A. Cruise summary

1. Cruise information

(1) Cruise designation (research vessel)
MR11-02 (R/V MIRAI)

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

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

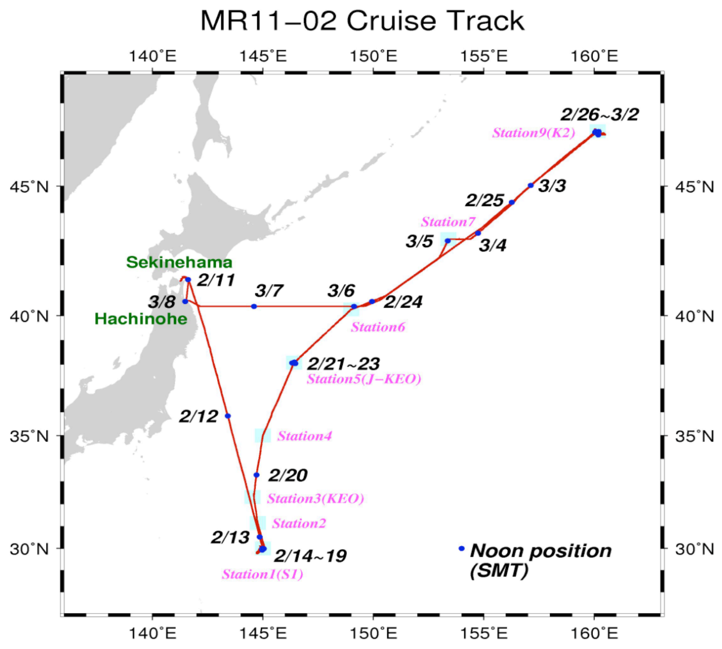
Affiliation	PI	Proposal titles
AORI / The Univ. Tokyo	Koji HAMASAKI	Studies on the microbial-geochemical processes that regulate the operation of the biological pump in the subarctic and subtropical regions of the western North Pacific
Kagoshima Univ.	Toru KOBARI	Effects of meso-zooplankton on food web and vertical flux
Nagoya Univ.	Osamu ABE	An evaluation of past change of primary productivity at the region of NPIW formation using oxygen triple isotopes, O_2, N_2 and noble gases.
NIES	Masanobu KAWACHI	Taxonomy and genome analysis of eukaryotic picophytoplankton originated from cryopreserved marine environmental specimens
JAMSTEC	Makio HONDA	Research and development of optical measurement of marine snow

Okayama Univ.	Osamu TSUKAMOTO	Onboard continuous air-sea eddy flux measurement
Nagoya Univ,	Yoshihisa MINO	Settling velocity of particles in the twilight zone
JAMSTEC	Hisanori TAKASHIMA	Tropospheric aerosol and gas profile observations by MAX-DOAS on a research vessel
MRI	Michio AOYAMA	Long-term study on nutrients in global ocean
Toyama Univ.	Kazuma AOKI	Maritime aerosol optical properties from measurements of Ship-borne sky radiometer
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
NIES	Nobuo SUGIMOTO	Study of distribution and optical characteristics of ice/water clouds and marine aerosols
Chiba Univ.	Masao NAKANISHI	Tectonics of the mid-Cretaceous Pacific Plate
Ryukyu Univ.	Takeshi MATSUMOTO	Standardization of marine geophysical data and its application to the ocean floor geodynamics studies
JAMSTEC	Yoshimi KAWAI	Observational research on air-sea interaction in the Kuroshio-Oyashio Extension region
JAMSTEC	Naoyuki KURITA	Rain and seawater sampling for stable isotopes

(4) Cruise period (port call)
11 February 2011 (Sekinehama) – 9 March 2011 (Sekinehama)

(5) Cruise region (geographical boundary)
The western North Pacific (60°N – 30°N, 140°E – 165°W)

(6) Cruise truck and stations



2. Overview of MR11-02

(1) Objective

Objective of this cruise is to collect biological, biogeochemical and physical data in winter at our western Pacific time-series stations K2 (sub-arctic gyre) and S1 (sub-tropical data).

(2) Overview of MR11-02

We originally planned to start our observation at station K2 and end that at station S1. However we left Sekine-hama for station S1 because weather and sea condition was predicted to be bad at station K2. This decision was right and we fortunately conducted various biogeochemical observations including hydrocasting, drifting buoy, in situ pumping and plankton sampling by large plankton net tow system (IONESS). In addition, we successfully exchange the meteorological sensor on NOAA-KEO surface buoy, recovered the stranded part of JAMSTEC-K-TRITON buoy mooring system which was partitioned by longline fishing last October, and we re-deployed K-TRITON buoy at JKEO station.

We were in trouble for bad weather and rough sea condition at station K2. We were forced to cancel several observations. However we was able to conduct minimum observation enough to verify winter oceanography at station K2.

The followings are preliminary results at station S1 and K2.

1) S1

Water temperature upper 200m was approximately 18°C (Fig. 1a) and the lowest among three cruises (MR10-01: January-February 2010, MR10-06: October–November 2010, and this cruise). Surface mixed layer, established based on a difference in water density of 0.125 from the surface layer, of approximately 200 m was the deepest among three cruises (Fig. 1c). Concentrations of nutrients (nitrate and silicate) were almost same as or slightly higher level than that in winter 2010 (Fig. 2a, b). Surface pCO_2 (xCO_2) was 320 – 330 ppm while atmospheric pCO_2 was approximately 390 ppm. This indicated that station S1 was potentially sink of atmospheric CO_2.

It is noteworthy that concentration of chlorophyll *a* (chl-*a*) was quite higher than that in winter 2010 and autumn 2010. Concentration of chl-*a* was observed three times and concentration of chl-a at surface was measured to be approximately 0.8 $\mu g\ L^{-1}$ twice and that at subsurface maximum layer around 80 m was measured to be approximately 1 $\mu g\ L^{-1}$ once (Fig. 3a). Based on satellite observation during last 10 years (Sasaoaka, personal communication), annual maximum of surface chl-*a* is at most 0.5 $\mu g\ L^{-1}$ around station S1 and, therefore, observed chl-*a* this cruise was abnormally high. Integrated chl-*a* (chl-*a*(int)) upper 200 m this cruise was estimated to be 91 ± 19 mg m^{-2}. This was approximately 4 times higher than that in autumn 2010 (24 ± 6 mg m^{-2}) and approximately 2 times higher than that in winter 2010 (48 ± 6 mg m^{-2}). Based on measurement of accessory-pigments by HPLC, diatom was unexpectedly predominant (3b). In addition, primary productivity (PP) was also high. Integrated PP was 1153 - 1354 mg-C m^{-2} day^{-1}. These large values were higher than the maximum integrated PP at station K2 that must be more productive (ca. 700 mg-C m^{-2} day^{-1}).

It was also noted that freshwater and / or coastal zooplankton and phytoplankton were discovered at station S1 (Drs. Kawachi and Kobari, personal communication, Fig. 4). However high salinity did not support exist of freshwater or coastal water (Fig. 1b). In future, it is important to clarify what mechanism enhances ocean productivity and how fresh and or coastal plankton is transported horizontally to station S1.

2) K2

Surface seawater temperature (SST) at station K2 was approximately 1.8°C and lower than that in winter 2010. However SST was higher than that of intermediate cold water of ca. 1°C observed at around 100 in autumn2010 (Fig. 5a). It was suspected that K2 was going to the winter maximum and SST and surface mixed layer would be lower and deeper, respectively. Concentrations of nutrients (nitrate and silicate) were comparable to those in winter 2010 (Fig. 6a, b).

Concentration of chl-*a* at surface was approximately 0.45 μg L^{-1} and constant upper 100 m (Fig. 7a). Chl-*a* was 0 at around 125 m. Chl-*a*(int) was estimated to be 48±6 mg m^{-2}. This was 1.7 times higher than that in autumn 2010 (30±1 mg m^{-2}) and comparable to that in winter 2010 (50±11 mg m^{-2}). Measurement of accessory pigment revealed that diatom was relatively predominant followed by hyptophytes. (Fig. 7b). PP decreased with increased depth (Fig. 7c). Integrated PP was estimated to be approximately 200 mgC m^{-2} day^{-1}. This was two times larger than that in the winter 2010 (~ 90 mgC m^{-2} day^{-1}).

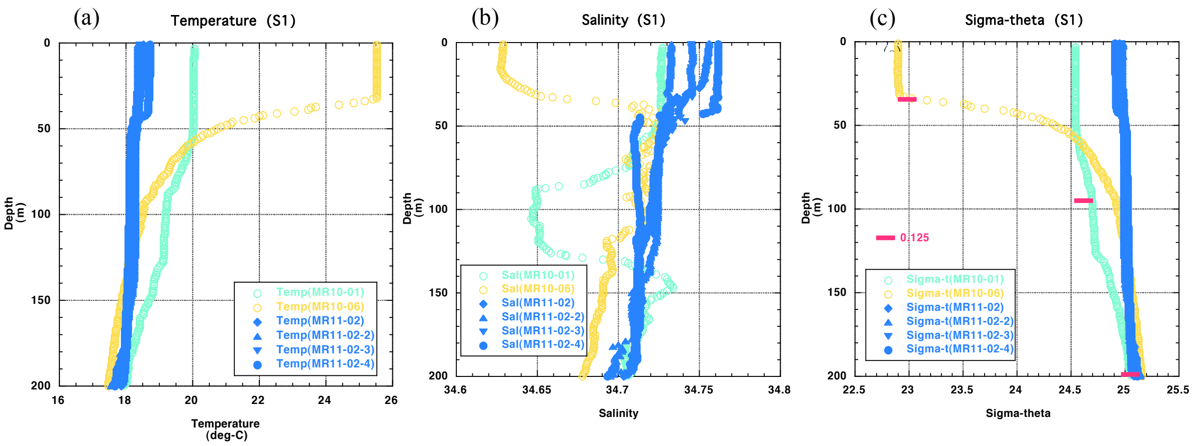


Fig.1 Vertical profiles of (a) temperature (b) salinity (c) density (sigma-theta) upper 200m at station S1.

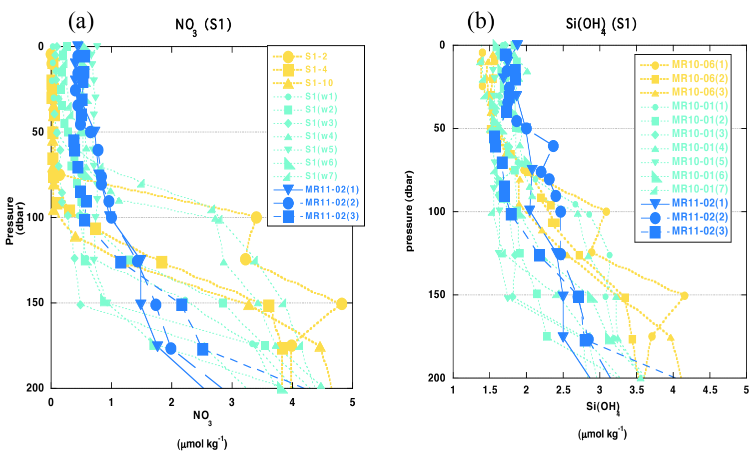


Fig.2 Vertical profiles of (a) nitrate (NO_3) and (b) silicate ($Si(OH)_4$) upper 200 m at station S1

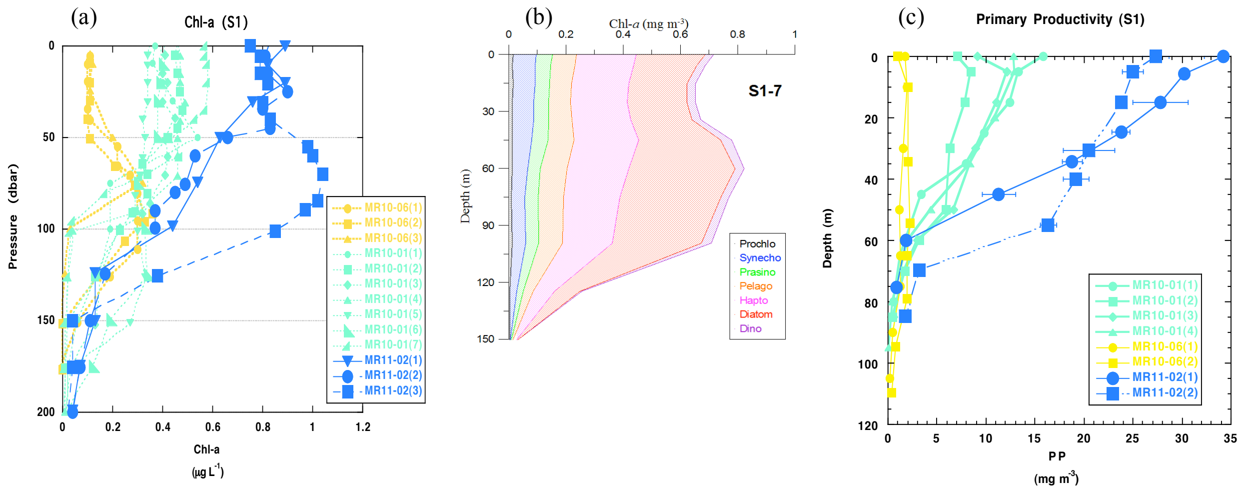


Fig. 3 Vertical profiles of (a) chl-a (b) composition of phytoplankton based on measurement of accessory pigments by HPLC and (c) primary productivity (simulated in situ method) at station S1

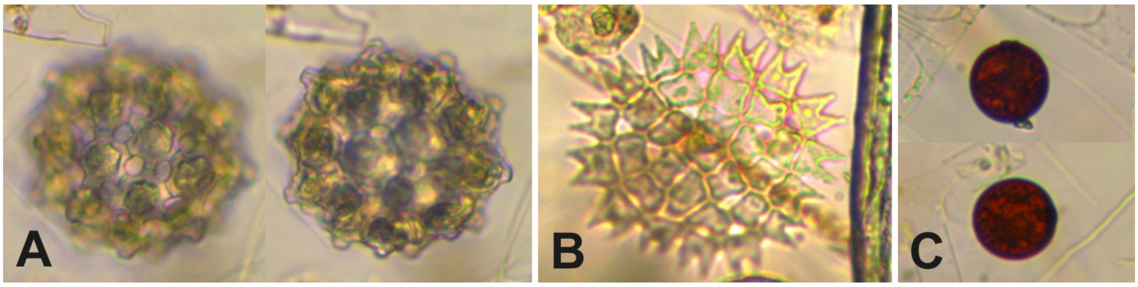


Fig. 4 Freshwater phytoplankton, usually living in pond and / or lake on land, discovered at station S1
A. *Coelastrum sp*., B. *Pediastrum sp*. , C. *Trachelomonas sp*. （courtesy of Dr. Kawachi of NIES）

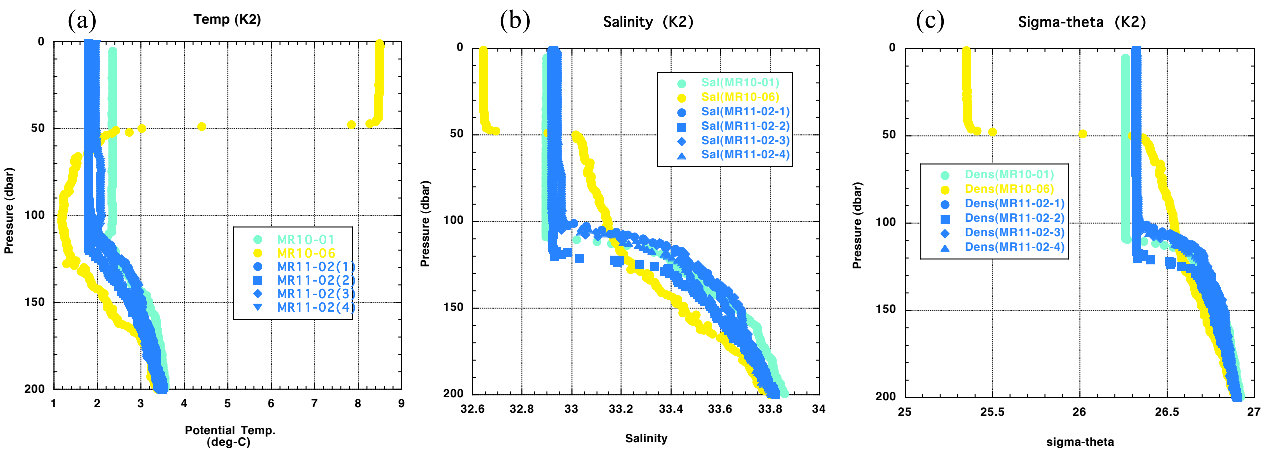


Fig. 5 Vertical profiles of (a) water temperature (b) salinity and (c) density (sigma-theta) upper 200 m at station K2

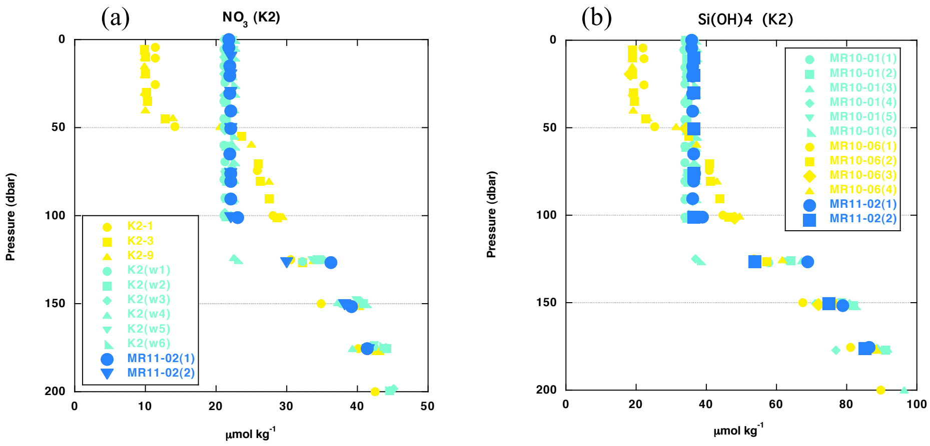


Fig.6 Vertical profiles of (a) nitrate (NO_3) and (b) silicate ($Si(OH)_4$) upper 200 m at station K2

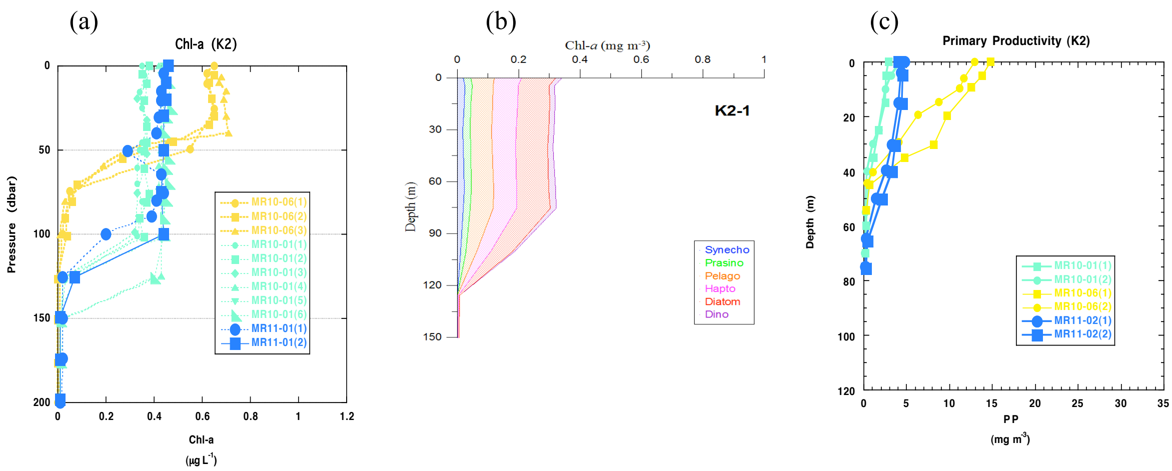


Fig. 7 Vertical profiles of (a) chl-a (b) composition of phytoplankton based on measurement of accessory pigments by HPLC and (c) primary productivity (simulated in situ method) at station K2