*JAMSTEC Report of Research and Development*, Volume 1, March 2005, 57–68

# Paleohydrography of the Kuroshio-Kuroshio Extension based on fossil diatoms

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**Abstract** The hydrographic history of the Kuroshio-Kuroshio Extension system east off Honshu during 200 thousand years was reconstructed based on high-resolution records of fossil diatoms in three cores recovered from the area beneath the Kuroshio Warm Core. The influences of the terrestrial environments are implicated in the fluctuations in number of diatom valves, and in relative abundances of extinct, freshwater and littoral diatom species; in the Kuroshio Extension off shore area extinct, freshwater and littoral diatoms showed decrease in their relative abundance. The Earth's orbital parameters and the variations in isostatic balance in the Northern Hemisphere are considered to have controlled the species composition of diatom flora. The warm-water diatom species in littoral-neritic association are predominant in the near shore area due to the Kuroshio flowing northeast along the coast of southwest Japan. The cold-water species of oceanic association are predominant in the Kuroshio Extension off shore, where southward Oyashio flows in from the Bering and Okhotsk Seas.

**Keywords**: diatoms, Kuroshi-Kuroshio Extension, Earth's orbital parameters, *Td*' value, Tsugaru Warm Current, Younger Dryas event, eustatic sea level change

## 1. Introduction

The water in the Tohoku Area, which is crucial to determine the hydrographic relationship between the subtropical North Pacific Ocean and subarctic North Pacific Ocean, is hydrographically subdivided by eastward Kuroshio Front, which is the stream axis of the Kuroshio Extension in the surface, and southward Oyashio Front into three areas: the Kuroshio Area, the Perturbed Area and the Oyashio Area (Kawai, 1972). The Kuroshio Extension is the eastward continuation of the Kuroshio beyond Inubo-zaki, and further to the North Pacific Current (Fig. 1). The Kuroshio Extension meanders along the southern margin of the Perturbed Area and forms occasionally the secondary Kuroshio Front, which is branched off northwards. Remarkably, streaky structures and a warm core remain along the Kuroshio Front in the Kuroshio-Kuroshio Extension.

The research vessel "Mirai" systematically collected many piston cores from 1997 to 2002. We are analyzing the diatom fossil assemblages in several cores and with significant results to understand the changing Kuroshio-Kuroshio Extension system during the past 200 thousand years. Diatoms photosynthesize, making a contribution to the assimilation of atmospheric carbon, and they supply foods to animals as a primary producer in the nature. Diatoms, therefore, cause substantial changes in the composition of their assemblages when they react to the slightest change in the waters.

This study aims to obtain paleohydrographic records in the Kuroshio Front during the past 200 thousand years. The diversity of diatom species and wide distribution in the mixed layer in the water helps investigating paleohydrographic changes.

## 2. Core materials and age model

Three cores were recovered in the area beneath the main track, the warm core, of the Kuroshio and the Kuroshio Extension (Fig. 1). The core MD01-2421 was recovered by R/V Marion Dufresne from at 36.014°N, 141.468°E, 2224 m deep, off Kashima during the IMAGES VII-WEPAMA 2nd cruise in 2001. The age model for the core was constructed by AMS $^{14}C$ ages of planktonic foraminifer tests (black triangles in Figs. 2–3, 5), Aira-Tanzawa (AT) tephra (circle), and oxygen isotope variation of benthic foraminifer tests (squares; Koizumi et al., 2004).

Two cores MR02-03-2 and MR99-04-3 were recovered by R/V Mirai at 36.007°N, 146.000°E, 5712 m deep, during the MR02-K03 cruise in 2002 and the MR99-K04 cruise in 1999, respectively. The age model for MR02-03-2 was obtained by the correlation between the paleomagnetic intensity (NRM15/ARM15) of the core and then global changes in intensity of the Earth's magnetic field (SINT800; Guyodo and Valet, 1999): core depth 3.79 m is assigned to age 54 cal kyr BP (calendar kiloyear Before Present), 8.13 m to 130 cal kyr

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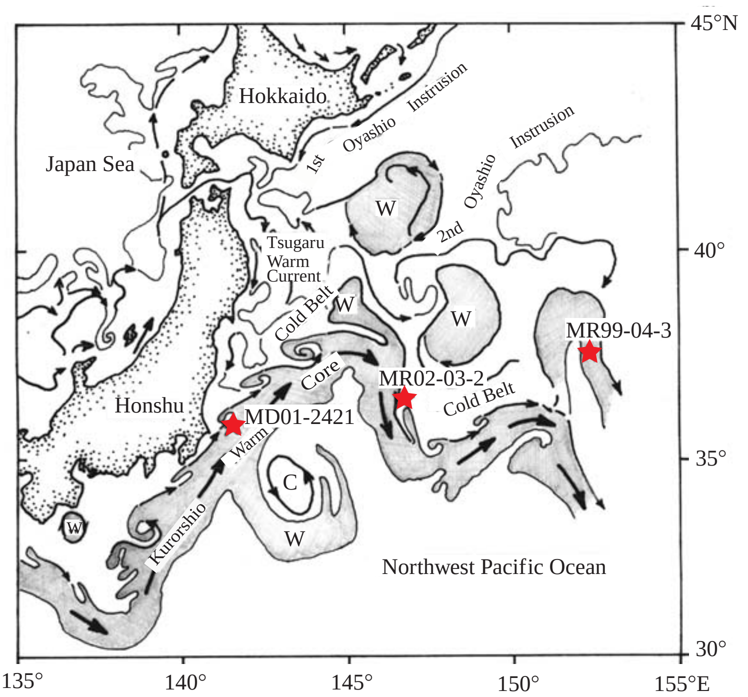


Figure 1: Location (black stars) of three cores. Arrows indicate flow of the currents. W=warm-water, C=cold-water (Kawai, 1991)

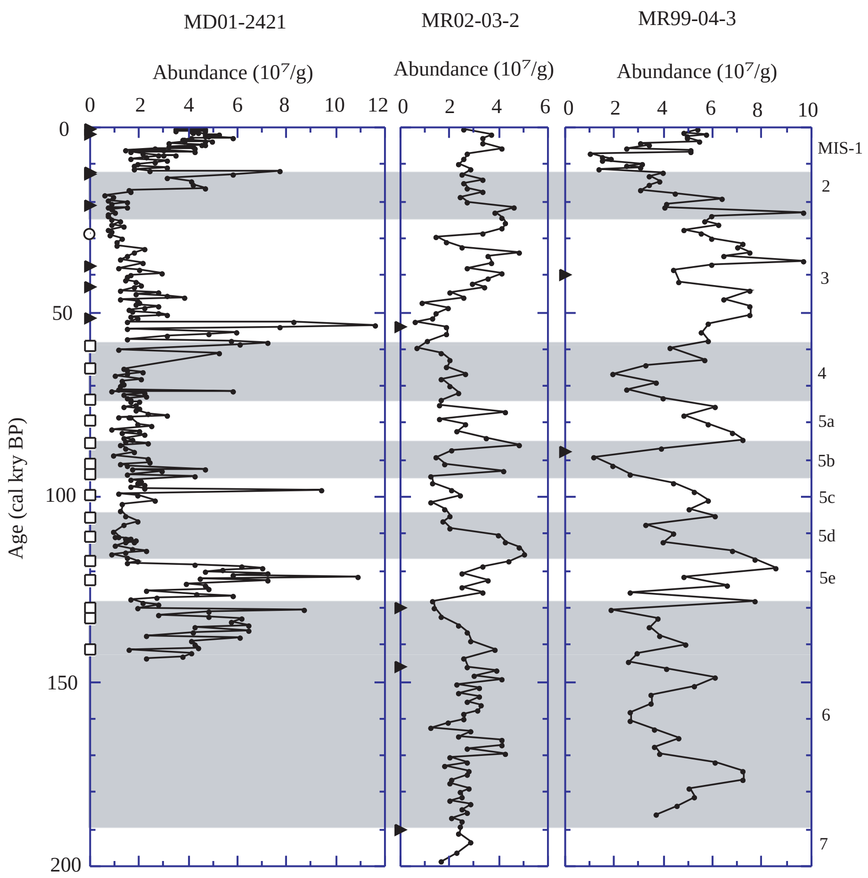


Figure 2: Chronostratigraphic variations of diatom abundance ($10^7$ valves/dry g of material) in MD01-2421, MR02-03-2, and MR99-04-3. The marks for age model (see text) are indicated on the left-side of each column, respectively.

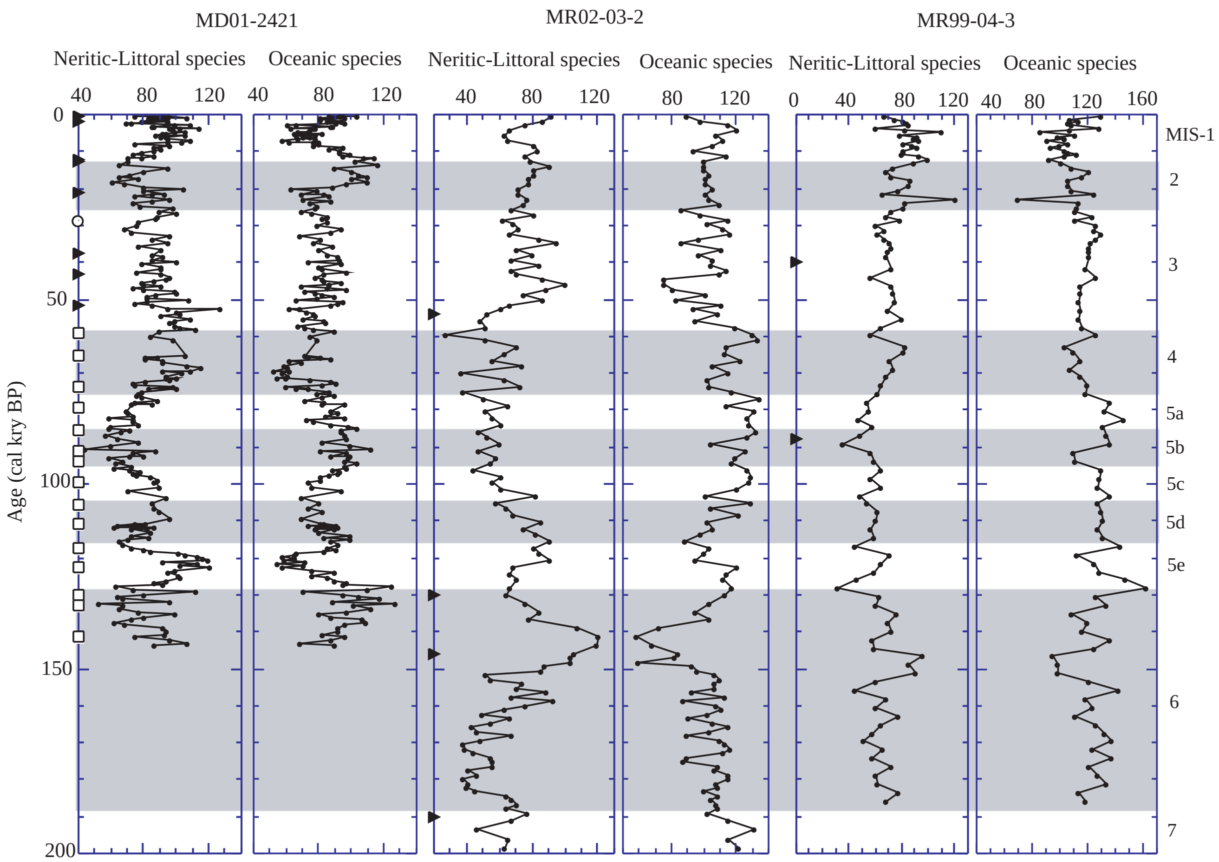


Figure 3: Chronostratigraphic variations of biogeographical (valves/200 valves) in MD01-2421, MR02-03-2, and MR99-04-3. The markers for age (see text) are indicated on the left-side of each core, respectively.

BP, 8.84 m to 146 cal kyr BP, and 12.59 m to 190 cal kyr BP (triangles in Figs. 2-3, 5; Koizumi et al., 2003). MR99-04-3 contains two marker tephra layers: Shikotsu-Daiichi tephra (Spfa-1) is assigned to 39.8 cal kyr BP at 329–314 cm (center depth 321.5 cm) and Aso-4 tephra to 88.0 cal kyr BP at 537–533 cm (535 cm) (triangles in Figs. 2–3, 5; Aoki et al., 2000).

## 3. Method of Study

The average sampling interval in MD01-2421 is 20 cm corresponding to 0.6 kyr throughout the core, in MR02-03-2 10 cm corresponding to 1.5 kyr and in MR99-04-3 9 cm corresponding to 1.7 kyr (Table 1). However, the sampling intervals in both horizons of 80.35–78.63 and 69.41–68.40 cal kyr BP in MD01-2421 are more than 1 kyr because of the presence of disturbed, soupy layers and lower sedimentation rates.

The procedures of slide preparation, microscopic examination, and paleoceanographic analyses follow to Koizumi et al. (2004), involving diatom abundance (number of diatom valves in 1 g of the dried material), relative abundance of extinct diatoms, ecological and biogeographical categories based on the habitats of diatom species, living warm-water and cold-water diatom species, and revised diatom temperature ($Td' = [(Xw+XW)/(Xw+XW + Xc+XC)] \times 100$) values (Figs. 2–5).

## 4. Results and Discussion

Distributions of diatom abundance ($\times 10^7$ valves/dry g) and of the diatom species that occurred within 200 valves counted in MD01-2421 are reported in Koizumi et al. (2004), those in MR02-03-2 are in Koizumi et al. (2003), and those in MR99-04-3 are shown as Table 1 in this paper.

The fragments of big diatom *Coscinodiscus wailesii* show abundant to common occurrence exclusively in the upper most part of MIS's stage 6 in three cores: at 143.78–137.46 cal kyr BP in MD01-2421, 130.06–141.83 cal kyr BP in MR02-03-2, and 126.01–146.71 cal kyr BP in MR99-04-3. The abundances of the fragments show an increase as the location of the core becomes far from near shore area. This species is common in the Japanese coastal waters and sometimes abundant in Tokyo Bay and Sagami Bay in spring (Takano, 1990).

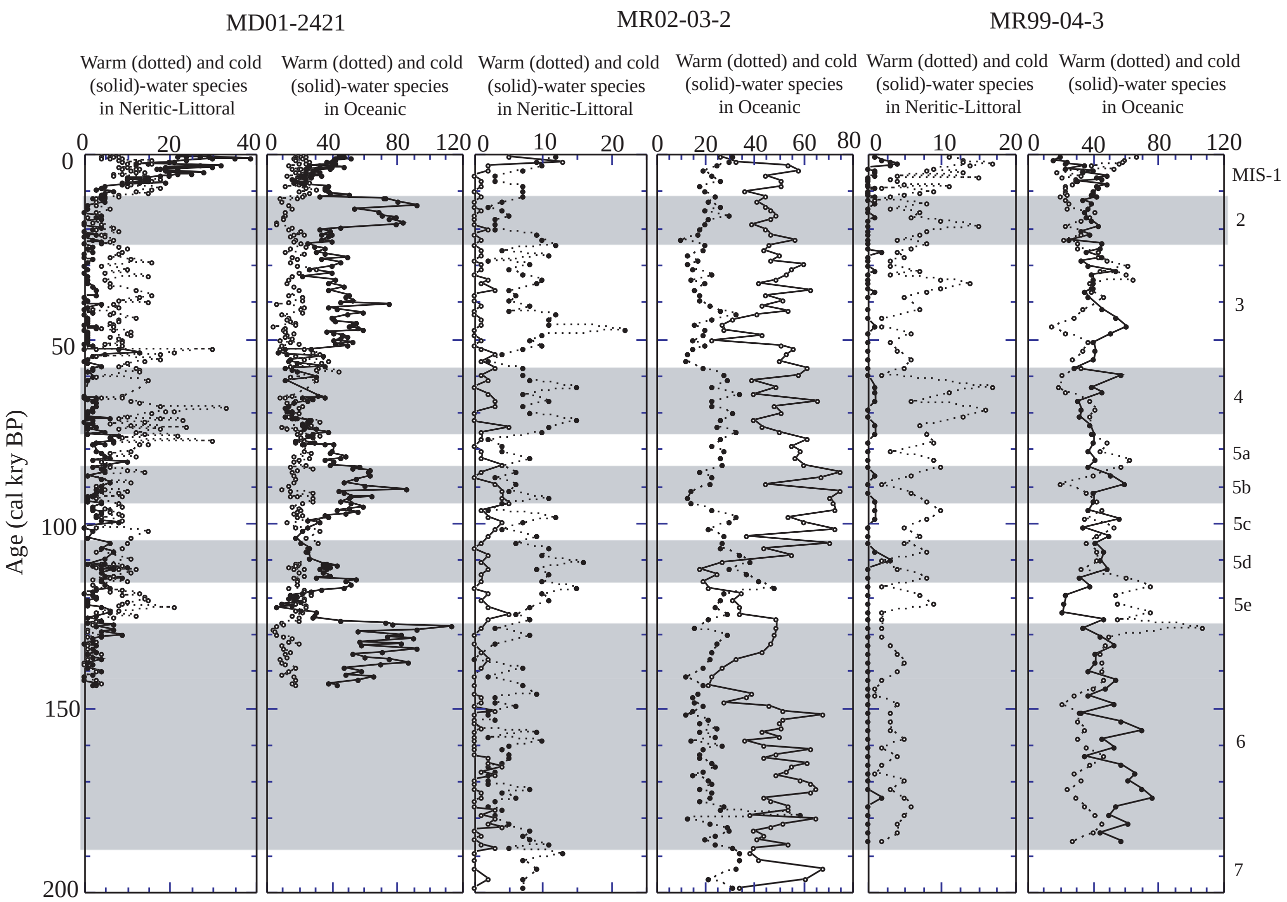


Figure 4: Chronostratigraphic variations of warm- and cold-water diatom species (valves/200 valves) in MD01-2421, MR02-03-2, and MR99-04-3, respectively.

## 4.1 Diatom abundance

The fluctuations of diatom abundance ($\times 10^7$ valves/dry g) in MD01-2421 are larger than that in MR99-04-3, and moderate in MR02-03-2 (Fig. 2). It suggests that the environmental changing affect more seriously in near shore area than in off shore area. In MD01-2421, large fluctuations with secondary and smaller fluctuations occur near the MIS's stage boundaries at the intervals of ~40-kyr. On the other hand, ~20-kyr intervals are dominant in MR02-03-2 and MR99-04-3, and larger fluctuations are situated near the stage boundaries and in the interglacial phase.

The cyclicities in diatom abundances in near shore area are considered to be corresponding to the obliquity (tilt) band variations (41–54 kyr), which modulates seasonality (e.g., De Bore and Smith, 1994). This implies that seawater mixing during the glacial to interglacial transition induced by orbital-obliquity cycles played an important role in changing composition of diatom flora. The fluctuations at ~20-kyr intervals in off shore area is correlated to precessional (19–23 kyr) changes in distribution of insolation over the earth and hence changes in the contrast between summer and winter.

## 4.2 Ecological and biogeographical associations

The abundances of extinct and freshwater diatom species occupy less than 10% of the total diatom flora, except in a few samples assigned to be in glacial phase, indicating that the contribution of reworked and displaced diatoms derived from the continent or/and sea bottom was minor. It is notable that such allochthonous diatoms to these cores sites as extinct, freshwater, and littoral diatom species are become smaller in number in MR99-04-2 and MR02-03-2 located off shore than in MD01-2421 located near shore.

The relative abundances of littoral-neritic association show resembling decrease as the locations of the cores become far from near shore area, with large fluctuations, in MD01-2421, repeatedly at ~60-kyr intervals throughout the core, and in MR02-03-2, at ~100-kyr intervals, which is likely to correspond to 95-124 kyr cycle of the orbital eccentricity among the Earth's orbital parameters. The ~60-kyr cyclicity in MD01-2421 suggest a correlation between the diatom flora and eustatic changing during the glacial, which was peculiar in near shore area (Birchfield and Gurmbine, 1985; Koizumi et al., 2004). The fluctuations in MR99-04-3

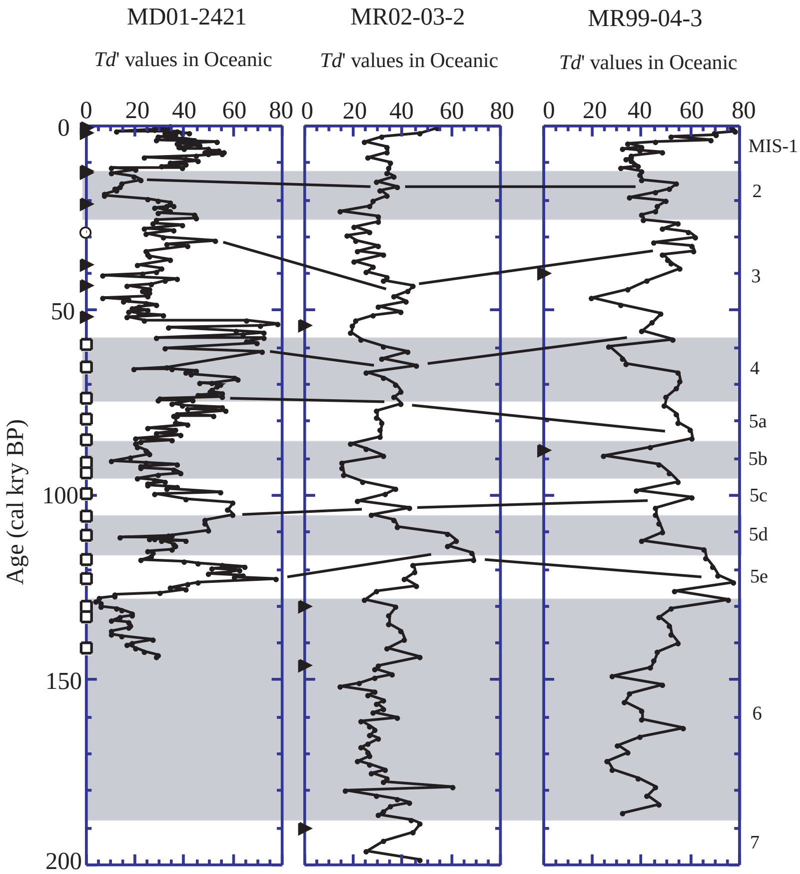


Figure 5: Chronostratigraphic variations of *Td*’ values in MD01-2421, MR02-03-2, and MR99-04-3. Remarkably high *Td*’ values are correlated within the limits of age indicating by markers on the left-side of each core among three cores.

do not show any cyclicities.

In littoral-neritic association, the relative abundances of warm-water species dominate over those of cold-water ones throughout the cores, except at 8.0-0 cal kyr BP in MD01-2421 and at 1.7 cal kyr BP in MR02-03-2. Its contribution to the total diatom flora in MD01-2421 and in MR99-04-3 shows a gradual decrease. The higher occurrences of warm-water species since 3.0 cal kyr BP in MR99-04-3 suggest the invasion of Tsugaru Warm Current to the core site (Fig. 1; Koizumi et al., 2003).

### 4.3 Revised diatom temperature (*Td*’) values

The relative abundances of warm-water species in oceanic association, in contrast, are generally lower than those of cold-water species throughout the cores. However, the abundances of warm-water species are almost equal to those of cold-water species in MR99-04-3 located in the warm tongue along the Kuroshio branch (Fig. 1). In MD01-2421 and MR02-03-2, the relative abundances of warm-water and of cold-water species in oceanic association show the cyclicities at ~20-kyr intervals. In MR99-04-3, the relative abundances dominate alternately between warm-water species and cold-water species at ~40-kyr intervals composed of 20-kyr intervals (Fig. 4).

Each of the *Td*’ curves for the oceanic association is almost a mirror image of each of the relative abundance curves of oceanic cold-water species, as expected (Figs. 4 and 5). Large fluctuations occur, with secondary and smaller fluctuations, at ~20- and ~40-kyr intervals in three cores, possibly indicating the cyclicities. Fluctuations are recognized like saw-tooth since 130 cal kyr BP in the first MIS’s stage 5e in MR99-04-3, but fluctuations become less frequent in 90-55 cal kyr BP and 25-0.5 cal kyr BP in MR02-03-2. And in MD01-2421, in particular, reversed saw-tooth are recognized twice in 90-20 cal kyr BP. High *Td*’ values occur at MIS 5e, 5d/c boundary, 5a/4 boundary, 4/3 boundary, the middle part of MIS 3, and 1, all leading the interglacial phase. The correspondence of high *Td*’ values to the periods turning toward interglacial phase is recognized common among three cores (Fig. 5).

The Younger Dryas event at 13.0–11.2 cal kyr BP was clearly recorded in three cores, especially in MD01-2421 and MR99-04-3.

Table 1: Distribution of diatom abundance ($10^7$ valves/dry g of material) and diatom species in MR99-04-3.

| Core | Pilot | | Main | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm) | 5.25 | 10.25 | 5.25 | 10.25 | 15.25 | 20.25 | 25.25 | 30.25 | 35.25 | 40.25 | 45.25 | 50.25 | 55.25 | 60.25 | 65.25 | 70.25 | 75.25 | 80.25 | 85.25 | 90.25 | 100.25 | 110.25 | 120.25 | 130.25 | 140.25 | 150.25 | 160.25 | 170.25 | 180.25 |
| Total depth (cm) | 5.25 | 10.25 | 15.25 | 20.25 | 25.25 | 30.25 | 35.25 | 40.25 | 45.25 | 50.25 | 55.25 | 60.25 | 65.25 | 70.25 | 75.25 | 80.25 | 85.25 | 90.25 | 95.25 | 100.25 | 110.25 | 120.25 | 130.25 | 140.25 | 150.25 | 160.25 | 170.25 | 180.25 | 190.25 |
| Age (cal kyr BP) | 0.63 | 1.23 | 1.83 | 2.43 | 3.03 | 3.63 | 4.23 | 4.83 | 5.43 | 6.03 | 6.63 | 7.23 | 7.83 | 8.43 | 9.03 | 9.63 | 10.24 | 10.84 | 11.44 | 12.04 | 13.24 | 14.44 | 15.64 | 16.84 | 18.04 | 19.24 | 20.44 | 21.64 | 22.84 |
| Diatom number ($10^7$/g) | 5.42 | 4.90 | 5.78 | 5.00 | 5.00 | 5.50 | 3.09 | 3.43 | 2.57 | 5.15 | 5.14 | 1.03 | 1.54 | 1.93 | 1.54 | 3.21 | 2.57 | 3.09 | 1.40 | 4.00 | 3.43 | 3.86 | 3.43 | 3.09 | 4.50 | 6.43 | 4.17 | 4.09 | 9.71 |
| *Actinocyclus ellipticus* | | | | | | | | | 1 | 1 | | | | | | | | | | | | | 1 | | | | | | |
| *Actinocyclus elongatus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Alveus marinus* | 5 | 6 | 3 | 4 | 1 | 2 | 1 | 1 | 3 | 2 | 14 | 2 | 5 | | 2 | 2 | 3 | 3 | 1 | 2 | 1 | 1 | 4 | 2 | 1 | 1 | 1 | 2 | 2 |
| *Asterolampra marylandica* | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | | | | | 1 | |
| *Asteromphalus arachne* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Asteromphalus flabellatus* | | 1 | 1 | | 1 | 3 | 1 | 1 | | 1 | | 1 | | | | 1 | | 2 | | 1 | 1 | | 1 | | | | | | |
| *Azpeitia africana* | 1 | | | | 1 | 1 | 1 | | | | | | 1 | 1 | | | | | 1 | | | | 1 | 1 | | | | 1 | |
| *Azpeitia nodulifera* | 6 | 5 | 2 | 2 | 2 | 5 | 2 | | 1 | 1 | 6 | | | | | | | | 1 | 2 | 4 | 1 | 1 | 5 | 2 | 1 | 2 | | 1 |
| *Azpeitia tabularia* | 9 | 5 | 5 | 4 | 3 | 5 | 6 | 3 | 5 | 6 | 10 | 8 | 6 | 7 | 7 | 4 | 7 | 4 | 2 | 2 | 4 | 5 | 5 | 5 | 2 | 4 | 5 | 9 | 3 |
| *Fragilariopsis doliolus* | 13 | 18 | 20 | 13 | 14 | 17 | 6 | | 4 | | 2 | 5 | 3 | 2 | 1 | 4 | 2 | 5 | 1 | 1 | 1 | 2 | 2 | 4 | 4 | 2 | 6 | 5 | |
| *Hemidiscus cuneiformis* | | 1 | | 4 | 1 | 1 | | 1 | 1 | | | 2 | 1 | 1 | 1 | 4 | 1 | 3 | 2 | 5 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | |
| *Nitzschia interruptestriata* | 2 | 2 | | | | | | | 2 | | | | | | | | | | | | | | | | | | 1 | 1 | 1 |
| *Nitzschia kolaczekii* | 1 | 1 | | | 1 | | 1 | | | | | | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 2 | 2 | 1 | | | 1 |
| *Planktoniella sol* | | | | 2 | | | | | | 1 | | | 1 | 1 | | | | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | |
| *Pseudosolenia calcar-avis* | 1 | 1 | 2 | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | | | 2 | | 1 | | 2 | 1 | 1 | | | 1 | | 1 | | | | |
| *Rhizosolenia acuminata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia bergonii* | 2 | 1 | 3 | 1 | | 2 | | | 2 | 1 | | 2 | | | | 1 | | 1 | 1 | 1 | 1 | | 2 | | 2 | 1 | | | |
| *Rhizosolenia imbricata* | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| *Roperia tesselata* | 10 | 2 | 6 | 7 | 2 | 1 | 4 | 2 | 3 | 3 | 2 | 3 | | 2 | 2 | | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 5 | 2 | 2 | 2 | 2 | 3 |
| *Thalassiosira leptopus* | | 3 | 3 | 3 | 1 | 2 | | 2 | 1 | | 2 | 2 | 2 | 1 | 1 | 2 | 1 | | 1 | 2 | 5 | 1 | 3 | 4 | 4 | 3 | 2 | 3 | |
| *Thalassiosira oestrupii* | 17 | 14 | 13 | 16 | 11 | 11 | 10 | 5 | 9 | 4 | 5 | 5 | 8 | 4 | 8 | 2 | 6 | 3 | 3 | 3 | 3 | 13 | 14 | 6 | 8 | 4 | 10 | 7 | 11 |
| *Xw* + *XW* | 67 | 60 | 59 | 56 | 39 | 53 | 34 | 18 | 33 | 21 | 30 | 30 | 28 | 23 | 23 | 22 | 24 | 25 | 17 | 23 | 26 | 25 | 42 | 38 | 32 | 23 | 33 | 33 | 22 |
| *Actinocyclus curvatulus* | 1 | 3 | 5 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 | 1 | 2 | 6 | 2 | 1 | 5 | 1 | 2 | 2 | 1 | 3 | 3 | 4 | 5 | 3 | 2 | 3 | 1 |
| *Actinocyclus ochotensis* | | | | | | | | | | | 1 | | 2 | | | | 1 | | | | | | | | | | | 1 | |
| *Asteromphalus robustus* | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | 1 | 1 | | | | |
| *Bacterosira fragilis* | | | | 2 | | | | 2 | | | | | 1 | 2 | | | 1 | | | 1 | | | 1 | | | | 2 | | |
| *Chaetoceros furcellatus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coscinodiscus marginatus* | 10 | 8 | 6 | 5 | 11 | 11 | 9 | 10 | 13 | 14 | 14 | 10 | 20 | 9 | 18 | 12 | 14 | 13 | 20 | 14 | 20 | 12 | 8 | 10 | 11 | 14 | 15 | 17 | 14 |
| *Coscinodiscus oculus-iridis* | 1 | | 2 | 3 | 5 | 3 | | 1 | 12 | 3 | 4 | 6 | 7 | 2 | 10 | 5 | 7 | 6 | 8 | 8 | 7 | 8 | 8 | 11 | 9 | 10 | 3 | 4 | 3 |
| *Fragilariopsis cylindrus* | | | | | | | | | 1 | | | | | 1 | 1 | | | | | | | | | | 1 | | | | |
| *Fragilariopsis oceanica* | 1 | | | | 1 | | | | 2 | | | | 1 | 1 | 1 | | 1 | 1 | 1 | | | 2 | 2 | 1 | 1 | 2 | 1 | 3 | |
| *Neodenticula seminae* | 3 | 2 | 4 | 3 | 5 | 3 | 4 | 4 | 4 | 2 | 2 | | 1 | 4 | 3 | 4 | 1 | 2 | 3 | 3 | 5 | 5 | 2 | 4 | 2 | 5 | | 1 | 4 |
| *Porosira glacilis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia hevetata* f. *hiemalis* | | 1 | | | 1 | 1 | 1 | 4 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 6 | | 3 | | 2 | | 1 | 1 | | | 1 | 1 | 1 | |
| *Thalassiosira gravida* | 1 | 1 | 2 | 1 | 5 | | 10 | 3 | 1 | 5 | 2 | 3 | 5 | 6 | 3 | 4 | 1 | 3 | 3 | | 1 | 2 | 2 | 1 | 2 | 1 | 4 | 3 | 1 |
| *Thalassiosira hyalina* | | | | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira nordenskioldii* | | | 2 | | | | 1 | 2 | 2 | | 1 | | 1 | | | | 1 | 3 | | | | | 1 | | 1 | 1 | | 1 | 1 |
| *Thalassiosira trifulta* | 3 | 1 | 3 | 6 | 6 | 3 | 12 | 4 | 9 | 16 | 15 | 10 | 8 | 8 | 5 | 6 | 8 | 7 | 6 | 4 | 5 | 4 | 7 | 4 | 5 | 6 | 5 | 4 | 2 |
| *Xc* + *XC* | 20 | 16 | 25 | 23 | 35 | 24 | 40 | 34 | 49 | 43 | 46 | 31 | 49 | 40 | 44 | 38 | 40 | 39 | 43 | 34 | 39 | 37 | 35 | 36 | 38 | 43 | 33 | 38 | 26 |
| *Td'* values | 77.0 | 78.9 | 70.2 | 70.9 | 52.7 | 68.8 | 45.9 | 34.6 | 40.2 | 32.8 | 39.5 | 49.2 | 36.4 | 36.5 | 34.3 | 36.7 | 37.5 | 39.1 | 28.3 | 40.4 | 40.0 | 40.3 | 54.5 | 51.4 | 45.7 | 34.8 | 50.0 | 46.5 | 45.8 |
| *Asteromphalus* spp. | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | |
| *Coscinodiscus centrais* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coscinodiscus obscurus* | | | | | | 1 | | 1 | | | | | 1 | | | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 2 | 2 | | 2 |
| *Coscinodiscus radiatus* | | | | 3 | | 2 | | | | | | | | | | | | | | | | 1 | | | | | | | |
| *Coscinodiscus wailesii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia bicapitata* | | 1 | | | | | | | | | | | 1 | 1 | | 1 | 1 | 2 | | 1 | | | 1 | | | | | | |
| *Nitzschia capaluspalae* | | | 2 | | 1 | 2 | 1 | 1 | | 2 | | 1 | | 1 | | 1 | 2 | | 1 | | 2 | 3 | 1 | 2 | | 1 | | 2 | |
| *Nitzschia sicula* | 1 | 2 | 3 | 1 | 4 | 3 | 3 | 1 | 2 | 1 | | | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 3 | 1 | 3 | | 1 | 4 | 5 | 2 | 3 | 1 |
| *Proboscia alata* | | | 1 | | 2 | 1 | | 1 | | 1 | 1 | | 1 | | 1 | | 1 | 1 | | | | | | | | | | | |
| *Rhizosolenia setigera* | 4 | 2 | 3 | 1 | 7 | 6 | 2 | 2 | 2 | 1 | 6 | 2 | 3 | 5 | 7 | 3 | 4 | 4 | 3 | 6 | 8 | 6 | 5 | 6 | | 6 | 4 | 1 | 2 |
| *Rhizosolenia styliformis* | | 2 | 3 | | 4 | 4 | 2 | 1 | 1 | 5 | | 2 | 2 | 1 | 1 | | 4 | 2 | | 3 | 5 | 5 | 4 | 3 | 1 | 1 | 3 | | 1 |
| *Stellarima stellaria* | 1 | | 1 | | | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | | 2 | 4 | 2 | 4 | 4 | 3 | | | 7 | 8 | 3 | 3 | 6 | 30 | 2 |
| *Thalassiosira decipiens* | | | | | | | | | | | | | | 1 | | 1 | | | | | 1 | | | | | | | | |
| *Thalassiosira eccentrica* | 11 | 7 | 4 | 9 | 3 | 8 | 4 | 9 | 3 | 8 | 6 | 7 | 8 | 11 | 4 | 13 | 7 | 7 | 8 | 9 | 6 | 6 | 8 | 2 | 5 | 6 | 8 | 5 | 3 |
| *Thalassiosira ferelineata* | 5 | | | | | 2 | 1 | | 1 | 1 | 1 | | | 1 | 1 | 1 | | 3 | 1 | 2 | 1 | 1 | 3 | | | | | | 1 |
| *Thalassiosira gravida* v. | | | | | | | | | | | | | | | | | | 7 | 1 | | | | 1 | 1 | | | | 1 | |
| *Thalassiosira lineata* | 2 | 5 | 3 | 4 | 2 | 2 | 4 | 4 | 5 | 6 | 2 | 4 | 3 | 4 | 2 | 7 | 3 | 5 | 3 | 3 | 4 | 5 | 4 | 7 | 5 | 3 | 9 | 4 | 1 |
| *Thalassiosira pacifica* | 5 | 4 | 1 | 3 | 2 | 1 | 4 | 2 | 3 | 2 | 1 | | 2 | 3 | | 2 | 2 | 3 | 2 | | 1 | 4 | 3 | 2 | 4 | 2 | 4 | 4 | 1 |
| *Thalassiosira subtilis* | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira* spp. | | | | | 3 | 7 | 3 | | 2 | 1 | 1 | 2 | 1 | 2 | 1 | | 1 | 2 | 1 | | 1 | 1 | 3 | | 2 | 2 | | | 2 |
| *Thalassiothrix frauenfeldii* | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 5 | 1 | 3 | 3 | 2 | 1 | 1 | 1 |
| *Thalassiothrix longissima* | 11 | 7 | 6 | 3 | 5 | 7 | 4 | 7 | 6 | 5 | 8 | 10 | 4 | 4 | 6 | 4 | 7 | 3 | 11 | 3 | 5 | 7 | 2 | 7 | 6 | 6 | 4 | 3 | 5 |
| Oceanic | 130 | 108 | 114 | 106 | 109 | 129 | 108 | 87 | 111 | 99 | 104 | 92 | 106 | 99 | 94 | 100 | 106 | 113 | 101 | 93 | 102 | 109 | 121 | 117 | 104 | 105 | 109 | 125 | 70 |
| *Cyclotella styroleum* | | | | 2 | 1 | | | | | 1 | 1 | | 1 | 1 | | 1 | 2 | | | | | | | | | | | | |
| *Cymatotheca weissflogii* | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| *Hemiaulus sienesis* | | | | | 2 | | 1 | 3 | | 2 | 1 | | | 1 | | 1 | | | | | 1 | | 1 | 5 | 6 | 6 | 4 | 1 | 3 |
| *Mastogloia* spp. | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| *Odontella longicruris* | | | 1 | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | | |
| *Odontella sinensis* | 2 | 1 | 4 | 7 | 2 | 1 | 2 | 1 | 1 | 7 | | 4 | 2 | 2 | 1 | 6 | 3 | 3 | 2 | 1 | 3 | | 3 | | 1 | 4 | | | |
| *Thalassionema nitzschioides* v. *parva* | 9 | 12 | 8 | 8 | 9 | 7 | 5 | 8 | 3 | 4 | 1 | | 2 | 7 | 1 | | 4 | 2 | 1 | | 4 | 3 | 3 | 1 | | | 4 | 6 | 1 |
| *XW* in Neritic-Littoral | 11 | 13 | 13 | 17 | 14 | 9 | 8 | 13 | 4 | 15 | 3 | 4 | 5 | 11 | 2 | 9 | 7 | 5 | 3 | 1 | 8 | 3 | 7 | 6 | 7 | | 8 | 7 | 4 |
| *Odontella aurita* | 1 | 2 | 3 | 4 | 3 | | 1 | 1 | 1 | | | | | | 1 | | | | 1 | | 1 | | | 1 | | | | | |
| *XC* in Neritic-Littoral | 1 | 2 | 3 | 4 | 3 | | 1 | 1 | 1 | | | | | | 1 | | | | 1 | | 1 | | | 1 | | | | | |
| *Actinocyclus octonarius* | 5 | 5 | 6 | 5 | 6 | 2 | 3 | 6 | 2 | 11 | 6 | 13 | 6 | 10 | 5 | 11 | 6 | 11 | 10 | 12 | 7 | 4 | 6 | 5 | 8 | 7 | 2 | 3 | 4 |
| *Actinoptychus senarius* | 5 | 8 | 6 | 9 | 7 | 3 | 5 | 2 | 4 | 3 | 3 | 1 | 1 | | 1 | 1 | 2 | | 1 | 3 | 2 | 2 | 1 | 5 | 3 | 1 | 2 | 4 | |
| *Actinoptychus splendes* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Biddilphia pulchella* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Odontella reticulata* | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Paralia sulcata* | 9 | 7 | 1 | 11 | 8 | 7 | 9 | 20 | 10 | 14 | 16 | 10 | 4 | 6 | 2 | 14 | 4 | 2 | | 2 | 2 | 8 | 2 | | 2 | 9 | 2 | 2 | 8 |
| *Stephanopyxis* spp. | 1 | 2 | 3 | | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 7 | 4 | 7 | 1 | 3 | 2 | 5 | 5 | 7 | 1 | 1 | 7 | 1 | 3 | 12 | 2 | 4 |
| *Synedra indica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassionema nitzschioides* | 34 | 38 | 49 | 38 | 45 | 38 | 54 | 68 | 57 | 48 | 60 | 63 | 59 | 58 | 74 | 45 | 59 | 60 | 73 | 77 | 62 | 56 | 51 | 49 | 70 | 58 | 52 | 48 | 101 |
| Neritic-Littoral | 67 | 75 | 81 | 84 | 85 | 60 | 83 | 111 | 79 | 92 | 89 | 93 | 82 | 89 | 92 | 81 | 81 | 80 | 93 | 100 | 89 | 74 | 68 | 73 | 91 | | 78 | 66 | 121 |
| *Achnanthes* spp. | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| *Amphora* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Arachnoidiscus ehrenbergi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bacillaria paradoxa* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Campyloneis grevillei* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cocconeis* spp. | | 1 | | | | | | | | | | | 2 | 1 | 1 | 1 | 2 | 1 | | 1 | 1 | 1 | | 1 | 1 | 2 | 1 | 2 | 1 |
| *Coscinodiscus nitidus* | | | | 1 | | 1 | 1 | 1 | 2 | 1 | 1 | | | | | 1 | | | | | 1 | | | | | | | | |
| *Cyclotella striata* | | 1 | 2 | 1 | | 1 | 2 | 1 | 3 | 3 | 2 | 4 | | 2 | 4 | 3 | | | 2 | | 2 | 4 | | 4 | | 1 | 7 | 3 | 2 |
| *Cymatosira lorenziana* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Delphineis margalitalimbata* | | | | | | | | | 1 | | | | 3 | | | | | 2 | | | | 1 | | | | | | | |
| *Delphineis surirella* | 1 | 1 | 2 | 1 | | 1 | | | | 1 | | 2 | | 1 | 3 | | 1 | | 1 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | | | 1 |
| *Diploneis* spp. | | 2 | | 1 | 1 | 2 | 1 | | | | | | 1 | | | | 2 | | | 1 | | | | 1 | 2 | | | | |
| *Ditylum brightwellii* | 1 | 11 | 1 | 4 | 2 | 2 | | 2 | 1 | 4 | 2 | | 2 | 2 | 3 | 4 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | | | | 1 | 1 | 1 |
| *Grammatophora* spp. | | | | | | 1 | | | | | | 1 | | | | 1 | | | | | | | | | | | | | |
| *Gyrosigma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Hyalodiscus* spp. | | | | | | | | | 1 | | | | | | | | | | | | | | | | | 1 | | 1 | |
| *Navicula cancellata* | | | | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula elginenesis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula finmarchia* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula mutica* | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| *Navicula* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| *Nitzschia compressa* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia constricta* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | |
| *Nitzschia granulata* | | | | | | | | | | | | | | | | | | | | | | | 3 | | | | | | |
| *Nitzschia littoralis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Opephora* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Plagiogramma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pleurosigma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhabdonema arcuatum* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhaphoneis amphiceros* | | | | | | | | | 1 | | | | | | | | 1 | 2 | | | 1 | | | | | | | | |
| *Rhoicosphenia curvata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhopalodia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Stauroneis* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Surirella* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Synedra undulata* | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Thalassiosira lacustris* | 1 | 1 | | | 1 | 1 | 3 | | 1 | | | | | 1 | | 2 | | | | | | | 1 | | | | | | |
| *Trachyneis antillarum* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trachyneis aspera* | | | | | | 1 | | | | | | | | | | | | | | | | 1 | | | | | | | |
| *Triceratium* spp. | | | | | | | | | | | | | | 1 | | 1 | | | | | | | | | | | 1 | | |
| Littoral | 3 | 10 | 5 | 9 | 4 | 10 | 8 | 4 | 10 | 9 | 5 | 7 | 9 | 9 | 11 | 13 | 8 | 7 | 5 | 6 | 9 | 14 | 9 | 8 | 5 | 1 | 11 | 7 | 5 |
| *Aulacosira* spp. | | | | | | | | | | | | | | 1 | 1 | 2 | | | | | | | | | | | | | 1 |
| *Cyclotella* spp. | | | | | | | | | | | | 1 | | | | | | | | | | 1 | | | | | | | |
| *Cymbella* spp. | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | |
| *Epithemia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Eunotia* spp. | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | |
| *Fragilaria* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Gomphonema* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Meridion circulare* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Neidium iridis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pinnularia* spp. | | | | 1 | | | | | | | | 1 | | | | | | | | | | | 2 | | | | | 1 | |
| *Stephanodiscus* spp. | | | | | 1 | | | | | | | | | | 1 | 1 | | | | | | | | | | | | 1 | |
| *Tabellaria* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Freshwater | | | | 1 | 1 | | | | | | | 3 | | | 2 | 3 | | | | | | 2 | 2 | | | | | 2 | 1 |
| *Actinocyclus ingens* | | | | | | | | | | | | | | | | 2 | | | 1 | | | | | 1 | | | | | |
| *Actinocyclus oculatus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Crucidenticula nicobarica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Denticulopsis* spp. | | | | | | | | | | | | 2 | 1 | 1 | | | 1 | | | | | | | | | | | | |
| *Goniothecium tenue* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Kiesellavia carina* | | | | | | | | | | | | 1 | | 1 | | | | | | | | | | | | | | | |
| *Melosira albicans* | | | | | | | | | | | 1 | | | | | | | | | | | | | | | 1 | | | 1 |
| *Neodenticula kamtschatica* | | | | | 1 | 1 | 1 | | | | 1 | 2 | | | | | 1 | | | | | | | | | | 1 | | |
| *Neodenticula koizumii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| *Nitzschia reinholdii* | | | | | | | | | | | | | 1 | | | 1 | | | | 1 | | | | | | | | | |
| *Proboscia curvirostris* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pseudopodosira elegans* | | | | | | | | | | | | | | | 1 | | | | | | | 1 | | 1 | | | 1 | | 1 |
| *Pyxidicula zabelinae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia matutamae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia miocenica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rouxia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Synedra jouseana* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassionema schraderi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira antiqua* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira jacksonii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira nidulus* | | | | | | | | | | | | | 1 | | | | 1 | | | | | | | | | | | | |
| *Thalassiosira temperi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Extinct | | | | | 1 | 1 | 1 | | | | 2 | 5 | 3 | 2 | 1 | 3 | 3 | | 1 | 1 | | 1 | | 2 | | | 2 | | 3 |
| Total valves counted | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |

Table 1: (continued)

| Core | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm) | 190.25 | 200.25 | 210.25 | 220.25 | 230.25 | 240.25 | 250.25 | 260.25 | 270.25 | 280.25 | 290.25 | 300.25 | 310.25 | 330.25 | 340.25 | 350.25 | 360.25 | 370.25 | 380.25 | 390.25 | 400.25 | 410.25 | 420.25 | 430.25 | 440.25 | 450.25 | 460.25 | 470.25 | 480.25 |
| Total depth (cm) | 200.25 | 210.25 | 220.25 | 230.25 | 240.25 | 250.25 | 260.25 | 270.25 | 280.25 | 290.25 | 300.25 | 310.25 | 320.25 | 340.25 | 350.25 | 360.25 | 370.25 | 380.25 | 390.25 | 400.25 | 410.25 | 420.25 | 430.25 | 440.25 | 450.25 | 460.25 | 470.25 | 480.25 | 490.25 |
| Age (cal kyr BP) | 24.04 | 25.24 | 26.44 | 27.64 | 28.84 | 30.05 | 31.25 | 32.45 | 33.65 | 34.85 | 36.05 | 37.25 | 38.45 | 41.78 | 44.03 | 46.29 | 48.55 | 50.81 | 53.06 | 55.32 | 57.58 | 59.84 | 63.09 | 64.35 | 66.61 | 68.87 | 71.12 | 73.38 | 75.64 |
| Diatom number ($10^7$/g) | 5.98 | 5.68 | 6.30 | 4.85 | 5.55 | 5.98 | 7.28 | 7.06 | 7.51 | 6.47 | 9.70 | 5.98 | 4.48 | 4.66 | 7.52 | 6.47 | 7.52 | 7.52 | 5.82 | 5.55 | 5.82 | 4.31 | 5.68 | 3.33 | 2.01 | 3.76 | 2.51 | 4.02 | 6.13 |
| *Actinocyclus ellipticus* | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| *Actinocyclus elongatus* | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| *Alveus marinus* | 1 | 2 | 1 | 2 | 1 | 2 | | 2 | 2 | 1 | | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | | 1 | | 1 | 1 | 6 | 4 | 7 | 8 |
| *Asterolampra marylandica* | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| *Asteromphalus arachne* | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| *Asteromphalus flabellatus* | | | | | 2 | 1 | 2 | 1 | | | | | | | 1 | | | 1 | | | | | | | | | 2 | 1 | |
| *Azpeitia africana* | | | | | | | | | 2 | | | 1 | 1 | | | | | 1 | | | | 1 | | | | | | | |
| *Azpeitia nodulifera* | 3 | 1 | 2 | 3 | 1 | 3 | 1 | 1 | 1 | 3 | 1 | 1 | | 2 | 2 | | 2 | 4 | | 2 | 2 | | | 1 | 2 | 1 | 1 | 3 | 5 |
| *Azpeitia tabularia* | 2 | 10 | 7 | 11 | 10 | 13 | 9 | 11 | 15 | 10 | 11 | 5 | 16 | 14 | 8 | 2 | 8 | 11 | 13 | 6 | 14 | 8 | 5 | 8 | 12 | 10 | 12 | 7 | 4 |
| *Fragilariopsis doliolus* | 1 | 1 | 4 | 5 | 5 | 2 | 4 | 3 | 1 | 1 | 1 | 2 | 2 | | 2 | 2 | 2 | 2 | 1 | 3 | 1 | | | | | 2 | 1 | 2 | 3 |
| *Hemidiscus cuneiformis* | 2 | 2 | 3 | | 3 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | | | 2 | | | | 2 | | 1 | 1 | | | 3 | | | 1 | 3 |
| *Nitzschia interruptestriata* | 1 | 1 | 1 | 3 | 1 | | 1 | | 1 | | 2 | | 1 | | | | | 1 | | 1 | | 2 | | 1 | 2 | 2 | | 1 | |
| *Nitzschia kolaczekii* | | 1 | | 1 | 1 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | | 1 | 1 | 3 | 3 | 1 | | 1 |
| *Planktoniella sol* | 1 | 2 | | 2 | | 5 | 1 | | 1 | | | | | | | | | 1 | | | | | | 3 | | | 3 | | |
| *Pseudosolenia calcar-avis* | | | | | 1 | | | 1 | | | 4 | 1 | | 1 | 1 | | | 2 | | 1 | 1 | | | 1 | 1 | | | | |
| *Rhizosolenia acuminata* | | | | | | 1 | | | 1 | | | | | | | | | | 1 | | | 1 | | | | | | | |
| *Rhizosolenia bergonii* | | | | | 1 | | | | | | | 3 | 1 | 2 | 1 | | | 1 | 2 | | 1 | | 1 | 1 | 1 | | 3 | 2 | 4 |
| *Rhizosolenia imbricata* | | 1 | | | 1 | | | 1 | | | | | | | | | | 1 | 1 | | 1 | | | 1 | | | | | |
| *Roperia tesselata* | 3 | 4 | 8 | 2 | | 3 | 3 | 1 | | 1 | 2 | 2 | 1 | | 1 | 2 | 2 | 1 | 1 | 2 | 3 | 1 | 3 | | 1 | 2 | 2 | 3 | 2 |
| *Thalassiosira leptopus* | 2 | 1 | 3 | 3 | 3 | 2 | 1 | 3 | 5 | 1 | 1 | 7 | 2 | 4 | | | | | | | 2 | | | 1 | 3 | | 2 | 1 | |
| *Thalassiosira oestrupii* | 14 | 5 | 15 | 12 | 19 | 28 | 18 | 34 | 31 | 19 | 17 | 14 | 19 | 9 | 8 | 5 | 8 | 8 | 9 | 9 | 5 | 6 | 9 | 5 | 9 | 16 | 6 | 10 | 9 |
| *Xw + XW* | 31 | 31 | 44 | 44 | 49 | 62 | 45 | 61 | 65 | 38 | 41 | 39 | 47 | 34 | 29 | 15 | 24 | 37 | 34 | 28 | 33 | 21 | 19 | 24 | 38 | 42 | 38 | 38 | 39 |
| *Actinocyclus curvatulus* | 3 | 4 | 3 | 3 | 6 | 5 | 4 | 2 | 3 | 1 | 1 | 5 | 5 | 4 | 3 | 6 | 5 | 1 | 3 | 6 | 3 | 14 | 6 | 7 | 2 | 3 | 5 | 4 | 4 |
| *Actinocyclus ochotensis* | 1 | | | | 1 | 1 | | | | 2 | 2 | 1 | | | | 1 | 2 | | | 1 | | | | | | | 2 | | 1 |
| *Asteromphalus robustus* | | 1 | | 1 | | | | | | | | | | | | | | | | 1 | | | | | | | | | |
| *Bacterosira fragilis* | 2 | 5 | | 1 | 2 | | 4 | 1 | 1 | 1 | | 3 | 3 | 2 | 1 | | 3 | 1 | | | 1 | 3 | 1 | 1 | 2 | | 1 | 1 | 4 |
| *Chaetoceros furcellatus* | | | 1 | | | | 1 | 2 | | | | 1 | | | | | | | | | | | | 1 | 1 | | | | |
| *Coscinodiscus marginatus* | 15 | 13 | 16 | 19 | 9 | 13 | 23 | 19 | 20 | 12 | 15 | 12 | 12 | 25 | 24 | 24 | 23 | 18 | 12 | 10 | 12 | 12 | 8 | 13 | 7 | 10 | 4 | 7 | 6 |
| *Coscinodiscus oculus-iridis* | 5 | 6 | 5 | 6 | 3 | 5 | 10 | 1 | 9 | 3 | 7 | 4 | 3 | 5 | 5 | 6 | 7 | 1 | 3 | 4 | | 2 | 2 | 3 | 1 | 3 | 5 | 5 | 4 |
| *Fragilariopsis cylindrus* | | | | | 1 | | | 1 | | 1 | 1 | | 2 | | | 1 | | 1 | | | | 2 | 1 | 1 | | 1 | 2 | 1 | 1 |
| *Fragilariopsis oceanica* | 3 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 5 | | 1 | 2 | | 1 | 3 | 3 | 5 | 3 | 6 | 1 | 3 | 1 | | 2 | 6 | 2 | 3 | 2 |
| *Neodenticula seminae* | 5 | 3 | 3 | 3 | 2 | 1 | 1 | 4 | 4 | 5 | 4 | 4 | 2 | 4 | 10 | 6 | 4 | 4 | 6 | 2 | 3 | 6 | 6 | 4 | 2 | 3 | 1 | 3 | 5 |
| *Porosira glacilis* | | | | | | 1 | 1 | | | | 1 | | 1 | | | 1 | | | | 2 | 1 | | | | | | | | |
| *Rhizosolenia hevetata* f. *hiemalis* | 3 | 1 | | | 1 | | 1 | 1 | | | 2 | | | | | 1 | 1 | 1 | | 1 | 2 | 3 | 2 | 3 | 1 | | 2 | 1 | |
| *Thalassiosira gravida* | 3 | 4 | 1 | 4 | 2 | 6 | 3 | 5 | 1 | 2 | 2 | 3 | 3 | 1 | 6 | 4 | 1 | | 3 | 2 | 1 | 3 | 6 | 7 | 6 | 1 | 4 | 1 | 4 |
| *Thalassiosira hyalina* | | | | | | | | | | 1 | | | | | | | | 2 | | | | | 1 | | | | 2 | 1 | |
| *Thalassiosira nordenskioldii* | 2 | | | | 1 | 3 | 2 | | | 2 | 1 | | | 1 | | | | 2 | 2 | 2 | | 2 | 2 | | 2 | 2 | | 2 | 2 |
| *Thalassiosira trifulta* | 4 | 5 | 5 | 6 | 3 | 1 | 3 | 2 | 2 | 5 | 3 | 1 | 4 | 4 | 4 | 8 | 2 | 4 | 10 | 4 | 5 | 8 | 3 | 6 | 5 | 4 | 2 | 9 | 7 |
| *Xc + XC* | 46 | 45 | 36 | 46 | 33 | 37 | 54 | 39 | 41 | 40 | 39 | 35 | 37 | 46 | 54 | 61 | 51 | 40 | 42 | 41 | 29 | 58 | 39 | 46 | 31 | 33 | 32 | 38 | 40 |
| *Td'* values | 40.3 | 40.8 | 55.0 | 48.9 | 59.8 | 62.6 | 45.5 | 61.0 | 61.3 | 48.7 | 51.3 | 52.7 | 56.0 | 42.5 | 34.9 | 19.7 | 32.0 | 48.1 | 44.7 | 40.6 | 53.2 | 26.6 | 32.8 | 34.3 | 55.1 | 56.0 | 54.3 | 50.0 | 49.4 |
| *Asteromphalus* spp. | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coscinodiscus centrais* | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Coscinodiscus obscurus* | 1 | | | | 1 | | | | | | 1 | | 1 | 1 | 2 | 1 | | 1 | 1 | | | | | | | | | 1 | |
| *Coscinodiscus radiatus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coscinodiscus wailesii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia bicapitata* | | | | | | | | | | | | | 1 | 1 | | | | | | 2 | 3 | | 2 | 1 | | | 2 | | 2 |
| *Nitzschia capaluspalae* | | 1 | 2 | 1 | | | | | 1 | | | 2 | | | 1 | 1 | | | | | | 2 | | | | | 1 | | |
| *Nitzschia sicula* | 1 | 3 | 3 | 2 | 2 | 1 | | 1 | | 6 | | 4 | 4 | 1 | 1 | | 2 | 1 | 2 | 2 | 3 | 4 | 3 | 3 | 4 | 1 | 4 | 3 | 3 |
| *Proboscia alata* | | | | | | | | | | 2 | | | | | | | | | | | | | | 1 | 3 | | 2 | | |
| *Rhizosolenia setigera* | 2 | | 2 | 2 | 3 | 2 | | 1 | | 1 | | 4 | 3 | 3 | 1 | | 2 | 3 | 2 | 1 | 2 | 2 | | 1 | 2 | | 2 | 2 | |
| *Rhizosolenia styliformis* | 6 | 6 | | | 2 | 2 | 2 | 4 | 4 | 10 | 4 | 3 | 3 | 7 | 4 | 4 | 6 | 11 | 3 | 2 | 4 | 3 | 5 | 3 | | 1 | | 5 | 3 |
| *Stellarima stellaria* | 1 | 6 | 2 | 2 | | 2 | | 4 | 1 | 4 | 7 | 10 | 13 | 5 | 3 | 4 | 2 | 2 | | | 10 | 1 | 1 | 1 | 5 | 2 | 2 | 7 | 1 |
| *Thalassiosira decipiens* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira eccentrica* | 10 | 5 | 9 | 9 | 7 | 5 | 13 | 9 | 6 | 9 | 19 | 6 | 2 | 5 | 6 | 7 | 6 | 5 | 8 | 11 | 14 | 11 | 7 | 11 | 11 | 12 | 12 | 10 | 16 |
| *Thalassiosira ferelineata* | | | | | | | | | | | | | | | | 4 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 2 | | | | |
| *Thalassiosira gravida* v. | 2 | | | | | | 1 | | | 1 | | 1 | | | 2 | | | | | 1 | 1 | | 2 | 1 | 1 | | 2 | | |
| *Thalassiosira lineata* | 5 | 6 | 5 | 7 | 6 | 3 | 3 | 1 | 3 | 1 | 3 | 5 | 4 | 7 | 9 | 3 | 2 | 2 | 2 | 3 | 2 | 6 | 2 | 4 | 3 | 2 | 6 | 2 | 7 |
| *Thalassiosira pacifica* | 4 | 1 | 3 | 4 | 2 | 3 | 4 | 3 | 1 | 4 | 2 | 1 | 1 | 3 | 2 | 1 | 4 | 1 | 5 | 4 | 4 | 6 | 1 | 3 | 2 | 3 | 2 | | 2 |
| *Thalassiosira subtilis* | | | | 1 | 1 | | | | | | | | | | | | | 1 | 1 | 1 | | | | | | | | | |
| *Thalassiosira* spp. | | | | | | | | | | | | | | | 1 | | 1 | | | | | 1 | 1 | | | | | | |
| *Thalassiothrix frauenfeldii* | 2 | 4 | 2 | 1 | 3 | 3 | 1 | 2 | | 3 | 1 | 4 | 1 | | 1 | | 1 | 3 | 5 | 1 | | | 6 | | 4 | 7 | 6 | 6 | 3 |
| *Thalassiothrix longissima* | 3 | 5 | 2 | 5 | 3 | 6 | 2 | 5 | 5 | 4 | 5 | 7 | 5 | 5 | 11 | 14 | 11 | 5 | 7 | 15 | 10 | 9 | 15 | 10 | 9 | 5 | 4 | 8 | 3 |
| Oceanic | 114 | 113 | 111 | 124 | 112 | 126 | 125 | 130 | 127 | 123 | 122 | 121 | 122 | 119 | 127 | 115 | 115 | 114 | 115 | 114 | 117 | 127 | 104 | 110 | 115 | 108 | 115 | 120 | 119 |
| *Cyclotella styroleum* | | | | 1 | | | | | 5 | 6 | 5 | 2 | 2 | 2 | | | 1 | | | 3 | 1 | | 10 | 3 | 3 | 5 | 5 | 1 | |
| *Cymatotheca weissflogii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Hemiaulus sienesis* | 5 | 2 | 2 | 3 | 1 | | 2 | | 1 | 2 | 3 | 1 | 2 | 1 | | | 1 | | | 1 | | 1 | 1 | 1 | 1 | 1 | | | 1 |
| *Mastogloia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| *Odontella longicruris* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| *Odontella sinensis* | | 1 | | 1 | | 1 | 2 | | | 3 | 1 | 2 | 1 | 1 | | | 1 | | 1 | 1 | | | | | | | | | |
| *Thalassionema nitzschioides* v. *parva* | 3 | 3 | 2 | 1 | 2 | 2 | 3 | 3 | 4 | 3 | 1 | 3 | | 3 | 2 | 2 | 3 | 3 | 3 | 1 | 4 | 1 | 6 | 7 | 1 | 10 | 8 | 6 | 6 |
| *XW* in Neritic-Littoral | 8 | 6 | 4 | 5 | 3 | 3 | 7 | 3 | 10 | 14 | 10 | 8 | 5 | 7 | 2 | 2 | 6 | 3 | 4 | 6 | 5 | 2 | 17 | 11 | 6 | 16 | 13 | 7 | 8 |
| *Odontella aurita* | | | 2 | | | | 1 | | | | | 1 | | | | 1 | | | | | | | 1 | 1 | 1 | | | 1 | 1 |
| *XC* in Neritic-Littoral | | | 2 | | | | 1 | | | | | 1 | | | | 1 | | | | | | | 1 | 1 | 1 | | | 1 | 1 |
| *Actinocyclus octonarius* | 5 | 4 | 6 | 7 | 3 | 4 | 4 | 2 | 5 | 6 | 5 | 3 | 3 | 12 | 4 | 6 | 6 | 15 | 4 | 9 | 9 | 7 | 3 | 4 | 6 | 3 | 5 | 11 | 6 |
| *Actinoptychus senarius* | | 1 | 3 | 6 | 2 | 2 | 1 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | | 2 | 2 | 1 | 3 | 4 | 3 | 4 | 4 | 4 | | 1 | 2 | 1 |
| *Actinoptychus splendes* | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| *Biddilphia pulchella* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Odontella reticulata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Paralia sulcata* | 5 | 3 | | 2 | 2 | 4 | 6 | 2 | 2 | 4 | 7 | 6 | 4 | 9 | 7 | 5 | 6 | 10 | 4 | 8 | 3 | 4 | 2 | 1 | | 2 | 1 | 2 | 3 |
| *Stephanopyxis* spp. | 22 | 8 | 8 | 7 | 7 | 10 | 15 | 13 | 6 | 3 | 1 | 7 | 5 | 4 | 3 | 7 | 4 | 5 | 12 | 12 | 7 | 4 | 9 | 8 | 10 | 2 | 11 | 14 | 11 |
| *Synedra indica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassionema nitzschioides* | 43 | 59 | 50 | 40 | 62 | 38 | 33 | 39 | 42 | 41 | 48 | 43 | 49 | 39 | 40 | 50 | 50 | 40 | 45 | 42 | 37 | 37 | 47 | 52 | 44 | 51 | 38 | 28 | 32 |
| Neritic-Littoral | 83 | 81 | 73 | 68 | 79 | 61 | 67 | 62 | 67 | 71 | 73 | 70 | 68 | 72 | 57 | 72 | 74 | 75 | 70 | 80 | 65 | 57 | 83 | 81 | 71 | 74 | 69 | 65 | 62 |
| *Achnanthes* spp. | | | | | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | | |
| *Amphora* spp. | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | |
| *Arachnoidiscus ehrenbergi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bacillaria paradoxa* | | | | | | | | | | | 1 | | 1 | | | | | | | | 1 | | | | | | | | |
| *Campyloneis grevillei* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cocconeis* spp. | 1 | 1 | 1 | 2 | 1 | 1 | 4 | | | | | 2 | | | | | 1 | | 1 | | 1 | 1 | | | 3 | 1 | | 2 | 1 |
| *Coscinodiscus nitidus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cyclotella striata* | 1 | 2 | 3 | | 2 | 1 | | 4 | | 1 | 2 | 2 | 1 | 4 | 8 | 3 | 4 | 2 | 6 | 2 | 9 | 8 | 6 | 6 | 8 | 5 | 4 | | |
| *Cymatosira lorenziana* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Delphineis margalitalimbata* | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| *Delphineis surirella* | | | 1 | | 1 | 1 | | | | | | | 1 | | | | 1 | 2 | | 1 | | | 1 | | 1 | 2 | 2 | 2 | 3 |
| *Diploneis* spp. | | | | | | | | | | 1 | | | | | | 1 | 1 | | | | | | | | 2 | | 2 | 1 | 2 |
| *Ditylum brightwellii* | | 2 | 8 | 5 | 4 | 4 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 1 | 4 | 4 | 2 | 2 | 3 | 1 | 4 | 1 | 5 | 2 | | 5 | 6 | 4 | 10 |
| *Grammatophora* spp. | 1 | | 1 | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | | |
| *Gyrosigma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | |
| *Hyalodiscus* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula cancellata* | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| *Navicula elginenesis* | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| *Navicula finmarchia* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula mutica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia compressa* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia constricta* | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia granulata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia littoralis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Opephora* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Plagiogramma* spp. | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | |
| *Pleurosigma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhabdonema arcuatum* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhaphoneis amphiceros* | | | | | | | | | | | | | | 1 | | | | | | | | | 1 | | | 1 | 1 | | |
| *Rhoicosphenia curvata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhopalodia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Stauroneis* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Surirella* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Synedra undulata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira lacustris* | | | | | | | | | 1 | 2 | | | | 1 | | | | 1 | | | | 1 | | | | | | | |
| *Trachyneis antillarum* | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Trachyneis aspera* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Triceratium* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Littoral | 3 | 5 | 15 | 7 | 8 | 8 | 8 | 6 | 4 | 6 | 5 | 7 | 6 | 8 | 12 | 9 | 9 | 9 | 11 | 4 | 15 | 12 | 13 | 9 | 14 | 15 | 15 | 10 | 16 |
| *Aulacosira* spp. | | | | | | | | | | | | | | | | | 2 | 1 | | | | | | | | 1 | | 1 | |
| *Cyclotella* spp. | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | 1 | | | |
| *Cymbella* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Epithemia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Eunotia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Fragilaria* spp. | | | | | | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | |
| *Gomphonema* spp. | | | | | | | | | | | | | | | | | | | 2 | | | 1 | | | | | | | |
| *Meridion circulare* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Neidium iridis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pinnularia* spp. | | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | 1 | | | | | | | |
| *Stephanodiscus* spp. | | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | 1 |
| *Tabellaria* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Freshwater | | | | | | 2 | | | 1 | | | | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | | | | 2 | | 1 | 1 |
| *Actinocyclus ingens* | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Actinocyclus oculatus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Crucidenticula nicobarica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Denticulopsis* spp. | | | | | | 1 | | | | | | 1 | | | | 1 | | | | | | | | | | | | | |
| *Goniothecium tenue* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Kiesellavia carina* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Melosira albicans* | | | | | | 1 | | 2 | | | | | | | 2 | 2 | | | 2 | 1 | | 1 | | | | | 1 | 2 | 2 |
| *Neodenticula kamtschatica* | | | 1 | 1 | 1 | 1 | | | | | | | | | | | | 1 | | | | | | | | | | | |
| *Neodenticula koizumii* | | | | | | | | | | | | | | | 1 | | | | | | 1 | | | | | 1 | | | |
| *Nitzschia reinholdii* | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | 1 | |
| *Proboscia curvirostris* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pseudopodosira elegans* | | | | | | | | | | | | | 1 | | | | | | | | | 1 | | | | | | 1 | |
| *Pyxidicula zabelinae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia matutamae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia miocenica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rouxia* spp. | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | |
| *Synedra jouseana* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassionema schraderi* | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| *Thalassiosira antiqua* | | | | | | | | | 1 | | | 1 | | | | | | | | | | | | | | | | | |
| *Thalassiosira jacksonii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira nidulus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira temperi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Extinct | | 1 | 1 | 1 | 1 | 3 | | 2 | 1 | | | 2 | 3 | | 3 | 3 | | 1 | 2 | 1 | 2 | 2 | | | | 1 | 1 | 4 | 2 |
| Total valves counted | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |

Table 1: (continued)

| Core | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm) | 490.25 | 500.25 | 510.25 | 520.25 | 530.25 | 540.25 | 550.25 | 560.25 | 570.25 | 580.25 | 590.25 | 600.25 | 610.25 | 620.25 | 630.25 | 640.25 | 650.25 | 660.25 | 670.25 | 680.25 | 690.25 | 700.25 | 710.25 | 720.25 | 730.25 | 740.25 | 750.25 | 760.25 | 770.25 |
| Total depth (cm) | 500.25 | 520.25 | 520.25 | 530.25 | 540.25 | 550.25 | 560.25 | 570.25 | 580.25 | 590.25 | 600.25 | 610.25 | 620.25 | 630.25 | 640.25 | 650.25 | 660.25 | 670.25 | 680.25 | 690.25 | 700.25 | 710.25 | 720.25 | 730.25 | 740.25 | 750.25 | 760.25 | 770.25 | 780.25 |
| Age (cal kyr BP) | 77.90 | 80.15 | 82.41 | 84.67 | 86.93 | 89.21 | 91.51 | 93.81 | 96.11 | 98.41 | 100.71 | 103.10 | 105.31 | 107.61 | 109.91 | 112.21 | 114.51 | 116.81 | 119.11 | 121.41 | 123.71 | 126.01 | 128.31 | 130.61 | 132.91 | 135.21 | 137.51 | 139.81 | 142.11 |
| Diatom number ($10^7$/g) | 4.85 | 5.82 | 6.85 | 7.28 | 3.95 | 1.18 | 2.01 | 2.65 | 4.48 | 5.29 | 5.82 | 5.06 | 6.13 | 3.33 | 4.48 | 4.02 | 6.85 | 7.77 | 8.63 | 4.85 | 6.66 | 2.65 | 7.77 | 1.89 | 3.82 | 3.43 | 3.88 | 4.96 | 2.95 |
| *Actinocyclus ellipticus* | 1 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| *Actinocyclus elongatus* | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | |
| *Alveus marinus* | 8 | 6 | 7 | 3 | 3 | 1 | 3 | 1 | 7 | 3 | 4 | 6 | 7 | 5 | 4 | 4 | 5 | 4 | 4 | 3 | 3 | 7 | 5 | 4 | 4 | 1 | 4 | 2 | 3 |
| *Asterolampra marylandica* | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Asteromphalus arachne* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Asteromphalus flabellatus* | | | | 2 | | | | 1 | 1 | | | 1 | | 2 | | | | 1 | | | | | 1 | | 1 | 2 | 2 | | 1 |
| *Azpeitia africana* | | | | | | | | | | | | | | | 1 | | | | 1 | 1 | 1 | | | 1 | | | | | 1 |
| *Azpeitia nodulifera* | 2 | 5 | 3 | 3 | | | 5 | 4 | 6 | 4 | 3 | 3 | 2 | 2 | 1 | | 1 | | | | 1 | 2 | 4 | 12 | 9 | 7 | 8 | 5 | 8 |
| *Azpeitia tabularia* | 8 | 7 | 5 | 9 | 13 | 9 | 12 | 4 | 8 | 4 | 10 | 11 | 10 | 8 | 21 | 14 | 11 | 10 | 9 | 9 | 9 | 7 | 3 | 4 | 1 | 4 | 1 | 3 | 3 |
| *Fragilariopsis doliolus* | 3 | 3 | 4 | 4 | 3 | | 2 | 2 | | 1 | 1 | 2 | 1 | 1 | 1 | | 1 | 3 | 4 | 13 | 24 | 4 | 24 | 2 | 5 | 2 | 2 | 3 | 4 |
| *Hemidiscus cuneiformis* | | | 2 | 1 | | | | 1 | 2 | | 1 | 1 | | | 1 | | | | | | | 1 | | 2 | | 1 | | 2 | |
| *Nitzschia interruptestriata* | 1 | | 1 | | 3 | 1 | 1 | 4 | | 1 | | 4 | 3 | | 2 | 5 | 1 | 2 | 3 | 1 | 6 | 2 | 5 | 4 | 1 | 5 | 4 | 1 | |
| *Nitzschia kolaczekii* | 3 | 1 | 1 | 3 | 2 | 2 | | 1 | 1 | 2 | 1 | | 1 | 1 | 2 | 1 | | | | | 1 | 1 | 1 | | 1 | | | 1 | |
| *Planktoniella sol* | | | 2 | | | | | 2 | | | | | | | | | | | | | 1 | | 1 | | 2 | | 2 | | |
| *Pseudosolenia calcar-avis* | | | | | | | | 1 | | | | | | 1 | | | | | 1 | 1 | | | 3 | | 1 | | | | 1 |
| *Rhizosolenia acuminata* | | | | | | | | | | 1 | | | | | | | | 2 | | | | 2 | | | | 1 | | | 1 |
| *Rhizosolenia bergonii* | 1 | | 1 | 2 | | | | 1 | | 4 | 5 | 1 | 1 | 4 | | | | 1 | 1 | 2 | 2 | 3 | | 2 | 1 | | 1 | 2 | |
| *Rhizosolenia imbricata* | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | | | 1 | 1 | | 1 |
| *Roperia tesselata* | | 8 | 6 | 8 | 2 | | | 4 | 5 | 4 | 4 | 3 | 6 | 5 | | | 7 | 3 | 3 | 5 | 5 | 2 | 7 | 2 | 4 | 1 | 3 | 2 | 3 |
| *Thalassiosira leptopus* | | 1 | | | | | 1 | | 1 | | 1 | | 1 | | 1 | | | | 1 | | 2 | 1 | | | | 1 | 2 | | |
| *Thalassiosira oestrupii* | 21 | 14 | 31 | 22 | 13 | 6 | 12 | 17 | 14 | 11 | 23 | 11 | 4 | 14 | 9 | 9 | 35 | 50 | 27 | 19 | 20 | 23 | 53 | 17 | 18 | 19 | 16 | 25 | 21 |
| *Xw* + *XW* | 49 | 45 | 63 | 57 | 40 | 20 | 36 | 43 | 46 | 35 | 53 | 43 | 36 | 43 | 43 | 33 | 61 | 76 | 54 | 55 | 75 | 55 | 107 | 50 | 48 | 45 | 46 | 46 | 47 |
| *Actinocyclus curvatulus* | 3 | 2 | 5 | 1 | 4 | 2 | 4 | 4 | 2 | 2 | 4 | 4 | 9 | 6 | 3 | 5 | 1 | 1 | 4 | | 1 | 1 | 5 | | 2 | 3 | 1 | | 3 |
| *Actinocyclus ochotensis* | | | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 3 | | 1 | 1 | | 1 | | 1 | | | 2 | | | | | 1 |
| *Asteromphalus robustus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bacterosira fragilis* | 3 | 1 | | 5 | 8 | | 3 | 1 | | 3 | | 2 | 3 | 3 | 1 | 3 | | 3 | | | 1 | | 1 | | 2 | | | | |
| *Chaetoceros furcellatus* | 1 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | |
| *Coscinodiscus marginatus* | 7 | 6 | 12 | 3 | 5 | 8 | 3 | 6 | 11 | 17 | 12 | 14 | 11 | 12 | 7 | 9 | 12 | 13 | 15 | 14 | 10 | 24 | 13 | 21 | 18 | 19 | 19 | 15 | 31 |
| *Coscinodiscus oculus-iridis* | 7 | 2 | 2 | | 1 | 1 | 1 | 2 | 6 | 3 | 3 | | 2 | 1 | 2 | 1 | | 5 | 1 | | 2 | 5 | 1 | 1 | 6 | 2 | 1 | 1 | 4 |
| *Fragilariopsis cylindrus* | 2 | | | 2 | | 6 | 3 | | | | | 1 | | 1 | 3 | 1 | 2 | | | | | | | | 1 | | | | |
| *Fragilariopsis oceanica* | 4 | 10 | 8 | 6 | 7 | 1 | 4 | 6 | 2 | 3 | 1 | 3 | 3 | 2 | 6 | 9 | 6 | | | | | 3 | 2 | 2 | 1 | 4 | | 3 | 2 |
| *Neodenticula seminae* | 3 | 4 | 7 | 3 | 3 | 3 | 5 | 2 | 3 | 8 | 5 | 9 | 5 | 6 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 | | 5 | 11 | 4 | 8 | 13 | 8 |
| *Porosira glacilis* | | 1 | | 1 | | 2 | | | 1 | | | 2 | | | | | | 1 | | | | | | | | | | 1 | |
| *Rhizosolenia hevetata* f. *hiemalis* | 2 | | | | 1 | | | | | | 2 | 2 | | | 2 | 2 | | 2 | | | | | 2 | | | 1 | 1 | | 2 |
| *Thalassiosira gravida* | 5 | 6 | 2 | 6 | 13 | | 16 | 8 | 6 | 9 | 2 | 1 | 3 | 4 | 9 | 9 | 7 | 5 | 1 | 3 | 2 | 5 | 8 | 8 | 7 | 6 | 8 | 2 | 1 |
| *Thalassiosira hyalina* | | 1 | | 3 | | 5 | | 1 | | | | | | | | | | | | | 1 | | | | | | | | |
| *Thalassiosira nordenskioldii* | | | 2 | 5 | 5 | 30 | | 1 | 2 | 5 | 2 | 2 | 1 | 2 | | | | | | 1 | | | | 2 | | | | | |
| *Thalassiosira trifulta* | 4 | 3 | 3 | 2 | 2 | 1 | 1 | 8 | 3 | 5 | 2 | 9 | 5 | 7 | 10 | 7 | 2 | 7 | 1 | 1 | | 6 | 2 | 4 | 4 | 3 | 3 | 2 | 2 |
| *Xc* + *XC* | 41 | 37 | 42 | 37 | 51 | 60 | 40 | 40 | 37 | 56 | 34 | 50 | 42 | 47 | 45 | 49 | 32 | 38 | 24 | 22 | 21 | 47 | 34 | 45 | 53 | 42 | 42 | 37 | 54 |
| *Td'* values | 54.4 | 54.9 | 60.0 | 60.6 | 44.0 | 25.0 | 47.4 | 51.8 | 55.4 | 38.5 | 60.9 | 46.2 | 46.2 | 47.8 | 48.9 | 40.2 | 65.6 | 66.7 | 69.2 | 71.4 | 78.1 | 53.9 | 75.9 | 52.6 | 47.5 | 51.7 | 52.3 | 55.4 | 46.5 |
| *Asteromphalus* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Coscinodiscus centrais* | | | 1 | | | | | | | | | | | | | | 1 | | | 1 | | 5 | | 5 | 2 | 5 | 7 | 3 | 1 |
| *Coscinodiscus obscurus* | 2 | 1 | 1 | | | 1 | | 1 | 1 | | | | | 3 | | | | | 2 | | | 1 | | 1 | 1 | 3 | | | |
| *Coscinodiscus radiatus* | | | | | | | 1 | | | | | | | | | | | | | | | 1 | | | | | | | |
| *Coscinodiscus wailesii* | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | 5 | 14 | 5 | 3 | 2 | 8 |
| *Nitzschia bicapitata* | 1 | | | | 1 | 4 | | | 1 | 1 | 3 | 3 | 1 | 1 | | 1 | | 2 | | 1 | 3 | | 3 | | | | | 1 | |
| *Nitzschia capaluspalae* | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia sicula* | 2 | 2 | 1 | 3 | 3 | 5 | 3 | | 1 | 4 | 1 | 5 | 3 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 2 |
| *Proboscia alata* | | 1 | | 1 | | 2 | | | | | | | 1 | | 1 | | | | | 1 | 1 | | 1 | | | | | | |
| *Rhizosolenia setigera* | | 2 | 2 | | 1 | 2 | 1 | | 1 | 1 | 4 | 1 | 2 | | 1 | 3 | | | | 2 | 1 | 4 | | 1 | | | 1 | 5 | 4 |
| *Rhizosolenia styliformis* | 2 | 10 | 4 | 4 | 11 | 4 | 2 | 2 | 4 | 3 | 4 | 8 | 10 | 4 | 6 | 3 | 3 | 2 | 5 | 12 | 6 | 4 | 2 | 4 | 2 | 2 | 5 | 4 | 8 |
| *Stellarima stellaria* | 5 | 1 | 4 | 5 | 3 | 1 | 2 | 5 | 2 | 2 | 3 | 2 | 5 | 1 | 2 | 2 | 6 | | | | | 1 | | | | | | | |
| *Thalassiosira decipiens* | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | |
| *Thalassiosira eccentrica* | 9 | 9 | 3 | 10 | 3 | 4 | 6 | 3 | 12 | 14 | 11 | 9 | 8 | 12 | 10 | 8 | 15 | 4 | 5 | 6 | 4 | 6 | 3 | 5 | 3 | 2 | 2 | 5 | 3 |
| *Thalassiosira ferelineata* | 3 | 2 | 2 | 3 | 2 | 3 | | 1 | 1 | 2 | 2 | 3 | 1 | | 4 | | 1 | | | 3 | 2 | 1 | 2 | 1 | 1 | | | 2 | |
| *Thalassiosira gravida* v. | 1 | 1 | | | | 2 | | 1 | | | | | | 2 | 1 | 2 | | | | | | | | | | | 1 | | |
| *Thalassiosira lineata* | 2 | 1 | 4 | 2 | 4 | 19 | 6 | 3 | 12 | 2 | 7 | 3 | 9 | 7 | 7 | 8 | 5 | 14 | 13 | 10 | 6 | 5 | 4 | 2 | 4 | 3 | | 2 | 1 |
| *Thalassiosira pacifica* | | 1 | 2 | | | 1 | 1 | 5 | | | 2 | | | | 2 | 3 | | 2 | | 2 | 2 | 2 | 2 | | | | | 1 | |
| *Thalassiosira subtilis* | | | | | | 1 | | 1 | 1 | | 1 | | | | | 1 | | | 2 | | 1 | | | | | | | 1 | |
| *Thalassiosira* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiothrix frauenfeldii* | 5 | 4 | 7 | 5 | 3 | 1 | 6 | 2 | 2 | 4 | | 3 | 2 | 4 | 1 | 5 | 1 | | 1 | 2 | 3 | 1 | | | 3 | | 2 | 1 | |
| *Thalassiothrix longissima* | 14 | 15 | 10 | 4 | 12 | 6 | 6 | 4 | 9 | 5 | 3 | 7 | 8 | 5 | 8 | 7 | 4 | 4 | 5 | 6 | 3 | 12 | 3 | 7 | 2 | 1 | 8 | 3 | 8 |
| Oceanic | 136 | 133 | 147 | 131 | 134 | 136 | 110 | 111 | 130 | 129 | 128 | 137 | 128 | 130 | 132 | 128 | 131 | 144 | 113 | 125 | 129 | 148 | 163 | 127 | 134 | 109 | 120 | 116 | 136 |
| *Cyclotella styroleum* | 2 | 1 | 2 | 1 | 1 | | 1 | 4 | 1 | 1 | | 1 | | | 1 | | 1 | | 1 | 2 | 1 | 2 | | 1 | 1 | | 3 | | |
| *Cymatotheca weissflogii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Hemiaulus sienesis* | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | |
| *Mastogloia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Odontella longicruris* | | 1 | 1 | | | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| *Odontella sinensis* | | | | | | | | | | | | | | | | | 1 | | | 1 | | | | | 1 | | | | |
| *Thalassionema nitzschioides* v. *parva* | 7 | 1 | 6 | 9 | 5 | 2 | 4 | 4 | 9 | 7 | 4 | 6 | 5 | 8 | 1 | 4 | 6 | 2 | 6 | 6 | 1 | | 2 | 1 | 1 | 4 | 2 | 4 | 2 |
| *XW* in Neritic-Littoral | 9 | 3 | 9 | 10 | 6 | 2 | 6 | 8 | 10 | 8 | 5 | 7 | 5 | 8 | 2 | 4 | 8 | 2 | 7 | 9 | 2 | 2 | 2 | 2 | 3 | 4 | 5 | 4 | 2 |
| *Odontella aurita* | | | | | 1 | | | 1 | 1 | 1 | | | | 1 | 3 | | | | | | | | | | | | | | |
| *XC* in Neritic-Littoral | | | | | 1 | | | 1 | 1 | 1 | | | | 1 | 3 | | | | | | | | | | | | | | |
| *Actinocyclus octonarius* | 6 | 8 | 5 | 5 | 4 | 2 | 5 | 6 | 7 | 5 | 4 | 2 | 4 | 7 | 4 | 5 | 3 | | 2 | 2 | 7 | 8 | 1 | 9 | 10 | 10 | 19 | 11 | 3 |
| *Actinoptychus senarius* | | 6 | 4 | 1 | | | | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 8 | 1 | 5 | 2 | 2 | 4 | 2 | 3 | 1 | 7 | 1 | 6 | 7 |
| *Actinoptychus splendes* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Biddilphia pulchella* | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | |
| *Odontella reticulata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Paralia sulcata* | 5 | 3 | 3 | 10 | 8 | 4 | 7 | 4 | | 3 | 3 | | 4 | 6 | 1 | 6 | 6 | 6 | 5 | 16 | 9 | 3 | 2 | 4 | | 1 | 1 | | 1 |
| *Stephanopyxis* spp. | 13 | 10 | 5 | 4 | 10 | | 6 | 6 | 3 | 7 | 14 | 7 | 8 | 8 | 12 | 10 | 4 | 3 | 2 | 3 | 4 | 2 | 4 | 8 | 5 | 6 | 6 | 8 | 3 |
| *Synedra indica* | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Thalassionema nitzschioides* | 21 | 25 | 21 | 28 | 20 | 28 | 33 | 32 | 41 | 30 | 35 | 31 | 30 | 31 | 37 | 28 | 30 | 33 | 50 | 31 | 35 | 27 | 20 | 37 | 41 | 48 | 38 | 43 | 42 |
| Neritic-Littoral | 54 | 55 | 47 | 58 | 49 | 36 | 57 | 59 | 65 | 56 | 64 | 49 | 54 | 62 | 60 | 56 | 59 | 45 | 71 | 64 | 59 | 46 | 32 | 63 | 60 | 76 | 70 | 72 | 58 |
| *Achnanthes* spp. | 1 | | | | 1 | | 3 | 1 | | | | | | | | 1 | | | | | 1 | | | 1 | | 1 | | | |
| *Amphora* spp. | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| *Arachnoidiscus ehrenbergi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Bacillaria paradoxa* | | | | | | 1 | 1 | | | | | | | | | 1 | | | | | 1 | | | | | | | 1 | |
| *Campyloneis grevillei* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cocconeis* spp. | | 1 | | | 1 | | 2 | 3 | | | | 1 | 2 | | 2 | 1 | | 1 | 1 | | | | | | | 6 | 1 | 2 | 1 |
| *Coscinodiscus nitidus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Cyclotella striata* | | | 1 | 1 | | 4 | 1 | 3 | | 1 | | 1 | | 2 | | 1 | | | 1 | 1 | 3 | | 2 | 1 | | 1 | 1 | 3 | 2 |
| *Cymatosira lorenziana* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Delphineis margalitalimbata* | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| *Delphineis surirella* | 2 | 1 | | 2 | 3 | 1 | 6 | 1 | | | 1 | | 4 | | 1 | 2 | 1 | | 4 | 2 | 3 | 2 | | | | | 2 | | |
| *Diploneis* spp. | 1 | 2 | 1 | 1 | 2 | | 5 | 6 | | | 1 | 1 | 4 | 2 | | 5 | 3 | 2 | 2 | 1 | | | | | | | 1 | | |
| *Ditylum brightwellii* | 1 | 3 | 1 | 4 | 2 | 1 | 6 | 6 | 3 | 6 | 2 | 1 | 3 | 1 | 1 | | 2 | 4 | 5 | 4 | 3 | 1 | 2 | 3 | 2 | 5 | 2 | 1 | 1 |
| *Grammatophora* spp. | | 1 | | | | | 1 | | 1 | | | | | | | | | | | | | 1 | | 1 | | | 2 | | |
| *Gyrosigma* spp. | | | | | | 1 | 1 | | | | | 2 | | | | | | | | | | | | | | | | 1 | |
| *Hyalodiscus* spp. | 1 | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | |
| *Navicula cancellata* | | | | | | 2 | | | | | | 1 | | | | | | | | | | | | | | | | | |
| *Navicula elginenesis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula finmarchia* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula mutica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Navicula* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia compressa* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia constricta* | | | | | 2 | | | 1 | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia granulata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia littoralis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Opephora* spp. | | | | | | 1 | | | | | | | | | | | | | 1 | | | | | | | | | | |
| *Plagiogramma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pleurosigma* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhabdonema arcuatum* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhaphoneis amphiceros* | 2 | 1 | 1 | | 3 | | | 2 | | | 1 | 2 | 1 | 1 | | | | | | | | | | | | | | 1 | |
| *Rhoicosphenia curvata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhopalodia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Stauroneis* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Surirella* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Synedra undulata* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira lacustris* | | 1 | 1 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trachyneis antillarum* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trachyneis aspera* | | | | | | | | | | | | | | | | | | 1 | | 2 | | | | | 1 | | | | |
| *Triceratium* spp. | | | 1 | | | | | 1 | 1 | | | | | | 1 | | | | | | | | | | | | | | |
| Littoral | 8 | 11 | 6 | 8 | 15 | 11 | 26 | 24 | 5 | 7 | 5 | 9 | 14 | 6 | 5 | 11 | 7 | 8 | 14 | 10 | 11 | 4 | 4 | 7 | 3 | 13 | 9 | 10 | 4 |
| *Aulacosira* spp. | 1 | | | | | 3 | | | | | | | | | | 2 | | | | | | | | | | | | | |
| *Cyclotella* spp. | 1 | | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | | 2 |
| *Cymbella* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Epithemia* spp. | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| *Eunotia* spp. | | | | | | | | | | | | | 1 | | | | | | | | | | | | 1 | | | | |
| *Fragilaria* spp. | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | |
| *Gomphonema* spp. | | 1 | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| *Meridion circulare* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Neidium iridis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pinnularia* spp. | | | | | | | | 1 | | | | | | | | | 1 | | | | | | | | | | | | |
| *Stephanodiscus* spp. | | | | | | 5 | 1 | | | | | | 1 | | | | 1 | 1 | | | | | | | | | | | |
| *Tabellaria* spp. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Freshwater | 2 | 1 | | | | 10 | 2 | 1 | | | | | 3 | | 1 | 2 | 2 | 1 | | | | | | | 1 | | | | 2 |
| *Actinocyclus ingens* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Actinocyclus oculatus* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Crucidenticula nicobarica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Denticulopsis* spp. | | | | | | | | | | 1 | | | | 1 | | | | | | | | 1 | | | 1 | 1 | | | |
| *Goniothecium tenue* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Kiesellavia carina* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Melosira albicans* | | | | 2 | | 7 | 2 | 3 | | 4 | 3 | 4 | | | 1 | 2 | | 1 | 1 | 1 | 1 | 1 | | 1 | | | | 2 | |
| *Neodenticula kamtschatica* | | | | | 1 | | 1 | 1 | | | | 1 | | | 1 | 1 | 1 | | | | | | | 2 | | 1 | | | |
| *Neodenticula koizumii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Nitzschia reinholdii* | | | | | | | | | | 2 | | | | | | | | | | | | | | | | | | | |
| *Proboscia curvirostris* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pseudopodosira elegans* | | | | 1 | 1 | | 1 | | | 1 | | | | 1 | | | | | 1 | | | | 1 | | | | | | |
| *Pyxidicula zabelinae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia matutamae* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia miocenica* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rouxia* spp. | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| *Synedra jouseana* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassionema schraderi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira antiqua* | | | | | | | 1 | 1 | | | | | 1 | | | | | 1 | | | | | | | | | | | |
| *Thalassiosira jacksonii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira nidulus* | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| *Thalassiosira temperi* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Extinct | | | | 3 | 2 | 7 | 5 | 5 | | 8 | 3 | 5 | 1 | 2 | 2 | 3 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 | 1 | 2 | |
| Total valves counted | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 619 | 200 | 200 | 200 | 200 | 200 | 200 |

Table 1: (continued)

| Core | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm) | 780.25 | 790.25 | 800.25 | 810.25 | 820.25 | 830.25 | 840.25 | 850.25 | 860.25 | 870.25 | 880.25 | 890.25 | 900.25 | 910.25 | 920.25 | 930.25 | 940.25 | 950.25 | 960.25 |
| Total depth (cm) | 790.25 | 800.25 | 810.25 | 820.25 | 830.25 | 840.25 | 850.25 | 860.25 | 870.25 | 880.25 | 890.25 | 900.25 | 910.25 | 920.25 | 930.25 | 940.25 | 950.25 | 960.25 | 970.25 |
| Age (cal kyr BP) | 144.41 | 146.71 | 149.01 | 151.31 | 153.61 | 155.91 | 158.21 | 160.51 | 162.81 | 165.11 | 167.41 | 169.71 | 172.01 | 174.31 | 176.61 | 178.91 | 181.21 | 183.51 | 185.81 |
| Diatom number ($10^7$/g) | 2.59 | 4.16 | 6.13 | 5.29 | 3.53 | 3.53 | 2.65 | 2.65 | 3.64 | 4.66 | 3.70 | 3.88 | 6.13 | 7.28 | 7.28 | 5.06 | 5.29 | 4.57 | 3.76 |
| *Actinocyclus ellipticus* | | | | | | | 1 | | | | | | | | | | | | |
| *Actinocyclus elongatus* | | | | | | | | | | | | | | | | | | | |
| *Alveus marinus* | | 3 | 4 | 2 | 3 | 2 | 2 | 2 | 5 | 9 | 3 | 2 | 5 | 3 | 3 | 2 | 3 | 3 | 2 |
| *Asterolampra marylandica* | | | | | | | | | | | | | | 1 | | | | | |
| *Asteromphalus arachne* | | | | | | 1 | | 1 | | | | | | | | | | | |
| *Asteromphalus flabellatus* | | | | | | | 1 | | | | 1 | 1 | | | | | | | |
| *Azpeitia africana* | | | 1 | | 1 | | | | | | | | | 1 | | | 1 | 1 | |
| *Azpeitia nodulifera* | 3 | 2 | 3 | 3 | 4 | 2 | 2 | 2 | 2 | 5 | 2 | 3 | | 1 | | 1 | | 1 | 3 |
| *Azpeitia tabularia* | 5 | 7 | 2 | 3 | 1 | 3 | 4 | 5 | 5 | 2 | 2 | 4 | 2 | 7 | 8 | 7 | 4 | 2 | 3 |
| *Fragilariopsis doliolus* | 4 | 3 | 1 | 3 | | 1 | 4 | 3 | | 2 | 2 | 1 | 2 | 1 | 4 | 5 | 5 | 5 | 1 |
| *Hemidiscus cuneiformis* | 1 | | | | 3 | | | | 2 | | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | |
| *Nitzschia interruptestriata* | 1 | 1 | 2 | 2 | 3 | 4 | 2 | 3 | 6 | 2 | 3 | 3 | 5 | 4 | 3 | 2 | 2 | 1 | 4 |
| *Nitzschia kolaczekii* | | 1 | 1 | | 2 | | 1 | 1 | 1 | 1 | | | | 1 | 1 | 2 | 1 | 1 | 1 |
| *Planktoniella sol* | | | | 1 | | 4 | 1 | 2 | 3 | 1 | | | | | | | | | |
| *Pseudosolenia calcar-avis* | | | | | | | | | | | 1 | | | | 1 | 10 | 11 | 1 | |
| *Rhizosolenia acuminata* | | | | | | | | | | | | | | | | | | | 1 |
| *Rhizosolenia bergonii* | 1 | 2 | | 1 | | 1 | | 1 | 1 | | 1 | 3 | 1 | | 1 | 2 | 1 | | 1 |
| *Rhizosolenia imbricata* | 1 | | | | | | 1 | 1 | 1 | | 1 | 3 | | 1 | | | | 1 | |
| *Roperia tesselata* | 2 | | 2 | 2 | 2 | 2 | 2 | | 2 | 3 | 1 | 1 | | 1 | 2 | 1 | 6 | 2 | 4 |
| *Thalassiosira leptopus* | | | | 3 | | 1 | | | | | | | | 1 | 2 | | | | |
| *Thalassiosira oestrupii* | 22 | 10 | 5 | 12 | 12 | 14 | 10 | 15 | 19 | 13 | 11 | 9 | 9 | 7 | 9 | 9 | 10 | 22 | 8 |
| *Xw* + *XW* | 40 | 29 | 21 | 32 | 31 | 35 | 31 | 36 | 47 | 38 | 29 | 33 | 25 | 30 | 35 | 42 | 46 | 41 | 28 |
| *Actinocyclus curvatulus* | 1 | 1 | 2 | 3 | 2 | | | 2 | 1 | 5 | 3 | 1 | 1 | 1 | | 3 | 1 | | 1 |
| *Actinocyclus ochotensis* | | 2 | | | | 2 | | | | | | | | | | | | 1 | |
| *Asteromphalus robustus* | | | | | | | | | | | | | | | | | | | |
| *Bacterosira fragilis* | | 1 | 2 | | 2 | 1 | | | | 1 | | 1 | 2 | | 1 | | | 1 | |
| *Chaetoceros furcellatus* | | | | | | | 1 | | | | | | | | | | | | |
| *Coscinodiscus marginatus* | 23 | 20 | 20 | 17 | 24 | 32 | 19 | 24 | 13 | 27 | 29 | 24 | 25 | 26 | 17 | 20 | 29 | 13 | 28 |
| *Coscinodiscus oculus-iridis* | 4 | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 3 | 6 | 4 | 1 | 1 | | 7 | 4 | 3 | 1 | 5 |
| *Fragilariopsis cylindrus* | | | | | | | 1 | | | | | | | | 1 | 1 | 1 | | 1 |
| *Fragilariopsis oceanica* | 2 | | 1 | 1 | 2 | 2 | 4 | 1 | | | 2 | | 3 | 2 | 2 | 6 | 2 | 9 | 1 |
| *Neodenticula seminae* | 9 | 4 | 11 | 5 | 7 | 10 | 6 | 8 | 7 | 10 | 8 | 17 | 29 | 38 | 12 | 8 | 15 | 10 | 9 |
| *Porosira glacilis* | | | | | | | 1 | | | | 7 | | | | 2 | | | | 1 |
| *Rhizosolenia hevetata* f. *hiemalis* | 2 | | 1 | | 2 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | | 1 | | | | 1 | 3 |
| *Thalassiosira gravida* | 1 | 6 | 9 | 2 | 7 | 10 | 5 | 7 | 7 | 3 | 1 | 12 | 3 | 4 | 4 | 3 | 1 | 3 | 2 |
| *Thalassiosira hyalina* | | | | | | | | 2 | | | 1 | | 1 | | | | | | |
| *Thalassiosira nordenskioldii* | 1 | 1 | 1 | | 3 | | 2 | | 1 | 2 | 2 | 2 | 1 | 1 | 3 | | 3 | 2 | 3 |
| *Thalassiosira trifulta* | 5 | 1 | 4 | 3 | 6 | 10 | 4 | 3 | 1 | 3 | 7 | 3 | 4 | 4 | 5 | 5 | 7 | 4 | 3 |
| *Xc* + *XC* | 48 | 37 | 53 | 33 | 57 | 70 | 46 | 53 | 35 | 58 | 66 | 62 | 70 | 77 | 54 | 50 | 62 | 45 | 57 |
| *Td'* values | 45.5 | 43.9 | 28.4 | 49.2 | 35.2 | 33.3 | 40.3 | 40.4 | 57.3 | 39.6 | 30.5 | 34.7 | 26.3 | 28.0 | 39.3 | 45.7 | 42.6 | 47.7 | 32.9 |
| *Asteromphalus* spp. | | | | | | | | | | | | | | | | 2 | | | |
| *Coscinodiscus centrais* | 1 | 1 | 1 | 1 | 2 | 3 | 5 | 1 | 1 | 1 | 1 | 1 | | | | 1 | | | 1 |
| *Coscinodiscus obscurus* | | | | 1 | | | | | | | | | | | 1 | | | | |
| *Coscinodiscus radiatus* | | | | | | | | | | | | | | | 1 | | | | |
| *Coscinodiscus wailesii* | 9 | 3 | 2 | 4 | 4 | 3 | 3 | 3 | 1 | 1 | 2 | | 1 | 1 | 2 | 1 | | | 3 |
| *Nitzschia bicapitata* | 2 | | | 2 | | | 1 | | 2 | | | | 1 | 1 | | 1 | | 1 | 1 |
| *Nitzschia capaluspalae* | | | 1 | 2 | | 1 | | | | 1 | | | | | | | | | |
| *Nitzschia sicula* | 2 | | 2 | 2 | 1 | 4 | 2 | 3 | 2 | 2 | 5 | 2 | 3 | 4 | 1 | 5 | | 1 | 1 |
| *Proboscia alata* | | 1 | | | 1 | | 2 | | | | | | | | | | 1 | 1 | |
| *Rhizosolenia setigera* | 2 | 1 | 1 | 2 | 1 | 3 | 1 | 1 | | 2 | 3 | 1 | 5 | 4 | 2 | | 2 | 1 | 2 |
| *Rhizosolenia styliformis* | 5 | 5 | 5 | 2 | 5 | 5 | 6 | 6 | 4 | 2 | 9 | 9 | 1 | 2 | 2 | 4 | 4 | 7 | 2 |
| *Stellarima stellaria* | 1 | 1 | | | 1 | 1 | 2 | | | | | | | | 1 | | 1 | 2 | |
| *Thalassiosira decipiens* | | | | 1 | | 2 | | | | | | | | | | | | | |
| *Thalassiosira eccentrica* | 3 | 3 | 5 | 3 | 1 | 2 | 2 | 6 | 5 | 12 | 7 | 6 | 5 | 8 | 3 | 5 | 6 | 5 | 8 |
| *Thalassiosira ferelineata* | | | 1 | 1 | 1 | 1 | 2 | 1 | 3 | | | 1 | 1 | 1 | 4 | 2 | 1 | 1 | 3 |
| *Thalassiosira gravida* v. | | | 2 | | | 2 | 3 | | | | | | | | | | 2 | 2 | |
| *Thalassiosira lineata* | 5 | 4 | 4 | 4 | 3 | 5 | 4 | 6 | 2 | 1 | 2 | 6 | 4 | 5 | 8 | 6 | 2 | 4 | |
| *Thalassiosira pacifica* | | 1 | | 2 | 1 | | 1 | 2 | | 1 | 1 | 3 | 1 | 2 | | | 1 | 1 | 4 |
| *Thalassiosira subtilis* | | | | 1 | 2 | | 1 | | | | | | | | 1 | | | | |
| *Thalassiosira* spp. | | | | | | | | | | | 1 | | | | | | | | |
| *Thalassiothrix frauenfeldii* | | 2 | | | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | | 3 |
| *Thalassiothrix longissima* | 7 | 7 | 1 | 6 | 10 | 3 | 4 | 3 | 6 | 4 | 5 | 11 | 5 | 1 | 5 | 7 | 5 | 2 | 6 |
| Oceanic | 125 | 95 | 99 | 99 | 122 | 143 | 119 | 124 | 112 | 126 | 133 | 138 | 124 | 138 | 122 | 128 | 134 | 114 | 119 |
| *Cyclotella styroleum* | 1 | | 1 | 1 | | | | | | | | | | | | | | 2 | 1 |
| *Cymatotheca weissflogii* | | | | | | | | | | | | | | | | | | | |
| *Hemiaulus sienesis* | | | | | | | | | | | | | | | | 1 | | | |
| *Mastogloia* spp. | | | | | | | | | | | | | | 1 | | | | | |
| *Odontella longicruris* | | | | | | | | | | | | | | | | | | | |
| *Odontella sinensis* | | | | | | | | | | | | | | | | | | | |
| *Thalassionema nitzschioides* v. *parva* | | 1 | 3 | 2 | 3 | 3 | 5 | 2 | 4 | 2 | 1 | 5 | 3 | 4 | 6 | 4 | 4 | 4 | 2 |
| *XW* in Neritic-Littoral | 1 | 1 | 4 | 3 | 3 | 3 | 5 | 2 | 4 | 2 | 1 | 5 | 3 | 5 | 6 | 5 | 4 | 4 | 2 |
| *Odontella aurita* | | | | | | | | | | | | | | 2 | | | | | |
| *XC* in Neritic-Littoral | | | | | | | | | | | | | | 2 | | | | | |
| *Actinocyclus octonarius* | 12 | 7 | 8 | 7 | 9 | 11 | 12 | 5 | 6 | 3 | 7 | 4 | 8 | 6 | 3 | 6 | 4 | 2 | 3 |
| *Actinoptychus senarius* | 2 | 5 | 2 | 1 | 1 | 1 | 4 | 4 | 1 | 2 | 2 | 3 | 8 | 1 | 6 | 1 | 4 | 4 | 3 |
| *Actinoptychus splendes* | | | | | | | | | | | | | | | | | | | |
| *Biddilphia pulchella* | | | | | | | | | | | | | | | | | | | |
| *Odontella reticulata* | | | | | | | | | | | | | | | | | | | |
| *Paralia sulcata* | 3 | | 1 | 1 | 1 | 1 | 3 | | 3 | | 1 | 2 | 2 | 1 | 5 | 1 | | | |
| *Stephanopyxis* spp. | 4 | 33 | 35 | 23 | 9 | 7 | 5 | 8 | 9 | 2 | 10 | 4 | 7 | 2 | 6 | 7 | 10 | 13 | 27 |
| *Synedra indica* | | | | | | | | | | | | | | | 1 | | | 1 | |
| *Thalassionema nitzschioides* | 37 | 50 | 36 | 56 | 37 | 22 | 39 | 41 | 59 | 58 | 37 | 34 | 38 | 41 | 45 | 41 | 40 | 53 | 34 |
| Neritic-Littoral | 59 | 96 | 86 | 91 | 60 | 45 | 68 | 60 | 78 | 65 | 58 | 52 | 66 | 58 | 72 | 61 | 62 | 77 | 69 |
| *Achnanthes* spp. | | | | | | 1 | | | | | 1 | | | | | | | | |
| *Amphora* spp. | | | | | 1 | | | 1 | | | | | | | | | 1 | | |
| *Arachnoidiscus ehrenbergi* | | | | | | | | | | | | | | | | | | | |
| *Bacillaria paradoxa* | | | | | | | | | | | | | | | | | | | |
| *Campyloneis grevillei* | | | | | | | | | | | | | | | | | | | |
| *Cocconeis* spp. | | 1 | | | 2 | | 2 | 2 | 2 | | | 1 | 1 | | | | | | 1 |
| *Coscinodiscus nitidus* | | | | | | | | | | | | | | | | | | | |
| *Cyclotella striata* | 5 | | 3 | 1 | 1 | 1 | 1 | | 1 | | 2 | | | 1 | | | 2 | | 4 |
| *Cymatosira lorenziana* | | | | | | | | | | | | | | | | | | | |
| *Delphineis margalitalimbata* | | | | | | | 2 | 1 | | | | | | | | 2 | | | |
| *Delphineis surirella* | 1 | | 1 | 1 | | | 1 | | | | | | 1 | | 2 | | 1 | 1 | 1 |
| *Diploneis* spp. | | | | | 2 | | | 1 | | | | | 1 | | | | | | 3 |
| *Ditylum brightwellii* | 4 | 3 | 8 | 3 | 5 | 3 | 5 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | | 2 | | 1 | 2 |
| *Grammatophora* spp. | 2 | 1 | | | | | | | | | | | | | | | | | |
| *Gyrosigma* spp. | | | | | | | | | | | | | | | | | | | |
| *Hyalodiscus* spp. | | | | | | | | | | | | | | | | | | | |
| *Navicula cancellata* | | | | | | | | | | | | | | | | | | | |
| *Navicula elginenesis* | | | | | | | | | | | | | | | | | | | |
| *Navicula finmarchia* | | | 1 | | | | | | | | | | | | | | | | |
| *Navicula mutica* | | | | | | | | | | | | | | | | | | 1 | |
| *Navicula* spp. | | | | | | | | | | | | | | | | | | | |
| *Nitzschia compressa* | | | | | | | | | | | | | | | | | | | |
| *Nitzschia constricta* | | | | | | | | | | | | | | | | | | | |
| *Nitzschia granulata* | | | | | | | | | | | | | | | | | | | |
| *Nitzschia littoralis* | | | | | | | | | | | | | | | | | | | |
| *Opephora* spp. | | | | | | | | | | | | | | | | | | | |
| *Plagiogramma* spp. | | | | | | | | | | | | | | | | | | | |
| *Pleurosigma* spp. | | | | | | | | | | | | | | | | | | | |
| *Rhabdonema arcuatum* | | | | | | | | 1 | | | | | | | | | | | |
| *Rhaphoneis amphiceros* | | 1 | | | | | | | | | 1 | 1 | 1 | | 2 | 1 | | | |
| *Rhoicosphenia curvata* | | | | | | | | | | | | | | | | | | | |
| *Rhopalodia* spp. | | | | | | 1 | | | | | | | | | | | | | |
| *Stauroneis* spp. | | | | | | | | | | | | | | | | | | | |
| *Surirella* spp. | | | | | | | | | | | | | | | | | | | |
| *Synedra undulata* | | | | 1 | | | | | | | | | | | | | | | |
| *Thalassiosira lacustris* | | | | | | | | | | | | | | | | | | | |
| *Trachyneis antillarum* | | | | | | | | | | | | | | | | | | | |
| *Trachyneis aspera* | | | | | | | | | 1 | | | | | | | | | | |
| *Triceratium* spp. | | | | | | | | | | | | | | | | | | | |
| Littoral | 12 | 6 | 13 | 6 | 11 | 6 | 11 | 9 | 6 | 3 | 6 | 4 | 7 | 4 | 4 | 5 | 4 | 3 | 11 |
| *Aulacosira* spp. | | | 1 | 1 | | | | | | 1 | | | | | | 5 | | | 1 |
| *Cyclotella* spp. | | | | | | | | | | | | | | | | | | | |
| *Cymbella* spp. | | | | | | | | | | | | | | | | | | | |
| *Epithemia* spp. | | | | | | | | | | | | | | | | | | | |
| *Eunotia* spp. | 1 | | | | | 1 | | | | | | 1 | | | | | | | |
| *Fragilaria* spp. | | | | | | | | 2 | | | | | | | | | | | |
| *Gomphonema* spp. | | | | | | | | | | | | | | | | | | | |
| *Meridion circulare* | | | | | | | | | | | | | | | | | | | |
| *Neidium iridis* | | | | | 1 | | | | | | | | | | | | | | |
| *Pinnularia* spp. | | | | | | | | 1 | | | 1 | | 1 | | | | | | |
| *Stephanodiscus* spp. | | | | | | | 1 | | | | | | | | | | | | |
| *Tabellaria* spp. | | | | | | 1 | | | | | | | | | | | | | |
| Freshwater | 1 | | 1 | 1 | 1 | 2 | 1 | 3 | | 1 | 1 | 1 | 1 | | | 5 | | | 1 |
| *Actinocyclus ingens* | | | | | | | | | | | | | | | | | | | |
| *Actinocyclus oculatus* | | | | | | | | | | | | | | | | | | | |
| *Crucidenticula nicobarica* | | | | | | | | | | | | | | | | | | | |
| *Denticulopsis* spp. | 1 | 1 | | | 1 | | | | | | 1 | 1 | | | 1 | | | 1 | |
| *Goniothecium tenue* | | | | | | | | | | | | | | | | | | | |
| *Kiesellavia carina* | | | | | | | | | | | | | | | | | | | |
| *Melosira albicans* | 1 | 1 | 1 | 2 | 2 | 2 | | 1 | | | | | 1 | | | | | | |
| *Neodenticula kamtschatica* | | 1 | | | 2 | | 1 | | | 1 | 1 | 1 | | | | 1 | | 3 | |
| *Neodenticula koizumii* | | | | | | | | 1 | | | | 1 | 1 | | | | | | |
| *Nitzschia reinholdii* | | | | | | | | | | | | | | | | | | | |
| *Proboscia curvirostris* | | | | | | | | | | | | | | | | | | | |
| *Pseudopodosira elegans* | | | | | | | | 1 | | 1 | | | | | 1 | | | | |
| *Pyxidicula zabelinae* | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia matutamae* | | | | | | | | | | | | | | | | | | | |
| *Rhizosolenia miocenica* | | | | | | | | | | | | | | | | | | | |
| *Rouxia* spp. | | | | | | | | | | | | | | | | | | | |
| *Synedra jouseana* | | | | | | | | | | | | | | | | | | | |
| *Thalassionema schraderi* | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira antiqua* | 1 | | | | 1 | 1 | | | | | | 2 | | | | | | | |
| *Thalassiosira jacksonii* | | | | | | | | | | | | | | | | | | | |
| *Thalassiosira nidulus* | | | | 1 | | 1 | | 1 | | 1 | | | | | | | | | |
| *Thalassiosira temperi* | | | | | | | | | | | | | | | | | | | |
| Extinct | 3 | 3 | 1 | 3 | 6 | 4 | 1 | 4 | | 3 | 2 | 5 | 2 | | 2 | 1 | | 4 | |
| Total valves counted | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |

Table 2: Ecological and biogeographical subdivision of diatom species in three cores.

| Taxa | Cores | | | Categories | Paleoecology | References |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | | |
| *Actinocyclus elongatus* Grunow, in Van Heurck 1883 | | | | O-Hp, w | tropical-subtropical | 5 |
| *Alveus marinus* (Grunow) Kaczmarska & Fryxell 1996 | | | | | tropical-subtropical | 4, 5, 6 |
| *Asterolampra marylandica* Ehrenberg 1844 | | | | | tropical | 1, 4, 5 |
| *Azpeitia africana* (Janisch) Fryxell & Watkins, in Fryxell, Sims, & Watkins 1986 | | | | | tropical | 4 |
| *Azpeitia nodulifera* (Schmidt) Fryxell & Sims, in Fryxell, Sims, & Watkins 1986 | | | | | tropical | 4, 6, 8 |
| *Fragilariopsis doliolus* (Wallich) Medlin & Sims 1993 | | | | | tropical-subtropical | 1, 5, 6, 8 |
| *Hemidiscus cuneiformis* Wallich 1860 | | | | | tropical | 1, 3, 4, 5, 8 |
| *Planktoniella sol* (Wallich) Schutt 1892 | | | | | tropical | 1, 3, 4, 5, 6 |
| *Rhizosolenia bergonii* Peragallo 1892 | | | | | tropical-subtropical | 1, 3, 4, 5 |
| *Roperia tessellata* (Roper) Grunow 1881 | | | | | tropical-subtropical | 5, 6 |
| *Thalassiosira leputopus* (Grunow) Hasle & Fryxell 1977 | | | | | tropical | 4 |
| *Actinocyclus ellipticus* Grunow, in Van Heurck 1881 | | × | | O-Hp, W | tropical-subtropical | 4 |
| *Asteromphalus arachne* (Brebisson) Ralfs, in Pritchard 1861 | | | | | tropical-subtropical | 5 |
| *Asteromphalus flabellatus* (Brebisson) Greville 1859 | | | | | tropical-subtropical | 5 |
| *Asteromphalus sarcophagus* Wallich 1860 | | | × | | tropical | 5 |
| *Azpeitia tabularia* (Grunow) Fryxell & Sims, in Fryxell, Sims, & Watkins 1986 | | | | | south temperate | 8 |
| *Nitzschia interruptestriata* (Heiden) Simonsen 1974 | | | × | | tropical-subtropical | 5 |
| *Nitzschia kolaczekii* Grunow 1877 | | | × | | warmer | 5, 6 |
| *Pseudosolenia calcar-avis* (Schultze) Sundstrom 1986 | | | | | tropical-subtropical | 1, 3, 5 |
| *Rhizosolenia acuminata* (Peragallo) Gran 1905 | | | | | subtropical-temperate | 1, 3 |
| *Rhizosolenia imbricata* Brightwell 1858 | | | | | warmer | 5 |
| *Thalassiosira oestrupii* (Ostenfeld) Hasle 1972 | | | | | subtropical | 4, 8 |
| *Actinocyclus curvatulus* Janisch, in Schmidt 1878 | | | | O-Hp, c | north temperate-subarctic | 3, 4, 7, 8, 10 |
| *Actinocyclus ochotensis* Jouse 1968 | | | | | north temperate | 4, 7 |
| *Asteromphalus robustus* Castracane 1875 | | | | | north temperate | 4, 7 |
| *Bacterosira fragilis* Gran 1900 | | | | | arctic-subarctic (sea ice) | 3, 4, 6, 7, 8, 10 |
| *Chaetoceros furcellatus* Bailey 1856 | | | | | arctic-subarctic | 3, 4, 7, 8, 10 |
| *Coscinodiscus marginatus* Ehrenberg 1841 | | | | | north temperate | 3, 4, 7 |
| *Coscinodiscus oculus-iridis* Ehrenberg 1839 | | | | | north temperate | 7 |
| *Fragilariopsis cylindrus* (Grunow) Krieger, in Helmck & Krieger 1954 | | | | | subarctic (sea ice) | 4, 6, 7, 10 |
| *Neodenticula seminae* (Simonsen & Kanaya) Akiba & Yanagisawa 1986 | | | | | north temperate | 4, 6, 7, 8, 10 |
| *Porosira glacilis* (Grunow) Jorgensen 1905 | | | | | arctic-north temperate | 3, 4, 6, 7 |
| *Rhizosolenia hebetata* (Bailey) Gran f. *hiemalis* Gran 1904 | | | | | north temperate | 3, 4, 7, 8 10 |
| *Thalassiosira gravida* Cleve 1896 | | | | | subarctic (sea ice) | 3, 4, 6, 7, 10 |
| *Thalassiosira hyalina* (Grunow) Gran 1897 | | | | | arctic-temperate | 3, 4, 6, 7 |
| *Thalassiosira kryophila* (Grunow) Joergensen 1905 | | | | | arctic | 4 |
| *Thalassiosira nordenskioeldii* Cleve 1873 | | | | | arctic (sea ice) | 1, 3, 4, 6, 7, 10 |
| *Thalassiosira trifulta* Fryxell, in Fryxell & Hasle 1979 | | | | | subarctic-north temperate | 7, 8, 10 |
| *Fragilariopsis oceanica* (Cleve) Hasle 1965 | | | | O-Hp, C | arctic (sea ice) | 4, 6, 7, 10 |
| *Asteromphalus* Ehrenberg 1844 spp. | | | | O-Hp | cosmopolitan | |
| *Coscinodiscus centralis* Ehrenberg 1839 | | | | | cosmopolitan | |
| *Coscinodiscus obscurus* Schmidt 1878 | | | | | | |
| *Coscinodiscus radiatus* Ehrenberg 1839 | | | | | cosmopolitan | |
| *Coscinodiscus wailesii* Gran and Angst 1931 | | | | | | |
| *Nitzschia bicapitata* Cleve, in Kaczmarska & Fryxell 1900 | | | | | cosmopolitan | |
| *Nitzschia capuluspalae* Simonsen 1974 | | | | | | |
| *Nitzschia sicula* (Castracanea) Hustedt 1958 | | | | | cosmopolitan | |
| *Proboscia alata* (Brightwell) Sundstrom 1986 | | | | | cosmopolitan | |
| *Rhizosolenia setigera* Brightwell 1858 | | | | | colder | |
| *Rhizosolenia styliformis* Brightwell 1858 | | | | | warmer | |
| *Rhizosolenia* Brightwell 1858 spp. | | × | × | | | |
| *Stellarima stellaris* (Roper) Hasle & Sims 1986 | | | | | | |
| *Thalassiosira decipiens* (Grunow) Joergensen 1905 | | | | | temperate | |
| *Thalassiosira eccentrica* (Ehrenberg) Cleve 1904 | | | | | cosmopolitan | |
| *Thalassiosira ferelineata* Hasle & Fryxell 1977 | | | | | | |
| *Thalassiosira gravida* Cleve 1896 v. | | × | | | | |
| *Thalassiosira lineata* Jouse 1968 | | | | | temperate | |
| *Thalassiosira pacifica* Gran & Angst 1928 | | | | | temperate | |
| *Thalassiosira subtilis* (Ostenfeld) Gran 1900 | | | | | cosmopolitan | |
| *Thalassiosira* Cleve 1873 spp. | | | | | | |
| *Thalassiothrix frauenfeldii* (Grunow) Hallegraeff 1986 | | | | | | |
| *Thalassiothrix longissima* Cleve & Grunow 1880 | | | | | temperate | |
| *Cyclotella stylorum* Brightwell 1860 | | | | N-L-Mp, W | warmer | 5 |
| *Cymatotheca weissflogii* (Grunow) Hendey 1958 | | | | | tropical | 5 |
| *Glyphodesmis rhombica* (Cleve) Simonsen 1974 | | × | × | | warmer | 5 |
| *Hemiaulus sinensis* Grrville 1865 | | | | | subtropical-temperate | 1, 5 |
| *Lithodesmium undulatum* Ehrenberg 1840 | | × | × | | warmer | 1, 3 |
| *Mastogloia* Thwaites, in Smith 1856 spp. | | | | | warm-temperate | 5 |
| *Odontella sinensis* (Greville) Grunow 1884 | | | | | warmer-temperate | 3 |
| *Odontella longicruris* (Greville) Hoban 1983 | × | × | | | | |
| *Pseudotriceratium puntatum* (Wallich) Simonsen | × | | × | | tropical-subtropical | 5 |
| *Thalassionema nitzschioides* Grunow v. *parva* Heiden, in Heiden & Kolbe 1928 | | | | | warmer-subtropical | 2, 9, 11 |
| *Odontella aurita* (Lyngbye) Agardh 1830 | | | | N-L-Mp, c | north temperate | 1, 3, 4, 7 |
| *Actinocyclus octonarius* Ehrenberg 1861 | | | | N-L-Mp | | |
| *Actinoptychus senarius* (Ehrenberg) Ehrenberg 1843 | | | | | | |
| *Actinoptychus splendens* (Shadbolt) Ralfs, in Pritschard 1861 | | | | | | |
| *Biddulphia pulchella* Gray 1821 | | | | | | |
| *Biddulphia tuomeyi* (Bailey) Roper 1859 | × | | × | | | |
| *Odontella reticulata* (Roper) De Toni 1894 | | | | | | |
| *Paralia sulcata* (Ehrenberg) Cleve 1873 | | | | | | |
| *Skeletonema costatum* (Greville) Cleve 1878 | | | | | | |
| *Stephanopyxis* (Ehrengerb) Ehrenberg 1845 spp. | | | | | | |
| *Synedra indica* Taylor 1966 | | × | | | | |
| *Thalassionema nitzschioides* Grunow 1881 | | | | | | |
| *Trigonium alternans* (Bailey) Mann 1907 | | × | × | | | |
| *Achnanthes* Bory 1822 spp. | | | | L-Mp-Tp | | |
| *Amphora* Ehrenberg, in Kutzing 1844 spp. | | | | | | |
| *Arachnoidiscus ernebrgi* Bailey, in Ehrenberg 1849 | × | × | | | | |
| *Bacillaria paradoxa* Gmelin 1791 | | | | | | |
| *Caloneis* Cleve 1894 spp. | | × | × | | | |
| *Campyloneis grevillei* (Wm. Smith) Grunow 1870 | | | | | | |
| *Climacosphenia moniligera* Ehrenberg 1841 | | × | × | | | |
| *Cocconeis* Ehrenberg 1837 spp. | | | | | | |
| *Coscinodiscus nitidus* Gregory 1857 | | | | | | |
| *Cyclotella striata* (Kutzing) Grunow 1880 | | | | | | |
| *Cymatosira lorenziana* Grunow 1862 | × | × | | | | |
| *Delphineis margalitalimbata* (Mertz) Koizumi 1992 | | | | | | |
| *Delphineis surirella* (Ehrenberg) Andrews 1980 | | | | | | |
| *Dimeregramma* Ralfs, in Pritchard 1861 spp. | | × | × | | | |
| *Diploneis* Ehrenberg 1844 spp. | | | | | | |
| *Ditylum brightwellii* (West) Grunow 1881 | | | | | | |
| *Grammatophora* Ehrenberg 1840 spp. | | | | | | |
| *Gyrosigma* Hassall 1845 spp. | | | | | | |
| *Hantzschia Grunow* 1877 spp. | × | | × | | | |
| *Hyalodiscus* Ehrenberg 1845 spp. | | | | | | |
| *Licmophora* Agardh 1827 spp. | | × | × | | | |
| *Navicula cancellata* Donkin 1872 | | × | × | | | |
| *Navicula clementis* Grunow 1882 | | × | × | | | |
| *Navicula distans* (W. Smith) Schmidt 1876 | | × | × | | | |
| *Navicula elginensis* (Gregory) Ralfs, in Pritchard 1861 | × | × | | | | |
| *Navicula finmarchia* (Cleve & Grunow) Cleve 1895 | × | × | | | | |

Table 2: (continued)

| Taxa | Cores | | | Categories | Paleoecology | References |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | | |
| *Navicula forcipata* Greville 1859 | | × | × | | | |
| *Navicula marina* Ralfs, in Pritchard 1861 | | × | × | | | |
| *Navicula mutica* Kutzing 1844 | | × | | | | |
| *Navicula pygmaea* Kutzing 1849 | | × | × | | | |
| *Navicula* Bory 1822 spp. | | | | | | |
| *Nitzschia compressa* (Bailey) Boyer 1916 | | × | | | | |
| *Nitzschia constricta* (Kutzing) Ralfs, in Pritchard 1861 | | | | | | |
| *Nitzschia granulata* Grunow, in Cleve & Moller 1880 | | | | | | |
| *Nitzschia levidensis* (W. Smith) Van Heurck, in Van Heurck 1881 | | × | × | | | |
| *Nitzschia littoralis* Grunow, in Cleve & Grunow 1880 | | × | | | | |
| *Nitzschia panduriformis* Gregory 1857 | | × | × | | | |
| *Nitzschia trybionella* Hantzsch, in Rabenhorst 1860 | | × | × | | | |
| *Nitzschia* Hassall 1845 spp. | × | | × | | | |
| *Opephora* Petit 1888 spp. | | | | | | |
| *Plagiogramma* Greville 1859 spp. | | | | | | |
| *Pleurosigma* W. Smith 1852 spp. | | | | | | |
| *Rhabdonema arcuatum* (Lyngbye) Kutzing 1844 | | × | | | | |
| *Rhaphoneis amphiceros* (Ehrenberg) Ehrenberg 1844 | | | | | | |
| *Rhoicosphenia curvata* (Kutzing) Grunow 1860 | | | | | | |
| *Rhopalodia* O. Muller 1895 spp. | | | | | | |
| *Stauroneis* Ehrenberg 1843 spp. | | × | | | | |
| *Surirella* Turpin 1828 spp. | | × | | | | |
| *Synedra tabulata* (Agardh) Kutzing 1844 | | | × | | | |
| *Synedra undulata* Bailey 1853 | × | × | | | | |
| *Thalassiosira lacustris* (Grunow) Hasle, in Hasle & Fryxell 1977 | | | | | | |
| *Trachyneis antillarum* (Cleve & Grunow) Cleve 1894 | | | | | | |
| *Trachyneis aspera* (Ehrenberg) Cleve 1894 | | | | | | |
| *Triceratium* Ehrenberg 1839 spp. | | | | | | |
| *Aulacoseira* Thwaites 1848 spp. | | | | Freshwater | | |
| *Cyclotella* (Kutzing) Brebisson 1838 spp. | | | | | | |
| *Cymbella* Agardh 1830 spp. | | | | | | |
| *Epithemia* Kutzing 1844 spp. | | | | | | |
| *Eunotia* Ehrenberg 1837 spp. | | | | | | |
| *Fragilaria* Lyngbye 1819 spp. | | | | | | |
| *Frustulia rhomboides* (Ehrenberg) Kutzing 1844 | | × | × | | | |
| *Gomphonema* Agardh 1824 spp. | | | | | | |
| *Meridion circulare* (Greville) Agardh 1831 | | | | | | |
| *Navicula americana* Ehrenberg 1843 | | × | × | | | |
| *Neidium iridis* (Ehrenberg) Cleve 1894 | × | × | | | | |
| *Pinnularia* Ehrenberg 1843 spp. | | | | | | |
| *Stephanodiscus* Ehrenberg 1845 spp. | | | | | | |
| *Synedra ulna* (Nitzsch) Ehrenberg 1838 | | × | × | | | |
| *Tabellaria* Ehrenberg, in Kutzing 1844 | | | | | | |
| *Actinocyclus ingens* Rattray 1890 | | | | Extinct | Miocene (18.0-6.5 Ma) | |
| *Actinocyclus oculatus* Jouse 1968 | × | | | | Plio-Pleistocene (4.0-1.0 Ma) | |
| *Crucidenticula nicobarica* (Grunow) Akiba & Yanagisawa 1986 | | × | | | Miocene (15.1-12.3 Ma) | |
| *Denticulopsis* Simonsen 1979 spp. | | | | | Miocene | |
| *Goniothecium tenue* Brun 1894 | | | | | Miocene | |
| *Kisseleviella carina* Sheshukova-Poretzkaya 1962 | | × | | | Miocene (24.0-20.3 Ma) | |
| *Melosira albicans* Sheshukova-Poretzkaya 1964 | | | | | Pliocene? | |
| *Neodenticula kamtschatica* (Zabelina) Akiba & Yanagisawa 1985 | | | | | Mio-Pliocene (7.4-2.6 Ma) | |
| *Neodenticula koizumi* Akiba & Yanagisawa 1985 spp. | | | | | Pliocene (3.9-2.0 Ma) | |
| *Nitzschia fossilis* (Frenguelli) Kanaya, in Schrader 1973 | | × | × | | Mio-Pleistocene (8.0-0.6 Ma) | |
| *Nitzschia reinholdii* Kanaya, in Barron & Baldauf 1986 | | | | | Mio-Pleistocene (6.6-0.6 Ma) | |
| *Proboscia barboi* (Brun) Jordan & Priddle 1991 | | × | × | | Mio-Pliocene (12.3-0.3 Ma) | |
| *Probosia curvirostris* (Jouse) Jordan & Priddle 1991 | × | × | | | Pleistocene (1.6-0.3 Ma) | |
| *Pseudopodosira elegans* Sheshukova-Poretzkaya 1964 | | | | | Mio-Pliocene | |
| *Pyxidicula zabelinae* (Jouse) Makarova 1986 | | | | | Pliocene (3.13-2.8 Ma) | |
| *Rhizosolenia matuyamai* Burckle, in Burckle, Hammond, & Seyb 1978 | | × | | | Pleistocene (1.2-1.0 Ma) | |
| *Rhizosolenia miocenica* Schrader 1973 | | × | | | Miocene | |
| *Rouxia* Brun & Heribaud, in Heribaud 1893 spp. | | × | | | Miocene (15.0-5.1 Ma) | |
| *Synedra jouseana* Sheshukova-Poretzkaya 1962 | | × | | | Miocene | |
| *Thalassionema schraderi* Akiba 1982 | | | | | Miocene (8.75-7.0 Ma) | |
| *Thalassiosira antiqua* (Grunow) Cleve-Euler 1941 | | | | | Mio-Pliocene | |
| *Thalassiosira jacksonii* Koizumi & Barron, in Koizumi 1986 | | × | | | Pliocene | |
| *Thalassiosira nidulus* (Tempere & Brun) Jouse 1961 | | | | | Pliocene | |
| *Thalassiosira temperi* (Brun) Akiba & Yanagisawa 1986 | | × | | | Pliocene | |

Cores: 1=MD01-2421, 2=MR02-03-2, 3=MR99-04-3; ×=absence

References: 1 = Cupp (1943), 2 = Hasle (1960), 3 = Hendey (1964), 4 = Jouse et al. (1969), 5 = Simonsen (1974), 6 = Hasle(1976), 7 = Sancetta (1982), 8 = Sancetta and Silvestri (1986), 9 = Tanimura (1992, 1999), 10 = Shiga and Koizumi (2000), 11 = Hasle (2001)

Cores: 1=MD01-2421, 2=MR02-03-2, 3=MR99-04-3

## 5. Conclusion

The extinct, freshwater, and littoral diatom species did not contribute to the total diatom flora as reworked and displaced diatoms derived from the continent or/and sea bottom, but their relative abundances decreased as the locations of the cores become far from near shore area.

The fragments of a big diatom *Coscinodiscus wailesii* occurred with abundant to common frequencies at the uppermost part of MIS's stag 6 in three cores. The abundances of fragments were larger in MR99-04-3 than in MD01-2421, suggesting a relationship between the geographical situations of core sites and the sedimentological process on settling of the valves.

In the Kuroshio off Kashima: (1) Diatom abundance fluctuated largely and large fluctuations occurred near the MIS's stage boundaries at intervals of ~40-kyr corresponding to the orbital-obliquity (tilt) cycles. (2) The relative abundances of littoral-neritic diatom association was higher and fluctuated at ~60-kyr intervals suggesting changes in the sea level due to glacial phase in climate. (3) The relative abundances of warm-water species in littoral-neritic association dominated over those of cold-water ones. (4) The relative abundances of warm- and of cold-water species in oceanic association fluctuated at ~20-kyr intervals. (5) In the *Td*' curve fluctuations in the shape of reversed saw-tooth at ~30-kyr intervals developed during 90-20 cal kyr BP.

In the Kuroshio Extension off Joban: (1) Large fluctuations in the diatom abundance occurred near the stage boundaries and in the interglacial phases at intervals of ~20-kyr corresponding to the precession cycles.

(2) The fluctuations in the relative abundances of littoral-neritic association occurred at ~100-kyr intervals suggesting the orbital-eccentricity cycles. (3) The relative abundances of cold-water species in oceanic association dominated over those of warm-water ones, but in MR99-04-3 whose location is under the influences of the Tsugaru Warm Current, the abundances of warm- and of cold-water species both were almost equal. (4) The relative abundances alternated between warm and cold-water species at ~40-kyr intervals composed of ~20-kyr intervals. (5) In the *Td*' curve the saw-tooth shaped fluctuations occurred at ~40-kyr intervals since 130 cal kyr BP in the MIS's stage 5e.

## 6. Future works

The changing process and hydrographic mechanism in the water in the studied area should be resolved by high resolution analysis of many paleoceanographic proxies.

The *Td*' values based on fossil diatoms should be translated to SST (sea surface temperature), and also biology of large diatom *Coscinodiscus wailesii* and sedimentological process which this species was involved should be researched to know the relationship between preservation and dissolution of biologic flux.

We have four piston cores to be analyzed. They were recovered on the eastern-western transect of 40°N in the Oyashio Area, and with several piston cores from near shore area off Joban at 37.5°N in the Perturbed Area, they help much to understand more precisely the water in the studied area.

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*(Received December 24, 2004)*