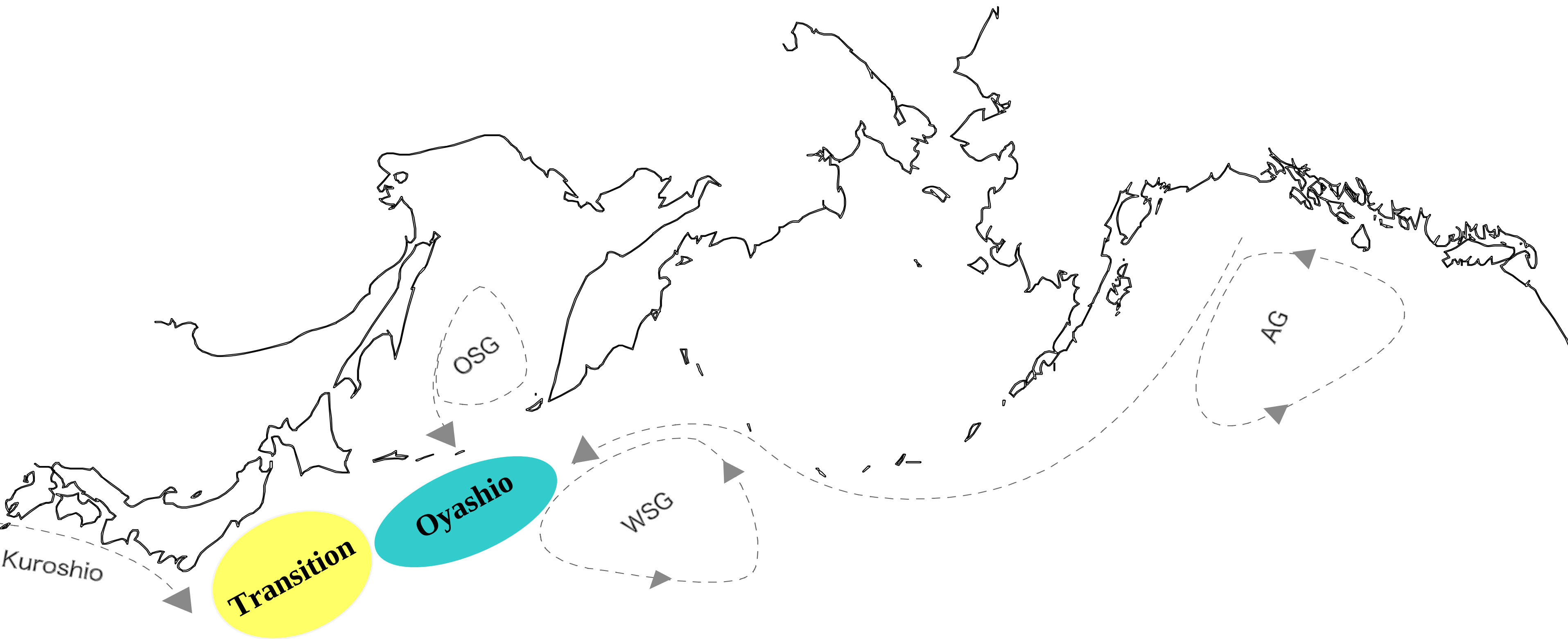
Possible mechanism of decadal-scale variation in PO_4 concentration in the western north Pacific, and the influence to the ocean productivity

Kazuaki Tadokoro, Tsuneo Ono, Ichiro Yasuda, Satoshi Osafune,
Yuji Okazaki, Akihiro Shiomoto, and Hiroya Sugisaki

Tohoku National Fisheries Research Institute
den@affrc.go.jp

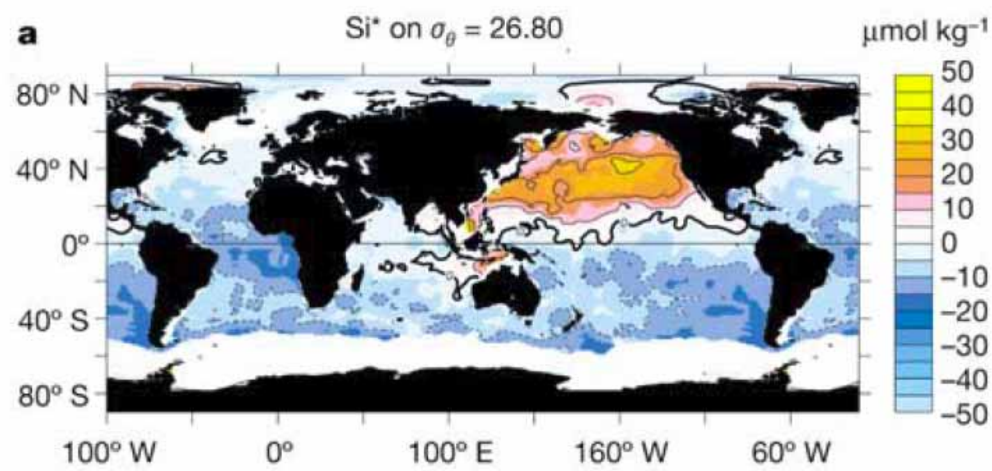


High-latitude controls of thermocline nutrients and low latitude biological productivity

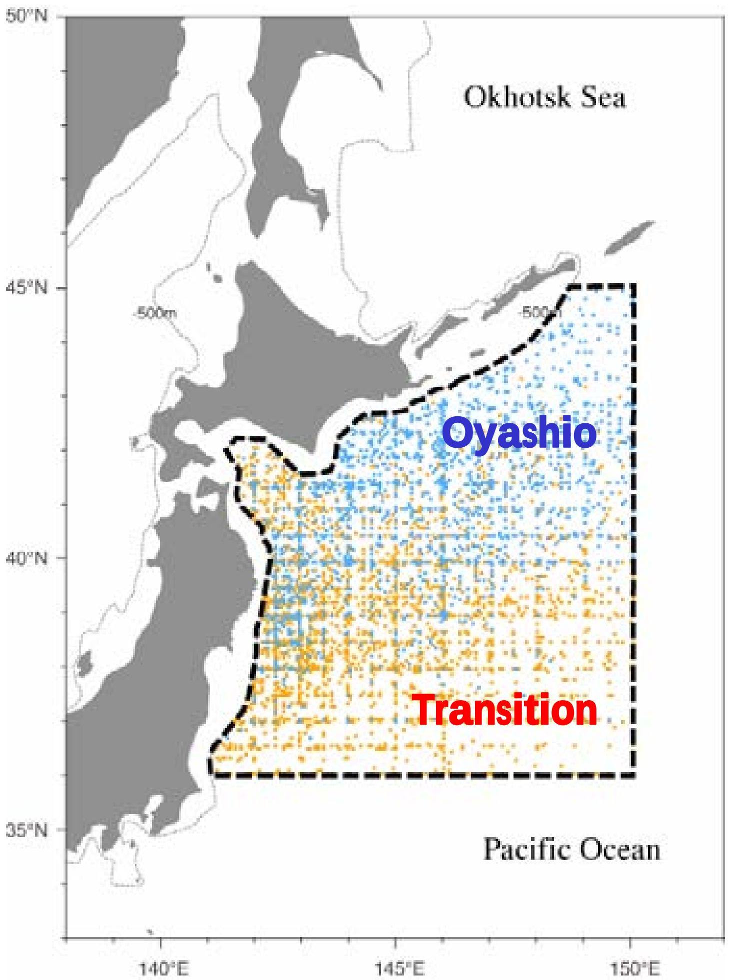
J. L. Sarmiento[1], N. Gruber[2], M. A. Brzezinski[3] & J. P. Dunne[4]

[1]*Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, New Jersey 08544, USA*
[2]*IGPP and Department of Atmospheric Sciences, University of California at Los Angeles, Los Angeles, California 90095, USA*
[3]*Department of Ecology, Evolution and Marine Biology and the Marine Science Institute, University of California, Santa Barbara, California 93106, USA*
[4]*NOAA/Geophysical Fluid Dynamics Laboratory, PO Box 308, Forrestal Campus B Site, Princeton, New Jersey 08542, USA*

The ocean's biological pump strips nutrients out of the surface waters and exports them into the thermocline and deep waters. If there were no return path of nutrients from deep waters, the biological pump would eventually deplete the surface waters and thermocline of nutrients; surface biological productivity would plummet. Here we make use of the combined distributions of silicic acid and nitrate to trace the main nutrient return path from deep waters by upwelling in the Southern Ocean[1] and subsequent entrainment into subantarctic mode water. We show that the subantarctic mode water, which spreads throughout the entire Southern Hemisphere[2,3] and North Atlantic Ocean[3], is the main source of nutrients for the thermocline. We also find that an additional return path exists in the northwest corner of the Pacific Ocean, where enhanced vertical mixing, perhaps driven by tides[4], brings abyssal nutrients to the surface and supplies them to the thermocline of the North Pacific. Our analysis has important implications for our understanding of large-scale controls on the nature and magnitude of low-latitude biological productivity and its sensitivity to climate change.



Data & Methods



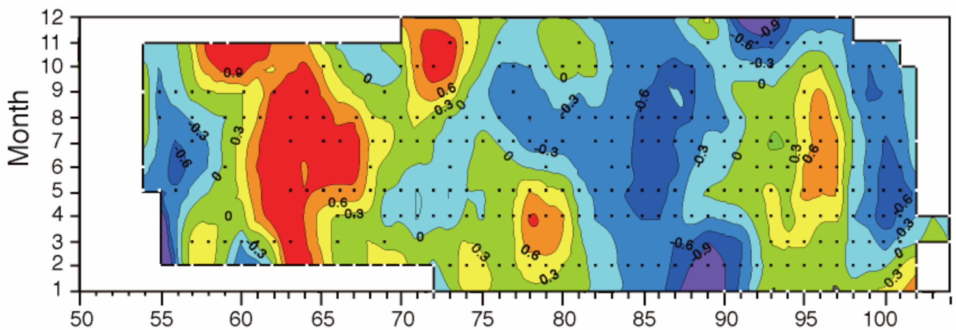
Period	1951-2004
Oceanographic data	WOD2001, A-line, JMA Nutrients・ temperature・ salinity
Mezooplankton	Odate collection *Neoclanaus plumchrus*
Criteria	Oyashio >5 degree C Transition 5-15 degree C at 100m depth Kawai (1972) bottom depth >500m

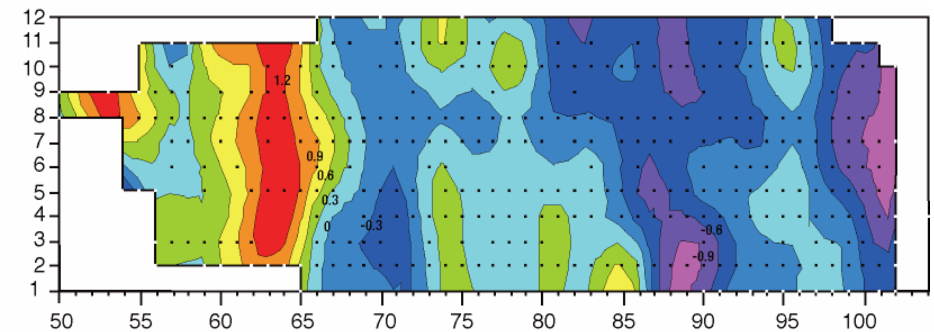
Variation in PO_4 (monthly normalized value)

Oyashio

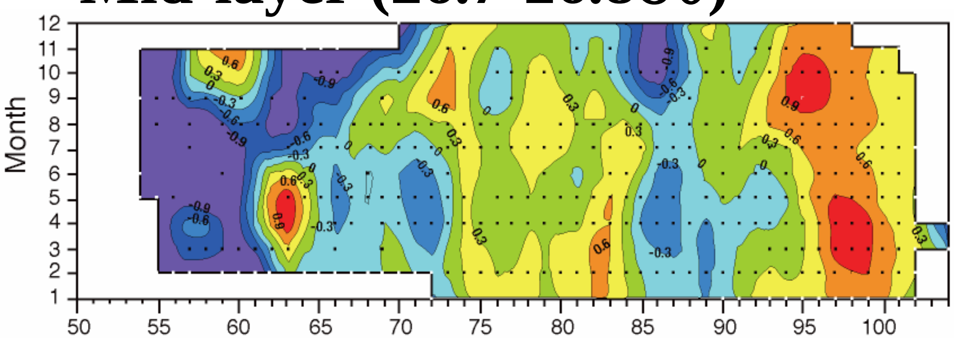
Transition

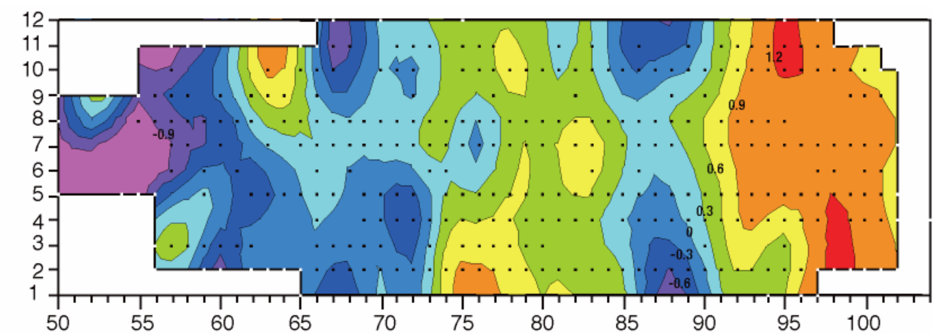
Surface layer (0m)



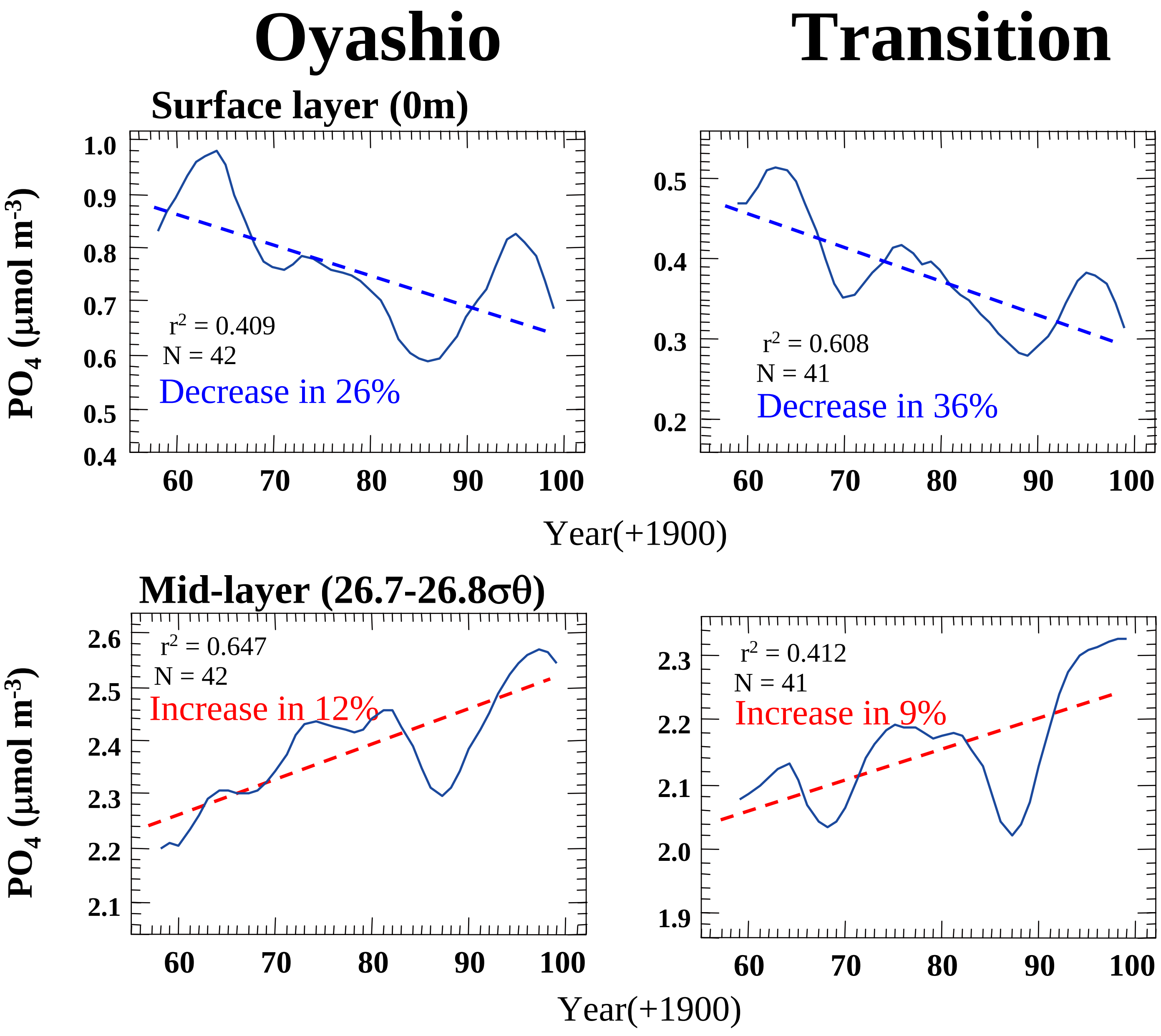


Mid-layer (26.7-26.8σθ)

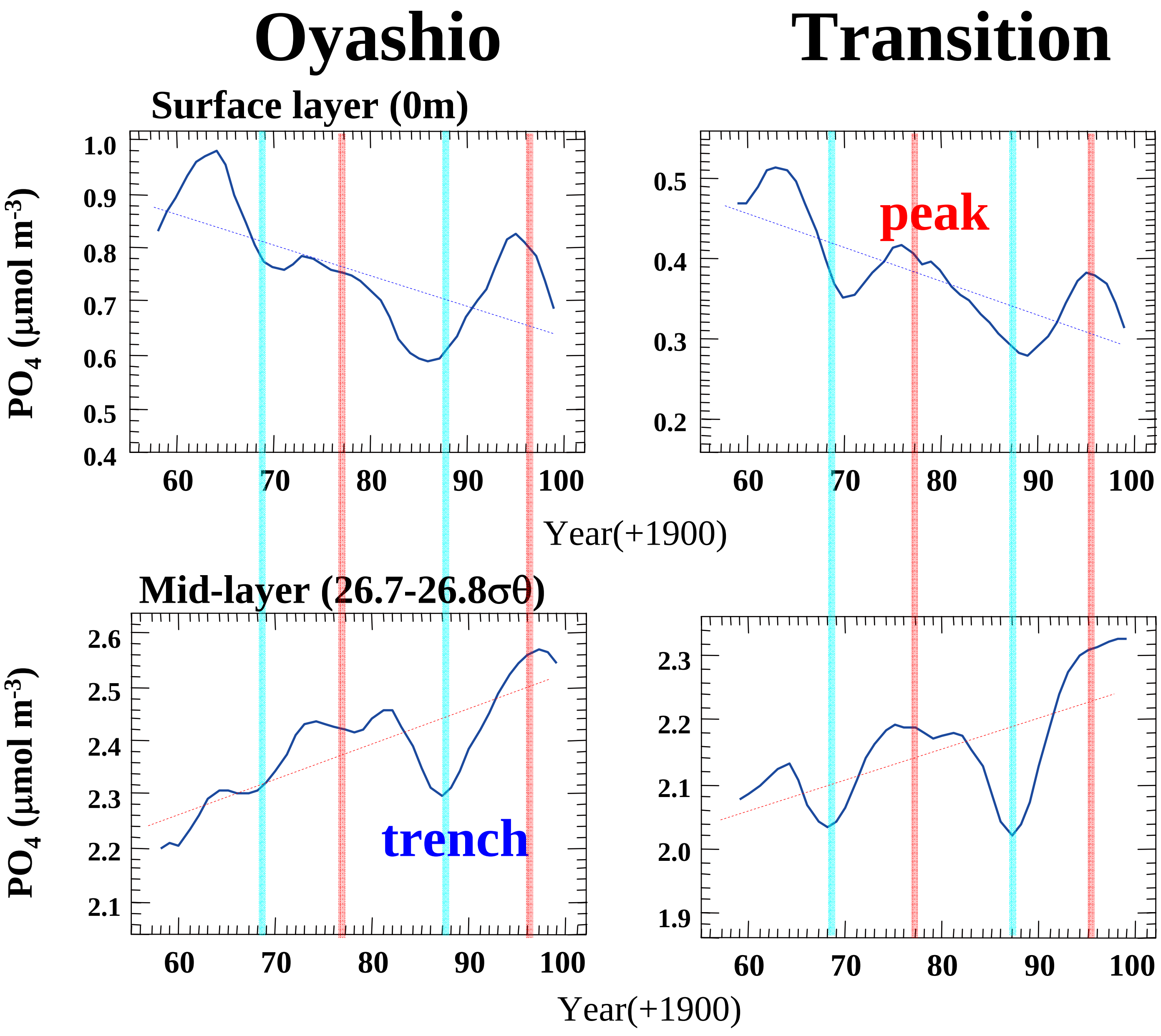




5-year running mean of annual mean PO_4



5-year running mean of annual mean PO_4

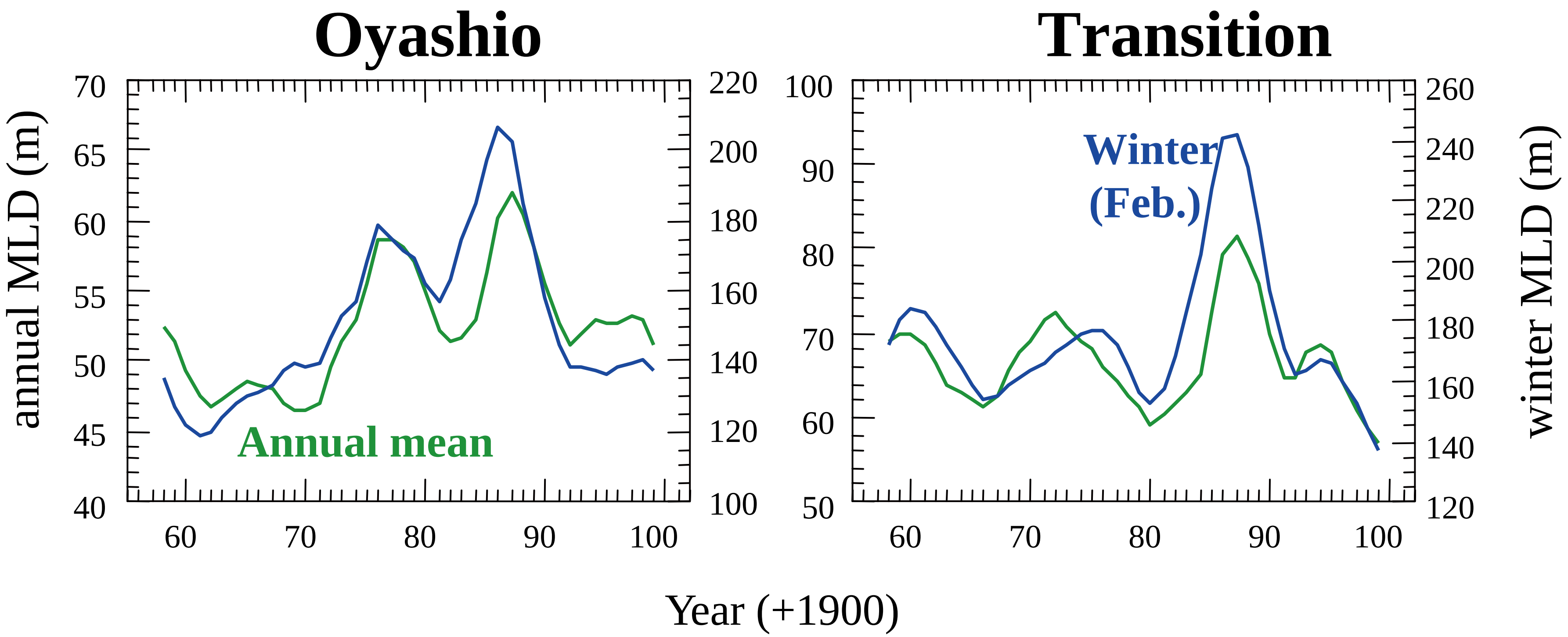


Relationship PO_4 between surface and mid layer

Trend: **inverse between two layers**

➡ Suggest decreasing of water exchange between two layers.

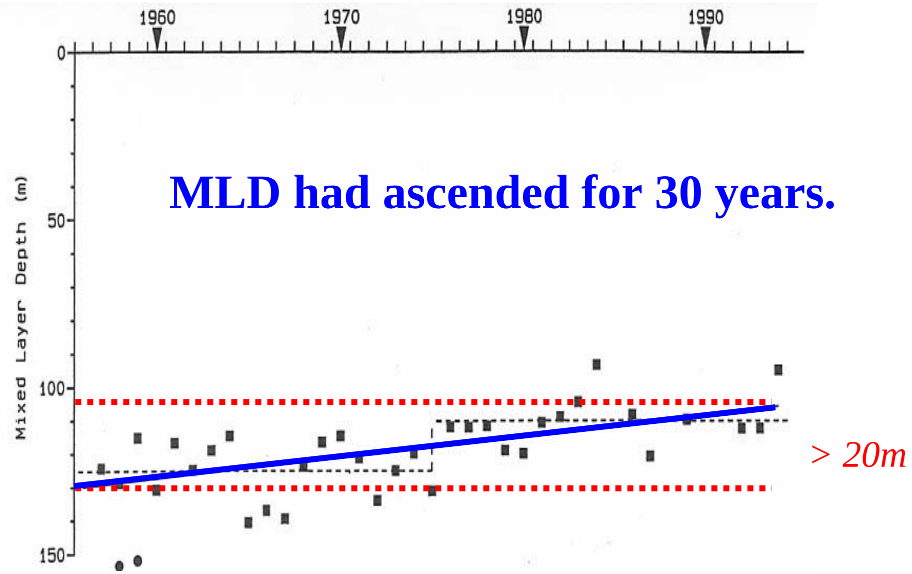
Variations in Mixed layer depth



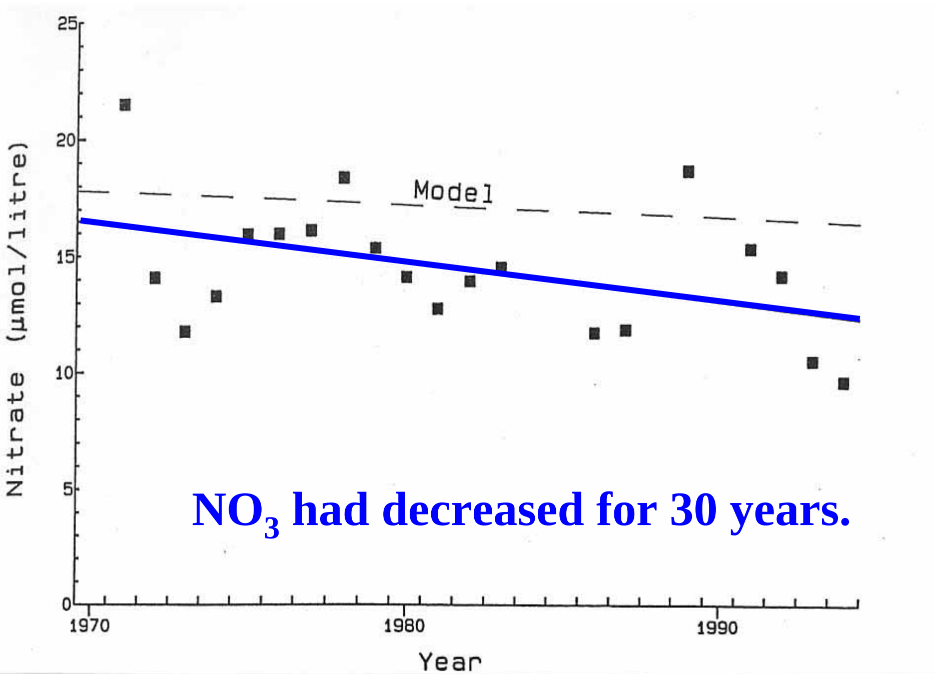
We did not observed significant trend of MLD in the both waters. However, it was reported that the shoaling trend of MLD in western subarctic and Alaskan Gyre (Joyce & Dunworth-Baker 2003, Freeland et al. 1998, 2005).

Shoaling trend of MLD in the Alaskan Gyre

MLD in winter



Surface NO_3 in winter

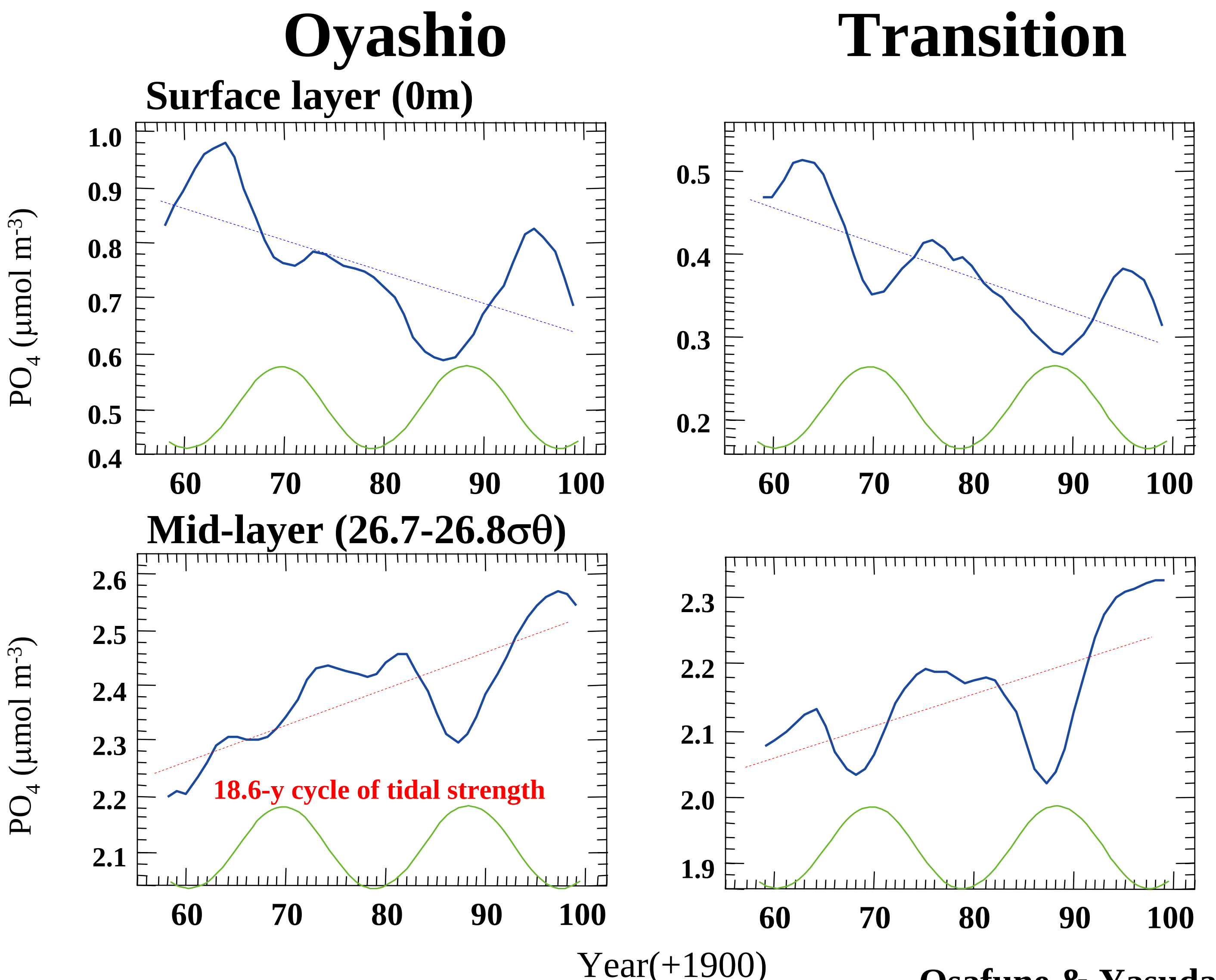


Freeland et al. (1997, 2005)

These are upstream of the Oyashio and Transition waters. The trends of PO_4 in the Oyashio and Transition waters may be related to the change of MLD in upstream waters.

Bidecadal-scale oscillation

Bidecadal-scale oscillation



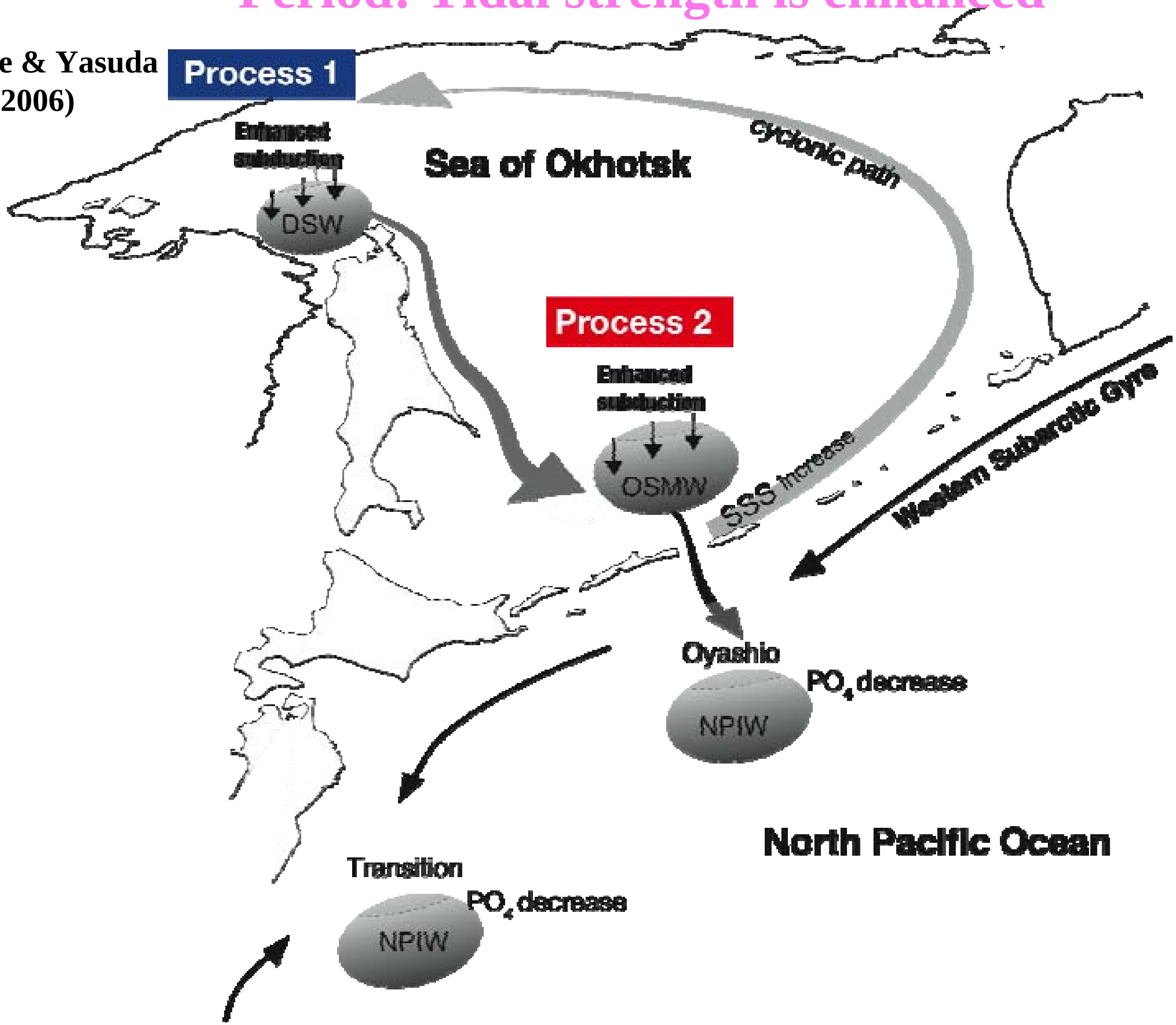
Osafune & Yasuda (2006) JGR

Oscillation component (anomaly from trend) of PO_4 had significant negative relationship with index of 18.6-year diurnal tidal strength in the both layers.

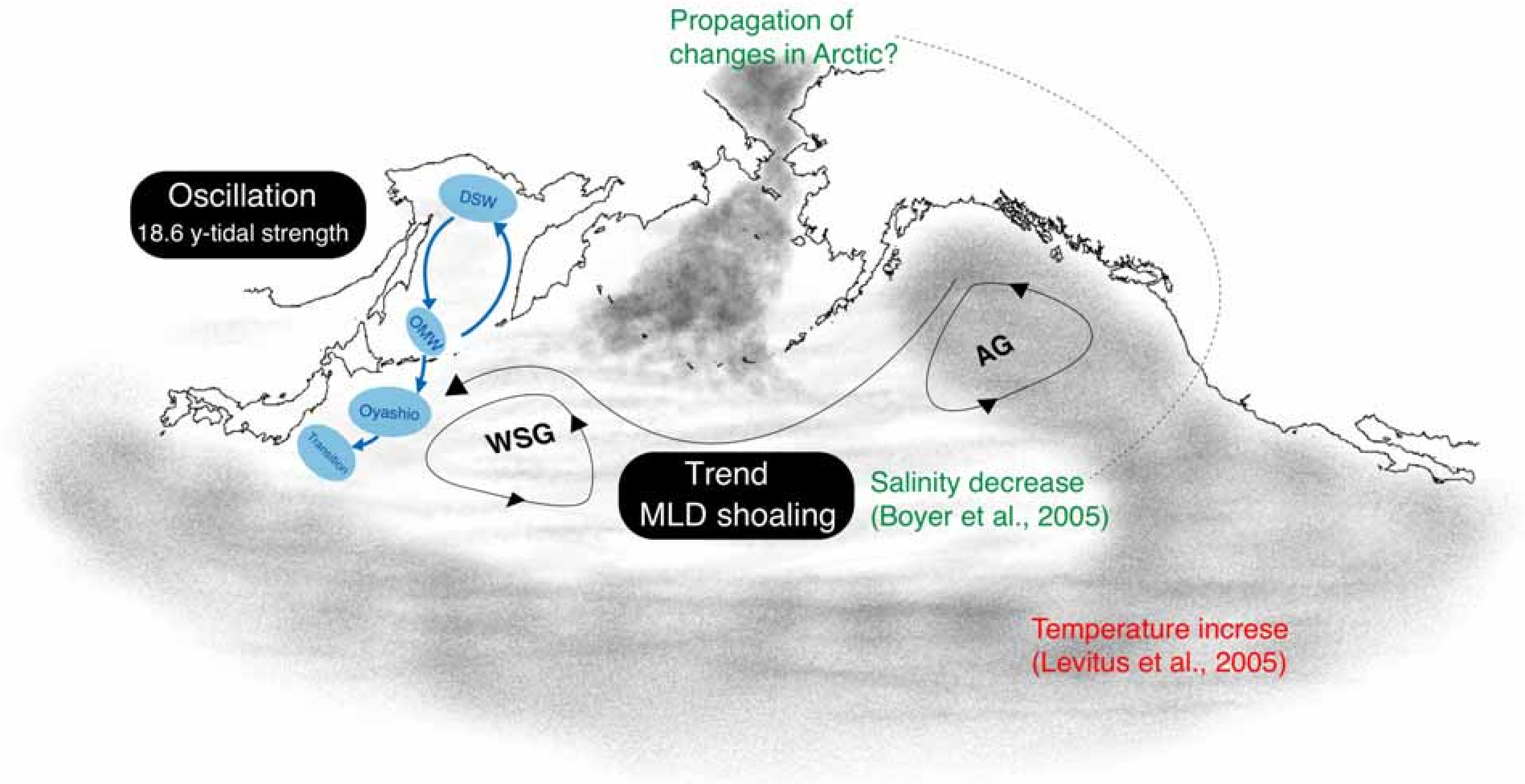
Possible processes of the bidecadal-scale oscillation in PO_4

Period: Tidal strength is enhanced

Osafune & Yasuda (2006)



Summary: possible process of variation in PO_4

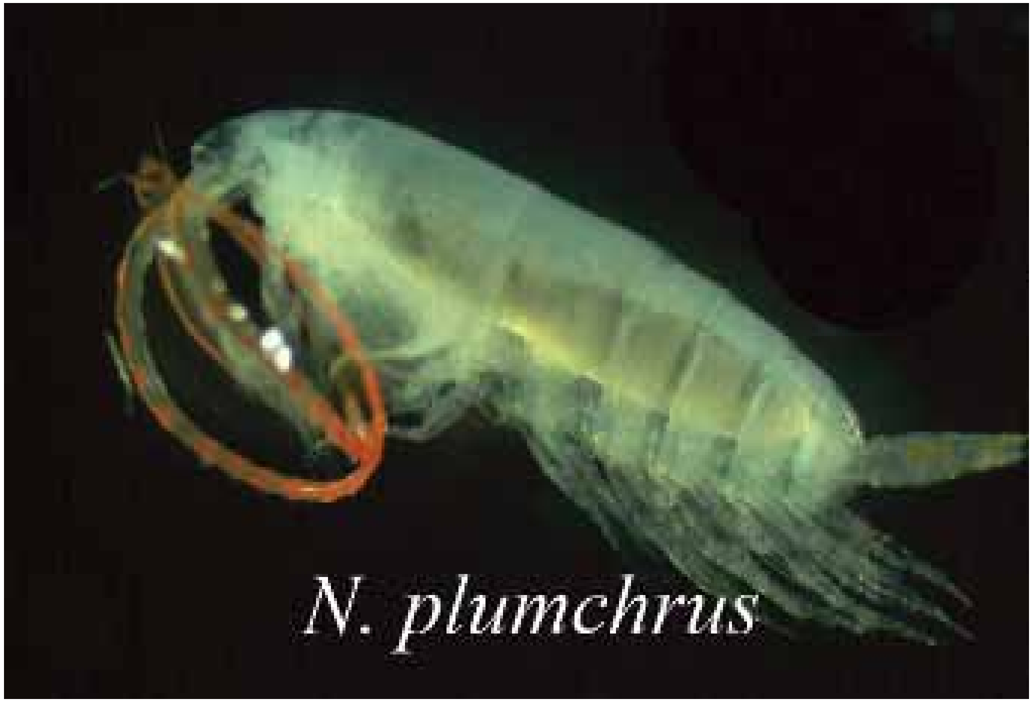


Neocalanus plumchrus

Predominant mesozooplankton

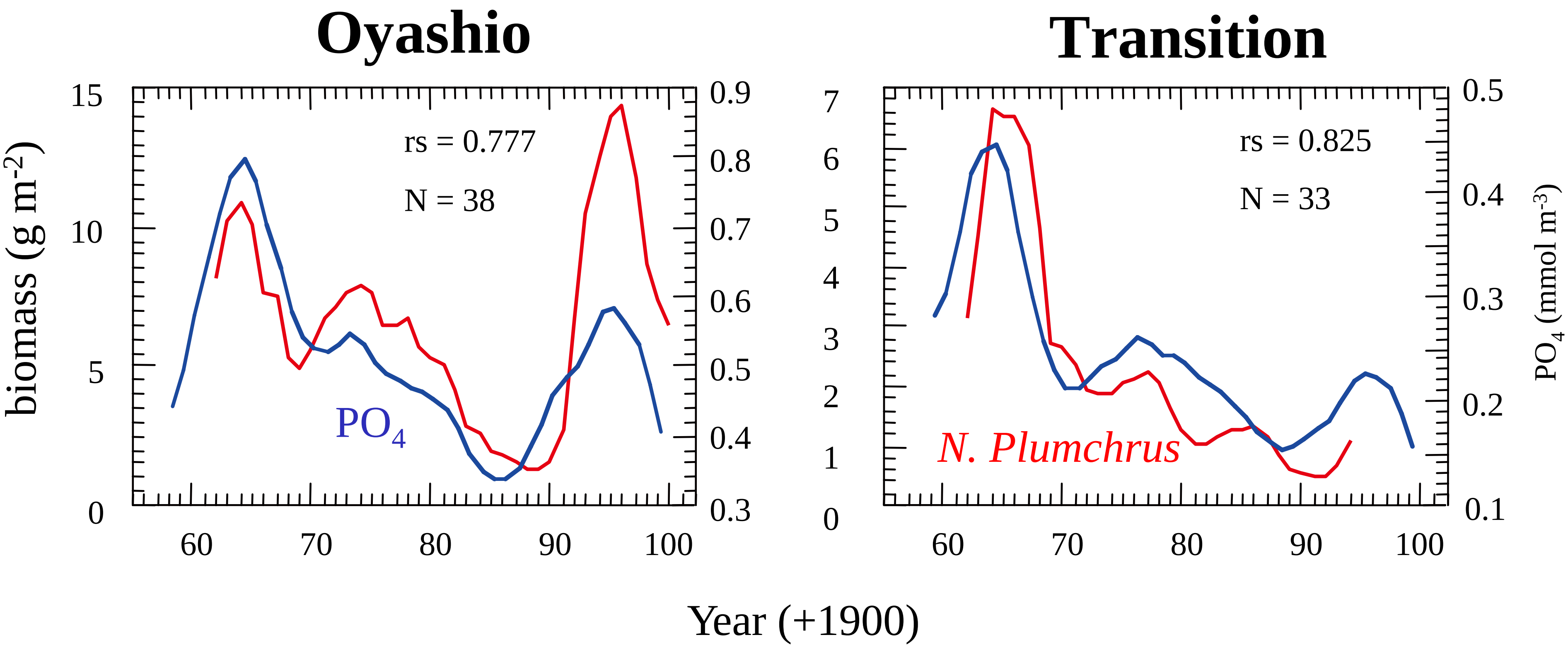
Spring-summer species

Feed on phytoplankton and micorozooplankton



Variaton in *N. plumchrus* biomass in spring-summer

N. Plumchrus biomass had significant positive relationship with PO_4.



The relationships suggests the change in PO_4 supply affect *N. Plumchrus* productivity via change the primary productively.