Form 3

# Annual Report

LaMer, Ehime University

Date (29, November, 2016)

To Director of LaMer


Principle Investigator:

Affiliation Ocean University of China

Position Graduate student

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Include the report on the result of the project/meeting in a separate sheet.

1. Project / Meeting title

The variation of nutrients concentration along the main stream of the Kuroshio and its controlling factors

2. Members of project / meeting

| Name | Affiliation | Position | Contribution part |
|---|---|---|---|
| PI<br>Haiyan Yang | Ocean University of China | Graduate student(M3) | Data processing and analyzing |
| Members<br>Xinyan Mao | Ocean University of China | Lecturer | Beneficial discussion |
| Xinyu Guo | Ehime University | Professor | Beneficial discussion |

3. Contents (please write in separate sheet, A4-size, within 5 pages including figures and tables. Itemize “Title, members’ names and affiliations, aim, procedure, result, publication/conference presentation, perspectives in future”).

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## Title

The variation of nutrients concentration along the main stream of the Kuroshio and its controlling factors

## Members' names and affiliations

| Name | Institution and Department | Employment n | E-mail |
|---|---|---|---|
| Xinyan Mao | College of Oceanic and Atmospheric Sciences, Ocean University of China | Lecturer | maoxinyan@ouc.edu.cn |
| Xinyu Guo | Faculty member of LaMer | Professor | guoxinyu@sci.ehime-u.ac.jp |

## Aim

With the help of Prof. Guo Xinyu in Ehime University, this project aims to explore the seasonal variation of average nutrients concentration in the mixed layer, and to study the contribution of physical processes influencing the variation of nutrients in the mixed layer.

## Procedure

1. Our joint research concentrated on processing the observed data from WOD13 (World Ocean Database 2013) in this year (2016). WOD13 contained standard depth level profile data with quality control, so we can remove the inadequate data and obtain the average value for one-degree analysis. The first-guess field was built up by applying IDW (Inverse Distance Weighted) to the statistical field. Then a correction (Barnes, 1964) to the first-guess value was computed. The climatological annual, seasonal and monthly mean fields were created after "three-pass correction" and median filter.

2. The climatological monthly mixed layer depths using Argo profiles was used to computed the winter mixed layer depths. In this way, the distribution of nutrients average concentration in winter mixed layer can be showed.

3. Based on some assumptions and backgrounds, the nutrient average concentration conservation equation was derived.

After the discussion with Prof. Guo Xinyu, we will set out further research as follows:

1. Processing the OFES model nutrients data and comparing the difference of seasonal variation between the model and observed nutrients data.

2. Quantifying each term in the nutrient average concentration conservation equation, and to study the influencing factors of nutrient seasonal variation.

## Results

Wintertime ML has been generally believed to deepens due to wind stirring and sea surface cooling. In Fig.1, we can find that the deepest mixed layer depth (MLD) appears in Kuroshio Extension and the region along the latitude of 40°N. Around latitude of 20°N, there are regions where wintertime oceanic mixed layer shoals (Takeuchi and Yasuda, 2003; Oka et al., 2007).

In the region to the north of 30°N， the nutrient average concentration in the winter mixed layer shows zonal distribution along latitude (Fig.2). The low values of nutrient average concentration in the subtropical regions result from downwelling.

The most apparent increase of average concentration in winter ML locates in the east of Japan and the Japan Sea (Fig.3). Phosphate and nitrate have similar distributions because they are governed by almost the same biological cycle, but the silicate distribution is not as closely similar (Talley et al., 2011). In winter, nitrate and phosphate average concentration basically increase along the Kuroshio path, and they remains largely unchanged in the subtropical regions.

We set out analyzing the seasonal details of the nutrient concentration in the 137°E section (Fig.4). It is obvious that contours of nutrient concentration are upraised in the top layer of winter ML around region of 0 ~ 10°N and north of 30°N. In summer, near latitude of 10°N or 30°N, nutricline is below the winter mixed layer, but in winter, it's no longer clear because of vertical convection.

In addition, to better understand the processes that affect the seasonal variation of nutrient, the upper-ocean nutrient budget is expected to study. We define an interface marking the maximum extent of the convection process, the thickness of the mixed layer in the winter, h=f(x,y,t). The equation for the variation of nitrate concentration in the winter ML is as follow:

$$\frac{\partial C_a}{\partial \mathrm{t}} = -\boldsymbol{v}_a \cdot \nabla C_a - \frac{1}{h}(C_a - C_{-h}) \times (v_{-h} \cdot \nabla h + w_{-h}) - \frac{1}{h}\left(K_v \frac{\partial C}{\partial z}\right)_{-h} + S \quad .$$

In the future, we will use OFES model results to estimate each term in this equation.

References:

Barnes, S. L. (1964). A technique for maximizing details in numerical weather map analysis. Journal of Applied Meteorology, 3(4), 396-409.

Holte, J., J. Gilson, L. Talley and D. Roemmich (2016): Argo Mixed Layers, Scripps Institution of Oceanography/UCSD http://mixedlayer.ucsd.edu.

Oka, E., Talley, L. D., & Suga, T. (2007). Temporal variability of winter mixed layer in the mid-to high-latitude North Pacific. Journal of oceanography, 63(2), 293-307.

Takakura, K., Xiaohong, W., Takeuchi, K., Yasuda, Y., & Fukuda, S. (2003). Deactivation of norepinephrine by peroxynitrite as a new pathogenesis in the hypotension of septic shock. The Journal of the American Society of Anesthesiologists, 98(4), 928-934.

Talley, L. D. (2011). Descriptive physical oceanography: an introduction. Academic press.

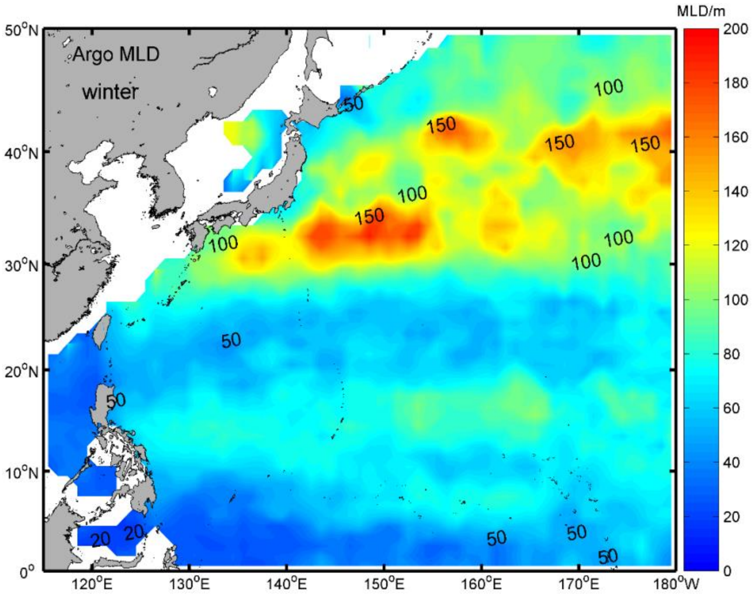


Fig. 1 Distribution of winter MLD calculated from the Argo data (Holte et al., 2016)

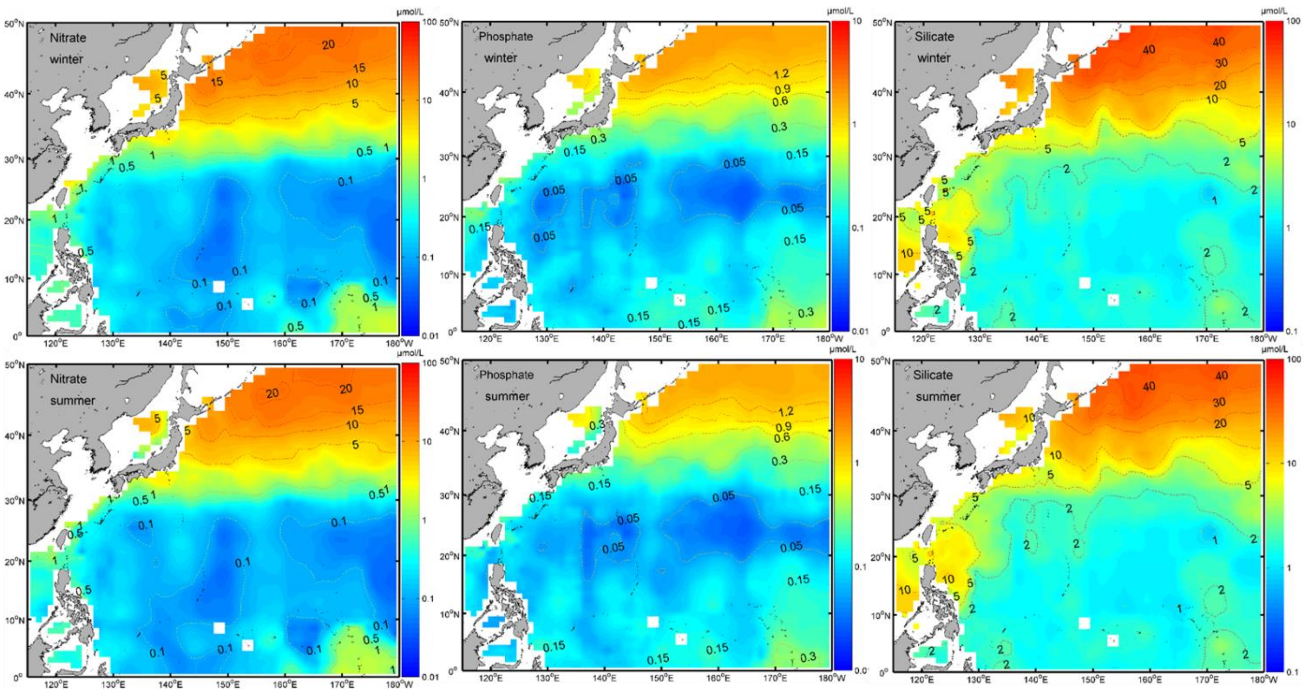


Fig. 2 Distribution of nutrient average concentration in winter MLD

(winter and summer)

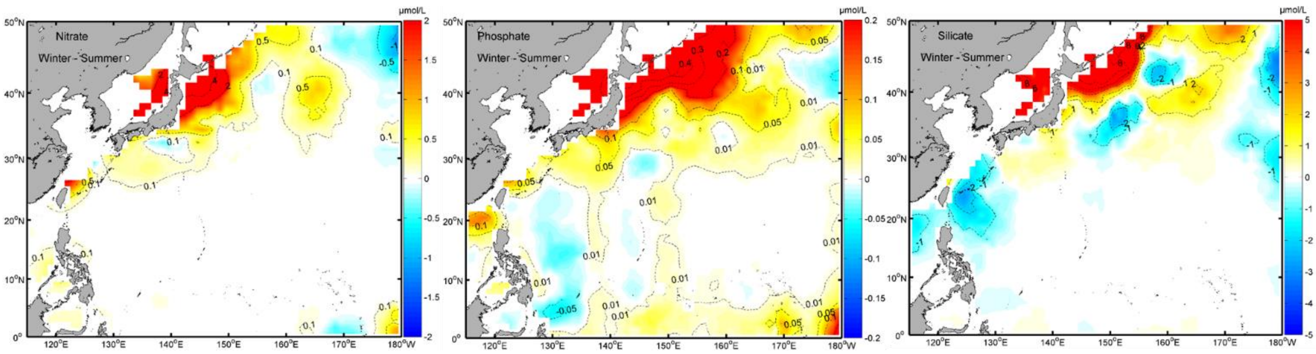


Fig. 3 Average concentration difference between winter and summer in winter MLD

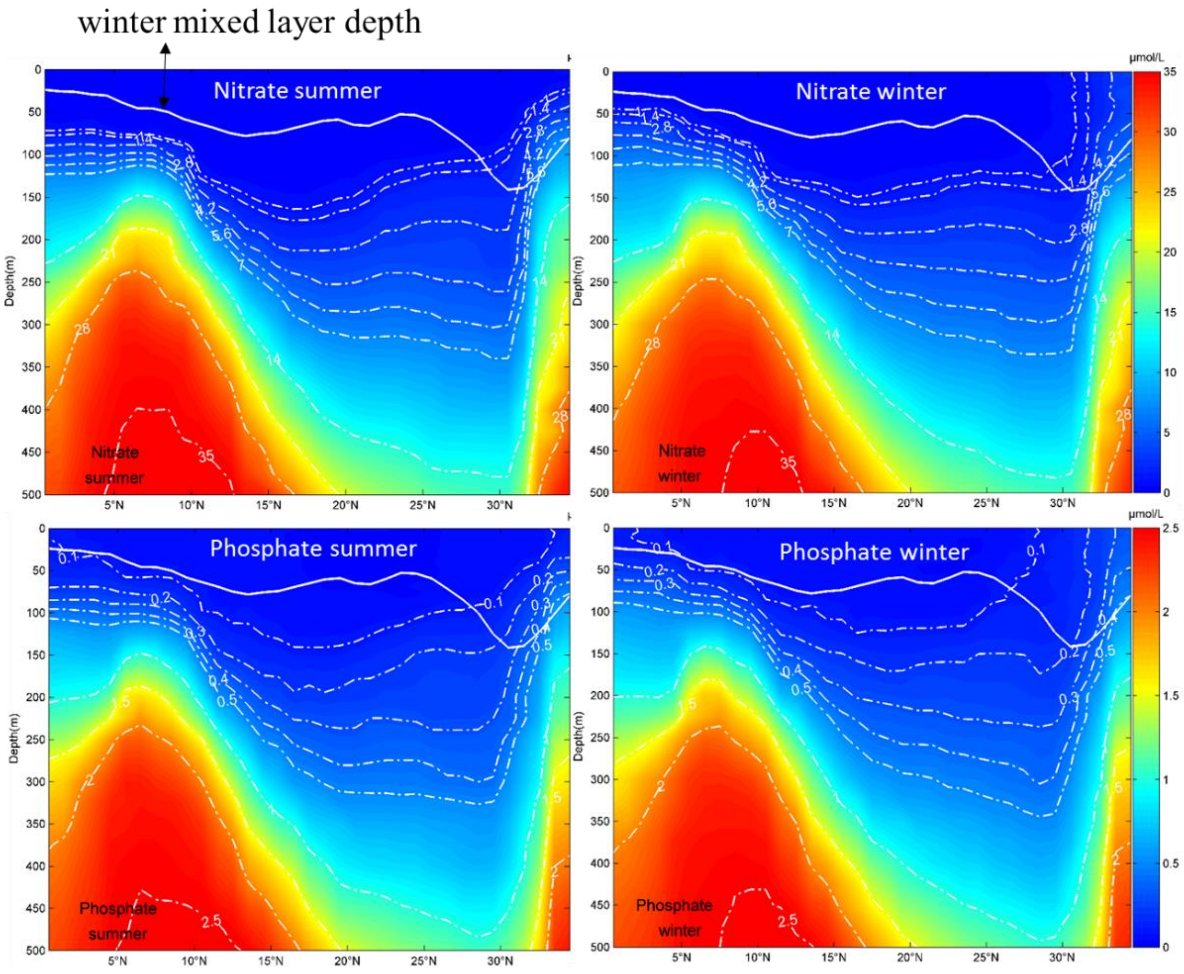


Fig. 4 Distribution of temperature along 137°E in winter/summer

## Publication/conference presentation

### Oral presentation:

Title: The variation of average nutrients concentration in the mixed layer from summer to winter

Speaker: Haiyan Yang.

Time: November 15, 2016.

Location: Ehime University.

## Perspectives in future

The reason for the seasonal variation of nutrient concentration in mixed layer is expected to further analyzing. We wish to explore the main influencing processes through observed data and model data, and to publish the research on a satisfied journal.