Difference of warm and cold waters in the Sea of Japan in terms of physical, chemical and biological properties

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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.

Keywords: Sea of Japan, Fisheries, Tsushima Warm Current, Subpolar front

Climate-related shifts in ichthyoplankton phenology of Beaufort Inlet, North Carolina, USA

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Global warming has shifted the timing of seasons in numerous ecosystems worldwide. Many organisms rely on seasonal cues for the timing of events such as reproduction, migration, or metamorphosis, which makes them exceptionally vulnerable to the negative effects of climate change. Furthermore, if the seasonal timings, also known as phenologies, of two or more historically-linked events change at different rates in response to climate change, entire communities could potentially to break down. It is therefore critical for science to develop an understanding of climate change’ s effects on the phenologies of organisms across ecosystems. The purpose of this study is to determine if there have been shifts in the reproductive phenology of winter-spawning estuarine-dependent fish species that spawn offshore of Beaufort Inlet, NC. To do this, we are investigating the phenology of larval fish ingress through the inlet from 1987-present. Data from the Bridgenet long-term ichthyoplankton sampling program conducted by the U.S. National Marine Fisheries Service are being used to assess changes in the beginning, peak, and end of ingress for species in the inlet. To determine if climate changes could be driving potential phenology changes, we are also attempting to correlate any observed phenology changes with environmental variables such as temperature, windspeed, and offshore current activity.

Keywords: Ichthyoplankton, Phenology, Climate change, Reproduction, Estuaries

Projected Changes in the Distribution and Phenology of Nassau Grouper (*Epinephelus striatus*) Spawning Aggregations

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Most projections of how climate change affects species distributions are based on a species' most conspicuous life stage. However, not all life stages are equally sensitive to temperature. Among fishes, spawning adults often have narrower thermal tolerances than other life stages and may constrain population responses to climate change. We tested this hypothesis using data on Nassau grouper (*Epinephelus striatus*), a critically endangered top predator on Caribbean coral reefs. Species distribution models of spawning aggregations and non-spawning adults were used to determine which of seven environmental variables exerted the greatest influence on monthly fish distribution. Based on model output, we calculated thermal niche and ecological niche breadth of each life stage. An earth system model was then applied to project how species distribution and phenology shift under the RCP 8.5 climate change scenario. Sea surface temperature and seasonal temperature gradients affected the distribution of both *E. striatus* spawning aggregations and non-spawning adults, but these life stages differed in their preferred temperatures and reaction to oceanic currents. While the two life stages exhibited similar ecological niche breadth, the thermal niche of spawning aggregations was significantly narrower than non-spawning adults. By 2081-2100, potential spawning habitat was projected to decline by 82% relative to a 1981-2000 baseline, whereas suitable habitat for non-spawning adults decreased by 46%. Poleward shifts in latitude occurred >4 times faster for spawning aggregations than non-spawning adults. These changes were attributed primarily to rising temperatures, whereas changes in hydrography did not have a substantial impact. The narrow thermal tolerance range among spawning *E. striatus* confirms that this life stage is likely to serve as a bottleneck constraining responses to climate change.

Keywords: climate change, Greater Caribbean, Nassau grouper, spawning aggregation, reef fish, species distribution modeling

Modeling effects of growth and temperature on the recruitment variability of Pacific saury (*Cololabis saira*)

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Pacific saury (*Cololabis saira*) is a commercially and ecologically important pelagic fish in the North Pacific. The variability in stock abundance cannot be explained solely by fisheries catch but also related to the reproductive success. In this study, we examine the recruitment variability of Pacific saury using an individual-based model combining a bioenergetics, migration and mortality models. We parameterize the mortality rate with the weight, growth rate and temperature. The annual survival rates (recruitment per spawning biomass: RPS) from the model (mRPS) are calculated from the number of survived fish at age-1, and compared with RPS derived from the stock assessment for 2003–2012. The interannual variability in RPS is well reproduced in the model, especially in cases parameterizing the mortality using the weight and temperature, and weighting the spring-spawned cohort. The importance of the spring–spawned cohort is consistent with the hypothesis derived from observations in 1990–1998.

Keywords: Pacific saury, Individual-based model, recruitment variability, growth, temperature

