Living coccolithophorids in surface waters of the Tsugaru Strait during March-September 2003

Xuedong Xu* and Katsunori Kimoto**

Abstract Surface water samples were collected from a site TP03 in the Tsugaru Strait during March-September 2003. Cell density and species composition of living coccolithophorids in these samples were studied under a scanning electron microscope (SEM). The cell density maximum was shown in September 2003, which corresponded to a high sea surface temperature. A total of fourteen coccolithophorid species were recognized. Seasonally, the coccolithophorid assemblages in spring and early summer were dominated by *Gephyrocapsa oceanica*, whereas the assemblage in late summer was dominated by *Emiliania huxleyi*.

Keywords: Tsugaru Strait, living coccolithophorid, cell density, species composition

1. Introduction

Coccolithophorids, marine unicellular haptophytes, are major phytoplankton components in the world oceans. A better understanding of modern coccolithophorid ecology is necessary in order to use them for monitoring possible change in the ecosystem structure of the modern ocean, and as a biotic proxy of past environmental change. In the open ocean of the North and Central Pacific, a lot of studies have been published on the distribution of living coccolithophorids (e.g. Okada and Honjo, 1973). Recently, Hagino (1997) documented distribution of living coccolithophorids in the western Pacific Ocean off the coast of Northeast Japan. As supplementary data in the offshore areas of Northeast Japan, this study reports the cell density and species composition of living coccolithophorids in surface waters from a site 5 miles off the coast of northernmost part of Honshu (Fig. 1). The sampling point TP03 (41°28.8'N, 141°14.2'E, water depth: ca. 230 m) is located in the mixing zone of the Tsugaru Warm Current and the Oyashio component water.

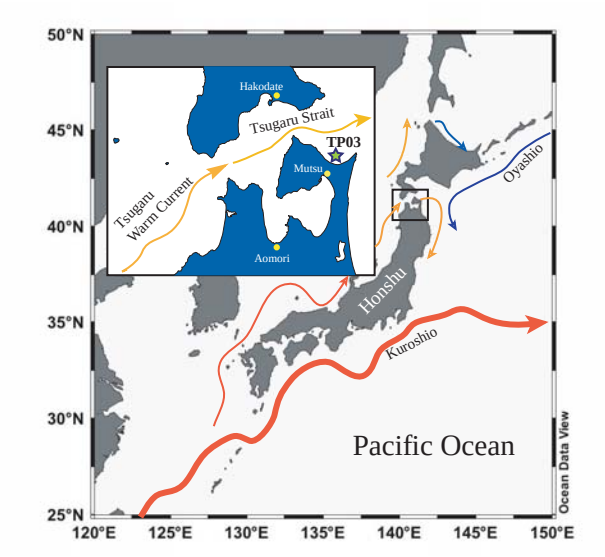

Figure 1: Sampling location (star) and major current system around Japan.

2. Material and method

Sea water samples were collected from the Tsugaru Strait during March-September 2003 (Table 1). Each water sample was collected from the sea surface using a bucket, and was put into a 9 liter HDPE bottle. A CT sensor was used to measure the water temperature and salinity (Table 1, Fig. 2a). In the laboratory, 2–4 litres of seawater was wet-sieved over 32 μm mesh. The fraction <32 μm was then filtered through a Millipore filter (0.8 μm pore size, 25 mm diameter) using a water pump. After filtering, the filters were put into a desiccator, and air dried for more than 1 day. A randomly chosen small section of the dried filter (approx. 5 × 5 mm)

Table 1: Sampling and hydrographic data.

Sample No.	Sampling Date	Temperature (°C)	Salinity (PSU)
TP03-03	2003.3.17	4.7	32.3
TP03-04	2003.4.15	9.1	33.7
TP03-05	2003.5.21	10.0	33.0
TP03-06	2003.6.30	12.7	33.7
TP03-07	2003.7.30	14.6	33.7
TP03-09	2003.9.29	19.3	33.6

* Japan Agency for Marine-Earth Science and Technology, Mutsu Institute for Oceanography, Mutsu Research Group
** Japan Agency for Marine-Earth Science and Technology, Institute of Observational Research for Global Change (IORGC)

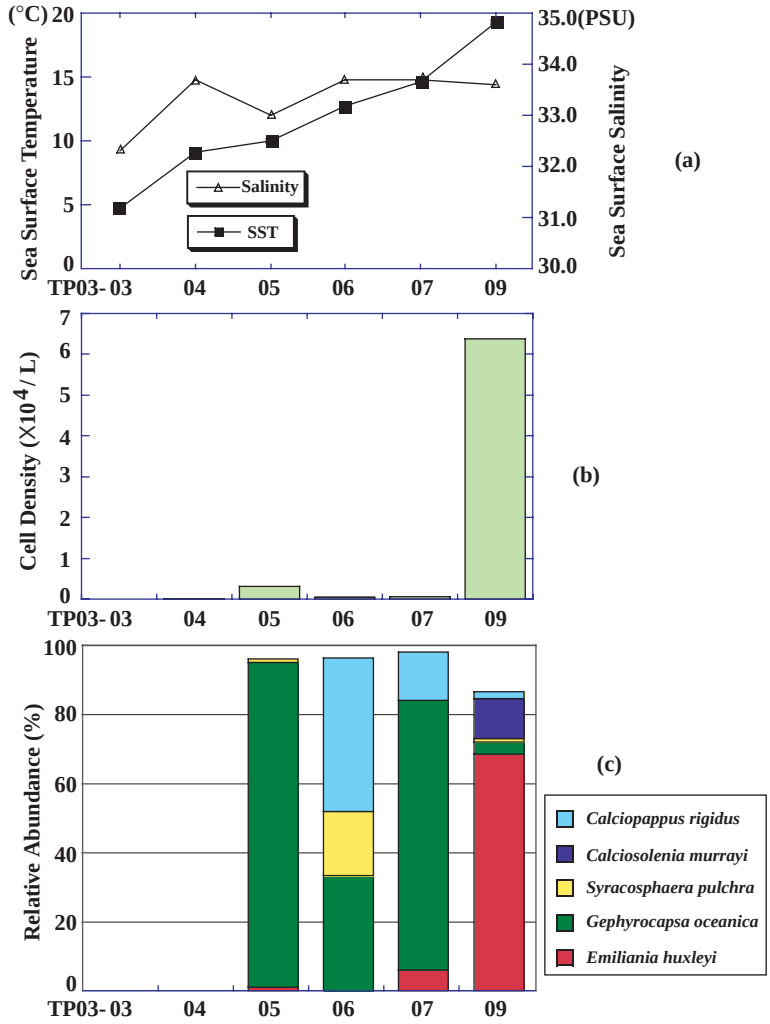

Figure 2: Living coccolithophorid populations in the Tsugaru Strait, vs. hydrographic data: (a) *in situ* sea surface temperature (SST) and salinity for the studied samples; (b) cell density of living coccolithophorid: the maximum was recorded in September; (c) relative abundance of dominant species in the coccolithophorid assembleges.

Table 2: Occurrence chart of all coccolithophorid species observed. Cell density of each sample is given at the bottom.

species	TP03-03	TP03-04	TP03-05	TP03-06	TP03-07	TP03-09
Emiliania huxleyi			1		3	137
Gephyrocapsa oceanica			94	9	39	7
G. muellerae						11
Coccolithus pelagicus			4			
Syracosphaera anthos						1
S. molischii				1		7
S. pulchra			1	5		2
Calyptrolithina multipora						1
Calciosolenia murrayi						23
Calyptrosphaera oblonga						5
Calciopappus rigidus				12	7	4
Cyrtosphaera cucullata						1
Algirosphaera robusta						1
Braarudosphaera bigelowii					1	
Total specimens identified			100	27	50	200
Cell density (No. / L)	0	105	3198	400	600	63850

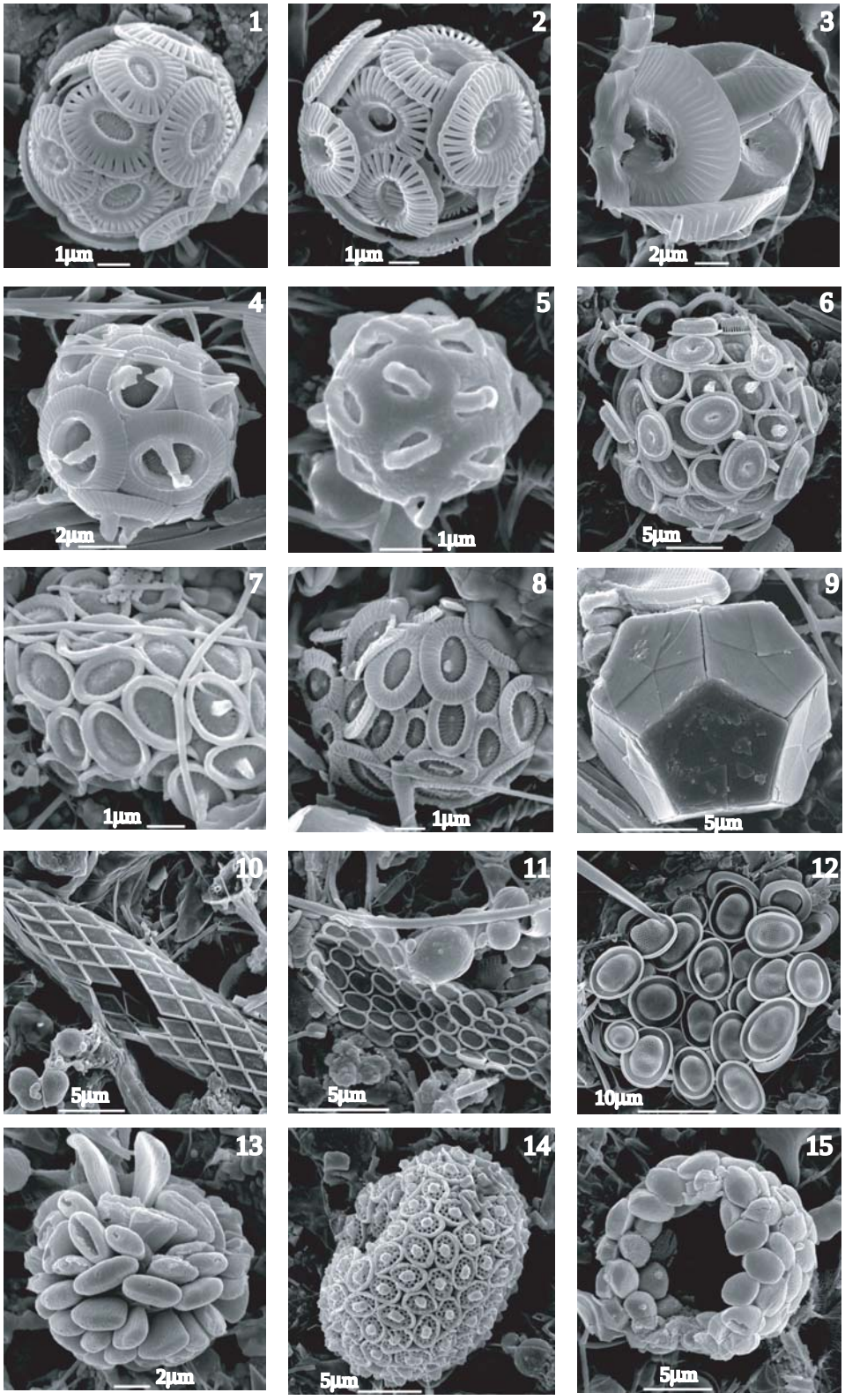

Plate 1: Scanning electron micrographs of living coccolithophorids collected from the Tsugaru Strait.
1. *Emiliania huxleyi*, type A (Young and Westbroek, 1991); from TP03-09, 2. *Emiliania huxleyi*, type B/C (Young et al, 2003); from TP03-03, 3. *Coccolithus pelagicus*; from TP03-05, 4. *Gephyrocapsa oceanica*; from TP03-05, 5. *Gephyrocapsa muellerae*; from TP03-09, 6. *Syracosphaera pulchra*; from TP03-06, 7. *Syracosphaera anthos*; from TP03-03, 8. *Syracosphaera molischii*; from TP03-06, 9. *Braarudosphaera bigelowii*; from TP03-07, 10. *Calciosolenia murrayi*; from TP03-09, 11. *Calciopappus rigidus*; from TP03-09, 12. *Cyrtosphaera cucullata*; from TP03-06, 13. *Algirosphaera robusta*; from TP03-09, 14. *Calyptrolithina multipora*; from TP03-09, 15. *Calyptrosphaera oblonga*; from TP03-09

was then fixed on an aluminum stub and sputtered with platinum (Pt) for coccolithophorid analysis with a scanning electron microscope (SEM).

The cell density was studied by counting the number of whole coccospheres in 100 SEM fields of view at 1000× magnification (equivalent to an area of 1.2 mm^2 of the filter). The actual specimen counts were then converted to cell density presented as number of specimens per liter of sea water. The species composition was then studied by identifying more than 100 coccospheres in two samples (TP03-05 and TP03-09). For samples in which coccolithophorids were of very low abundance (TP03-06 and TP03-07), more than 1,000 SEM fields of view at 1000× magnification were examined. The classification of species followed the taxonomy of Jordan and Kleijne (1994), and Young et al (2003).

3. Results

3.1 Cell density

The cell density, expressed as No. of cells / L, was calculated as follows: Cell density = [F × C / A × V], where F is the filtration area (mm^2); C is the number of coccospheres actually counted; A is the actual counting area (mm^2); V is the water volume filtered (L). During the studied period, the cell density ranged from 0 to 6.3×10^4 cells / L (Table 2), with the lowest values in March (TP03-03) and April (TP03-04), and highest in September (TP03-09). The cell density maximum in September 2003 corresponded to a high sea surface temperature in the Tsugaru Strait (Fig. 2a & 2b).

3.2 Species composition

Samples TP03-03 and TP03-04 were almost barren of coccosphere. In the rest four samples, a total of fourteen species were recognized (Table 2). SEM pictures of all these specie are given in Plate 1. Seasonally, the coccolithophorid assemblages in spring and early summer (TP03-05 – 07) were dominated by *Gephyrocapsa oceanica*, whereas the assemblage in late summer (TP03-09) was dominated by *Emiliania huxleyi* (Fig. 2c). In addition, *Calciopappus rigidus* was relatively abundant in June (TP03-06).

4. Acknowledgements

We wish to express our thanks to the fishery association of Ohata Town who provided boat "Wakashio" to us, and gave us help in sampling operations. We thank N. Ahagon, H. Sakoh, K. Hayashi, T. Idai and S. Kimura of MIO, JAMSTEC, for their on board supporting. This research was supported by an internal fund of JAMSTEC, to K. Kimoto.

References

1) Hagino, K., Distribution of living coccolithophores in the western Pacific Ocean off the coast of Northeast Japan. Fossil 63, 1-19 (1997). (in Japanese)
2) Jordan, R. and Kleijne, A., "A classification system of living coccolithophores", in Coccolithophores, Winter, A. and Siesser, W.G. Eds. (Cambridge University Press, 1994), p.83-105.
3) Okada, H. and Honjo, S., "The distribution of oceanic cocolithophorids in the Pacific" *Deep-Sea Research*, **20**, 355-374 (1973).
4) Young, J. R., Geisen, M., Cros, L., Kleijne, A., Sprengel, C., Probert, I., Ostergaard, J., "A guide to extant coccolithophore taxonomy". *Journal of Nannoplankton Research*, Special Issue **1**. 125pp (2003).
5) Young, J. R. and Westbroek, P., "Genotypic variation in the coccolithophorid species *Emiliania huxleyi*". *Mar. Micropaleontology*, **18**, 5-23 (1991).

(Received December 27, 2004)