A. Cruise summary

1. Cruise information

(1) Cruise designation (research vessel)
MR12-02 (R/V MIRAI)

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

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

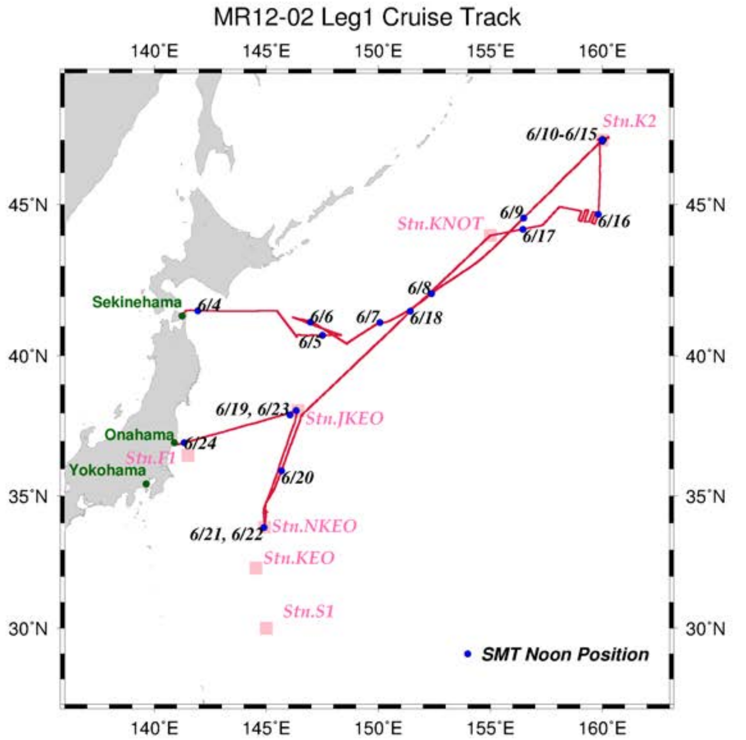
Affiliation	PI	Proposal titles
University of Tokyo	Koji HAMASAKI	Studies on the microbial-geochemical processes that regulate the operation of the biological pump in the subarctic and subtropical regions of the western North Pacific – IV
Tokyo Institute of Technology	Naohiro YOSHIDA	A study of the cycles 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

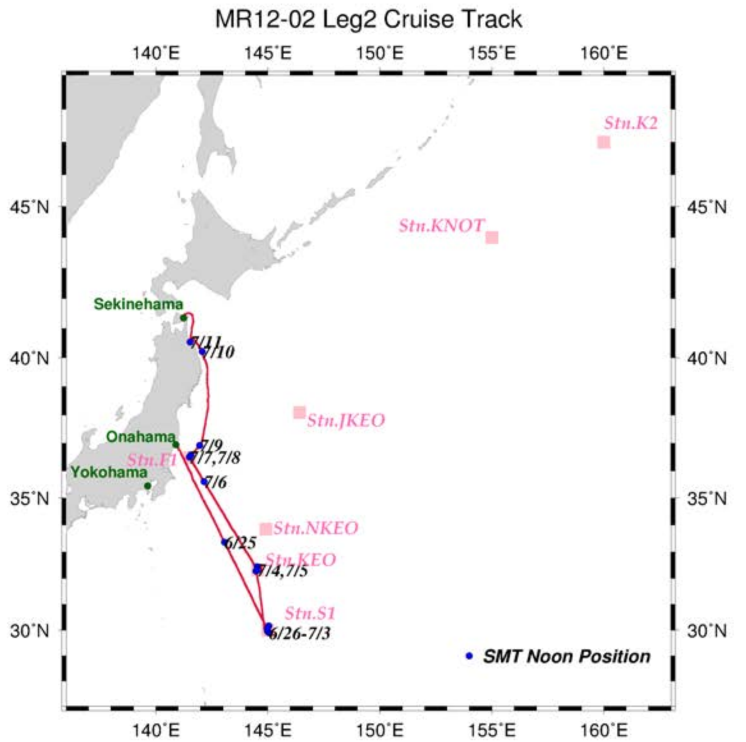
JAMSTEC	Toshio SUGA	Study of ocean circulation and heat and freshwater transport and their variability, and experimental comprehensive study of physical, chemical, and biochemical processes in the western North Pacific by the deployment of Argo floats and using Argo data
JAMSTEC	Hiroshi UCHIDA	Development of a high-quality dissolved oxygen measurement by an optode-based oxygen sensor
National Institute of Radiological Sciences	Tstuso AONO	The concentrations of radionuclides in the western North Pacific
JAXA	Shuji KAWAKAMI	Validation of GOSAT products over sea using a ship-borne compact system for measuring atmospheric trace gas column densities.
JAMSTEC	Yoshimi KAWAI	Observational research on air-sea interaction in the Kuroshio-Oyashio Extension region
not onboard study		
Hokkaido Univ.	Yasushi FUJIYOSHI	Continuous measurement of the water stable isotopes over the Ocean
Chiba Univ.	Masao NAKANISHI	Tectonics of the mid-Cretaceous Pacific Plate
NIES	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)
Leg.1: 4 June 2012 (Sekinehama) – 24 June 2012 (Onahama*)
Leg.2: 24 June 2012 (Onahama*) – 12 July 2012 (Sekinehama)
* Exchange of part of participants without dock

(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 MR12-02

2.1 Objective of this cruise

Principal objective of this cruise is to observe late spring or 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.

Beside this, we conducted the observation of physical and biogeochemical property of meso-scale warm eddy. Moreover, JKEO / NKEO and KEO surface buoys were recovered and / or deployed.

2.2 Cruise summary (highlights)

2.2.1 Time-series observation at stations K2 and S1

(1) Nutrients

Concentrations of nutrients were measured several times at each station. Concentration of NO_3 near surface at K2 was about 17 μmol kg^{-1}. Compared to winter value (~ 30 μmol kg^{-1}), NO_3 decreased, however did not become the annual minimum value. Concentration of $Si(OH)_4$ was about 30 μmol kg^{-1} and this concentration was comparable to medium value of annual variability. Concentration of NO_3 upper 50m at S1 was less than 0.1 μmol kg^{-1} and comparable to the annual minimum. However, it is notable that concentration of NO_3 at surface was higher (between 0.1 and 0.7 μmol kg^{-1}). It is still on argument whether this is natural increase (eolian input?) or contamination by bucket used for sampling. Unlike NO_3, concentration of $Si(OH)_4$ near surface at S1 was about 2 μmol kg^{-1} and comparable to winter value or the annual maximum. It might be supported by the fact that diatom which requires $Si(OH)_4$ was little at S1.

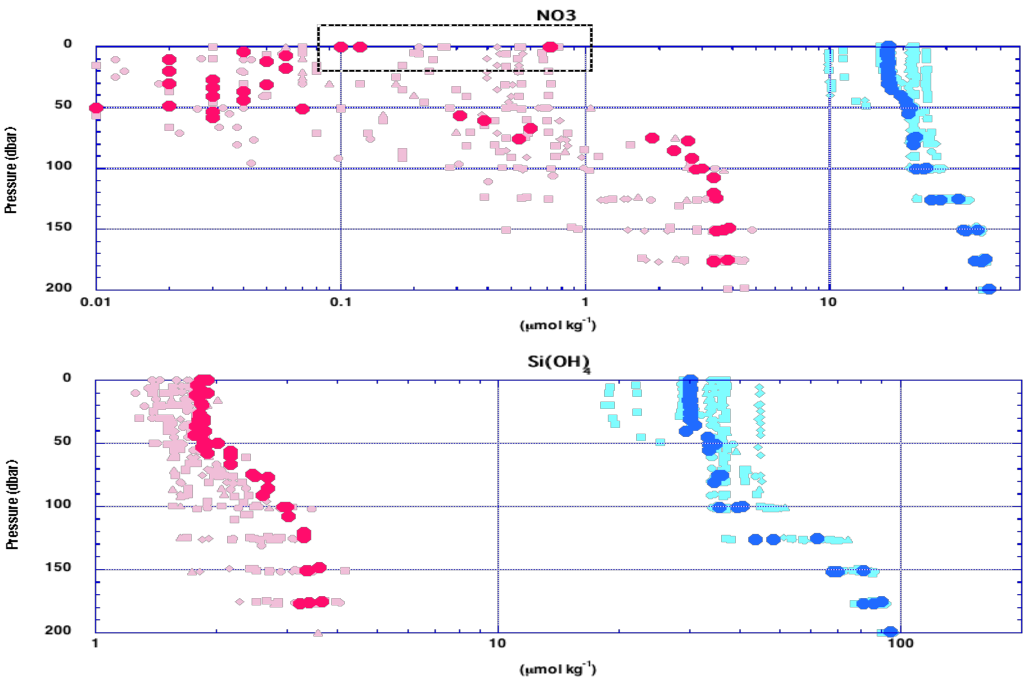


Fig. 1 Seasonal variability in nutrients: NO_3 (upper) and $Si(OH)_4$ (lower). Blue and red shows concentrations at K2 and S1, respectively and concentrations of dense color are data during this cruise.

(2) Pigments

Maximum chlorophyll-a (chl-a) at station K2 was about 1.2 μg L^{-1} observed at around 30 m water depth (Fig. 2a). Based on high-performance liquid chromatography (HPLC) analysis, diatom and *haptophyto* such as *coccolithophorids* were dominant species. At station S1, subsurface maximum of chl-a (~ 0.5 μg L^{-1}) was observed at around 65 m. Dominant species of phytoplankton were *haptophyto* and *prochlorococcus* and diatom was not found. This result might support that dissolved $Si(OH)_4$ was not consumed largely at station S1.

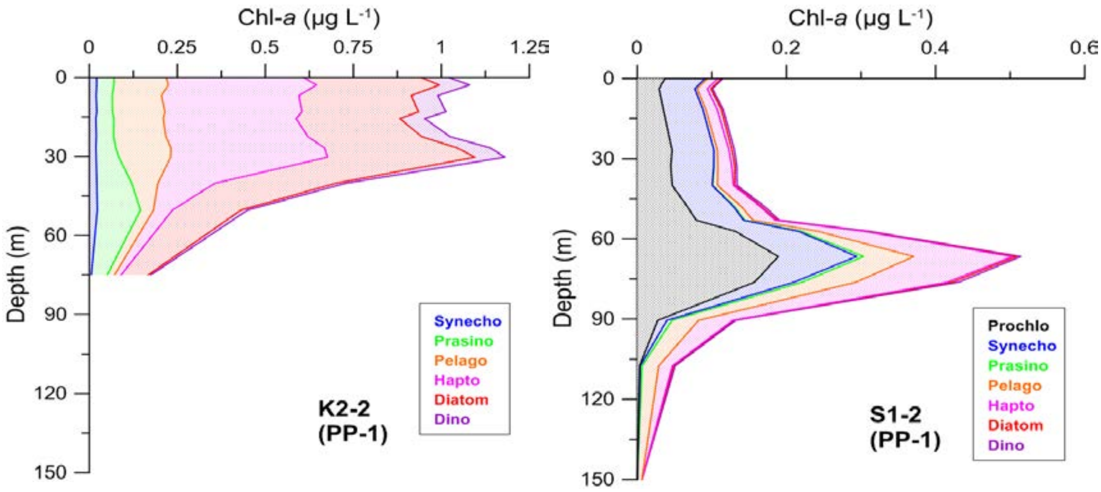


Fig. 2 Vertical profile of chlorophyll-a (chl-a) and contribution of chl-a of major major phytoplankton to total chl-a based on HPLC analysis.

(3) Primary productivity

Integrated primary productivity (PP) at station K2 ranged from approximately 400 to 600 mg-C m^{-2} day^{-1} (Fig. 3a). Based on seasonal variability in PP observed previously, PP during this cruise was close to the annual maximum. On the other hand, PP at station S1 was approximately 200 mg-C m^{-2} day^{-1}. This PP coincided well with seasonal variability.

PP observed during this cruise and previously correlated well with photosynthetic available radiation (PAR) at station K2 (Fig. 3b). Thus it can be said that the major limiting factor of PP at station K2 is light condition.

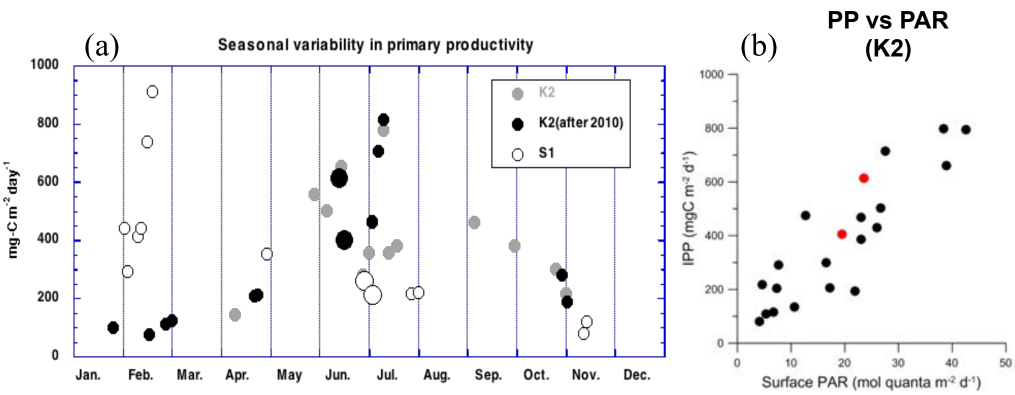


Fig. 3 (a) Seasonal variability in primary productivity (PP) at stations K2 (closed circles) and S1 (open circles). Larger circles are data obtained during this cruise. (b) relation between PP and photoshynthetically available radiation (PAR) at station K2. Red circles show data obtained during this cruise

(4) Sinking particle

(Station K2) (Fig. 4a)

Based on height of sinking particle collected in collecting cups, mass flux at 200 m increased in July just after deployment. However mass flux decreased thereafter. Mass flux at 500m increased relatively in July and August 2011. Mass flux decreased between autumn 2011 and early spring 2012. Mass flux increased again in late March and April 2012. Mass flux at 4810 m was large in July and August 2011 and decreased toward winter. Mass flux also increased in April 2012 same as 500 m with time lag.

(Station S1) (Fig. 4b)

At 200 m, mass flux increased in August and decreased toward winter. Mass flux increased again in February 2012. Mass flux at 200 m was higher at S1 than K2 on average. Smaller fluxes in October 2011 and in April 2012 were observed. It might be attributed to decrease of trapping efficiency by tilt based on increase of water depth. Although seasonal variability was small, mass flux at 500 m and 4810 m were relatively higher in autumn and late winter (February and March) in 2012. Mass fluxes at these depth were smaller than those at station K2 unlike mass flux at 200 m.

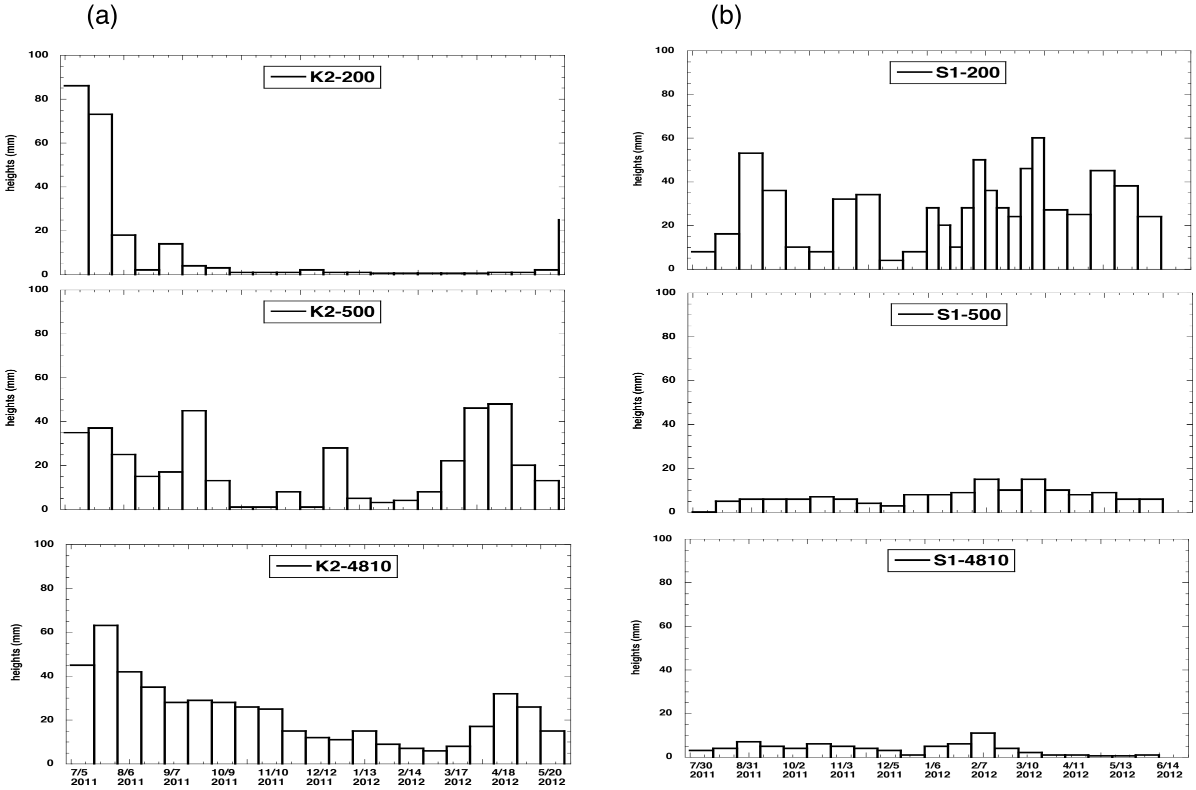


Fig. 4 Seasonal variability in sinking particle flux at (a) K2 and (b) S1. Vertical axis is height of collected materials in collecting cups.

2.2.2 Sediment trap experiment at station F1

Compared to settling particles at K2 and S1, larger materials were collected at station F1. Small increases of total mass flux at 200 m were observed in autumn 2011 and January 2012 (Fig. 5). Relatively larger flux was observed in April 2012. At 1000 m, two flux peaks were observed in September 2011 and January 2012 these increases synchronized well with shallower flux increases. Please note that several cups contained swimmer such as fish, shrimp and jellyfish. Based on vertical profile, high turbidity layer exist at around 600 m and 1000 m (Fig. 3.3.5 in the section "3.3 Sediment trap experiment at station F1") and, therefore, horizontal supply of materials should be taken into account.

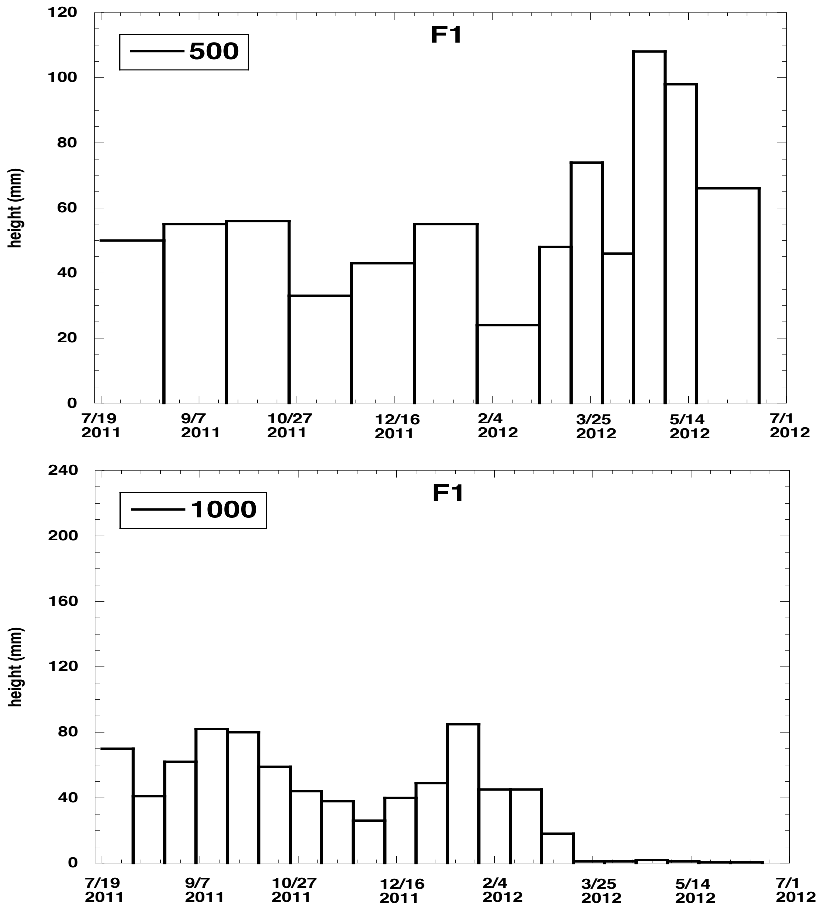


Fig. 5 Seasonal variability in total mass flux. Please note that size of collecting cup between 500 m and 1000 m are different (diameter of 500 ml cup has ca. two times higher than that of 1000 m cup).