331
14.2-14.3	MG				2.9	35.3				2.1					0.3	0.9	0.3	25.3		0.6	4.7		0.3			0.3	3.8	17.9						3.8	1.2	340
14.3-14.4	M				8.2	41.2				5.2				0.6		0.9	0.3	16.5			6.7		0.3	0.6	1.8	0.3	1.2	11.3		0.9	0.3			2.7	0.9	328
14.4-14.5	MG			0.7	7.6	36.2				2				1		1.3		4.9	0.7		7.6		0.7	0.3	1.3	1	6.3	21.1					0.3	5.3	1.6	304
14.5-14.6	M		0.3		7	34.1			0.7	3.3		0.3		0.3	0.3	1		6			7.4			0.7		0.3	4.7	26.4		1				4	2	299
14.6-14.7	MG				6.7	44.1			0.6	2				0.3	0.6	1.1		5.3		1.1	6.1		0.3	0.6	0.3	0.3	4.5	22.1			0.8			3.4		358
14.7-14.8	M		0.6	0.3	6.2	37.5				5.1				0.6		0.6	0.3	6.2			4.5		0.6		0.6	0.3	5.4	22		0.3	0.3		0.3	7	1.7	355
14.8-14.9	M			0.9	2	35				2.6				0.3		0.9		16	0.3	0.6	4.7		0.3		0.3	0.3	5.5	23.3					0.3	4.4	2.3	343
14.9-15.0	M		0.3		3.9	29.8	0.3			3.9				0.3		0.3		16.5		0.6	4.7	0.3	0.8				6.9	21.2		0.8			0.3	6.3	3	363
15.0-15.1	M			0.6	5.8	33.1				6.4	0.3			0.3		0.3		12.2			4.5		1.3		0.3	0.6	6.8	19.6		0.3	0.3			6.1	1	311
15.1-15.2	M	0.3			3	46.1				3				0.3	0.3	1.2		9.6		1.2	5.1		0.3	0.3	0.6		6	11.7		0.3				7.2	3.3	332
15.2-15.3	G		1		3.8	46				9.6				0.3	1.6			8.6		1	6.4		0.3	1.3	1	1.3	2.9	5.8		0.6			0.3	5.8	2.6	313
15.3-15.4	G				2.5	49.8				7.8				0.3	3.1			6.5			8.1		0.3	0.3	0.3		2.5	10.3			0.3			7.2	0.6	321

Table 1 (continued).

Depth (cm)	Preservation	*Actinocyclus curvatulus*	*Bacillaria* sp.	*Bacteriastrum* sp.	*Chaetoceros radicans*	*Chaetoceros* spp.	*Coscinodiscus radiatus*	*Coscinodiscus* sp.	*Cyclotella litoralis*	*Cyclotella* spp.	*Delphineis* spp.	*Ditylum* sp.	*Neodenticula seminae*	*Nitzschia pungens*	*Nitzschia pacifica*	*Proboscia alata*	*Rhizosolenia* sp. (*setigera*)	*Skeletonema costatum*	*Stephanopyxis* spp.	*Synedra* sp. (marine)	*Thalassionema nitzschioides*	*Thalassionema* sp.	*Thalassiosira eccentrica*	*Thalassiosira lineata*	*Thalassiosira nordenskioeldii*	*Thalassiosira oestrupii*	*Thalassiosira pacifica*	*Thalassiosira* spp.	*Thalassiothrix longissima*	Other planktic diatoms	*Actinoptychus senarius*	*Actinoptychus splendens*	*Paralia sulcata*	Benthic diatoms	Freshwater diatoms	Total counted
15.4-15.5	G	0.3		0.3	3.4	47				4.6	0.3			0.9	3.7			9.8			6.7		0.3			0.6	2.1	9.1			0.3		0.3	8.8	1.5	328
15.5-15.6	GM				3.2	45.8			0.3	7.4	0.3		0.3	0.3	8.7	0.3		6.5		0.3	7.1		1.6			1	1	6.8						7.7	1.3	310
15.6-15.7	MG		0.3		9.1	56.2				5.2	0.9			0.6	2.4	0.3		8.2		0.3	4.3		0.3	0.3	0.3		0.6	6.1		0.3	0.6		0.3	2.7	0.6	329
15.7-15.8	MG				1.5	48.7				4.8	0.3			0.6	10.1			8.4		0.6	4.8		1.2		0.9	1.5	0.9	8.4					0.6	5.7	1.2	335
15.8-15.9	G		0.3		5.1	57.6				1.9				0.6	3.5	1.3		4.1		0.6	3.8				5.1	0.6	0.6	5.7			0.3		0.3	6.7	1.6	314
15.9-16.0	G			0.6	10.2	48.1				0.8				0.3	0.8	1.7		7.5	0.3	0.6	4.4		0.8		7.7	0.6	2.5	6.6		0.3				6.1	0.3	362
16.0-16.1	G	0.3	0.3	0.3	10.5	43.2				2.8				0.3	1.4	0.9		8.2	0.3	0.3	4.5				6		5.1	7.1			0.3		0.3	6.8	1.1	352
16.1-16.2	M				6	47			0.3	2.9				0.3	0.6	2		12.9		1.1	7.2		0.6		1.7	0.6	1.7	5.7			0.3		0.3	8.3	0.6	349
16.2-16.3	M		0.3	0.3	5.4	53.7				4.2				0.6	0.6			12.5			6.6		0.3		1.5	0.3	1.2	4.8						6	1.8	335
16.3-16.4	M	0.6			6.5	56.2				5.3				0.6				11.2	0.6	0.3	6.8				0.3		1.6	5.9	0.3	0.3				3.1	0.3	322
16.4-16.5	M		0.3		2.4	61.9				2.1				0.6	0.3	0.6		1		0.3	7.9		0.9		0.3	0.3	1.8	3.3					0.3	6.6		331
16.5-16.6	M		0.3		3.9	56.1				3.3				0.3		0.6		8.3		0.3	7.1		0.6			0.3	1.8	10.1						6.5	0.6	337
16.6-16.7	M				2.9	51.6				4.8				0.3		0.3		12.7		0.3	7.3		0.3			0.6	1	11.8			0.3			5.4	0.3	314
16.7-16.8	M				2.6	50.9			0.3	3.2	0.3			0.3		0.3		7.6		0.6	8.1		0.3		0.9	0.6	2.9	11			0.6		1.7	6.7	1.2	344
16.8-16.9	M		0.6		4.6	45.8	0.3			2.9	0.3			0.6	0.3			9.5		0.6	9.8		0.3	0.3			2.3	10.4		0.6				9.8	1.2	347
16.9-17.0	M		0.5		10.3	38.3				6.3	0.5			0.5				17.1		0.5	8.2		0.5			0.3	1.6	6.8			0.3		0.5	6	1.6	368
17.0-17.1	M	0.6	0.3		7.7	46.6				5.6	0.6			0.6				16.8		1.2	5.6			0.3		0.3	1.5	8						3.2	1.2	339
17.1-17.2	GM	0.8	0.3		6.7	43				5.9				0.3		0.6	0.3	14.2		1.1	8.1		0.3		0.3	0.6	1.1	9.2					0.3	5.6	1.4	358
17.2-17.3	MG	0.3	0.6		5.8	42.8				6.1	0.3			0.6	0.3			18.9		0.6	6.1			0.3	0.3	0.3	3.9	5.6		0.3			0.3	5.3	1.7	360
17.3-17.4	G			0.3	8.9	42.1	0.3			3.9				0.3		0.8		24.2	0.3	0.3	6.1		0.3		0.3		0.6	7			0.3			3.3	0.8	359
17.4-17.5	G			0.6	7.8	47.1				3.9				0.6				12.7	0.3	0.6	6.4		0.3		0.3		3.3	9.7		0.3				4.4	1.9	361
17.5-17.6	G				4.7	44.8			0.3	3.6				0.6		0.3		14.1	0.3	0.8	8.8		0.3		0.6	0.6	3.9	10.8		0.3			0.3	3.9	1.4	362
17.6-17.7	GM		0.6		3.9	45.5				6				0.3		0.3		24.4		0.6	3.6		0.3				1.2	8.3		0.3				3.9	0.9	336
17.7-17.8	GM				1.1	37.5				7.3				0.6		0.3		35.5		0.3	3.7		0.6		0.3	0.3	1.1	4.2		0.3	0.3			5.6	1.1	355
17.8-17.9	G		0.6		1.5	27.1				4.4				0.6				41.1		0.3	6.7		0.3	0.3	0.3		1.5	10.2			0.3		0.6	4.1	0.3	343
17.9-18.0	G				4.5	21.5				12.1	0.6			0.6	0.3	0.3		42.6		0.9	4.5		1.2			0.3	1.2	5.4		0.6	0.3			2.7	0.3	331
18.0-18.1	GM		0.3		3.4	16.9								0.3	0.3			57.3	0.6	0.6	3.2		1.1		0.3		1.7	5.7		0.3				1.1	0.3	349
18.1-18.2	GM		0.2		2.6	15.3	0.2		0.2					0.4	0.4			61.1		0.2	3.3		0.2		0.4		2	4.1			0.2			2.6	1.4	491
18.2-18.3	G	0.2			4.1	14								0.4	0.8			61		0.2	2.6				0.2		1.6	4.7						3.5	0.2	492
18.3-18.4	GM		0.5		2.9	16.2			0.2		0.2			0.5				48		0.7	5.2		0.2				3.6	9						4.8	1	421
18.4-18.5	GM	0.2	0.2		3.8	22.1				3.6				0.4			0.4	42.4		0.7	5.4		0.2		0.7	0.7	3.6	8.9		0.4				3.3	2.2	448
18.5-18.6	MG		0.2		2.6	21.4				4.6				0.2				51.2		0.2	5.1		0.4		0.7		1.5	4.2						5.3	2.2	453
18.6-18.7	MG	0.3			2.4	26				2.7				0.3				48.3		0.3	4.8		0.3		1.2	0.3	1.5	6						4.8	0.6	331
18.7-18.8	GM		0.3		2.4	19.6			0.8	4.8	0.3			0.3				50.4		0.8	5				0.8		1.6	5.3		0.3	0.3			5.6	1.6	377
18.8-18.9	M		0.3		3.5	36				2.8	0.3							37.5			4.3		0.5		0.8	0.8	1	5		0.3				5.8	1.5	400
18.9-19.0	GM				4.8	18.5				5.1				0.3				51.1			2.9		0.6		0.3		3.8	5.8		1	0.3			4.5	1	313
19.0-19.1	G	0.3	0.6	0.3	5	28.4	0.3			4.4							0.6	35.5		0.6	5				1.2		3.6	6.8		0.9	0.3			4.4	1.5	338
19.1-19.2	G			0.8	1.1	36				3					0.3			39.2		0.5	3.8		0.5		0.5		1.9	6.5		1.1				3.5	0.8	367
19.2-19.3	MG		0.3	0.3	4.4	42.9				7.1	0.5							26.6			3.3			0.5	0.3		0.5	6.3					0.3	4.4	1.9	364
19.3-19.4	M				3.3	56.9	0.3		0.6	3.6								15.8		0.6	5.6		0.6		0.3	0.6	1.7	4.7		0.6				4.4	0.3	360
19.4-19.5	GM	0.3			2.4	48.2				6.3								16.1		0.6	5.1		0.6		1.5	0.3	3.6	6.8		1.8	0.3			5.7		336
19.5-19.6	G				1.6	60.6				3.2					0.3			16.1		0.5	3.8				0.3		1.6	6.4					1.1	2.9	1.1	373
19.6-19.7	GM	0.3			1	57.2			0.7	4.3								14.1			7.2		0.3		0.7	0.7	2.6	7.6		0.3				2	0.7	304
19.7-19.8	MG		0.3		2.7	52.1				3.6				0.3	0.6			17.5		0.9	6.6			0.3	1.5	0.9	1.5	6.3		0.3			0.3	3.6		332
19.8-19.9	G		0.3		1.8	45.6				5.4				1.5	0.3			22.5		0.3	6.9		0.3	0.6	1.2	0.3	2.4	3.9			0.6		0.3	4.2	1.2	333
19.9-20.0	G		0.3		1	36.3				4.2				0.3	0.6			30.9			10.3				1.9	0.6	1.6	5.1		0.6			0.3	3.9	1.6	311

Notes: All abundances expressed as percentages. Preservation: G = good, GM = good to moderate, MG = moderate to good, M = moderate. Blank space = species not found.

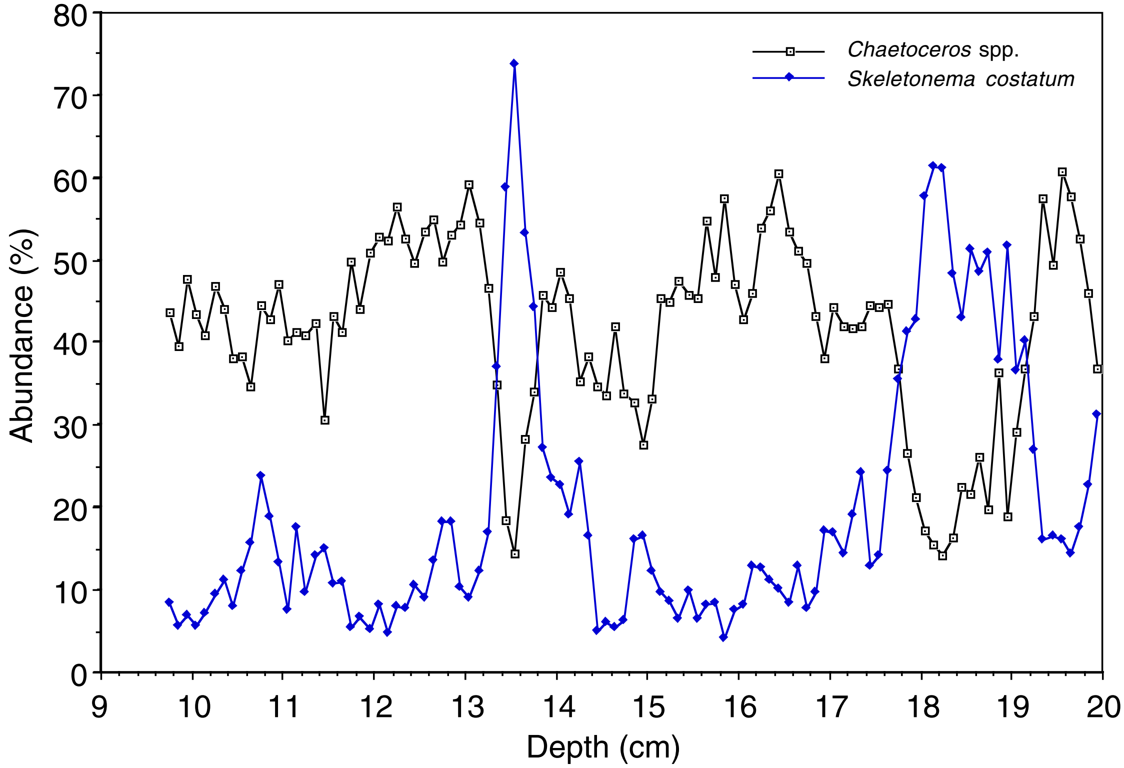

Figure 1. Abundance of *Chaetoceros* spp. and *Skeletonema costatum* vs. depth in section.

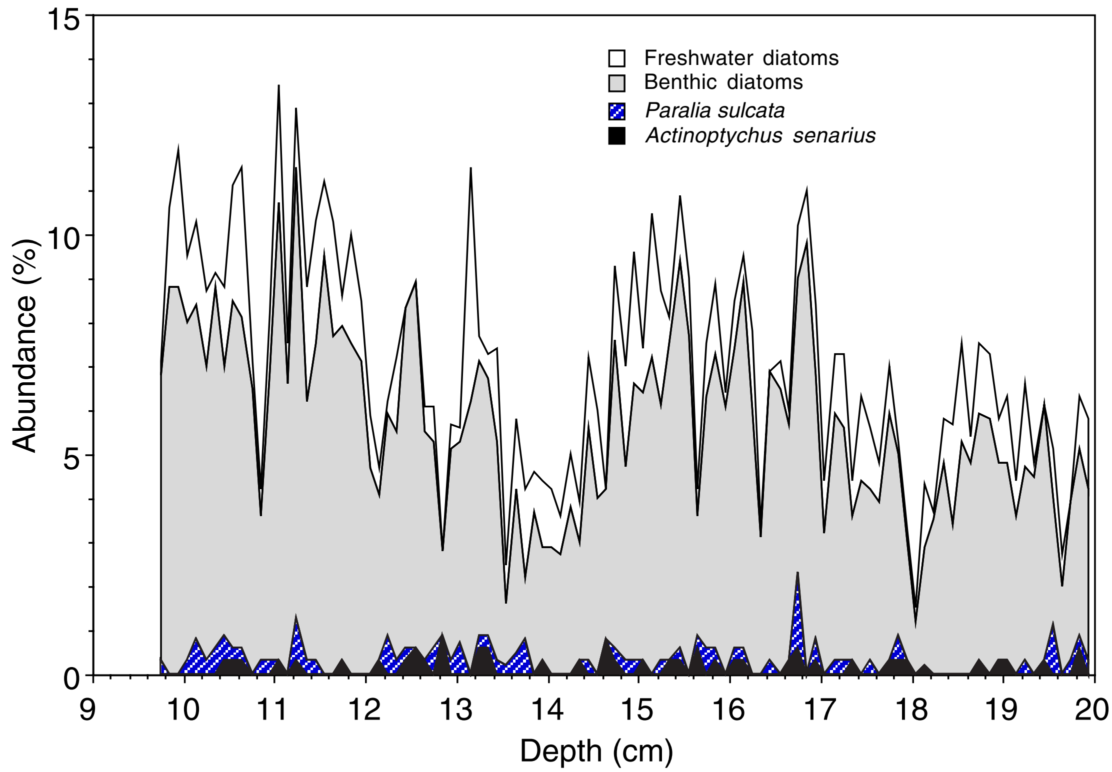

Figure 2. Composite (area) diagram of the abundance of littoral diatom taxa vs. depth in section.

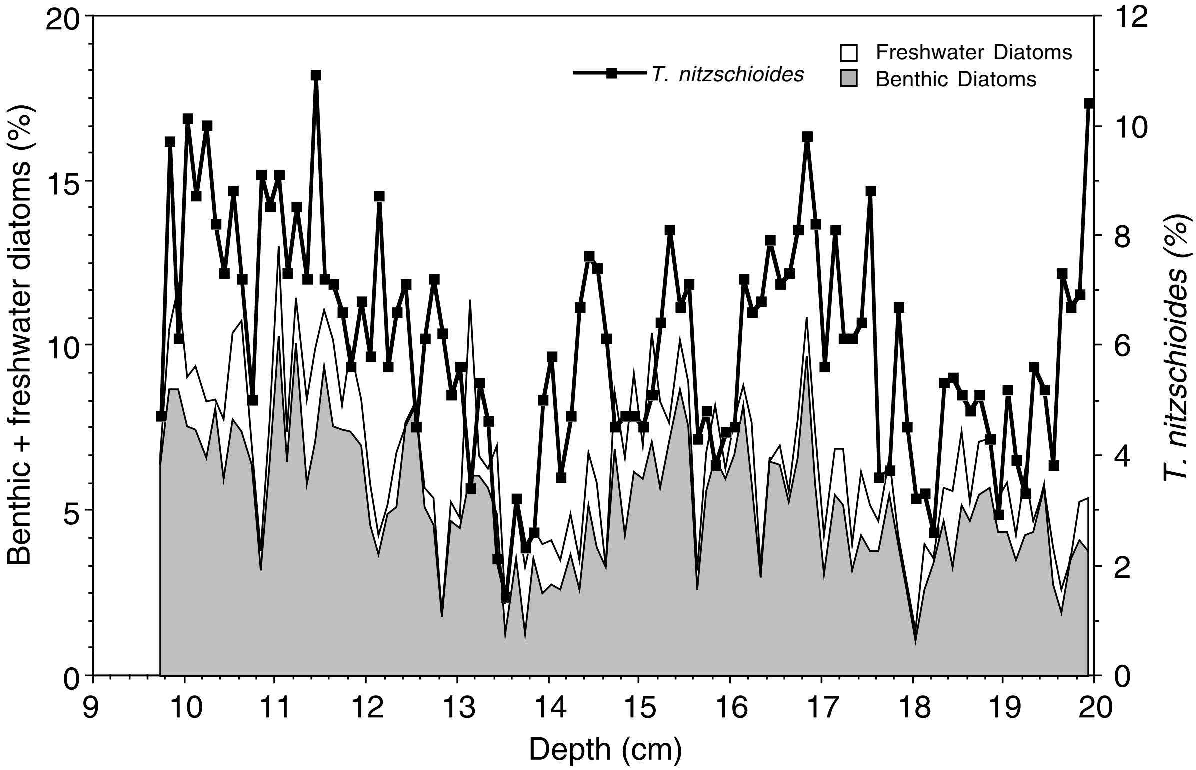

Figure 3. Abundance of littoral diatoms (benthic and freshwater), and the species *Thalassionema nitzschioides* vs. depth in section.

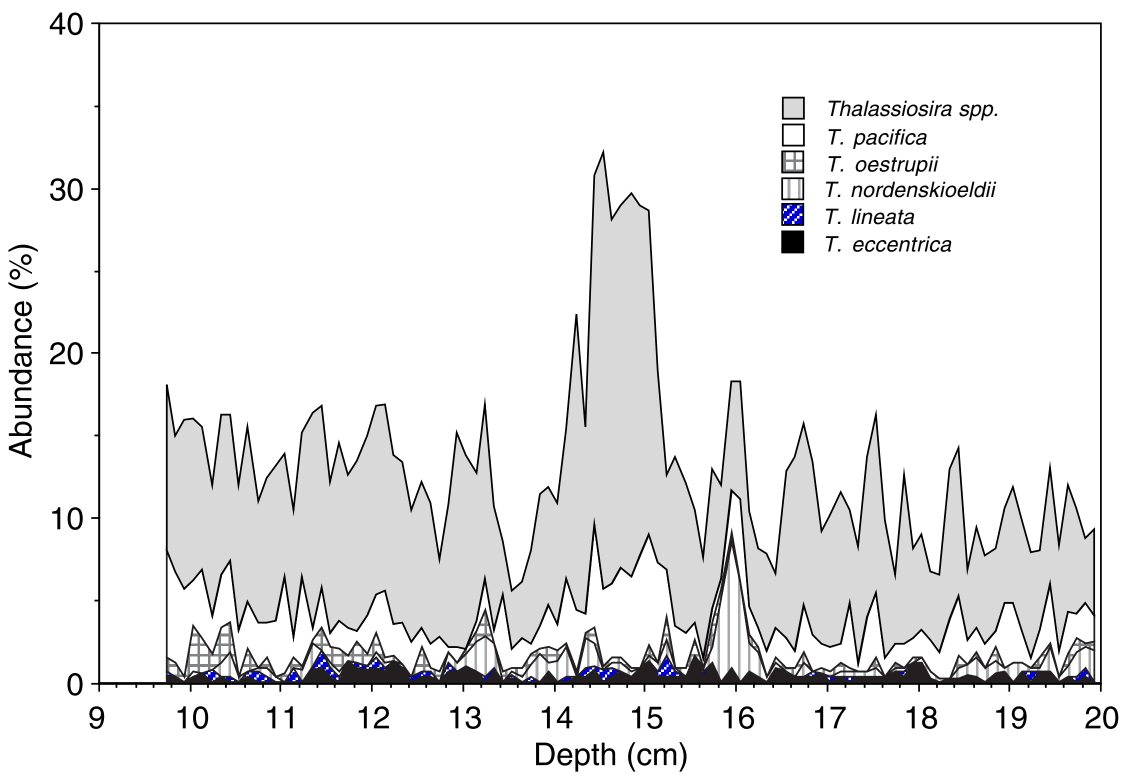

Figure 4. Abundance of the various *Thalassiosira* taxa (*Thalassiosira* spp., *T. pacifica, T. oestrupii, T. nordenskioeldii, T. lineata,* and *T. eccentrica*) vs. depth in section.

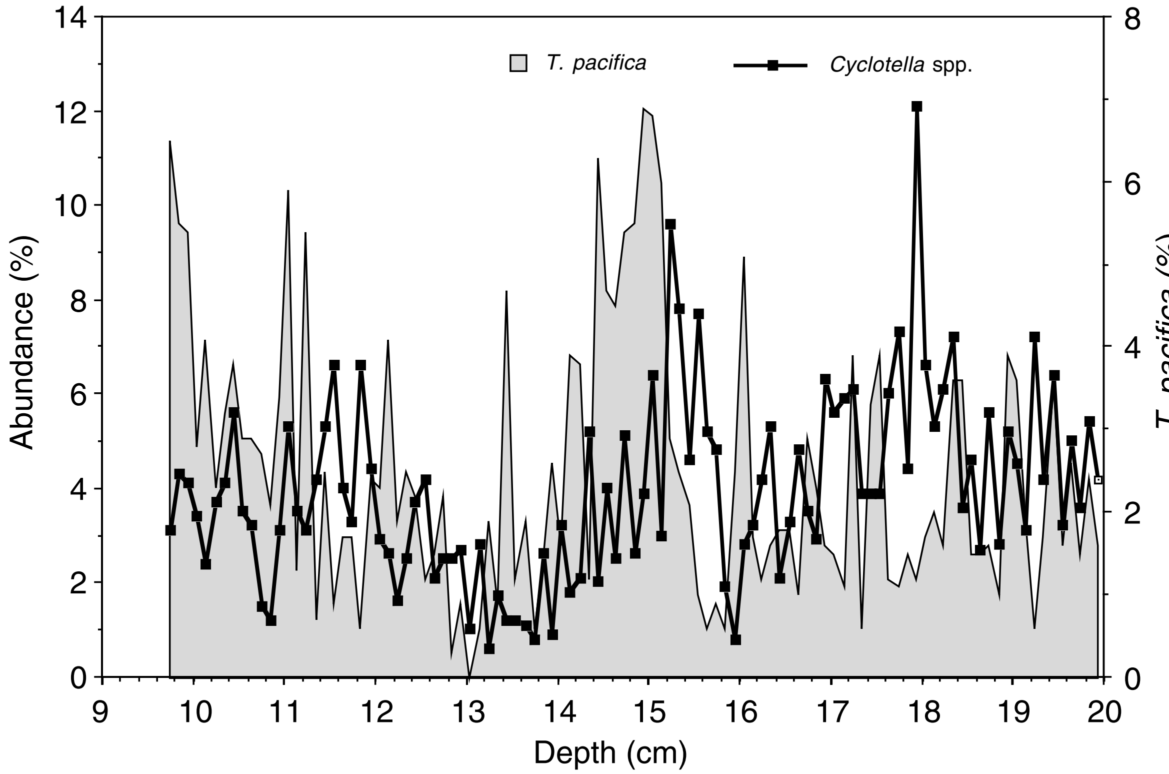

Figure 5. Abundance of *Thalassiosira pacifica* and *Cyclotella* spp. (mostly *Cyclotella caspia*) vs. depth in section.

Under this category were counted unidentified *Thalassiosira* species.

Thalassiothrix longissima: rare (<1%)

Meroplanktonic Diatoms

Actinoptychus senarius Ehrenberg: rare (<1%)

Paralia sulcata (Ehr.) Cleve: rare (<1%)

Littoral Diatoms

The diatom assemblages counted include between 2% and 10% pennate diatoms (e.g., *Amphora* spp., *Cocconeis* spp., *Diploneis* spp., *Navicula* spp.), which probably originated from the margins of the fjord. McQuoid (1995) suggested that these littoral species were more abundant in the sediment during times of heavy winter rains. Similarly, Sancetta (1989b) noted that the winter fluxes consisted mostly of single valves of benthic taxa such as *Paralia sulcata, Amphora* spp., *Gomphoneis* spp., *Navicula* spp. and *Cocconeis* spp., which probably represented passive transport from the margins of the fjord.

Freshwater Diatoms

A small number (~0%–2%) of allochthonous freshwater diatoms (e.g., *Aulacosira* spp., *Cyclotella* spp., *Fragilaria* spp., *Gomphonema* spp., *Hantzschia* sp., *Nitzschia* spp., *Synedra* spp.) was found in the sediments.

CONCLUSIONS

Further observations and conclusions will be possible when the results of the diatom analyses are integrated with pollen data (R.J. Hebda, unpubl. data) and dinoflagellate data (P.J. Mudie, unpubl. data), as well as with the sediment color descriptions.

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