物理・化学・生物学的な観点からの日本海暖水域と冷水域の違い
Difference of warm and cold waters in the Sea of Japan in terms of physical, chemical and biological properties

*児玉 武稔[1]、和川 拓[1]、久賀 みずき[1]、田村 沙織[1]、伊藤 雅[1]、井桁 庸介[1]、小埜 恒夫[2]、佐藤 拓也[2]、田和 篤史[2]、大下 誠二[2]
*Taketoshi Kodama[1], Taku Wagawa[1], Mizuki Kuga[1], Saori Tamura[1], Masashi Ito[1], Yosuke Igeta[1], Tsuneo Ono[2], Takuya Sato[2], Atsushi Tawa[2], Seiji Ohshimo[2]

1. 水産研究・教育機構　日本海区水産研究所、2. 水産研究・教育機構　国際水産資源研究所
1. Japan Sea National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2. National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency

The Sea of Japan, where is a semi-closed marginal seas of the western Pacific, is divided into warm and cold waters by a thermal front (the subpolar front) and currents (Tsushima Warm Current and the subarctic circulation, respectively). However, shipboard-observations in the cold water were very limited, and the physical, chemical and biological characteristics of the cold water were uncertain. Hence, observations were conducted during two cruises by R/V *Mizuho-maru* (MZ) and *Daigo-Kaiyo-maru* (KY) from the end of August to the middle of September of 2016 across the subpolar front to clear the difference of two waters, in particular, to describe characteristics in the cold water.
Vertical profiles of temperature, salinity, DO and chlorophyll fluorescence were investigated by using CTD and optional sensors at 37 stations. Discrete water samplings for nutrient and chlorophyll *a* concentrations were conducted at selected 25 stations. During the KY cruise, samples for alkalinity, particulate organic matters (>0.7 μm) for stable isotope analysis, and environmental DNA (>0.8 μm) for metagenetic analysis of 18S V9 rDNA were selectively collected at a 10 m depth. Zooplankton and nekton were collected by using a twin NORPAC net (0–200 m) and a mid-water trawl (20×20 m wide, trawled <40 m depth), respectively, at every station of the KY cruise.
On the basis of the clustering analysis of temperature and salinity from 5–200 m, our investigated area was mainly divided into cold and warm waters: 5 stations in approximately >40°N were grouped into the cold water, and the others were into the warm water. In the cold water, vertical distributions of salinity had no maximum.
Niutrient concentrations were depleted (<1 μM) except silicate at the surface in both waters; however, relationships between nitrate and density (temperature) was different: the nitrate concentration was depleted <1 μM in the water 26 σ_t in the cold water while >5 μM of nitrate in the warm water. Slopes of nitrate concentration at the nitracline was steeper in the cold-water than warm-water. DO concentration was high in the cold waters (>300 μM) and apparent oxygen utilization (AOU) was >-40 μM just below the surface mixed layer in the cold water.
The organisms were different between cold and warm waters; dictyochophyceae and *Neocalanus cristatus* was richly distributed in the cold water, while they were low or rare in the warm water. The amounts and diversities of nekton were very poor in the cold water; only a few individuals of common squid (*Todarodes pacificus*) were collected in the cold-water, while some small pelagic fish, anchovy (*Engraulis japonicus*), horse mackerel (*Trachurus japonicus*) and sardine (*Sardinops melanostictus*), were often sampled as well as the common squid in the warm water.
Our results demonstrated that the characteristics between warm and cold waters are quite difference even during summer from physics to biology. It is considered that temperature directly determines biota of waters, but the primary productivity does not. Primary productivity was suggested high in the

cold-water based on the AOU, chlorophyll *a* concentration, and slope of the nitracline. Therefore, the biological productivity will be high in the cold water, but both species diversity and abundance of nekton were poor. In particular, zooplanktivorous small pelagic fish were not caught in the cold water. In hence, these are questioned for future oceanographic and marine ecological studies of the Sea of Japan: who dominate the niche of zooplanktivorous species in the cold water which is corresponding to the small pelagic fish in the warm water and what controls fish productivity. In the Sea of Japan, surface temperature has been increasing and predicting primary production will decrease in the future according to global warming scenarios. The studies for our questions will help us understanding effects of global warming on fisheries.

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