

FORMATION AND RETENTION OF PHYTOPLANKTON ASSEMBLY IN THE KUROSHIO FRONT (EXTENDED ABSTRACT)

Tamiji YAMAMOTO

*Faculty of Agriculture, Tohoku University,
1-1, Tsutsumidôri-Amamiyamachi, Sendai 980*

The Kuroshio front is known as a typical oceanic front in the western North Pacific Ocean. Although it is generally said that waters in and around the oceanic fronts of the world oceans are productive, sampling stations occupied by the previous workers seem to have been located too coarse to elucidate the fine structure of biological phenomena around the Kuroshio front. In the present study, continuous and small-scale observations on phytoplankton and environmental conditions were carried out across the Kuroshio front from 1979 to 1982. Sea water was continuously pumped up from *ca.* 3 m depth and pooled into a 5 l polyethylene tank successively. Temperature, salinity, essential nutrients and chlorophyll *a* were measured for each sample. Identification and cell counting of phytoplankton were also made for each 1 l aliquot of formalin-fixed samples.

Temperature and salinity often changed sharply within a short distance across the front; the most prominent change, 7.5°C and 1.4‰ per mile, was found off Sanriku on June 4, 1979 when a total of 30 samples was taken along a 4 mile-transect line as shown in Fig. 1. The "frontal zone" was distinguished from two neighboring water masses on both sides of the front by the differences of species composition of phytoplankton using the Similarity Index (KIMOTO, 1967). The "frontal zone" was indicated as an extent between two triangles in Fig. 1. While concentrations of nutrients were uniform across the front, chlorophyll *a* and phytoplankton cell number were conspicuously higher in the zone than those on both sides of the front. The microplankton ($>10 \mu\text{m}$) occupied a significant portion of total chlorophyll *a* in the zone (Fig. 1). Cell numbers of whole and neritic phytoplankton were averaged for three different zones and are summarized in Table 1. Type I in Table 1 is a group of species which occurred abundantly on the cold water side of the front, and type II is a group that exhibited the reverse pattern to type I. Species found commonly across the front are categorized as type III. Type IV is a group of species which characteristically appeared in the "frontal zone". It is noticeable that the proportion of neritic species in type IV is much higher than those in the other three types. Representative neritic species of type IV were *Asterionella glacialis* and *Skeletonema costatum*. Therefore, it was considered that the phytoplankton assembly in the zone was not formed by a simple mixture of two neighboring water masses (YAMAMOTO *et al.*, 1981). But the entrainment of neritic microplankton on the Kuroshio current is considered to be responsible for the "formation" of the phytoplankton assembly in the Kuroshio front.

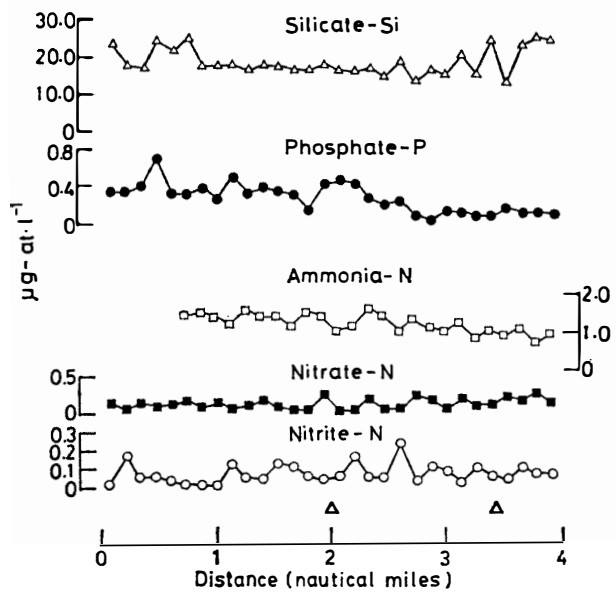
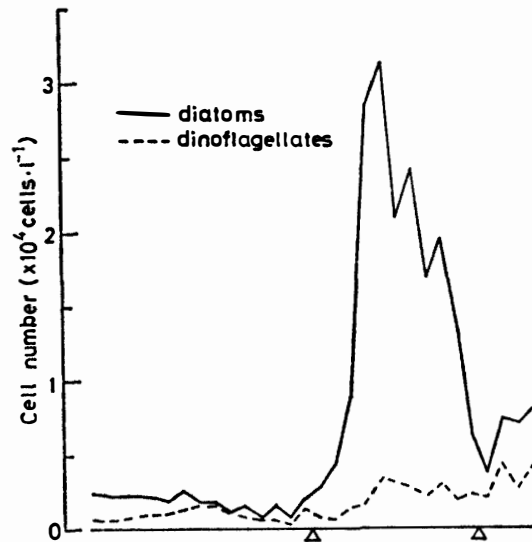
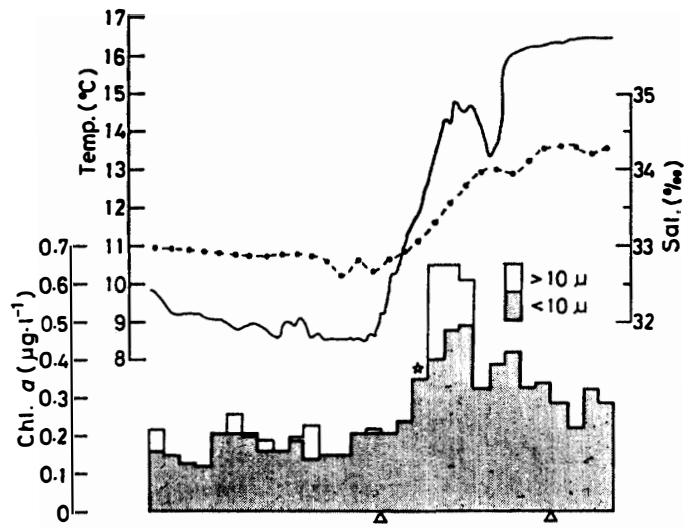


Fig. 1. Horizontal variations of temperature, salinity, chlorophyll a (top figure), cell number of diatoms and dinoflagellates (middle figure), and essential nutrients (bottom figure) in surface sea water (ca. 3 m depth) across the Kuroshio front off Sanriku on June 4, 1979. Open area and shaded one show microplankton ($>10 \mu\text{m}$) and nanoplankton ($<10 \mu\text{m}$) chlorophyll a, respectively. ☆ denotes a datum of microplankton missed. Five ammonia-N data of the cold water side were missed due to an analytical error. Two triangles indicate the boundaries of three different water masses. Most part of data were cited from YAMAMOTO et al. (1981).

Table 1. Average cell numbers (cells/l) of neritic and whole phytoplankton (neritic/whole) in three zones across the Kuroshio front off Sanriku on June 4, 1979. All phytoplankton counted were grouped into four types by their distribution patterns (see text). Numbers in parentheses indicate proportion (%) of neritic species to whole phytoplankton cells.

Type	Zone			Total
	Cold	Frontal	Warm	
I	31/1585	14/280	0/8	45/1873 (2.4)
II	15/21	634/1376	1528/2809	2177/4206 (51.8)
III	371/862	954/1422	2539/2820	3864/5104 (75.7)
IV	217/224	14921/15058	3133/3240	18271/18522 (98.6)
Total	634/2692 (23.6)	16523/18136 (91.1)	7200/8877 (81.1)	

Along the cross section of the Kuroshio front off Shikoku Island in June 1982, high concentrations of chlorophyll *a* were located in the midst of the dome-like rise of nutrient isopleths. Surface sea waters obtained along this section were incubated on deck for 24 h after the addition of nutrients (50 $\mu\text{g-at N/l}$, 4 $\mu\text{g-at P/l}$, vitamins and metals) under 8800 lx at the surface temperature. Specific growth rates, which were estimated by the increase of chlorophyll *a* concentrations, of the microplankton ($> 10 \mu\text{m}$, 2.61–3.31/*d*) were significantly higher than those of the nanoplankton ($< 10 \mu\text{m}$, 1.23–1.86/*d*). Especially, the microplankton in the “frontal zone” showed greater specific growth rates (3.04–3.31/*d*) compared with those in the cold and warm water masses (2.61–2.91/*d*). Microscopic examinations after the incubation experiments revealed that neritic species occupied 86.4% of microplankton increased. From these results, it is expected that the neritic microplankton flourish in the “frontal zone” in association with a possible upwelling which supplies nutrients around the front. Evidence mentioned above suggests that the upwelling contributes to the “retention” of the phytoplankton assembly in the Kuroshio front.

Very little is known of the ecology in many other oceanic fronts, especially those in the southern hemisphere, *i.e.* the Antarctic Convergence and the Subtropical Convergence. By employing the continuous and small-scale sampling schemes, the ecological features of these oceanic fronts will be studied in the SIBEX cruises.

References

- KIMOTO, S. (1967): Some quantitative analysis of the Chrysomelid fauna of the Ryukyu Archipelago. *Esakia*, **6**, 27–54.
- YAMAMOTO, T., TANIGUCHI, A. and NISHIZAWA, S. (1981): Microplankton distribution at an oceanic front formed in the Sanriku waters off northeast Japan. *Bull. Plankton Soc. Jpn.*, **28**, 111–120.

(Received December 14, 1983; Revised manuscript April 12, 1984)