# Annual to decadal variation in biogeochemical paramters in low potential vorticity water in the fomation region of North Pacific Subtropical Mode Water

*Naohiro Kosugi[1], Masao Ishii[1], Daisuke Sasano[2]

1. Meteorological Research Institute, 2. Japan Meteorological Agency

## Introduction

North Pacific Subtropical Mode Water (NPSTMW) is originated from the thick mixed layer with low potential vorticity (PV) in Kuroshio Extension (KE) region in late winter. This layer is capped by seasonal thermocline in following spring and transported to subtropical gyre in the North Pacific. Qui and Chen [2006] reported that NPSTMW formation was weak during unstable KE period. This was because NPSTMW formation was inhibited by high PV water which was transported from the north of KE. Oka et al., [2015] indicated that decline in dissolved oxygen in NPSTMW around Okinawa after unstable KE period. Variation in NPSTMW formation was large contribution to biogeochemistry. However, it is little known about annual variation in biogeochemistry in the formation region of NPSTMW.
Japan Meteorological Agency (JMA) has been conducting shipboard observations in NPSTMW formation region in winter and spring. Not only physical parameters but also biogeochemical parameters such as nutrients and dissolved inorganic carbon and total alkalinity are obtained by these observations. Here, we focused on annual variation in biogeochemical parameters in low PV water in NPSTMW formation region. This is fundamental study to understand NPSTMW and its variation

## Data

All shipboard data was obtained by R/V Ryofu-Maru and Keifu-Maru in KE region (142-150˚E, 28-36˚N). Period of observations was from January to May every year from 2005 to 2017. We calculated PV of 5 dbar above and below for each sample. Samples with PV > 2.0 * $10^{-10}$ $m^{-1}s^{-1}$ were excluded from the analysis.

## Results

There are three types of low PV water in this region. They are (1) mixing layer, (2) mixed layer capped with seasonal thermocline and (3) NPSTMW formed before year of the observation. Earlier study in this region showed that apparent oxygen utilization (AOU) was lower than about 15 $\mu$mol $kg^{-1}$ in case that only 6 months or less has passed since the formation of the water [Kosugi et al., 2013]. Figure (a) indicated that low AOU (< 15 $\mu$mol $kg^{-1}$) water was ubiquitous on isopycnal $\sigma_\theta$ = 25.2 kg $m^{-3}$ or more during stable KE period (2011-). In contrast, low AOU water was rarely found in unstable KE period (2006-2009). In other words, there was little formation of NPSTMW with $\sigma_\theta$ = 25.2 kg $m^{-3}$ or more in unstable KE period. This confirmed that the decline in the formation of new NPSTMW was the cause of the decrease in dissolved oxygen in NPSTMW reported by Oka et al., [2015].

We calculated "preformed $NO_3$" as ($NO_3$ + $NO_2$) - AOU * 17 /160 to correct biological variation in nitrate. Overall, preformed $NO_3$ is lower in the subtropics and higher in the subarctic zone. We tried to use preformed $NO_3$ as quasi-stable tracer to calculate mixing ratio of subtropical and subarctic waters. Figure (b) showed that potential $NO_3$ around $\sigma_\theta$ = 25.2 kg $m^{-3}$ during unstable KE period was higher than that during stable KE periods. This was consistent with the theory by Qiu and Chen [2006] that the contribution of water from north of KE was large during unstable KE period. At present, however, the

 

difference in preformed $NO_3$ was not so clear between stable and unstable KE period. It is essential to collect more datasets of nutrients with high precision to further discussion.

**Reference**

Kosugi et al., In the Proceeding of JOS annual meeting spring 2013, Tokyo, 2013.
Oka et al., Journal of Oceanography, 2015.
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Keywords: Subtropical mode water, Kuroshio Extension, Nutrients, Anthropogenic CO2