Spacio-temporal variation of the increasing rate of pCO_2 in Kuroshio shelf-slope area

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We investigated spacio-temporal variation of the increasing rate of pCO_2 within the summer season in the Kuroshio shelf-slope area, one of the largest transition waters between western boundary current and coast in Japan. Study area was set as 137E-140E and north of 34N (to coastline), and 4057 historical pCO_2 data observed on July, August and September from 1995 to 2015 in this area was extracted from SOCAT ver.4 database. Interannual variation of water temperature within the dataset was examined as well as salinity, and as this result, it was recognized that the following four temperature-salinity domains have been emerged constantly within the study area thought the whole study period.
LTLS: 24C<T<26C and 33.0<S<33.5
LTHS: 24C<T<26C and 34.0<S<34.5
HTLS: 26C<T<28C and 33.0<S<33.5
HTHS: 26C<T<28C and 34.0<S<34.5
Interannual variation of pCO_2 within each temperature-salinity domain was then examined. HTLS, and HTHS and LTHS showed positive linear trend of pCO_2 with the same increasing rate of +1.9±0.3ppm/y, which value was slightly higher than that observed by Ishii et al. (2014) in the time-series station of 34N, 138E. However, linear trend of pCO_2 in LTLS showed significantly higher increasing rate than other three domains, +2.8±0.5ppm/y. Detailed analysis indicated that LTHS and HTHS roughly correspond to the data observed in the offshore side of Kuroshio current in July and August, respectively, while LTLS and HTLS roughly correspond to those observed in the shelf-slope area in July and August, respectively. The observed results indicate that the increasing rate of pCO_2 in the Kuroshio shelf-slope area varies even within the summer season, reflecting wide spacio-tenporal variation of water properties caused by complex biogeochemical processes in this quasi-coastal area.

Keywords: coastal region, global warming, pCO2

Intermediate-water acidification and biologic responses of planktic foraminifera

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Anthropogenic CO_2 emission is making lower pH conditions in the ocean, thereby marine organisms will be affected severely to their ecology and physiology. Recent studies suggest that large changes of pH in intermediate water of the Atlantic Ocean and indicates ocean acidification enhances during past two decades. More recently, similar lowering pH in intermediate water had reported in the North Pacific, but such studies are very limited. To confirm the progress of intermediate water acidification, we started to investigate carbonate chemistry of intermediate water and its biological responses in the North Pacific.
As a preliminary result in this study, we show the spatial distribution and morphological features of one planktic foraminiferal species *Globorotalia scitula* (Brady) which lives in the intermediate water on the monitoring line near Hokkaido Island (A-line) of Japan Fisheries Research and Education Agency (JFR). We performed the MOCNESS plankton towing on July 2016 and collected planktic foraminifers from each layer above 1,000 m water depth. *Globorotalia scitula* (Brady), the one of the deepest habitat species in planktic foraminifers is considered the environmental indicator of intermediate water, therefore we choose this species for evaluating biological responses. Vertical distributions of this species indicated remarkable bimodal distribution patterns in the water column. Maximum numbers of adult and juvenile specimens occurred at water density (sigma θ) = 26.9 (ca. 300 m) and 27.2 (ca. 500 m), respectively. In other words, juveniles lived in deeper water depth than adult ones. Such habitat depth is unique in the whole planktic foraminiferal life and indicates different habitat compared to other surface-dwelled planktic foraminifers.
We also performed the analysis of individual shell density of *G. scitula* by using Microfocus X-ray Computed Tomography (MXCT). Shell density variations of each specimens had wider ranges and those were equal to ca. 2.1 ~ 2.5 ug/um3. Shell density of *G. scitula* did not show remarkable differences with the water depth. It suggests that shell density of *G. scitula* did not change in the water column if the carbonate saturation (Omega_calcite) of ambient seawater was less than 1.0. In this presentation, we will show the pore density of *G. scitula* and discuss the relationships with carbonate chemistry.

Keywords: Ocean Acidification , Planktic foraminifera, Shell density analysis, Intermediate water

Study of the influence of long-term ocean acidification on underwater sound wave propagation

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Absorption loss (α) is a key factor in sound wave propagation through seawater. It is known that α decreases with rising seawater temperature and decreasing pH, but the full implications of recent global changes in marine environments have yet to be explored. Current reports show that both seawater temperatures and anthropogenic atmospheric CO_2 levels are increasing rapidly. Dissolved atmospheric CO_2 causes a decrease in seawater pH (marine acidification). Here, we present a study of long-term changes in the value of α, using observational temperature and pH data from the Pacific Ocean off the Japanese coast. We find that α decreased steadily over the past 30 years, with the most rapid decrease seen at high latitudes. In addition, we produce predicted values of α for 2100, based on two ocean acidification model scenarios. We also calculate the impact of decreasing values of α on submarine noise levels from long-term off-shore installations. We find that predicted noise levels increased by a factor of up to 1.44 between 2014 and 2100, a level of increase that could have a significant impact on marine mammals and sonar technologies. Our results highlight the importance of considering noise reduction techniques for future long-term off-shore installations.

Keywords: underwater sound wave propagation, absorption loss (α), pH, underwater noise level, long-term change

The dynamics of pore water in subsurface sediments at the site of controlled CO_2 release experiment

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Carbon capture and storage (CCS) in sub-seabed geological formations is a mitigation strategy that can aid the reduction of anthropogenic CO_2 emissions. In 2012, the QICS (Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbon Storage) project was undertaken by researchers from the UK and Japan. The project conducted a field-scale controlled CO_2 release experiment in order to examine the impacts on the marine ecosystem and evaluate the methods for detection and impact monitoring, should CO_2 leakage occur. Changes in the chemical composition of water and seabed sediment were detected, in particular, pH and dissolved inorganic carbon (DIC) of the sediment pore water during the CO_2 release. After the gas release was stopped, concentrations of all pore water constituents rapidly returned to pre-release values. The QICS team concluded that the environmental impacts from small-scale leakage is not ecologically significant.
We address two unsettled issues from QICS: (1) the mechanism behind the rapid recovery of pore water parameters to pre-release levels, and (2) the fate of the released CO_2 potentially remaining in the subsurface sediments. To settle these issues, we conducted field observation measurements at the QICS site, Ardmucknish Bay, in 2016, four years after the CO_2 release. Time series in situ monitoring of pore water chemistry in the subsurface sediments was conducted in order to investigate pore water dynamics. To characterize pore water behaviour more precisely, we conducted a tracer test using the custom-made pore water extractors. To trace the injected CO_2, carbonate content and stable carbon isotope ratio of the sediment and pore water were compared between the area close to the CO_2 release point and the unaffected reference site. In this presentation we focus on the pore water dynamics at the QICS site and show the results of field observation that influence benthic recovery from a CO_2 leak.

Keywords: CCS, global warming, sediment, pore water

Response of dimethyl sulfide production by phytoplankton to change in multiple environmental stressors in the western Arctic Ocean

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The Arctic Ocean environment is experiencing rapid climate changes such as warming, ocean acidification and sea ice reduction, influencing ecosystem dynamics including biogeochemical cycling. Dimethyl sulfide (DMS) and its major precursor dimethylsulfoniopropionate (DMSP) are produced through physiological function of phytoplankton in marine environment. It has been suggested that oceanic DMS emissions could play a dominant role in climate regulation on a regional basis especially in the polar region. Unraveling the response of marine organisms against such environmental perturbations is important to better understand the present and future Arctic Ocean ecosystem and production of DMS and DMSP. We investigated the effects of temperature, CO_2 and salinity on plankton communities, DMS and DMSP in the Arctic Ocean using on-board manipulation experiment during R/V *Mirai* MR15-03 cruise. Temperature (2.2 or 7.2˚C), CO_2 (300 or 600 μatm) and salinity (29.4 or 27.8) were manipulated using thermostat circulator, the addition of high CO_2 seawater, and pure water, respectively. The higher temperature enhanced the growth of phytoplankton community in terms of chlorophyll-*a*. Nano-sized (~2–10 μm) phytoplankton growth was increased due to the higher temperature but not CO_2 in the community. On the other hand, pico-sized (< 2 μm) phytoplankton growth was unchanged during the incubation. DMS and DMSP concentration were getting higher during the experiment for all batches. We will further discuss the relationships between production of DMS and DMSP and changes in the biological variables in this presentation.

Keywords: dimethyl sulfide, DMS, DMSP, ocean acidification, Arctic Ocean

