Decadal scale variation in phosphate concentration in the Oyashio and Kuroshi-Oyashio Transition waters, western North Pacific from 1955 to 2010

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In our previous study (Tadokoro et al. 2009), we reported decadal scale variation of the phosphate concentration in the Oyashio and Kuroshio-Oyashio Transition waters from 1955 to 2000. In this presentation, we will extend the time series until 2010 to reveal the recent change of phosphate concentration.
Outline

1  Phosphate change from 1955 to 2010

2  Temperature and salinity changes in AR4 (2007) and AR5 (2013)

3  Changes of nutrients in the other areas of North Pacific

4  Summary
Data & Methods

Period 1951-2010

Data WOD2009, A-line, JMA nutrients, temperature salinity

Criteria Oyashio >5 degree C
Transition 5-15 degree C at 100m depth Kawai (1972)
bottom depth >500m
Variation in $\text{PO}_4$ (monthly normalized value)
1955-2002 (previous study)

Oyashio

Surface layer (0m)

Mid-layer (26.7-26.8sq)

Transition

Tadokoro et al., 2009
Variations in annual mean value from 1955 to 2000

Oyashio

Surface layer (0m)

PO$_4$ (mmol m$^{-3}$) Decreased in 26%
r\(^2\) = 0.409
N = 42

Mid-layer (26.7-26.8sq)

PO$_4$ (mmol m$^{-3}$) Increased in 12%
r\(^2\) = 0.647
N = 42

18.6-y cycle of tidal strength

Transition

PO$_4$ (mmol m$^{-3}$) Decreased in 36%
r\(^2\) = 0.608
N = 41

Increased in 9%
r\(^2\) = 0.412
N = 41

Previous study
Hypothesis:
Mechanisms of the phosphate change

Oscillation of 18.6-y tidal strength might be related to decadal-scale oscillation of PO4

Transition
OMW
Oyashio
DSW

Trend
Slinity decreased
Stratification enhanced

previous study
Variations 1955 to 2010

New data supported our hypothesis.
Temperature and salinity change in AR4 (2007) and AR5 (2013)
XBT and MBT biases introduced spurious warming in the 1970s and cooling in the early 1980s in the analyses assessed in AR4.

After removing XBT and MBT data, surface temperature increased in the broad area of North Pacific.
Salinity change

AR4

AR5

The 58-year (2008 minus 1950)

Salinity of surface layer decreased broad area of the North Pacific.
Stratification will be enhanced due to change temperature and salinity. Those might be cause of the decreasing of the nutrients supply from mid-layer to surface layer due to decrease the vertical water exchange.
Change in nutrients variation in the other areas of North Pacific
Winter NO$_3$ in surface layer

Winter NO$_3$ represented decrease trend from 1970s.
Gulf of Alaska, Central and Western NP

**Surface layer**

Western to Eastern Pacific

*Winter*

![Winter data graph](image1)

*Summer*

![Summer data graph](image2)

Whitney et al., 2013

Ono et al., 2008
Kuroshio, Subtropical and Tropical waters

Surface layer

Watanabe et al., 2005

PO₄(ave) (µmol l⁻¹)

Winter

Summer

Kuroshio
Subtropical
Tropical

Kuroshio
Subtropical
Tropical

Wintertime (Jan.-Feb.)
Summertime (Jul.-Aug.)
East China Sea

Surface layer

Bottom to mid layer

Aoyama et al., 2008

Guo et al., 2012
Sea of Japan

Mid layer

Watanabe et al., 2005
Summary of the nutrient trends

a Surface
Decrease trends

b Subsurface
Increase trends
このことから、表層と中層の水の交換の衰退が2010年までも引き続き続いていることが示唆された。また延長したデータも潮汐強度の18.6年周期変動による影響の仮説も指示した。

Schematic of TS change

Change in temperature and salinity might decrease of the nutrients supply from mid-layer to surface layer in the broad area of North Pacific.
Summary

1 Extended data until 2010 also represented the trend and bidecadal scale oscillation in the Oyashio and Kuroshio-Oyashio transition waters.

2 AR5 reported the increase trend of temperature and decrease trend of salinity in the surface layer in the North Pacific.

3 In the broad area of North Pacific, many studies reported the decreasing and increasing trends of nutrients in the surface and subsurface layer, respectively. Enhancement of the stratification might decrease nutrient supply from subsurface to surface layer in broad areas of the North Pacific.