Study on benthos from seafloor image using autonomous underwater robot

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We navigate autonomous underwater vehicles at altitudes of 2 m and 8 m, take photograph the ocean floor images, and make mosaicking to provide wide-area image mapping of the ocean floor. From the image, we can extract the benthos and investigate the their distribution. We will grasp the whole of the ecosystem from environmental information obtained from the ocean bottom topography and images. We present data including time change such as ecology of hydrothermal activity area and ecology of hydrate zone, and show new observation method using autonomous underwater vehicles.

Keywords: Benthos, Autonomous Underwater Vehicle, photograph

Acoustic remote sensing of marine organisms

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The goal of our project is to provide maps of aquatic animals similar to the satellite image of clouds. Three major means for the visualization were the passive acoustics, the active acoustics, and the submarine cables. Approximately 100,000 hours recording was conducted during 5 years period in this project. In addition, 20 years recordings, which was archived by the cable systems were included for the analysis. Species specific detectors were developed referring the sound feature database of crustaceans, fish and marine mammals. By far, passive acoustic monitoring have been applicable only for the presence of phonating animals. Hydrophone array systems and mathematical models enabled monitoring of spatial distribution, behavior and number of animals in Japanese waters. Off Chiba and Ibaraki prefectures, we showed movies of acoustic distribution of fish, crustacean and cetaceans using 20 passive acoustic monitoring stations. In Tateyama Bay, Chiba prefecture, combined methods of passive and active means visualized benthic and pelagic species simultaneously. Kushiro-Tokachi cable system, off Hokkaido showed seasonal presence of fin whales that has never been identified due to rough weather in winter time. Achieved sound data during 20 years revealed frequent presence of sperm whales in Sagami bay, off Kanagawa prefecture. Using support vector machine, deep learning and neural networks, classification of broadband echoes from fish was improved to monitor individual moment and identify species. Even in a limited area, species maps of marine animals have been presented. Acoustic remote sensing technology will be used for the census of aquatic animals.

Keywords: passive acoustic monitoring, submarine cable, fish echosounder

Seasonal dynamics of phytoplankton and bacteria community in Sendai Bay

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Phytoplankton and bacteria play ecologically and biogeochemically significant roles in marine ecosystem as a primary producer and as an interface of dissolved organic materials into marine food web. Recently, study about marine microbial diversity has been accelerated using molecular techniques, but basic information of those diverse types of microbes and seasonal dynamics are still limited because of insufficient reference sequence data in public database and of the difficulty of constant monitoring in short term interval. In this study, monthly level monitoring survey was continued for more than two years in 1–3 months interval in the Sendai Bay. Seawater samples were collected for analyzing phytoplankton abundance, diversity and environmental parameters. The abundance of picophytoplankton (pico-sized eukaryotes and cyanobacteria) was counted by flow cytometry, and diatoms and dinoflagellates were counted under microscopy. Size fluctuated seawater was used for phytoplankton composition analysis using both microscopy and molecular techniques (Shotgun metagenome sequencing), and was also used for bacterial 16S rDNA amplicon analysis. Furthermore, frozen preservation technique combined with flow-cytometry was applied to sort specifically the pico-/nano-size phytoplankton followed by metagenome analysis of 18S rDNA amplicon. The higher phytoplankton biomass, which was examined by chlorophyll *a* concentration, was observed from winter to spring in the Sendai Bay during the monitoring. Diatom was dominated throughout year, while small phytoplankton and dinoflagellates were abundant from summer to fall. Pico-eukaryotic phytoplankton was dominated ca. 50% of the small phytoplankton cells throughout year but in summer period when cyanobacteria prominently dominated them. In the Sendai Bay, massive diatom bloom was observed in spring, and the dominant diatom changed from genus *Chaetoceros* to *Skeletonema costatum*, *Leptocylindrus danicus* and *Thalassiosira* cf. mala according to the seasonal succession. For the small eukaryotic phytoplankton, taxonomic analysis showed that 19 operational taxonomic units (OTUs) were frequently distributed in all seasons. Composition analysis showed that the OTUs had characteristic patterns and were divided into four main groups. Two groups reflected the low-saline water and winter season, with the characteristic OTUs belonging to diatoms; to note, *Chaetoceros* and *Leptocylindrus* were characteristic of low saline water, and two diatom genera (*Minidiscus* and *Minutocellus*) and Cryptomonadales-related OTUs were prevalent in the winter. Bacteria in the 0.2–0.8 μm size fraction showed that the most frequent and abundant OTUs belonged to oceanic clade of SAR11, indicating inflowing oceanic water into the bay. Moreover, according to phytoplankton bloom state, a Rhodobacteraceae related OTU and cyanobacteria related OTUs increased in bloom formation period (January–April) and in high temperature period after the bloom was decayed (June–September), respectively. Those results indicated that the microbial community including phytoplankton and bacteria dynamically changed in the Sendai Bay.

Keywords: Microbial community, Phytoplankton, Bacteria, Sendai Bay, Metagenome analysis

Biodiversity of plankton community in the waters around Japan

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Plankton community relates significantly to the ambient environment in the ocean ecosystem and its feature reflect the oceanographic conditions. Although very high biomass of mesozooplankton appear in the Bering Sea in the North Pacific Ocean, high biomass area are also extent from offshore of Tohoku to Sea of Okhotsk. The biomass in the waters around Japan is one of the highest values in the world ocean except with upwelling regions (see website COPEPOD, http://www.st.nmfs.noaa.gov/copepod/). The high biomass might be caused by high nutrient supply from deep water to surface layer in the western North Pacific Ocean. Biodiversity of the plankton communities has been well studied in the recent years. For example, the study based on the foraminifer community represented very high biodiversity in the water around Okinawa Islands. And also the study of chaetognatha revealed very high biodiversity in the Kuroshio waters. Those result suggest the biodiversity plankton community is very high the waters around Japan. However the study for the copepod community is few around Japan. Copepod is the one of the most important group in the plankton community in the ocean ecosystems. Because they connect trophic levels between primary to third producer and play important role of carbon cycling in the ocean ecosystems. Therefore the biodiversity of copepod will be important to understand the marine ecosystem around Japan. We studied the biodiversity of copepod community in the waters around Japan. The zooplankton samples were collected by vertical haul of NORPAC nets (mouth diameter 45cm, mesh size 0.33mm) from 150 or sea bottom to sea surface in the 90 stations in April 2012 around Japan. The samples were identified in species level and counted abundance under the microscope. 190 species of copepod appeared in this study. The species number was high in the Pacific Ocean and low in the Sea of Japan. Species number in the eastern China Sea was higher than in the Sea of Japan and lower than in the Pacific Ocean. We also investigated the geographical variation of community structure based on the cluster analysis. The copepod community were classified 4 groups as 1)Pacific oceanic, 2) eastern China Sea to western Sea of Japan, 3)coastal, and 4)subarctic group. 1)Pacific groups was mainly composed by subtropical kuroshio related species. The group of 2) eastern China Sea to western Sea of Japan group was considered to originate in the eastern China Sea. 3) coastal group was mainly composed by coastal shallow water species. 4) subarctic group was mainly composed by large and abundant species. The biomass of the group is high the biodiversity is lowest among groups. Those results suggest the copepod community represented high biodivertsity in the waters around Japan, and it will be caused by complex and diverse oceanographic environment.

Keywords: biodiversity, copepoda, plankton, western north Paficic

Evaluating and projecting spatio-temporal changes in reef-building coral diversity

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Both global-scale (climate change) and local-scale (land-based pollution) have been causing significant change on corals. Japan provides an ideal setting to examine these changes, because it covers a wide latitudinal range, stretching from subtropical to temperate areas. This means that Japan provides a unique opportunity for examining baselines of species range shifts and/or expansions due to climatic warming over a large spatial scale. In addition, some islands have significant amount of sediment discharge through rivers as a result of extensive land development. So land-based pollution issues can be examined.
We collected records of coral species occurrence since 1930s. After careful examination of the species distribution, we detected four species showed range expansions. Annual variability of winter SST reconstructed the range expansions using histrically calculated SSTs by climate models. On the other hand, southern Japan, coral bleaching events were driven by anomalously high SSTs in summer. Further, poor recovery after the bleaching was observed at sites that suffer from terrestrial red-soil runoff. Future projection of coral habitats based on these results and climate model outputs suggests the importance of reducing CO_2 emission for conservation of corals. In addition, important marine areas for coral conservation was detected by using the EBSA criteria. These results would contribute to adaptation planning to climate change (e.g., reducing red-soil runoff, designating protected areas, etc.).

Conservation and assessment of marine biodiversity using EBSA criteria

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The S-9-5 project has collected over 2,213,148 records from database (BISMaL, OBIS, etc.), cruise reports, literatures and specimen records on species occurrence data obtained in all over the Asia-Pacific coastal sea. Based on the assessments of biodiversity states in target areas, this project would improve a assessment protocol using the criteria of ecologically and biologically significant area (EBSA) to apply conservation strategy. In each of the ecosystems, the IPCC scenario have been adopted to assess risk of biodiversity loss in future including potential effects on feeding and nursery condition and habitat states of the commercially important fishes and identify priority areas of future biodiversity conservation.

*EBSA: ecologically and biologically significant area, IPCC: intergovernmental panel on climate change, BISMaL: biological information system for marine life, OBIS: ocean biological information system

Keywords: Marine biodiversity, EBSA, OBIS, BISMaL

