Cruise Summary

1. Cruise Information

Cruise ID: KH-19-4

Name of vessel: Hakuho Maru

Title of cruise: Role of turbulence in ecosystem and material cycles in the Kuroshio recirculation region, western subtropical Pacific

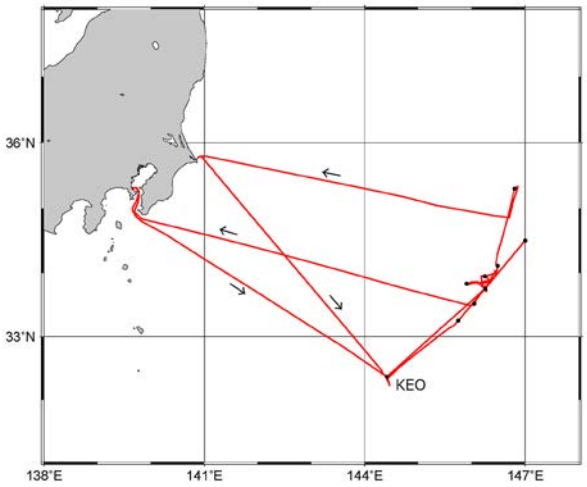
Chief Scientist: Minoru Kitamura (JAMSTEC)

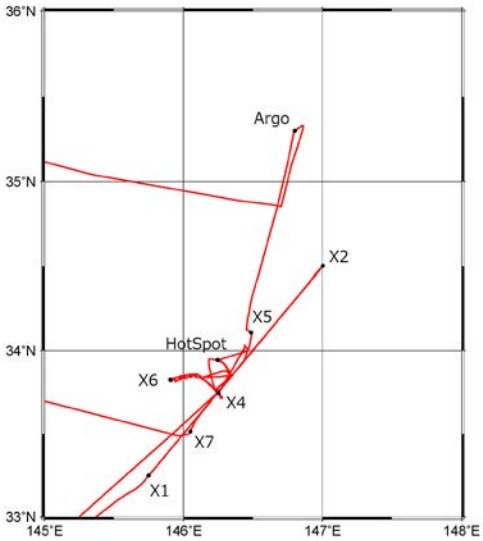
Cruise period: July 20 - 30, 2019

Ports of departure / call / arrival: Yokosuka / off Choshi (no entry into the port) / Yokosuka

Research area: Kuroshio recirculation region, western subtropical North Pacific

Research map





Representative of Science Party

1. Physical observations: Dr. Takeyoshi Nagai, Tokyo Univ. of Marine Science and Tech.

2. Suspended and sinking particle observations: Dr. Makio Honda, JAMSTEC

3. Biological observations: Dr. Minoru Kitamura, JAMSTEC

2. Overview of Research Activities

1. Physical observations

Fine-scale physical structures were investigated in a cyclonic eddy located northeast of the time-series station KEO in the western subtropical Pacific. At the first, XBT (eXpendable BathyThermograph) observations were conducted in July 22-23, 2019. The objective of the XBT observations was to determine the location of the cyclonic eddy, detected by sea surface height data. The obtained XBT data with acoustic Doppler current profiler data suggests that the XBT transect covers a core of the cyclonic eddy, spinning counterclockwise. After that, three sets of Underway-VMP (UVMP) and Underway-RINKO (URINKO) observations were carried out from the center of the cyclonic eddy toward its outside. The UVMP has a vertical freefall type microstructure profiler, VMP250 (Rockland Scientific International), and measures microstructure data including turbulent shear and high resolution temperature. During the UVMP observation, VMP250 was freely fallen and raised back to surface with a UCTD winch. On the other hand, URINKO consists of a RINKO profiler (JFE-Advantech) and an UCTD winch (Teledyne Oceanscience). The RINKO profiler carries a CTD sensor, a fluorescence and turbidity probe, and a RINKO oxygen sensor. The UVMP and URIKO observations were conducted alternately to collect two vertical profiles of the VMP and RINKO data quasi simultaneously.

To collect vertical profiles of turbulent shear intensity, Turbulence Ocean Microstructure data Acquisition Profiler Laser (TurboMAP-L) was also deployed in this cruise.

2. Observations of suspended and sinking particles

Marine aggregate is one of the key components of sinking materials transporting fixed carbon in the surface layer to the ocean interior and the seafloor. Nevertheless microscopic observation on marine aggregates shows that small phytoplankton including cyanobacteria can be incorporated into marine aggregate, transport efficiency of each species to them is not clear. In this study, molecular species composition of eukaryote in 6 different size class of POM (<0.4, 0.4-2, 2-5, 5-20, 20-120 and >120 μm) and particle size distribution (PSD) was examined under different shear intensity in the mixed layer. Species composition of eukaryote was examined by 18S rRNA V9 metabarcoding. POM were collected from two fixed layers (10 and 200 m) at station Hot spot 1 at which high turbulence was observed during the transect observation on turbulent dissipation rate in this cruise, in the daytime and in the nighttime. Simultaneously depth profiles of PSD and turbulent dissipation rate from the surface to 200 m were

determined by using an *in situ* particle sizing instrument (LISST-100X and LISST-Holo, Sequoia Scientific, USA) and a free-fall microstructure profiler (TurboMAP-L, JFE Advantech Co, Japan).

Additionally, we recovered and redeployed the KEO sediment trap moorings successfully. Based on the comparison study of biogeochemistry in the northwestern North Pacific eutrophic subarctic region and oligotrophic subtropical region ("K2S1 project" in 2010 - 2013), it was clarified that biological activity in the subtropical region is comparable to or slightly larger than that in the subarctic region. In order to verify the support mechanism of biological activity, that is the mechanism of nutrient supply, time-series sediment trap experiment was initiated in 2014 at about 4900 m of the station KEO. This station is the time-series station maintained by National Ocean and Atmosphere Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL). Surface buoy with meteorological sensors and physical oceanographic sensors have been deployed at station KEO since 2004. Therefore, these time-series data of meteorology and physical oceanography can be utilized to interpret time-series variability in sediment trap data. Owing to simultaneous analysis of time-series data obtained by NOAA surface buoy and JAMSTEC sediment trap between 2014 and 2016, it was verified that mesoscale cyclonic eddy potentially plays a role in nutrient supplier (Honda et al. 2018). In order to evaluate other potential mechanisms such as typhoon and aeolian dust input, sediment trap experiment has been continued at station KEO.

3. Biological observations

To understand interaction between fine-scale physical oceanic structure and zooplankton distribution, fine-scale vertical distribution of zooplankton was investigated by using acoustical and optical methods. As the acoustical method, we used Acoustic zooplankton and Fish Profiler (AZFP) and shipboard ADCP. From the vertical cast of the AZFP, we can observe vertical distribution of backscattering strength (a proxy of zooplankton biomass) in one meter resolution. Total four deployments of the AZFP was carried out during the cruise, and three of the four deployments were conducted just after/before the turbulence observations by using the Turbo-MAP. From the sound data obtained by using the shipboard ADCP, acoustic backscattering strength (proxy of the zooplankton biomass) can be estimated. The data sampling of ADCP was successfully carried out during the physical observations by using UVMP and URINKO. After the cruise, we will analyze horizontal distribution of zooplankton and will discuss interaction between the zooplankton distribution and physical structure including turbulence strength. As the optical method, we deployed Visual Plankton recorder (VPR). Two tows of the VPR were carried out along parts of the underway MVP and RINKO transects (Legs 1 and 2) in the cyclonic eddy area. And along the leg 3 in the cyclonic eddy, we towed underway RINKO sensor, underway VMP (turbulence sensor), and VPR in turns. There were some troubles in the battery supply into the VPR system, but continuous data samplings were carried out along parts of the leg 2 and leg 3.

Oceanic primary productivity was also estimated by the incubation experiments in a station,

turbulence hot spot 1, where high turbulence was observed. Purpose of this experiment was to understand the variability of primary productivity depending on the nutrient supply associated with the turbulence. To characterize the optimal productivity in response to light, the relationship between phytoplankton photosynthetic rate (P) and scalar irradiance (E) are estimated by the P vs. E curve experiment.