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Estimation of nutrient supply process in the spring Kuroshio-Oyashio transition region

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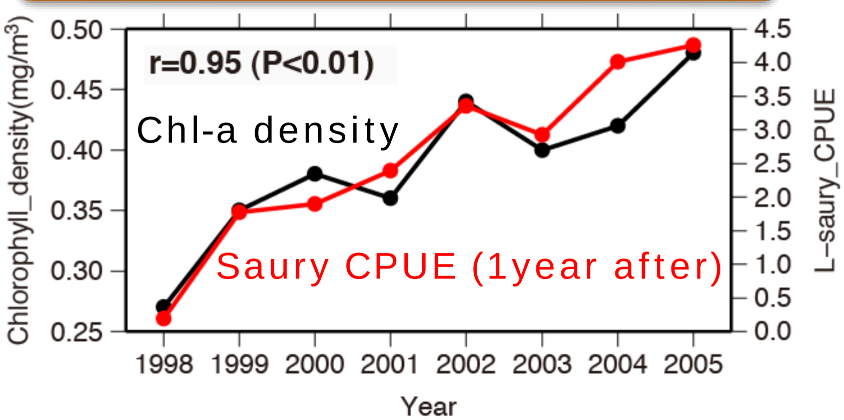
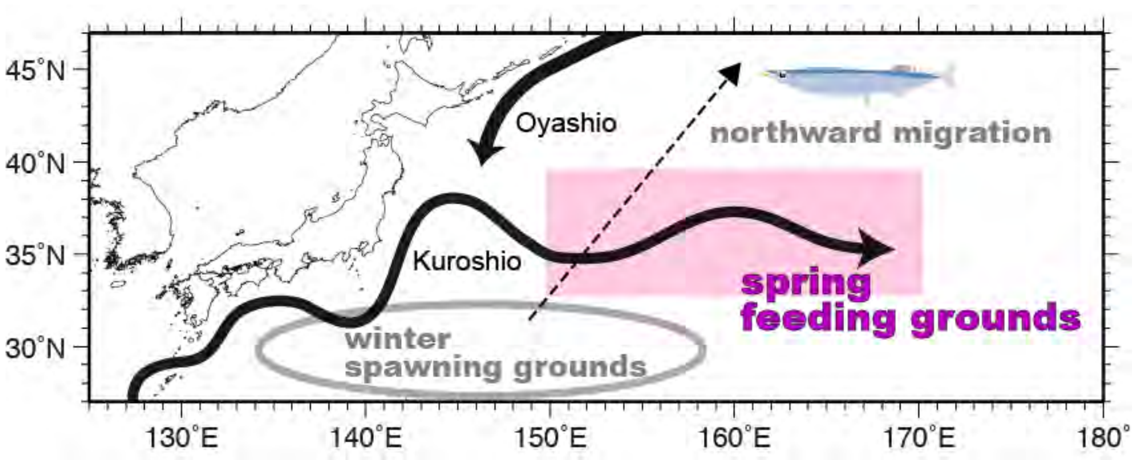
Introduction

Large Pacific saury CPUE and Chlorophyll-a density in the spring feeding grounds

Time series of box-averaged Chl-a density in the spring feeding grounds and Large-saury CPUE



Recently, Large Pacific saury (*Cololabis saira,* winter spawning cohort) CPUE has significant positive correlation with Chl-a in their spring feeding grounds (Ichii *et al*., 2012).
Details will be explained at tomorrow in Session 12 by Dr. Ichii.



Chl-a is a box-average density in the area, 150–170ºE and 30–40ºN from April to May.

This study wants to know why the Chl-a density varies year to year.

Data and Methods

Data

- The Chl-a data are derived by Standard Mapped Image products (Level-3) of atellite **SeaWiFS** (Sea-viewing Wide Field-of-View Sensor/NASA). We used monthly and horizontally 9km resolutions data from 1998 to 2007.
- Oceanographic data (velocity, MLD, temperature, salinity) are from Ocean Data Assimilation System, **MOVE/MRI.COM-WNP** (Usui *et al*., 2006). The system is composed of an ocean general circulation model and a variational analysis scheme. Horizontal resolution is variable. It is 1/10º from 117ºE to 160ºE and 1/6º from 160ºE to 160ºW zonally, and it is 1/10º from 15ºN to 50ºN and 1/6º from 50ºN to 65ºN meridionally. There are 54 vertical levels with thickness increasing 1 m at surface to 600 m near the bottom.

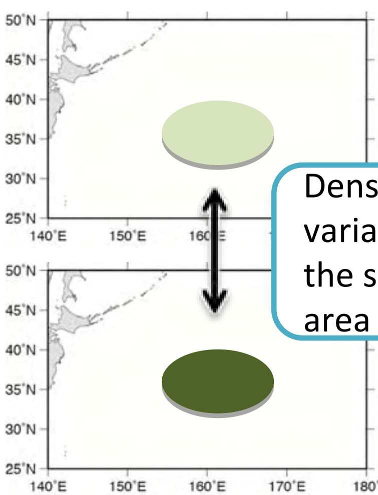
Particle tracking experiment

To know where is the origin of focused water and what type of environment focused water experienced, we conduce the backward particle tracking experiment for 6 months and record the environments.

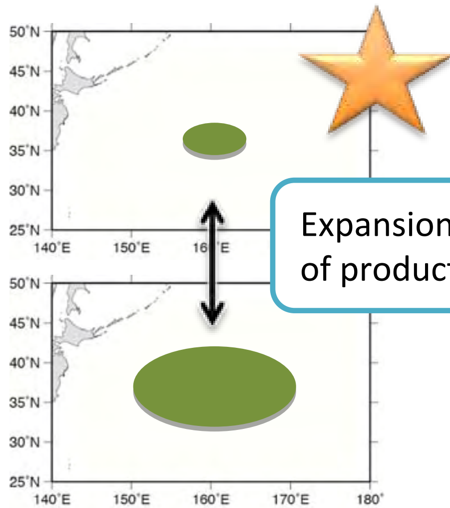
Particles are release on April 15th and May 15th from 1998 to 2007 at 5m depth.

Chl-a density and High productive area

Two possible causes for box-averaged Chl-a density variation in the whole spring feeding grounds

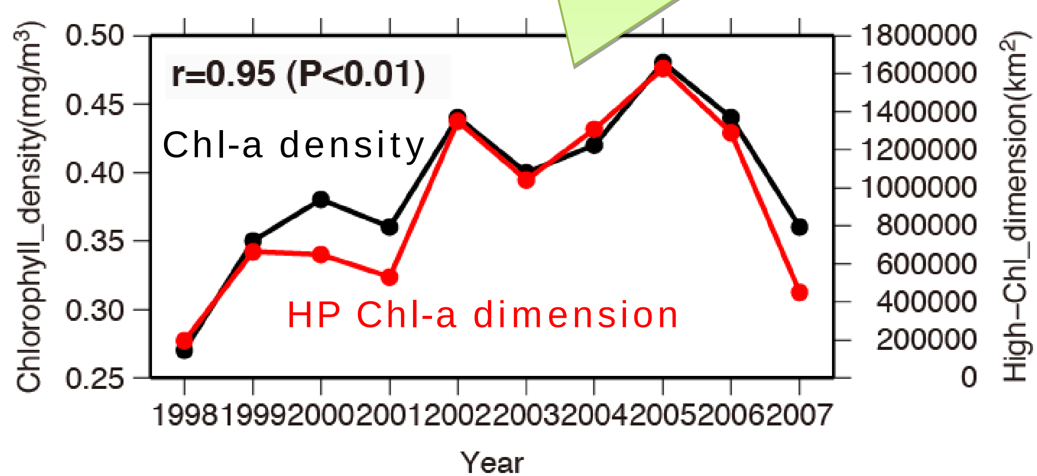


Density variation in the specific area



Expansion/shrinkage of productive area

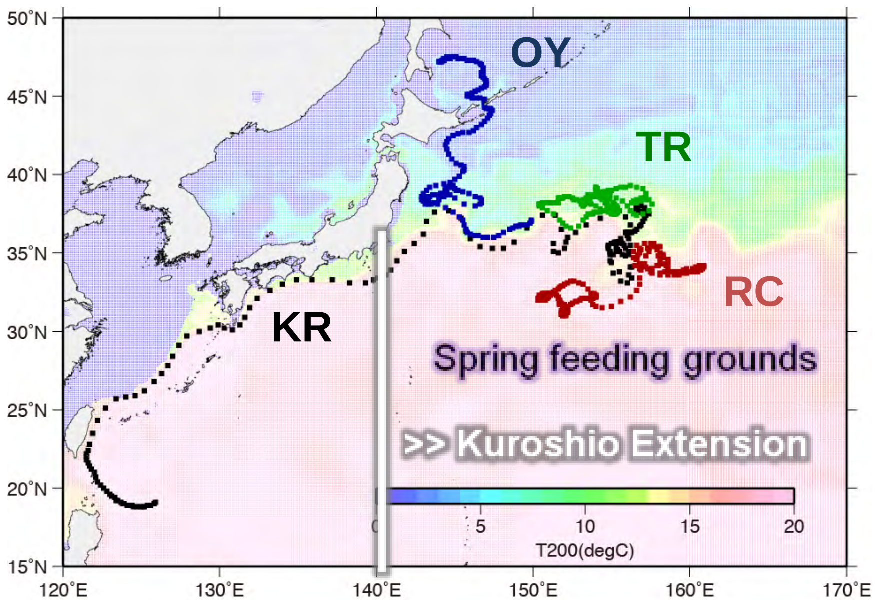
Box-averaged Chl-a density varies in proportion to High productive area (HPA) dimension that exceeds 0.5mg/m^3.



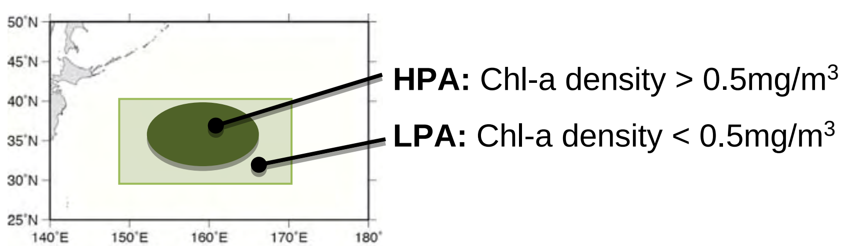
Interannual variation of box-averaged density in the feeding grounds depends on the expansion of HPA.

Why the HPA dimension varies?

Sources of the water in the feeding grounds



Trajectories of backward particle tracking for 6 months.
Particles are released at April 15, 2003 from HPA in the spring feeding grounds.

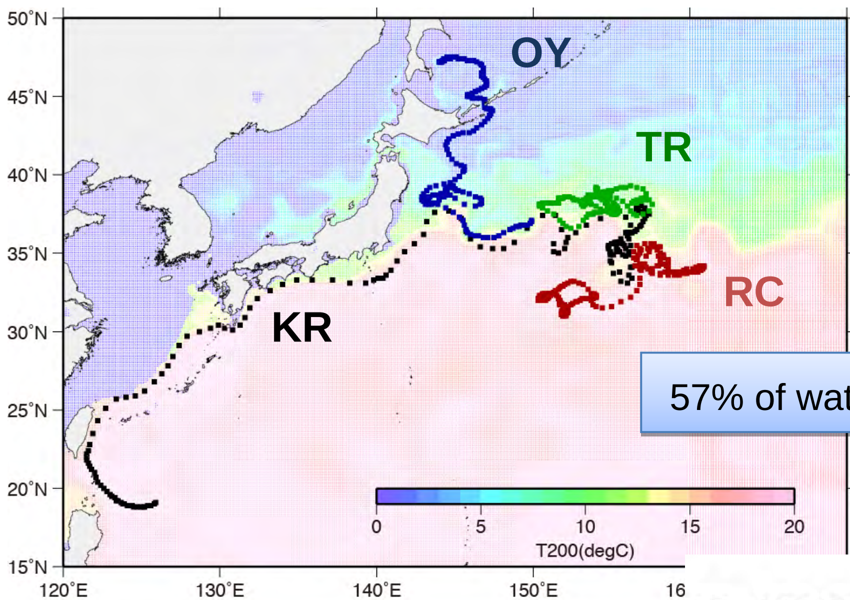


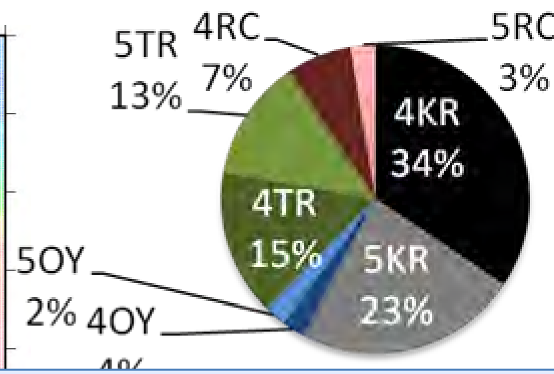
Four waters flow into the spring feeding grounds.
They are different in nutrient concentration.

- **Kuroshio region(KR)**: west of 140ºE, oligotrophic
- **Oyashio region(OY)**: T100 < 5ºC, eutrophic
- **Kuroshio-Oyashio transition region(TR)**: east of 140ºE and T200 < 14ºC, relatively eutrophic
- **Recirculaiton region(RC)**: east of 140ºE and T200 > 14ºC, oligotrophic

Most of high productive particles that are released from the feeding grounds remained in the Kuroshio Extension (east of 140ºE) after 3 months backward track, however, particles can be divided into 4 waters after 6 months backward track.

Sources of the water in the feeding grounds



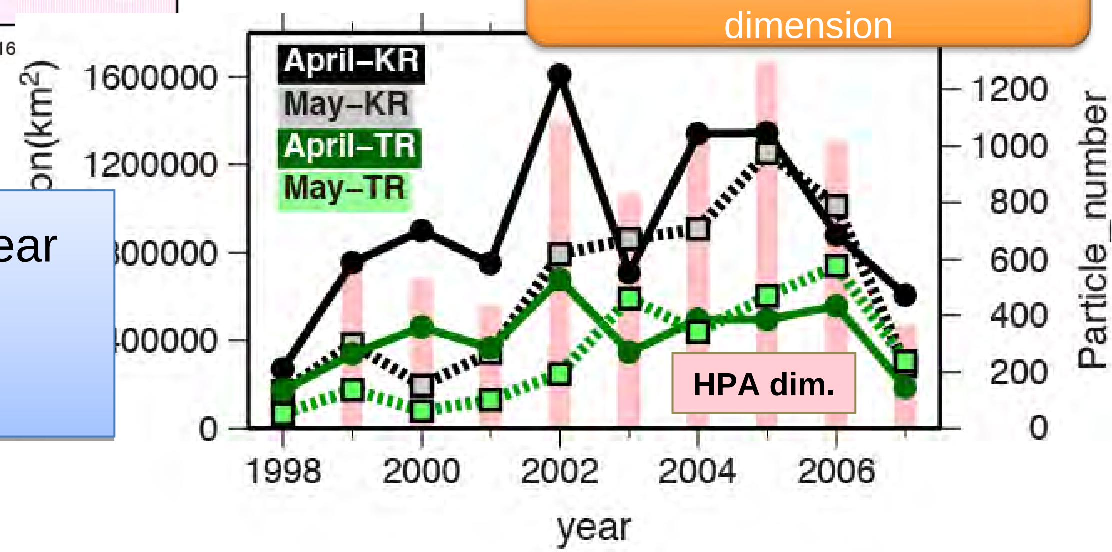


Proportion of high productive particle origins

4: backward from April
5: backward from May

57% of waters flow into the feeding grounds by the Kuroshio.

Time series of particle numbers from KR/TR and HPA dimension

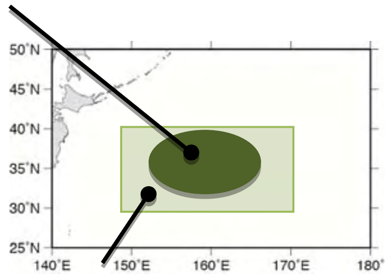


HPA dimension expands in the year when <u>high productive Kuroshio waters</u> increase.

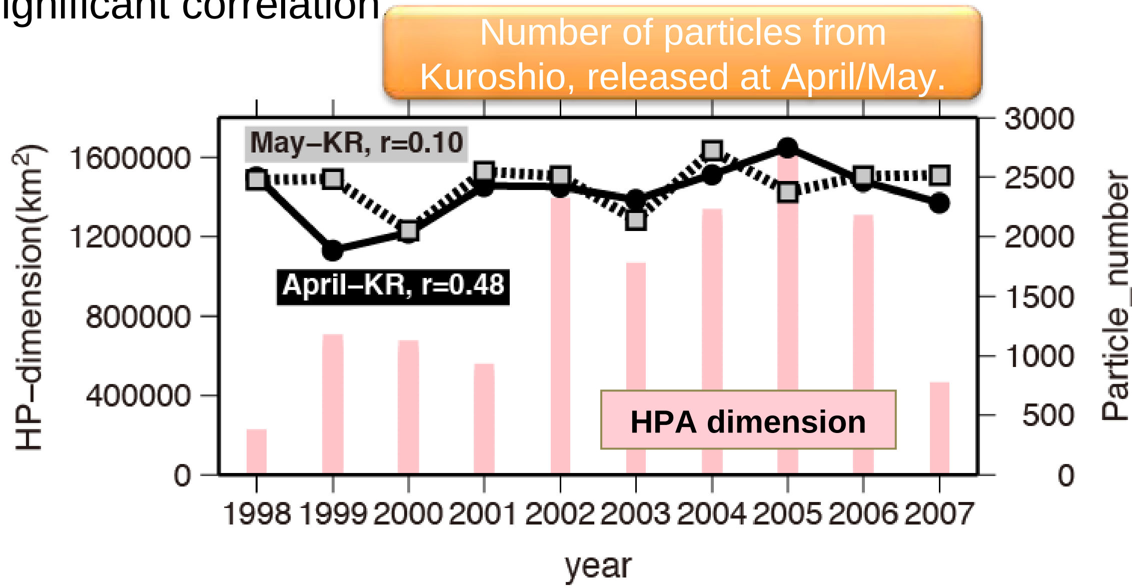
Waters from Kuroshio

- Note that Kuroshio particles of previous panel are backward from high productive area.
- Number of all particles (HPA + LPA) flows into saury feeding grounds from Kuroshio doesn’t have significant correlation

HPA: Chl-a density > 0.5mg/m^3



LPA: Chl-a density < 0.5mg/m^3



Kuroshio flow itself doesn’t have significant influence on HPA expansion.

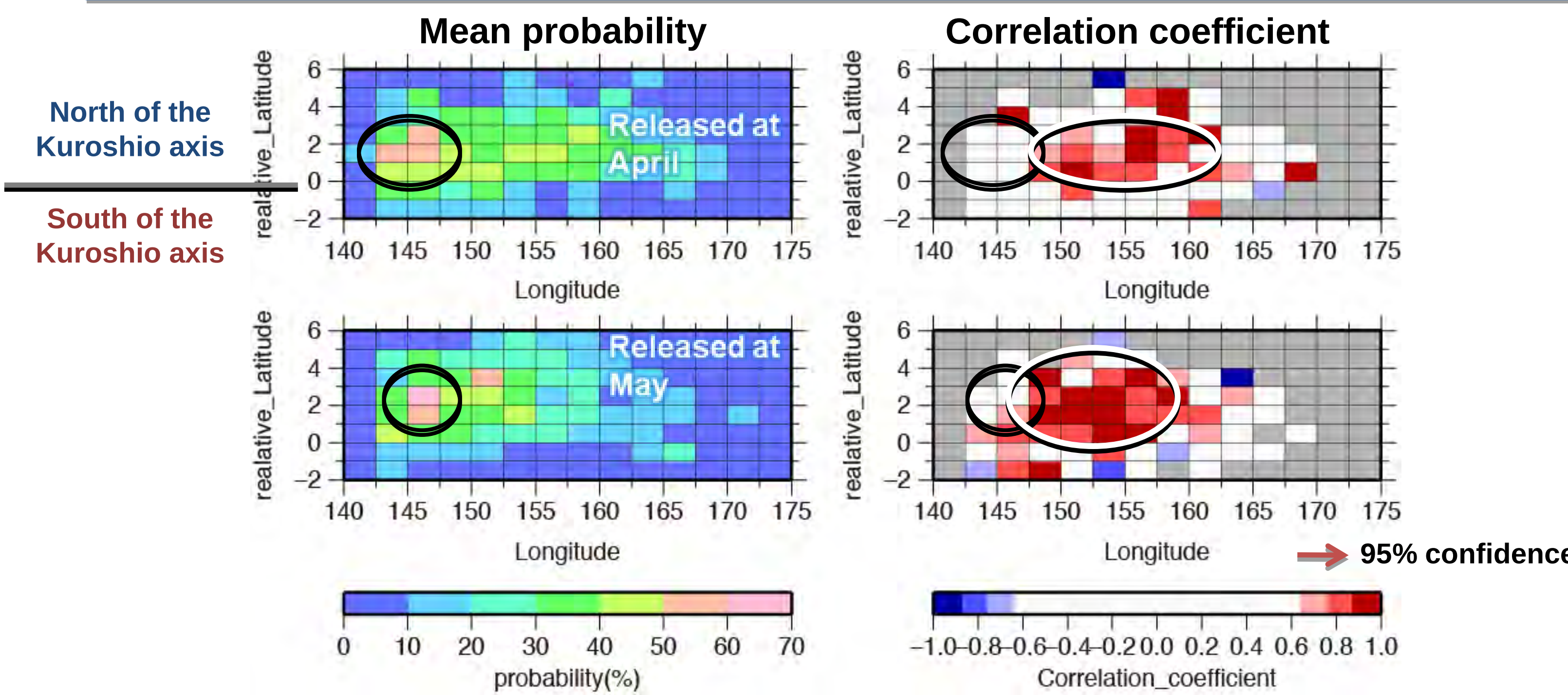
Maybe because Kuroshio water is originally oligotrophic.

If <u>a certain condition is met</u>, Kuroshio waters that supply good environment for phytoplankton increase and expands HPA dimension.

Probability of Kuroshio waters getting high productive

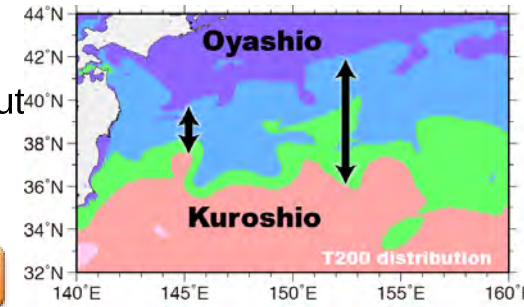
- Particles that are distributed in the North of the Kuroshio axis and **upstream in the Kuroshio Extension** (142.5–147.5ºE) tend to be high productive.
- However, North and **downstream in the Kuroshio Extension** (east of 147.5ºE) particles have significant positive correlation with HPA dimension.

>> At the downstream, Kuroshio waters became high productive in the HPA expansion years.



Difference between upstream and downstream in the north of the Kuroshio axis

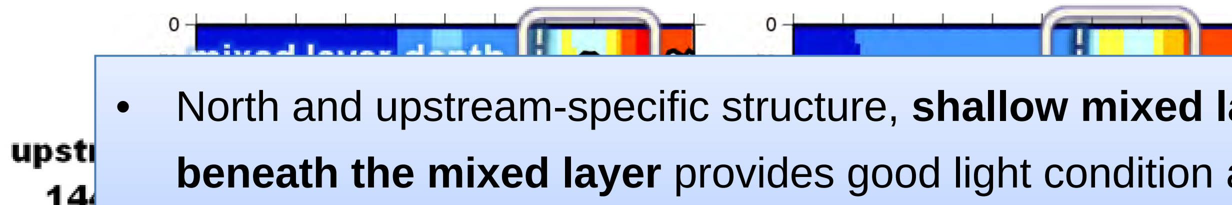
Previous analysis suggests the three features for HPA formation.
1.Environments of North of the Kuroshio axis are better than that of Sout
2.Environments of upstream are better than that of downstream.
3.Downstream environments are good in the HPA expanded year.



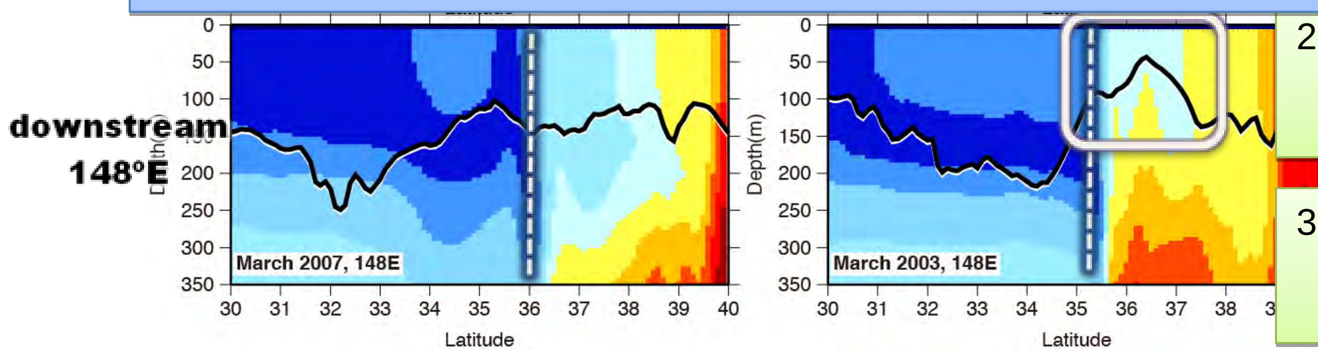
Vertical profile of mixing rate and mixed layer depth (MLD) along a latitude

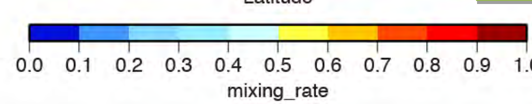
Mar. 2007, HPA shrunk year

Mar. 2003, HPA expanded year



- North and upstream-specific structure, **shallow mixed layer** and **high nutrient beneath the mixed layer** provides good light condition and nutrient condition for **photosynthesis**.
- Sometimes this good condition appears in the downstream.





1. At the north of the Kuroshio

2. This structure is clear in the upstream where Kuroshio collides against the Oyashio.

3. However, this structure extends to the downstream in the HPA expanded year.

Blue: Kuroshio-related water (oligotrophic)
Red: Oyashio-related water (eutrophic)

Hypothesis for high productive area expansion

We hypothesized that

1.Important conditions for the oligotrophic Kuroshio water turning out the high productivity are **shallow mixed layer** and **high nutrient entrainment** that is formed by the layer construction of Kuroshio and Oyashio waters.
2.Such condition is constantly formed in the north and upstream Kuroshio Extension but only appears in the HPA expansion year in the downstream. So, a **dimension where Oyashio water is overlaid by the Kuroshio water affects the HPA expansion**.

Then, we investigated the followings;

i.Presence of differences in mixed layer depth and in entrained nutrient density between high productive (Chl-a > $0.5 mg/m^3$) Kuroshio water and low productive (Chl-a < $0.5 mg/m^3$) Kuroshio water.

- In this study, we calculate the **Kuroshio-Oyashio mixing rate** instead of nutrient density.

ii.Interannual variation of **dimension where Oyashio water is overlaid by the Kuroshio water**.

MLD and mixing rate of entrained water of high/low productive water

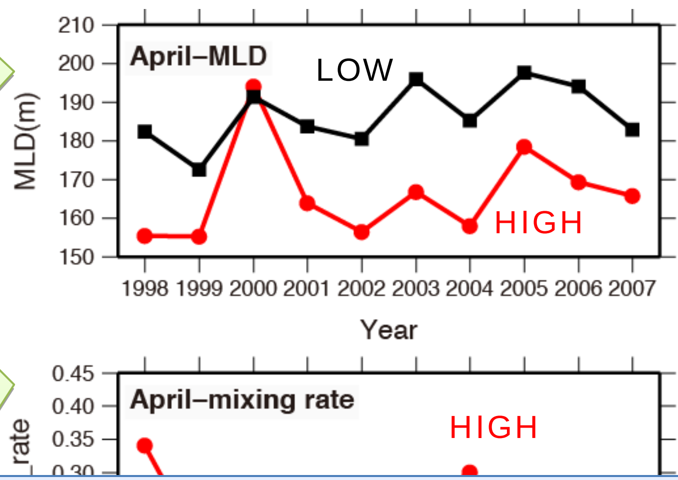
Interannual variation of mixed layer depth and mixing rate of entrained water that are experienced by particles transported by Kuroshio in the Kuroshio Extension.

Comparison between **high productive particles (red)** and **low productive particles (black)**.

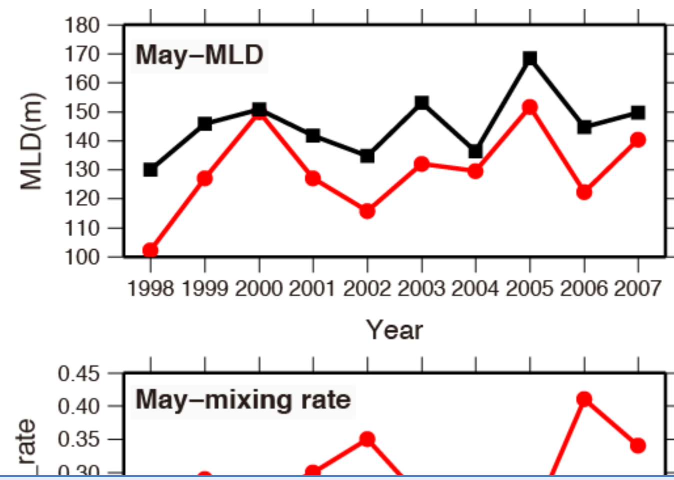
Shallow mixed layer is better for photosynthesis

High Oyashio mixing rate is related to the eutr
wate

Particles released at April



Particles released at May



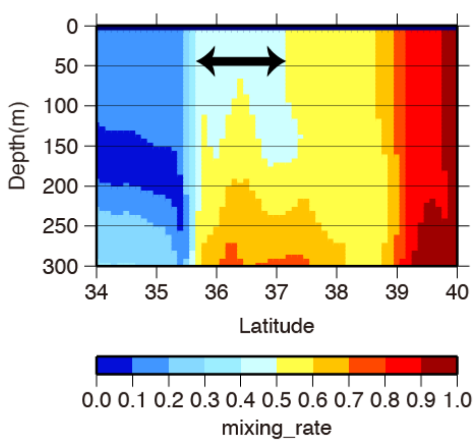
- High productive particles are experienced shallower mixed layer and take high mixing rate water compared with low productive particles.
- Supports our hypothesis that Kuroshio water gets high productivity on condition of good light availability and eutrophic water.

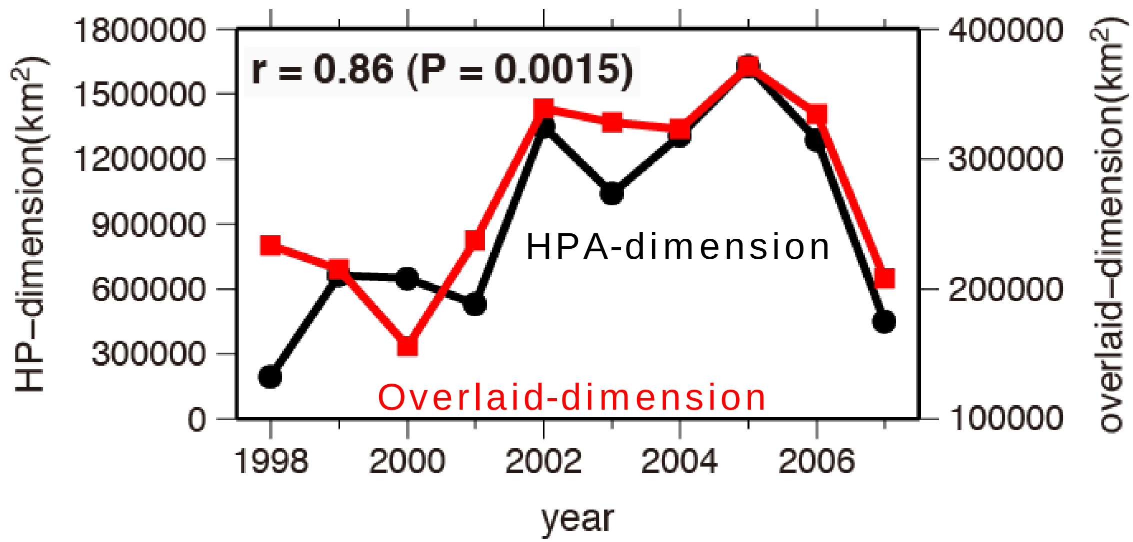
Interannual variation of Kuroshio-Oyashio structure

Interannual variation of dimension where Oyashio-related water is overlaid by the Kuroshio-

- There is a significant positive correlation between HPA-dimension and overlaid-dimension.
- This result supports our hypothesis that the overlaid structure affects the expansion/shrinkage of high productive area.

40°N)





Summary

We suggest a following cause for primary production variation in the spring Pacific saury feeding grounds, Kuroshio-Oyashio transition region.

Expansion of the layered structure where Oyashio-related water is overlaid by the Kuroshio-related water leads high productivity.

Future works

There are some problems.

- Lack of direct evidence of productivity variation.
    - MLD or nutrient is really important factor?
- Reliability of mixing rate as a substitute for nutrient density.

We plan to develop ecosystem model to examine these issues.