A. Cruise summary

1. Cruise information

(1) Cruise designation (research vessel)
MR11-05 (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

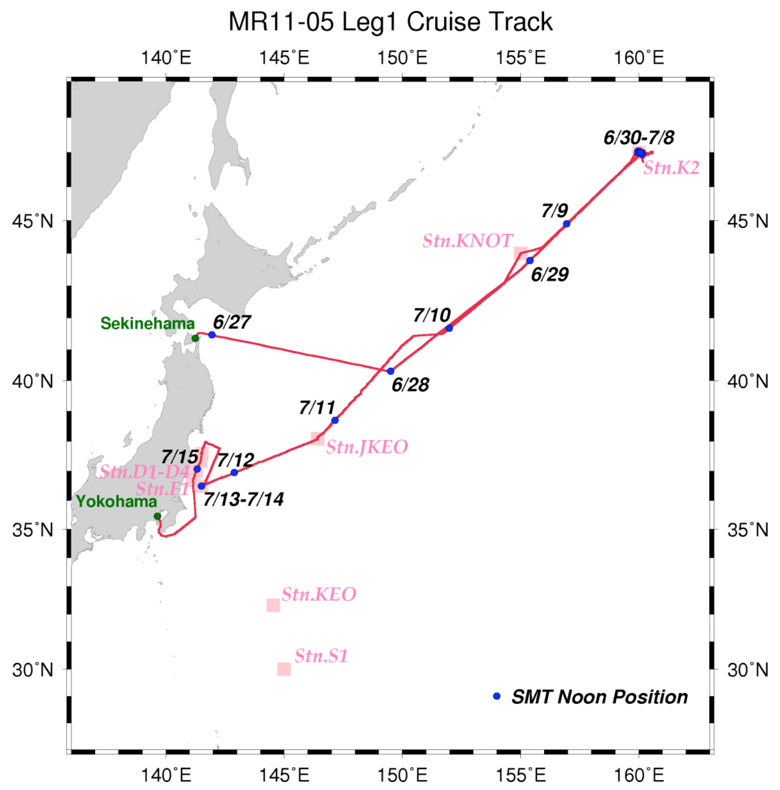
Affiliation	PI	Proposal titles
AORI / The Univ. Tokyo	Koji HAMASAKI	Studies on the microbial-geochemical processes that regulate the operation of the biological pump in the subarctic and subtropical regions of the western North Pacific
Kagoshima Univ.	Toru KOBARI	Effects of meso-zooplankton on food web and vertical flux
JAMSTEC RIGC	Hiroshi UCHIDA	Temporal changes in water properties of abyssal water in the western North Pacific
JAMSTEC RIGC	Yoshimi KAWAI	Observational research on air-sea interaction in the Kuroshio-Oyashio Extension region
JAMSTEC RIGC	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

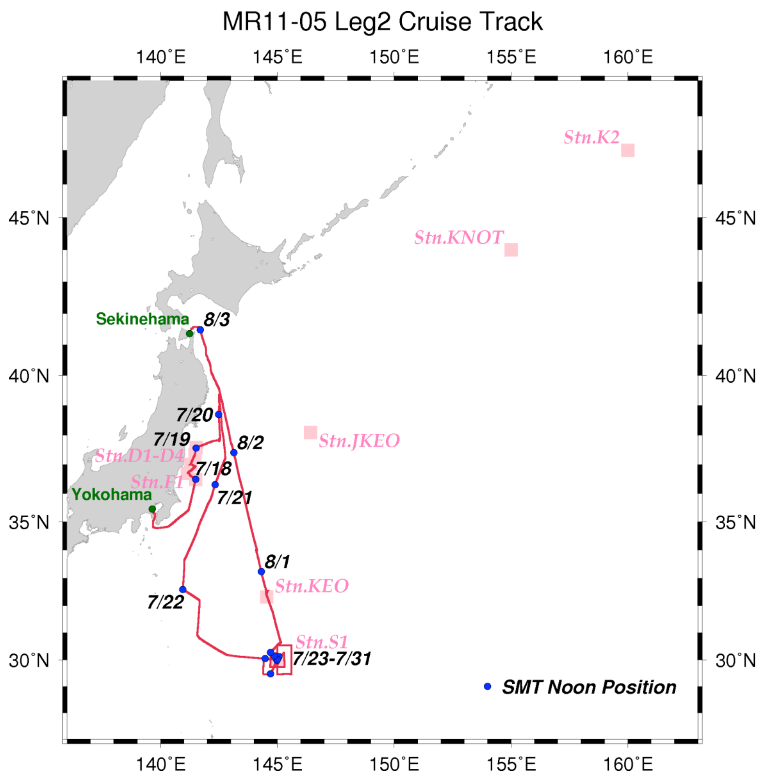
		Argo data
JAMSTEC RIGC	Hideki KOBAYASHI	Verification of DNA damage in microorganisms by the radioactive contamination
not onboard study		
NIES	Nobuo SUGIMOTO	Study of distribution and optical characteristics of ice/water clouds and marine aerosols
Okayama Univ.	Osamu TSUKAMOTO	Onboard continuous air-sea eddy flux measurement
JAMSTEC	Hisanori TAKASHIMA	Tropospheric aerosol and gas profile observations by MAX-DOAS on a research vessel
Toyama Univ.	Kazuma AOKI	Maritime aerosol optical properties from measurements of Ship-borne sky radiometer
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	Naoyuki KURITA	Rain and seawater sampling for stable isotopes
National Institute of Radiological Sciences	Tatsuo AONO	The concentrations of radionuclides in the western North Pacific
JAMSTEC RIGC	Masayuki TAKIGAWA	Estimation of radionuclides' deposition into the ocean in the western Pacific by using a regional chemical transport model
JAMSTEC RIGC	Yukio MASUMOTO	Model-observation comparison study on upper-ocean conditions and radionuclide dispersion off Tohoku
Kanazawa Univ.	Seiya NAGAO	Geochemical behavior of radionuclides released from Fukushima Daiichi NPP in marine environment
Tokai Univ.	Yoshihisa KATO	Distribution of radioisotopes in sediments off Fukushima, Japan
Tokyo Institute of Technology	Naohiro YOSHIDA	Detection of radioactive sulfur in the maritime air and surface seawater

(5) Cruise period (port call)
Leg.1: 27 June 2011 (Sekinehama) – 16 July 2011 (Yokohama)
Leg.2: 17 July 2011 (Yokohama) – 4 August 2011 (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 MR11-05

(1) Objective of this cruise

Objective of this cruise is to observe summer ecosystem and biogeochemical cycle at time-series stations in the sub-arctic and sub-tropical gyres. Additional purpose is to collect samples for measurement of artificial radioactive nuclides (ARN) accidentally emitted from the Fukushima Daiichi nuclear power plant caused by the Tohoku great earthquake and its induced tsunami on 11 March 2011 in order to verify mechanism of transport and circulation of ARN in the ocean.

(2) Cruise summary

1) Time-series observation at stations K2 and S1

Since last autumn 2010, time-series observation of ecosystem and biogeochemistry has been conducted at time-series stations (K2: sub-arctic gyre, S1: sub-tropical gyre). In this cruise, comprehensive oceanography in summer was observed and many samples were collected for analysis of ecosystem and biogeochemistry in summer at both stations.

a) Station K2

We stayed at station K2 for ca. 10 days and comprehensive observations were conducted. Sea surface temperature was ca. 7°C. Surface mixed layer was ca. 20 – 25 m and the shallowest among time-series cruises since winter 2010 (Fig. 1a). Chlorophyll-a in the surface water was ca. 1 mg L^{-1} on average and subsurface maximum was observed at around 30 m just below surface mixed layer (1b). Chlorophyll-a in the surface water was the maximum among time-series cruises (Fig. 2a). Integrated chlorophyll-a was estimated to be 70-80 mg m^{-2} and also the maximum. Integrated primary productivity was estimated 460 - 820 mg-C m^{-2} day^{-1} (average: 660 mg-C m^{-2} day^{-1}) (Fig. 2b). To sum up, biological activity and productivity was the greatest in this cruise among time-series cruises. In addition, sediment trap mooring system deployed last October 2010 was successfully recovered at station K2. Time-series sediment traps at 200m, 500m and 4810m collected seasonal sinking particles each 6 – 12 days interval. At 200m, relatively higher flux was observed in the early period after sediment trap started sampling in autumn. However amount of collected materials decreased since then (Fig. 3a). Distinct seasonal variability in sediment trap materials at 500 m and 4810 m did not appear. Compared to other years, amount and seasonal variability of sinking materials collected looked smaller. Moreover synchronization of seasonal variability between different depths was not seen either.

b) Station S1

We started observation at S1 just after typhoon passed. It was expected that primary productivity was high because nutrient in subsurface layer was supplied by increase of surface mixing. However chlorophyll-a maximum at subsurface (~ 100 m) was at most 0.6 μg kg^{-1} (Fig. 4a) and surface chlorophyll-a was only 0.06 μg kg^{-1} and the smallest among time-series cruises (Fig. 2a). Primary productivity (PP) was low (Fig. 4b) and integrated PP of approximately 220 mg-C m^{-2} day^{-1} was the second smallest among time-series cruises. Sediment trap mooring system deployed in October 2010 was also recovered successfully at station S1. At 200m, relatively higher flux was observed in late February and April 2011 (Fig. 3b). At 500m, similar seasonal variability was observed although variability was small. At 4810 m, high flux was observed in May 2011. Distinct synchronization of seasonal variability between different depths was not observed.

Seasonal observation at stations K2 and S1 since winter 2010 showed similar seasonal variability to previous one (Fig. 2a, 2b). However winter chlorophyll-a and primary productivity was higher than previous data. Especially its trend at station S1 was noteworthy and sinking particles were higher than that at station K2. Future chemical analysis will reveal this characteristic quantitatively.

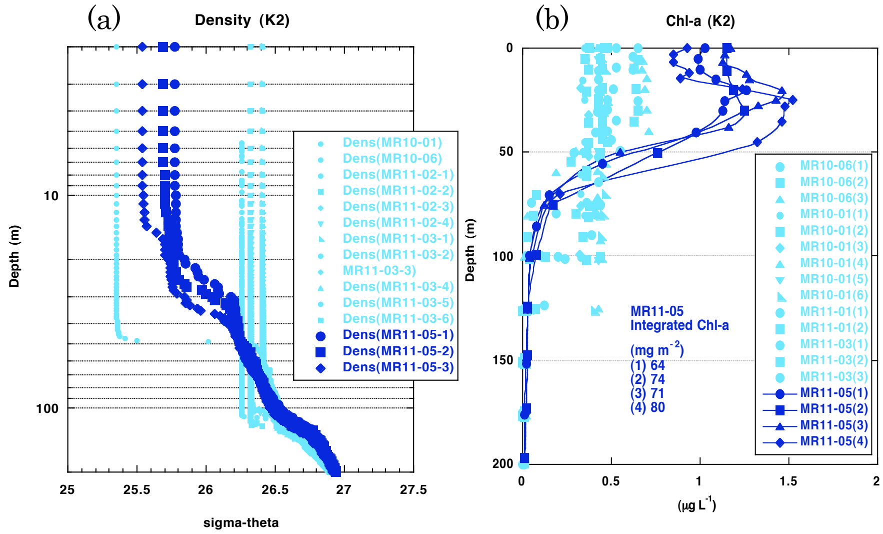


Fig.1 Seasonal variability in vertical profiles of (a) density (b)chlorophyll-a at station K2

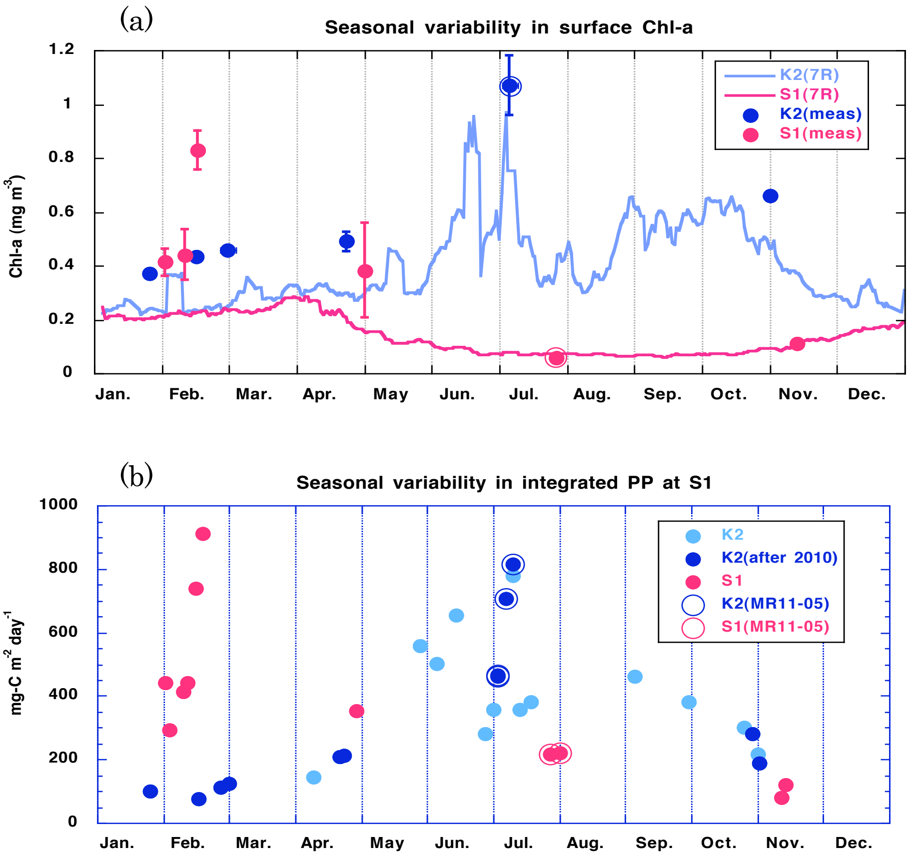


Fig. 2 Seasonal variability in (a) surface chlorophyll-a and (b) integrated primary productivity. Line graph in (a) is previous average of satellite based chlorophyll –a.

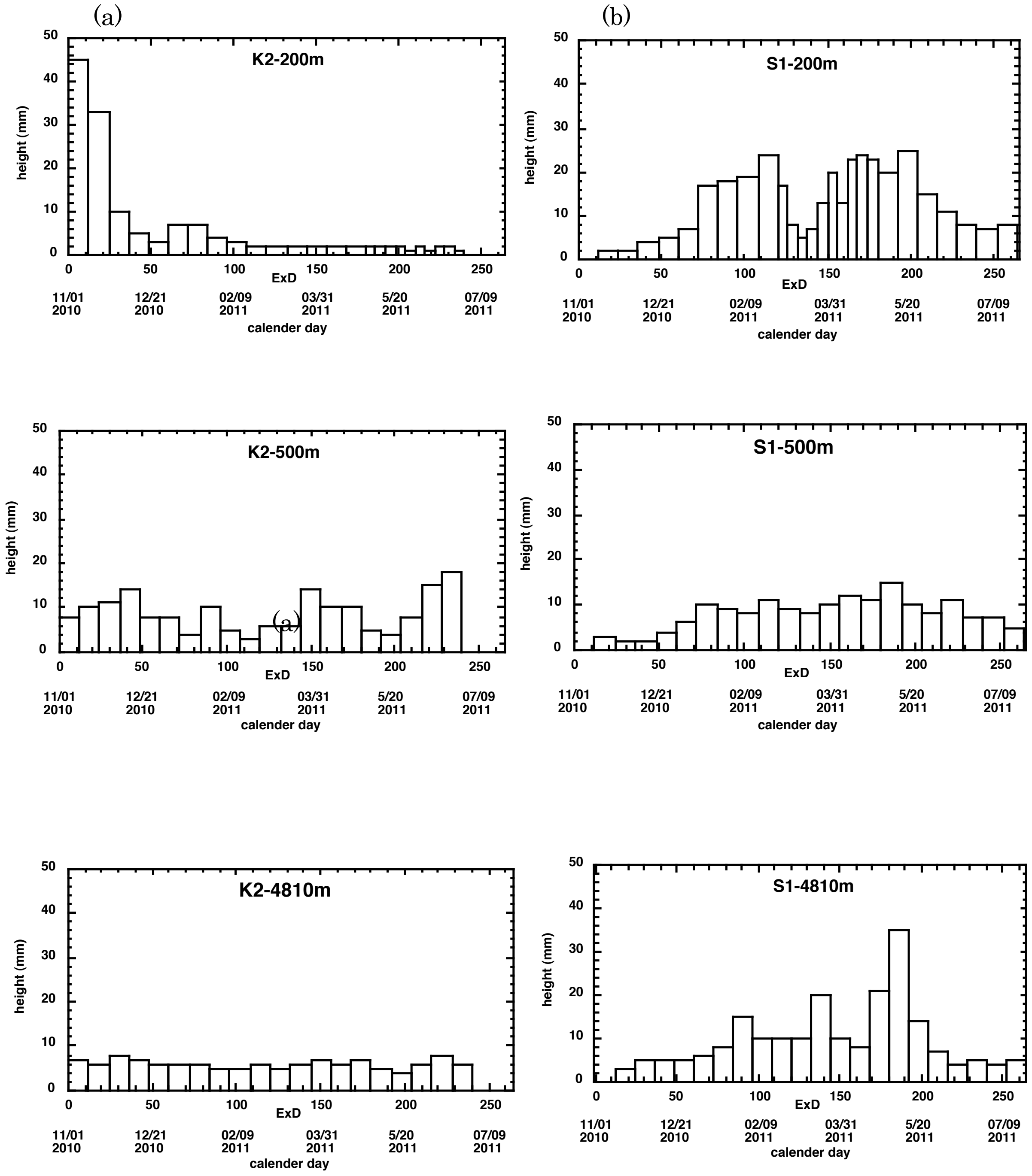


Fig. 3 Seasonal variability in sinking particle flux (a) K2-200m（upper）K2-500m（middle）K2-4810m（lower）and (b) S1-200m（upper）S1-500m（middle）S1-4810m（lower）. Vertical axis is height of collected materials in collecting cups.

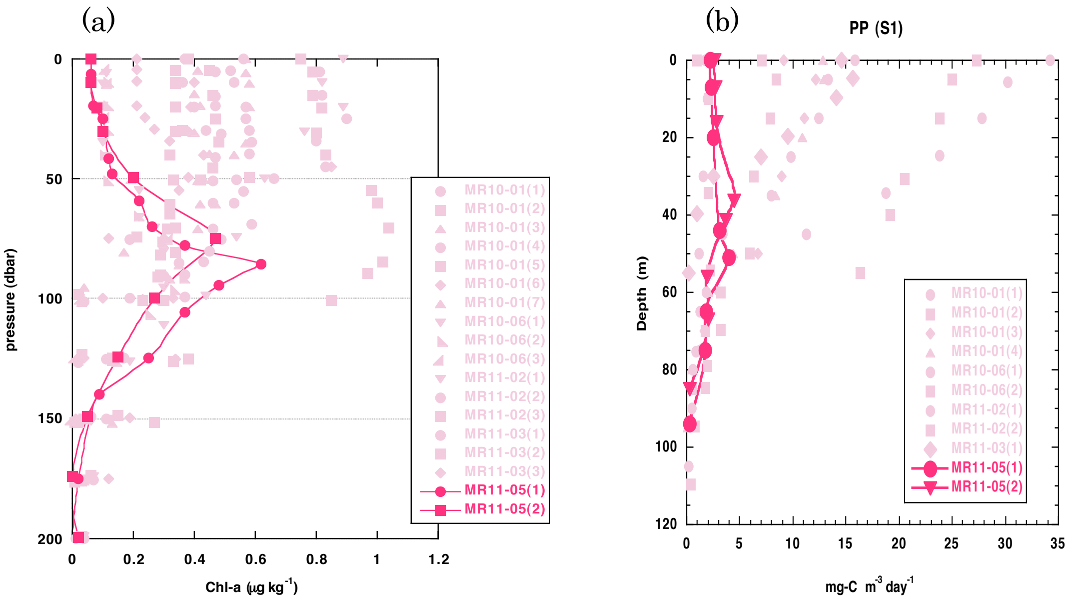


Fig. 4 Vertical profiles of (a) chlorophyll-a and (b)primary productivity at station S1

2) Observation of artificial radioactive nuclides

Along the cruise track and at stations K2, S1 and brand-new station F1, seawater, aerosol, suspended matter and seafloor sediment were collected in order to measure artificial radioactive nuclides (Fig. 5). At station F1, where is ca. 90 km southeast from the Fukushima Daiichi nuclear power plant, the small decrease of beam transmittance was observed at not only near surface, but also middle layer (around 700 m) and near bottom (1200 m) (Fig. 6). It was indicative of that there exist materials transported horizontally at station F1. The mooring system with time-series sediment traps at 500 m and 1000 m was deployed under cooperation with Woods Hole Oceanographic Institution. This mooring system will be recovered in June 2012.

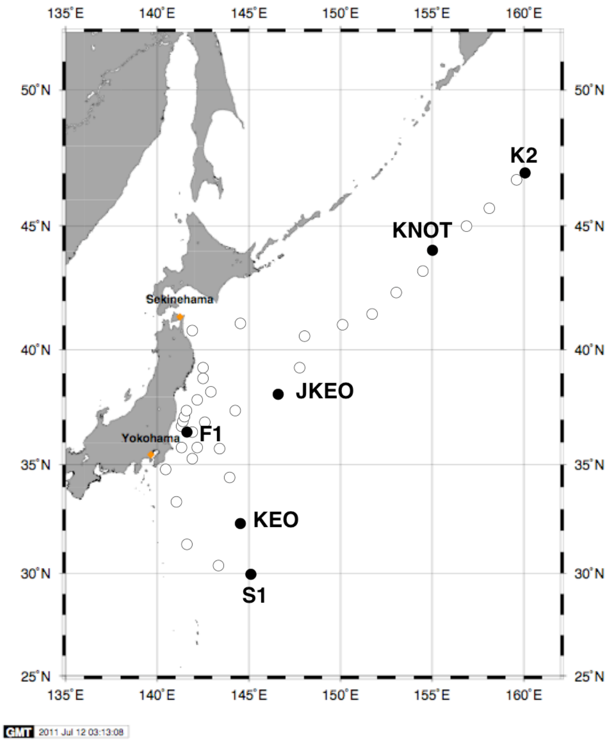


Fig. 5 Sampling stations of sea surface water for measurement of radioactive nuclides

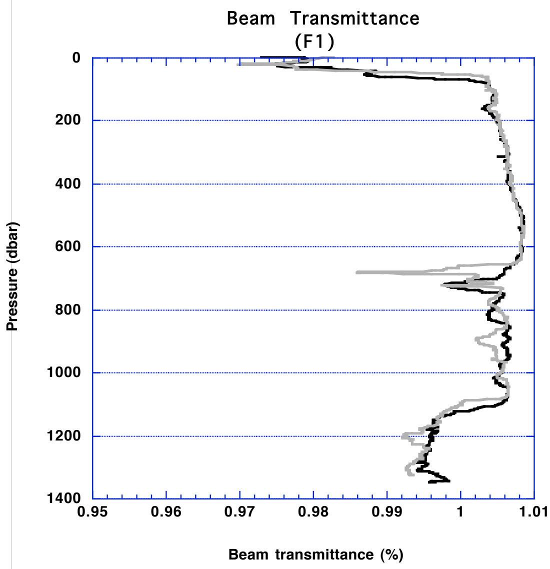


Fig. 6 Vertical profile of beam transmittance at station F1