A. Cruise summary

1. Cruise information

(1) Cruise designation (research vessel)
MR13-04 (R/V MIRAI)

(2) Cruise title (principal science proposal) and introduction
Change in material cycles and ecosystem by the climate change and its feedback

Some disturbing effects are progressively coming to the fore in the ocean by climate change, such as rising water temperature, intensification of upper ocean stratification and ocean acidification. It is supposed that these effects result in serious damage to the ocean ecosystems. Disturbed ocean ecosystems will change a material cycle through the change of biological pump efficiency, and it will be fed back into the climate. We are aimed at clarifying the mechanisms of changes in the ocean structure in ocean ecosystems derived from the climate change,

We arranged the time-series observation stations in the subarctic gyre (K2: 47°N 160°E) and the subtropical gyre (S1: 30°N, 145°E) in the western North Pacific. In general, biological pump is more efficient in the subarctic gyre than the subtropical gyre because large size phytoplankton (diatom) is abundant in the subarctic gyre by its eutrophic oceanic condition. It is suspected that the responses against climate change are different for respective gyres. To elucidate the oceanic structures in ocean ecosystems and material cycles at both gyres is important to understand the relationship between ecosystem, material cycle and climate change in the global ocean.

There are significant seasonal variations in the ocean environments in both gyres. The seasonal variability of oceanic structures will be estimated by the mooring systems and by the seasonally repetitive ship observations scheduled for next several years.

(3) Principal Investigator (PI)
Makio Honda
Research Institute for Global Change (RIGC)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

(4) Science proposals of cruise

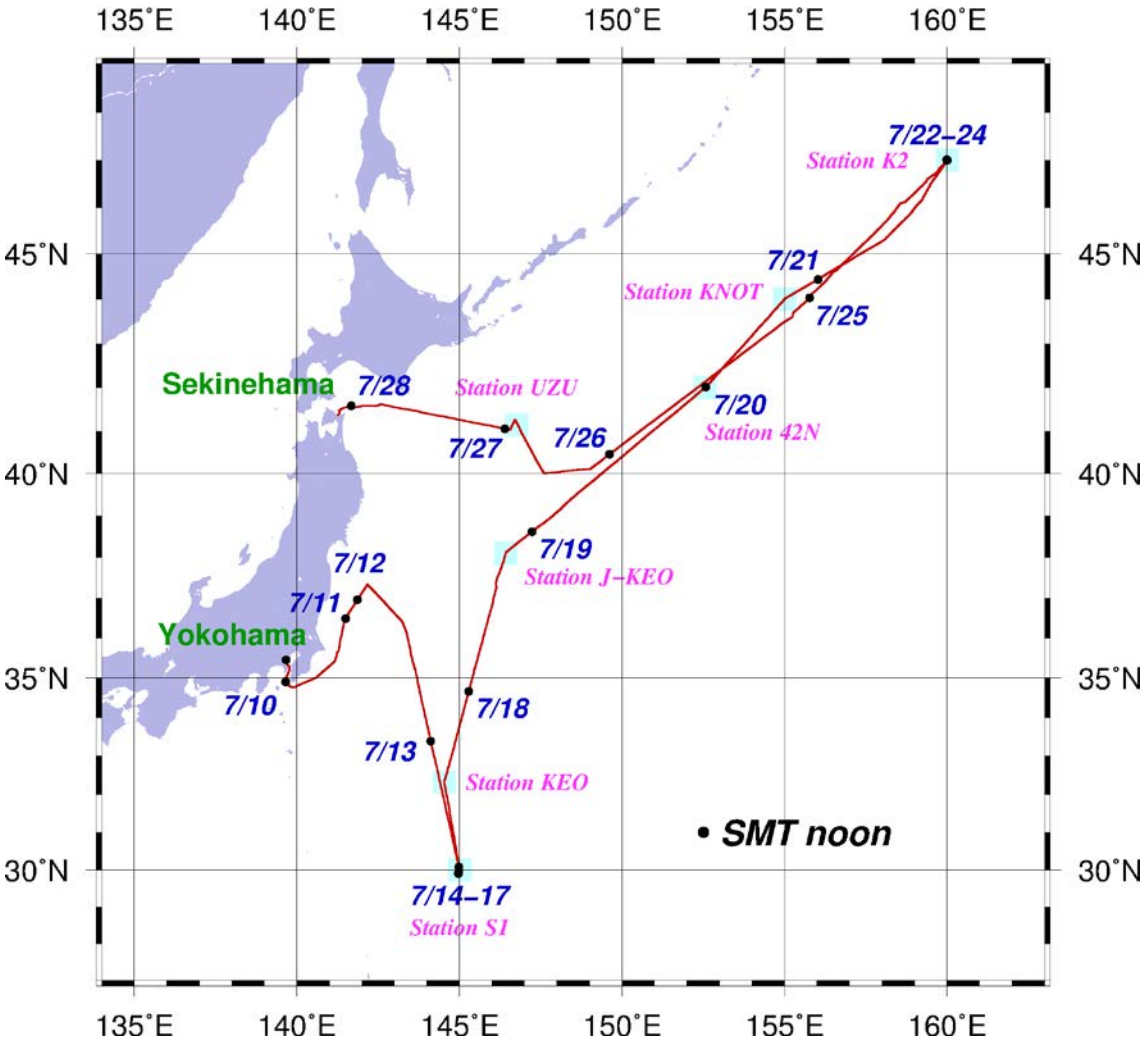
Affiliation	PI	Proposal titles
Japan Atomic Energy Agency	Shigeyoshi OTOSAKA	Biogeochemical cycle and accumulation of anthropogenic radionuclides derived from the accident of Fukushima-Daiichi Nuclear Power Plant
University of Tokyo	Koji HAMASAKI	Studies on the microbial-geochemical processes that regulate the operation of the biological pump in the subarctic and subtropical regions of the western North Pacific – IV
National Institute for Environmental Studies	Masanobu KAWACHI	Taxonomy and genome analysis of eukaryotic picophytoplankton originated from cryopreserved marine environmental specimens

Tokyo Institute of Technology	Naohiro YOSHIDA	A study of the cycles of global warming related materials using their isotopomers in the western North Pacific.
JAMSTEC	Hiroshi UCHIDA	Temporal changes in water properties of abyssal water in the western North Pacific
JAMSTEC	Toshio SUGA	Study of ocean circulation and heat and freshwater transport and their variability, and experimental comprehensive study of physical, chemical, and biochemical processes in the western North Pacific by the deployment of Argo floats and using Argo data
National Institute of Radiological Sciences	Tstuso AONO	The concentrations of radionuclides in the western North Pacific
Nagoya University	Osamu ABE	Estimation of Paleo-primary productivity by measurements of oxygen isotopes in the intermediate water
not onboard study		
Chiba Univ.	Masao NAKANISHI	Tectonics of the mid-Cretaceous Pacific Plate
National Institute for Environmental Sciences	Nobuo SUGIMOTO	Study of distribution and optical characteristics of ice/water clouds and marine aerosols
Ryukyu Univ.	Takeshi MATSUMOTO	Standardization of marine geophysical data and its application to the ocean floor geodynamics studies
Toyama Univ.	Kazuma AOKI	Maritime aerosol optical properties from measurements of Ship-borne sky radiometer

(5) Cruise period (port call)
10 July (Yokohama) – 29 July 2013 (Sekinehama)

(6) Cruise region (geographical boundary)
The western North Pacific (50°N – 30°N, 140°E – 160°W)

(7) Cruise truck and stations



2. Outline of MR13-04

2.1 Objective of this cruise

Principal objective of this cruise is to observe early summer ecosystem and biogeochemical cycle at time-series stations in the sub-arctic and sub-tropical gyres. In addition, we conducted biogeochemical observation off Fukushima in order to investigate dispersion of radionuclides from the Fukushima Daiichi nuclear power plant.

2.2 Cruise summary (highlights)

The length of this cruise was 2/3 ~ 1/2 of previous cruises for K2/S1 time-series observation for biogeochemistry. However, owing to good weather and sea condition, recovery and re-deployment of three mooring systems were successfully conducted at stations K2 and S1. In addition, we successfully recovered two sediment trap mooring systems off Fukushima and redeployed one sediment trap mooring system as scheduled. On the other hand, water sampling for various purposes were conducted at stations K2, S1, KEO, JKEO and KNOTS. At stations K2 and S1, phyto- / zoo-plankton sampling, measurement of primary productivity and collection of suspended substances by using in situ pumping were conducted successfully. Moreover, on the way back to Mutsu, water sampling and CTD observation was conducted inside and outside of meso-scale eddy located east of Hokkaido. A few cruise highlights are as follows.

(1) Time-series observation of vertical profile in chlorophyll-a

At station S1, a POPPS mooring system that consists of underwater winch, observation buoy, automatic water sampler (RAS) and ADCP was recovered. Time-series data of fluorometer was successfully obtained for about 8 months between July 2012 and March 2013. Fig. 1 shows seasonal variability in vertical profile of chlorophyll-a (chl-a). Between July 2012 and October 2013, relatively higher chl-a was observed in the subsurface layer (around bottom of euphotic layer) while surface chl-a was quite low. This data is very unique because subsurface chl-a maximum cannot be observed by satellite. Between November 2012 and January 2013, chl-a was very low upper 150 m. After January 2013, chl-a began to increase upper 150 m and higher chl-a was observed late March 2013. This seasonal variability qualitatively synchronized well with that of sinking particles observed by 200 m sediment trap (Fig.2).

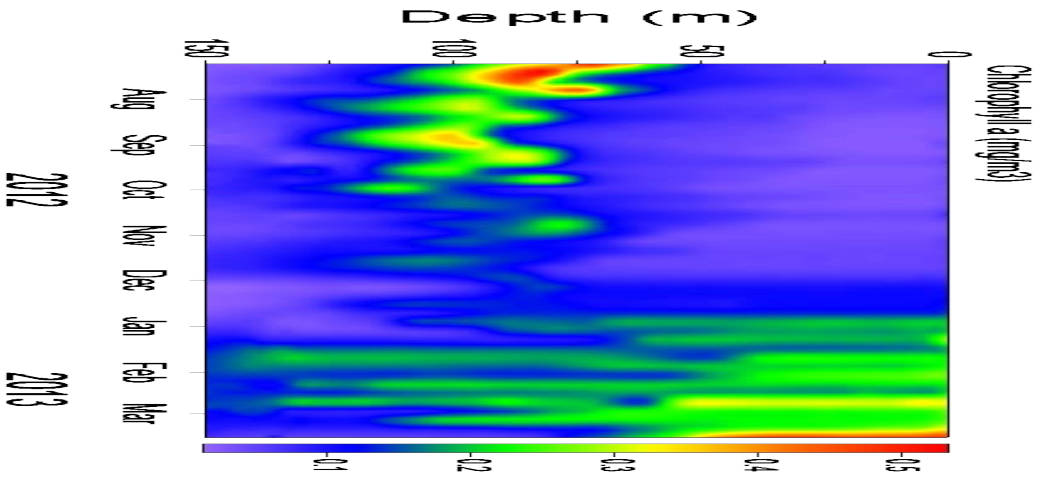


Fig. 1 Seasonal variability in vertical profile of chlorophyll-a upper 150 m between July 2012 and March 2013 observed by POPPS mooring system

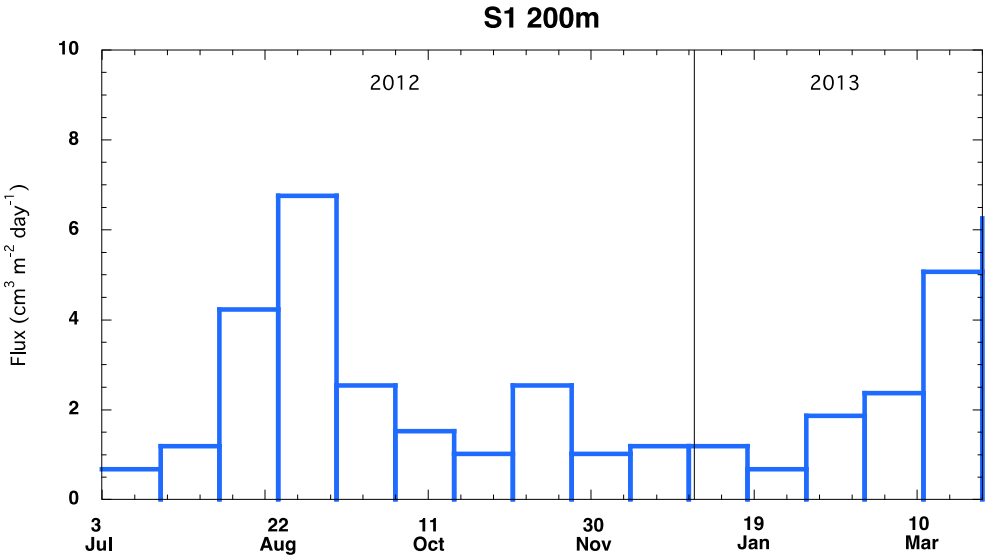


Fig.2 Seasonal variability in total mass flux observed by 200 m sediment trap between July 2012 and March 2013

(2) High primary productivity at S1

Integrated primary productivity (PP) at S1 was estimated to be 330±30mg m^{-2} day^{-1} and higher than that observed previously in summer and comparable to that in early spring (Fig. 3). Why is PP relatively high in summer when nutrients are little or depleted? Based on vertical profile of NO_3, relatively higher NO_3 was observed only near surface (Fig. 4). High nutrient near surface was also observed during last summer cruise (MR12-02: see MR12-02 Preliminary cruise report). It might be attributed to atmospheric input. On the other hand, nitrogen-fixing cyanobacteria that lives in a symbiotic relationship with diatom was detected at S1 (Photo 1). Nitrogen-fixation is another possibility to supply N

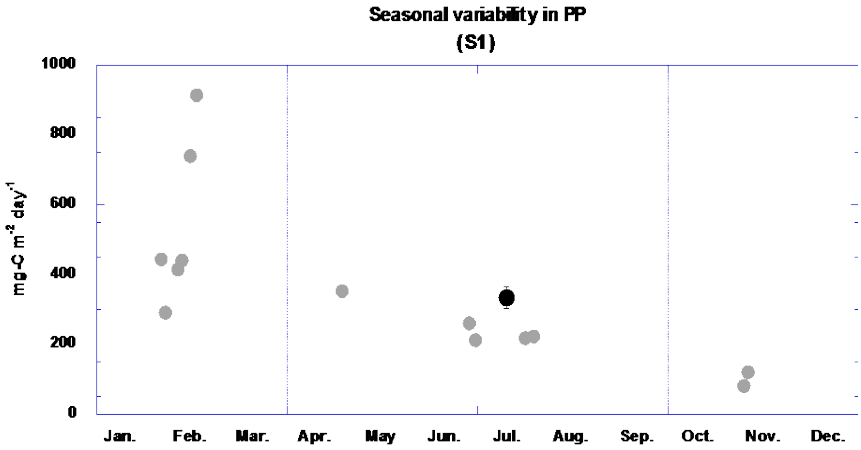


Fig.3 Seasonal variability of primary productivity. Black circle is observed value this cruise.

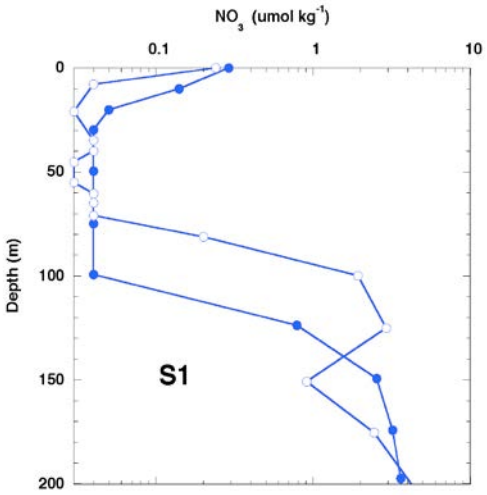


Fig.4 Vertical profile of NO_3 at S1

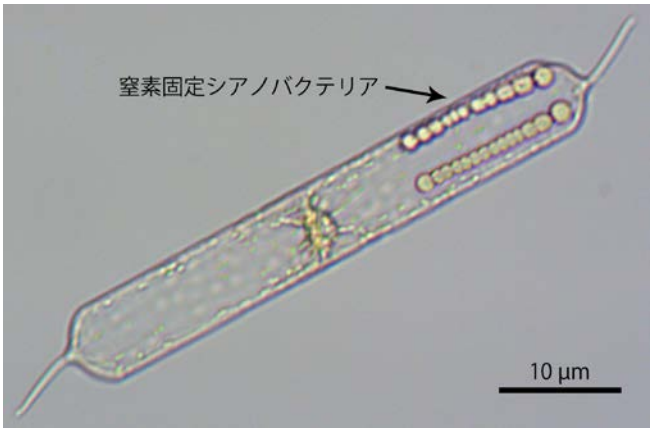


Photo 1 Cyanobacteria that lives in a symbiotic relationship with diatom