PICES XV POC Paper-2967

The processes of AOU change in the North Pacific

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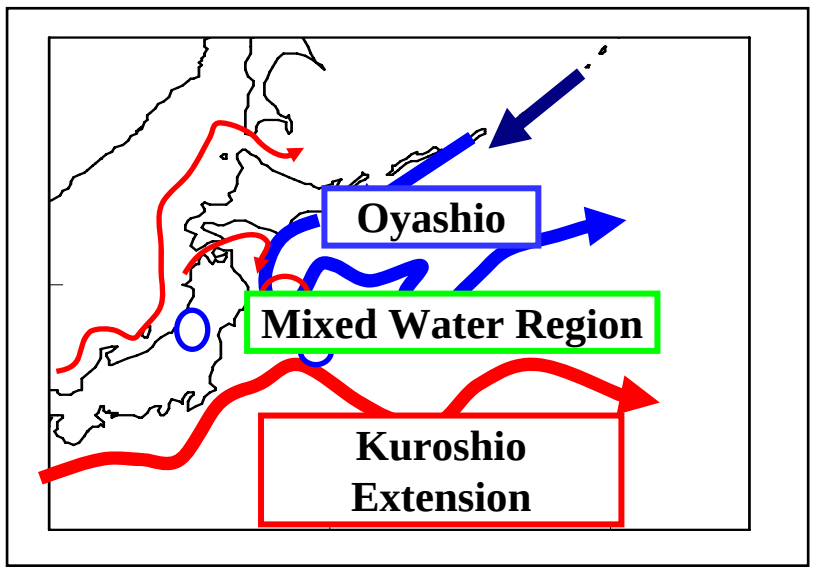
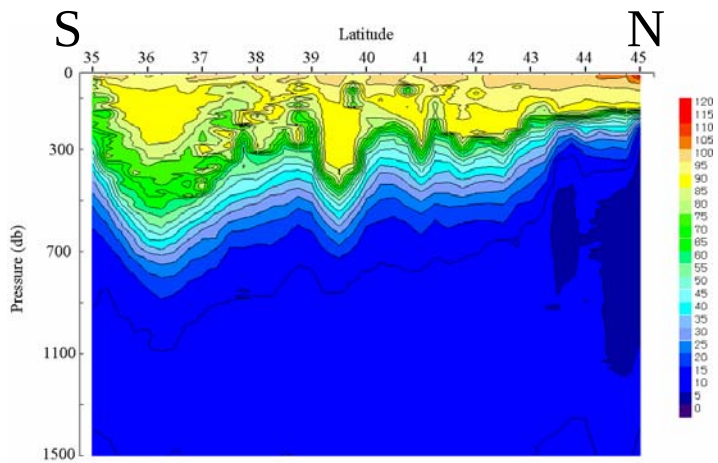
Introduction

Water masses in the mixed water regions of the North Pacific are formed as the result of mixing between Kuroshio and Oyashio water. Dissolved Oxygen (DO) originated from Kuroshio or Oyashio is also mixed in these regions. However, DO is affected by non-conservative processes such as biological activities or air-sea exchange. AOU (Apparent Oxygen Utilization) is often used as an index of freshness of water mass. This assumption is valid in the condition under which AOU increase by only respiration. Though, AOU is supposed to be changed by not only respiration but water mixing and air-sea exchange in the mixed water regions. It is still underdetermined that how large these three processes influence to AOU change.

※ AOU = DO saturated - DO observed



DO (%) along 155˚ E



Purpose

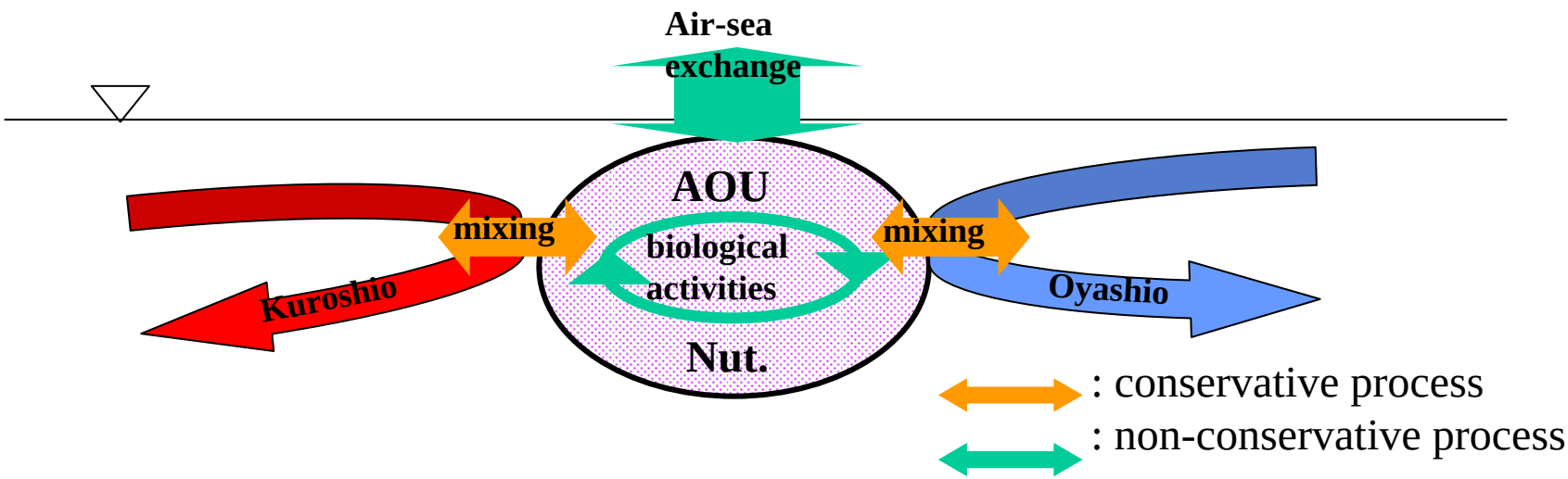
Elucidate the effect of

water mixing,

biological activities and

air-sea exchange

to **the AOU change** in the North Pacific mixed water regions.



Method

- **AOU change by mixing referred to pure Oyashio water (conservative change)**

is estimated from the mixing ratio and AOU of two end members.

r_S (%) = 100× (S - S_k) / (S_o - S_k)

AOU_{mix} = AOU_o× r_S / 100 + AOU_k× (1- r_S / 100)

$AOU_{conserve\text{-}change}$= AOU_{mix} - AOU_o

r_S : mixing ratio calculated from salinity assuming isopycnal mixing (pure Oyashio = 100)
$S_{k\,(o)}$: salinity of Kuroshio (Oyashio), AOU_{mix} : conservative AOU(ml/L), $AOU_{k\,(o)}$: AOU of Kuroshio (Oyashio) (ml/L)

- **AOU change by biological activities**

is estimated under the assumption that non-conservative nutrient change is resulted in biological activities.

$AOU_{nonconserve\text{-}change}$ = AOU_{obs} - AOU_{mix} $Nut_{nonconserve\text{-}change}$ = Nut_{obs} - Nut_{mix}

$AOU_{bio\text{-}change}$ = $NO_{23\ nonconserve\text{-}change}$ / 5.18

or $PO_{4\ nonconserve\text{-}change}$ / 0.37

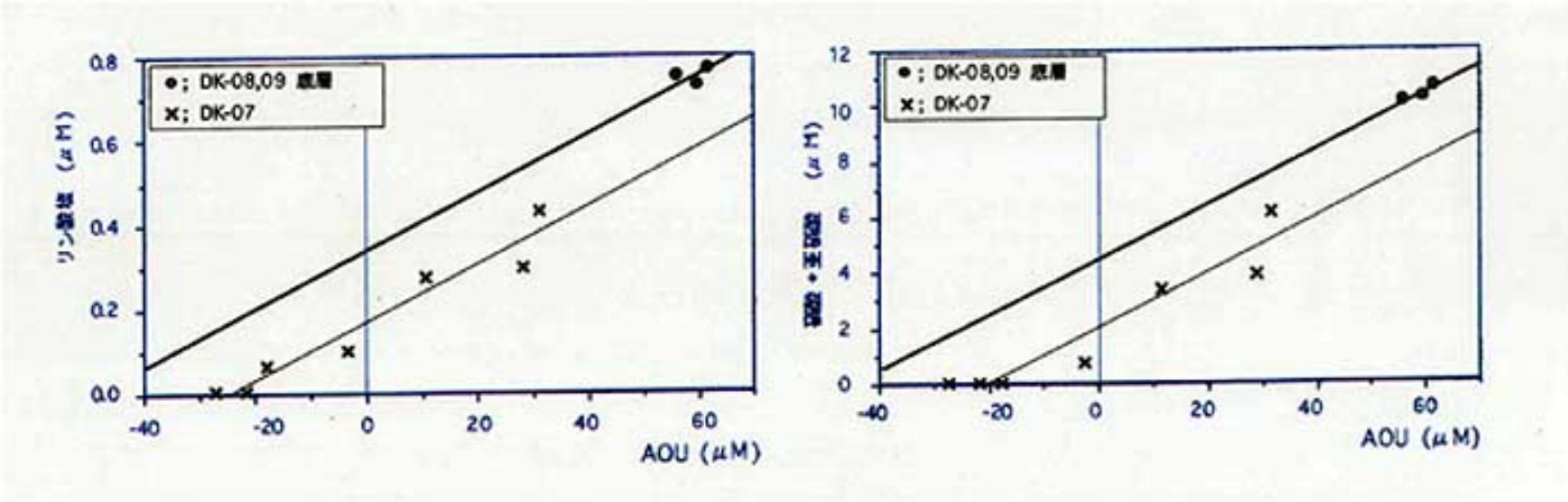
5.18, 0.37 : Redfield ratio of nutrient vs AOU [(μM nut.) / (ml/L AOU)]

- **AOU change by air-sea exchange**

is assumed to the residuals from observed AOU to AOU change by mixing and biological activities.

$AOU_{air\text{-}change}$ = AOU_{obs} - $AOU_{conserve\text{-}change}$ - $AOU_{bio\text{-}change}$

Redfield Ratio

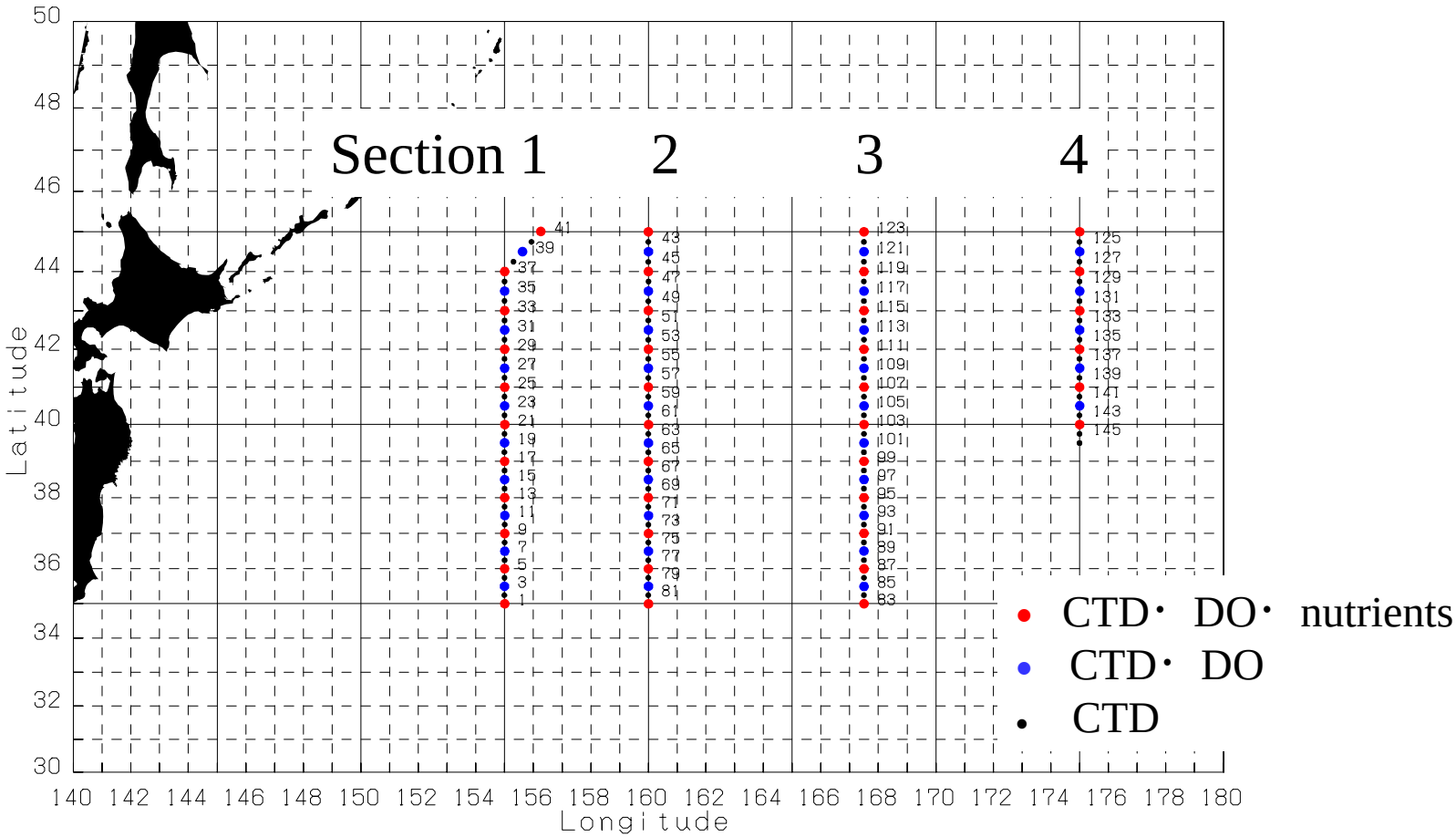


Redfield ratio is the relationship between organic matter derived from phytoplanktons and its principal elements composition (Redfield et al., 1963).

$(CH_2O)_{106}(NH_3)_{16}H_3PO_4+138O_2=106CO_2+16HNO_3+H_3PO_4+122H_2O$

In the case that
138μMO_2 is consumed for oxidation of organic matter，
16μM NO_3 ，1μM PO_4 are generalized.
This is equivalent to the generation of 5.18μM NO_3 ，0.32μM PO_4 for 1ml/L AOU increase.

Station



Shoyo-maru cruise（2004/05/20～06/18）

CTDO cast to 1500db depth and 19 layers water sampling were conducted.

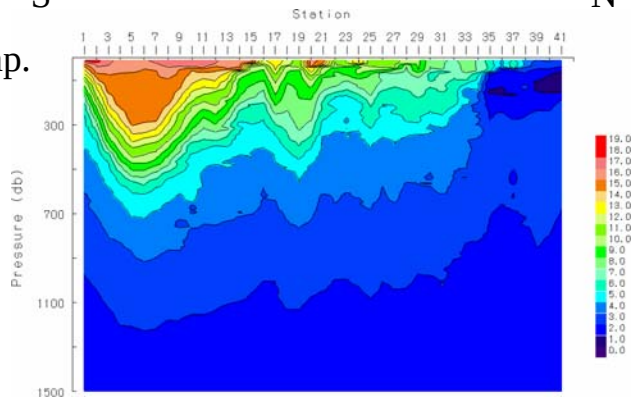
O_2 content of sampled water was also directly measured by Winkler method.

Nutrients were measured using a TRAACS after the cruise.

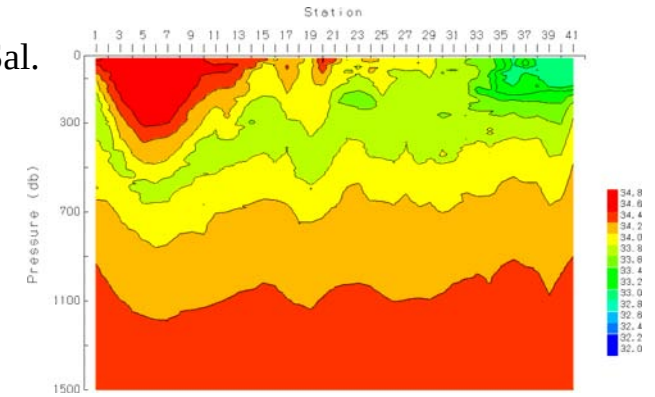
Distributions of T, S, density, AOU, $NO_{2,3}$ and PO_4 in section 1

S N

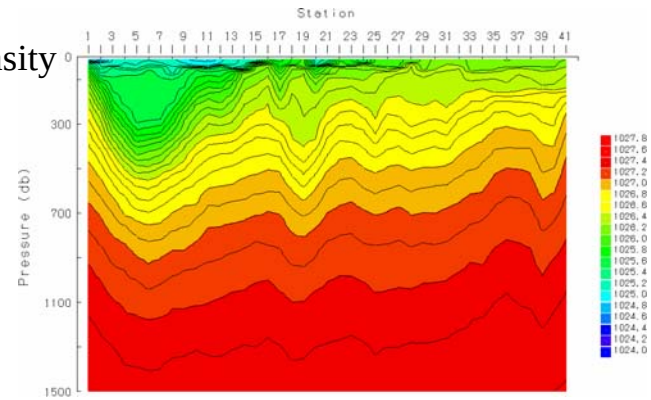
Temp.



Sal.

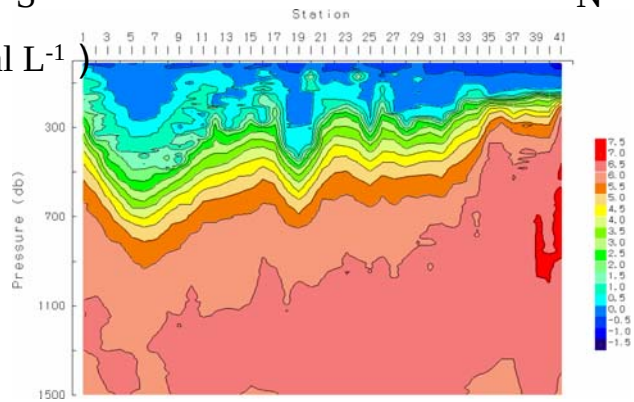


P. density

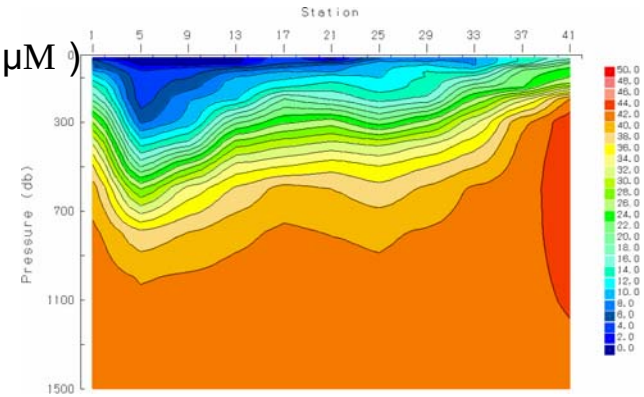


S N

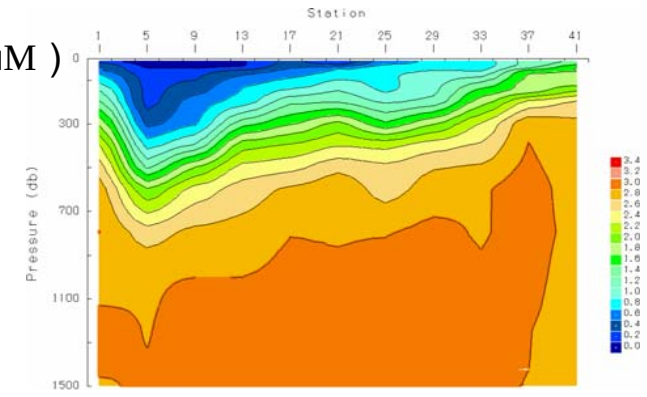
AOU (ml L^{-1})



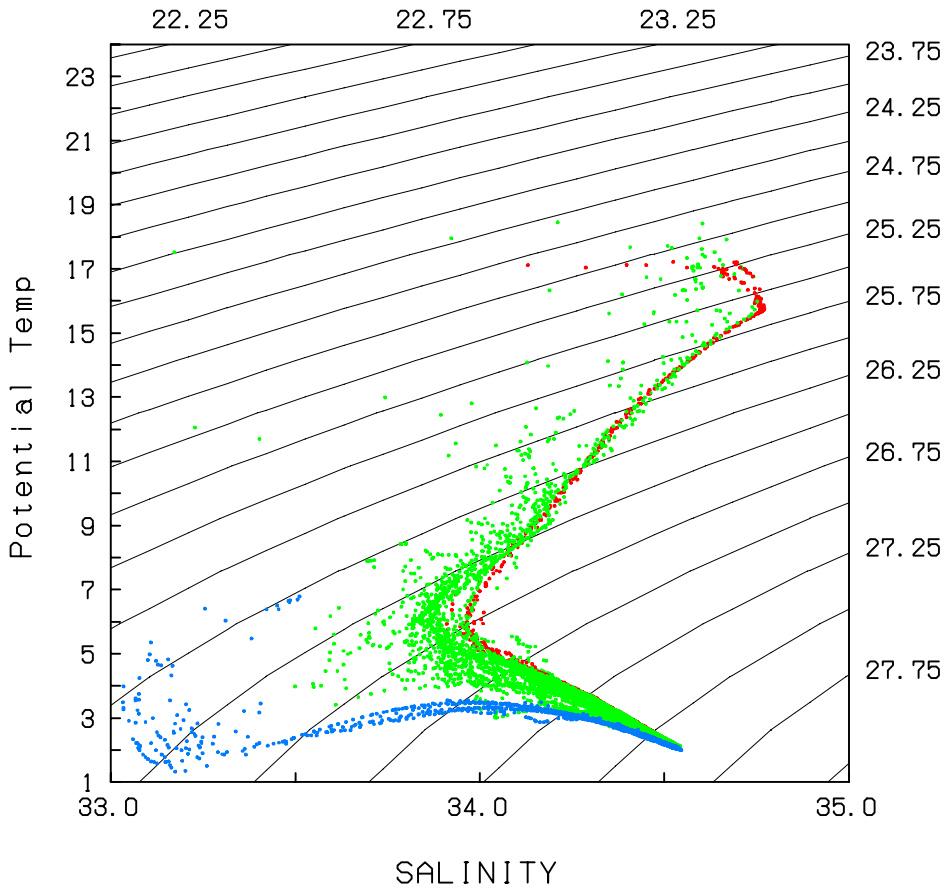
$NO_{2,3}$ (μM)



PO_4 (μM)



Water Mass Division

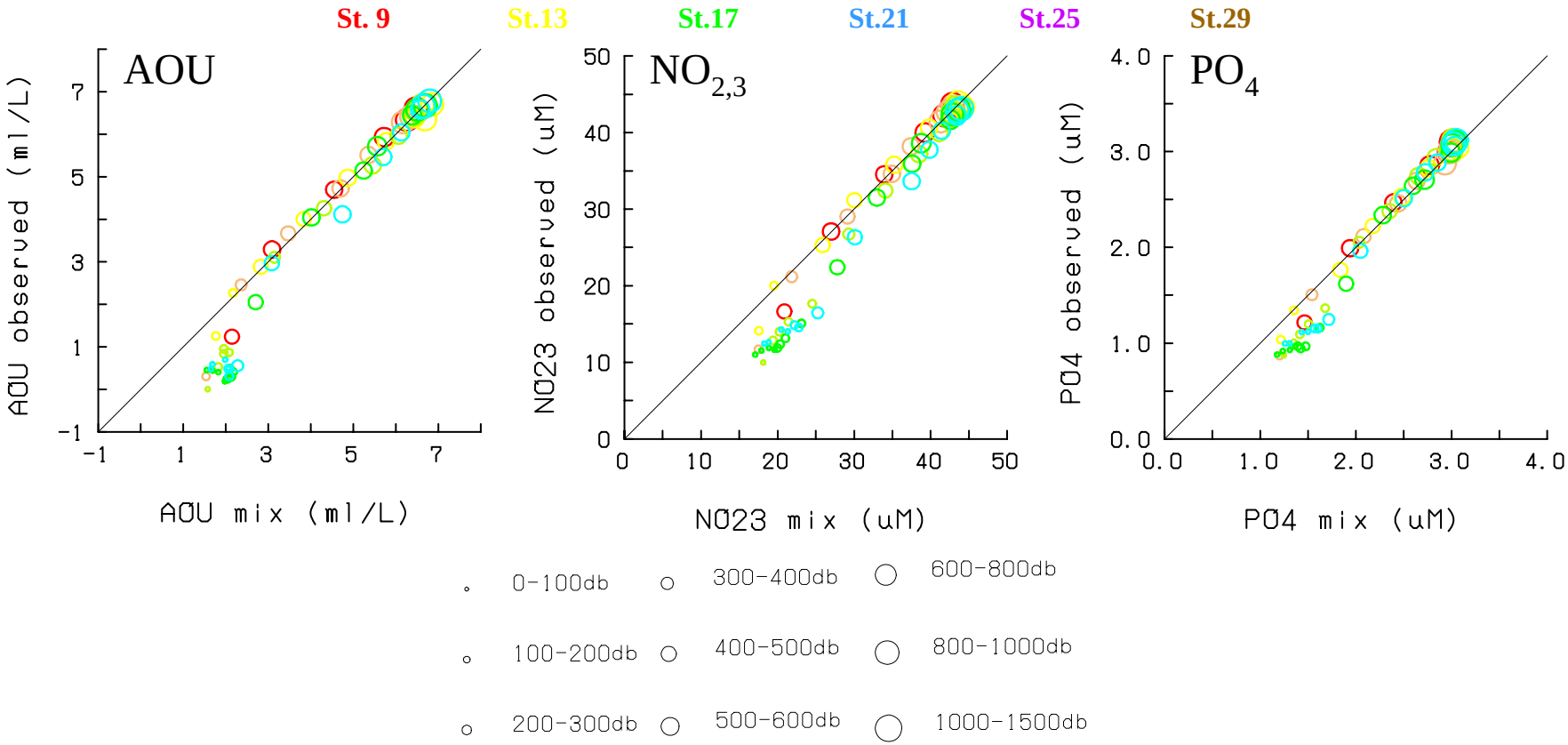


We divided observational data to Kuroshio water, Mixed region water and Oyashio water in the basis on TS diagram and temperature of 100m or 200m depth.

We concentrate on AOU of the Mixed water regions.

Comparisons between conservative and observed AOU and nutrients.

(X_{mix} *vs* X_{obs})



Deeper than 300 ~ 400db depth , AOU and nutrients are conservative.

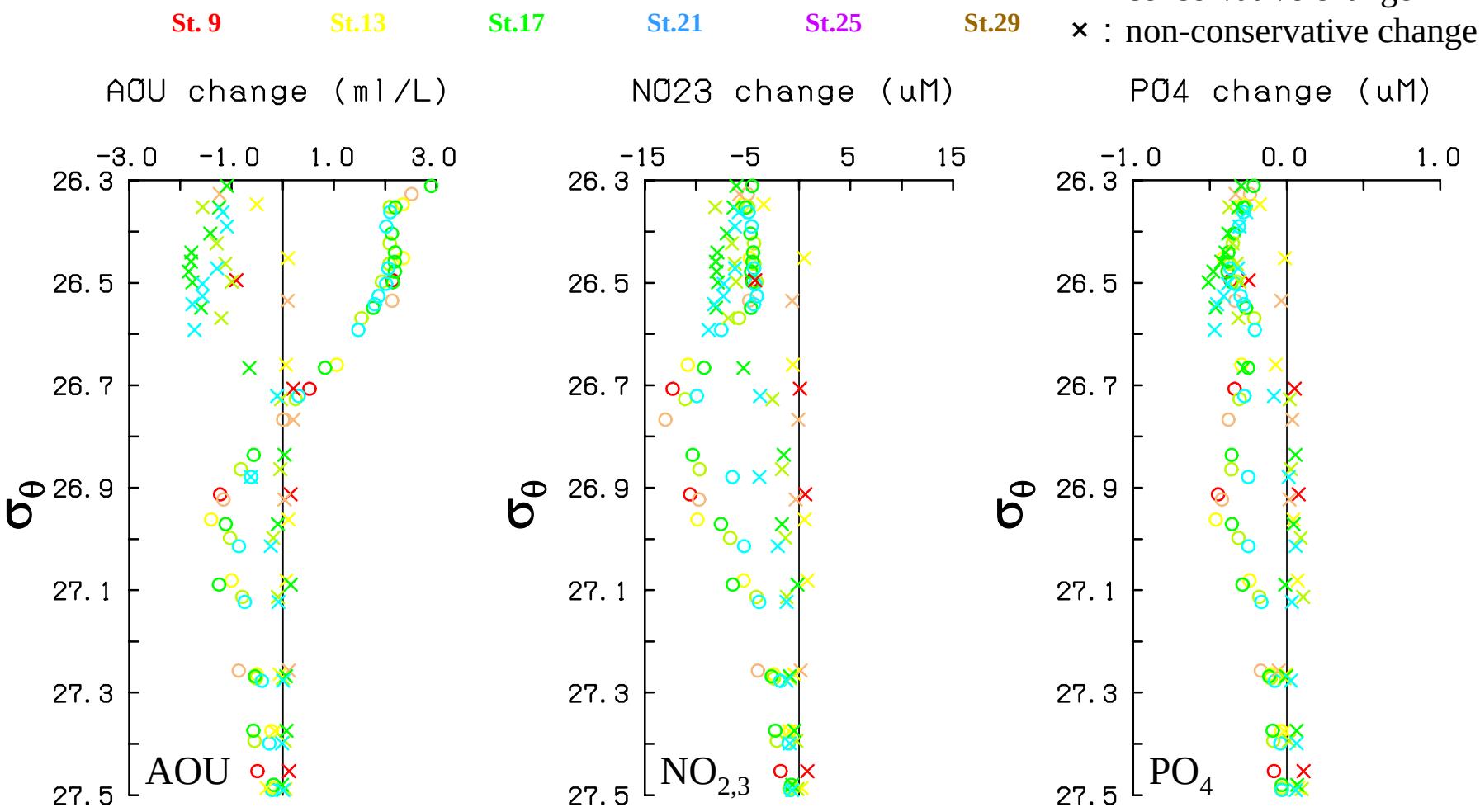
From surface to 300 ~ 400db depth, AOU and nutrients were decreased by non-conservative processes.

Profiles of AOU and nutrients change by conservative and non-conservative processes.

($X_{conserve\text{-}change}$, $X_{nonconserve\text{-}change}$)

○ : conservative change

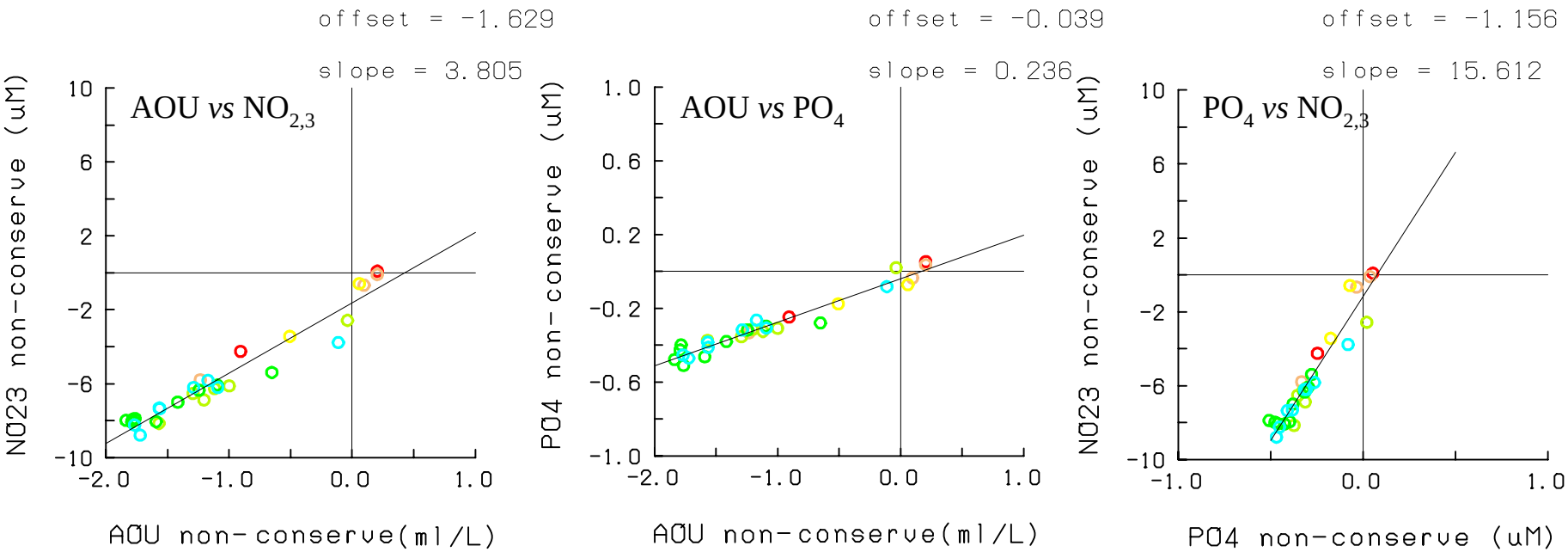
× : non-conservative change



Non-conservative processes are active upper than 26.7σ_θ depth.

Relationship between non-conservative change of AOU and nutrients upper than $26.8\sigma_\theta$ depth. ($X_{nonconserve\text{-}change}$ *vs* $Y_{nonconserve\text{-}change}$)

St. 9 St.13 St.17 St.21 St.25 St.29



The ratio of non-conservative PO_4 and **non-conservative** $NO_{2,3}$ **consists with Redfield ratio (= 16).**

→ **This means that nutrients change is occurred by biological activities (primary production).**

That of non-conservative AOU and non-conservative nutrient (AOU *vs* nutrient) **is different from Redfield ratio [= 5.18 ($NO_{2,3}$), 0.37 (PO_4)]**

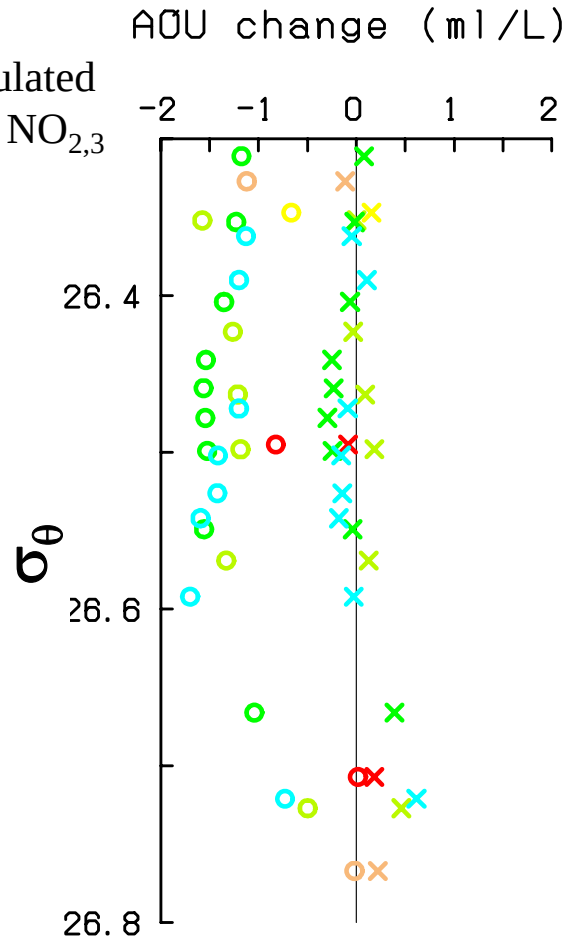
→ **AOU change is dependent on biological activities and air-sea exchange.**

Profiles of AOU change by biological activities and air-sea exchange upper than $26.8\sigma_\theta$ depth. ($AOU_{bio\text{-}change}$, $AOU_{air\text{-}change}$)

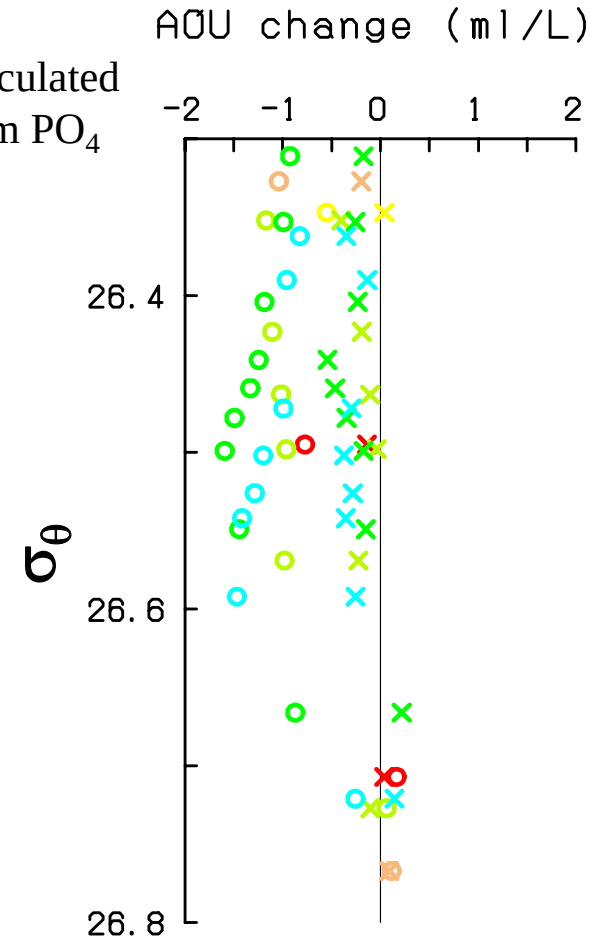
St. 9 St.13 St.17 St.21 St.25 St.29

○ : biological change
× : air-sea exchange

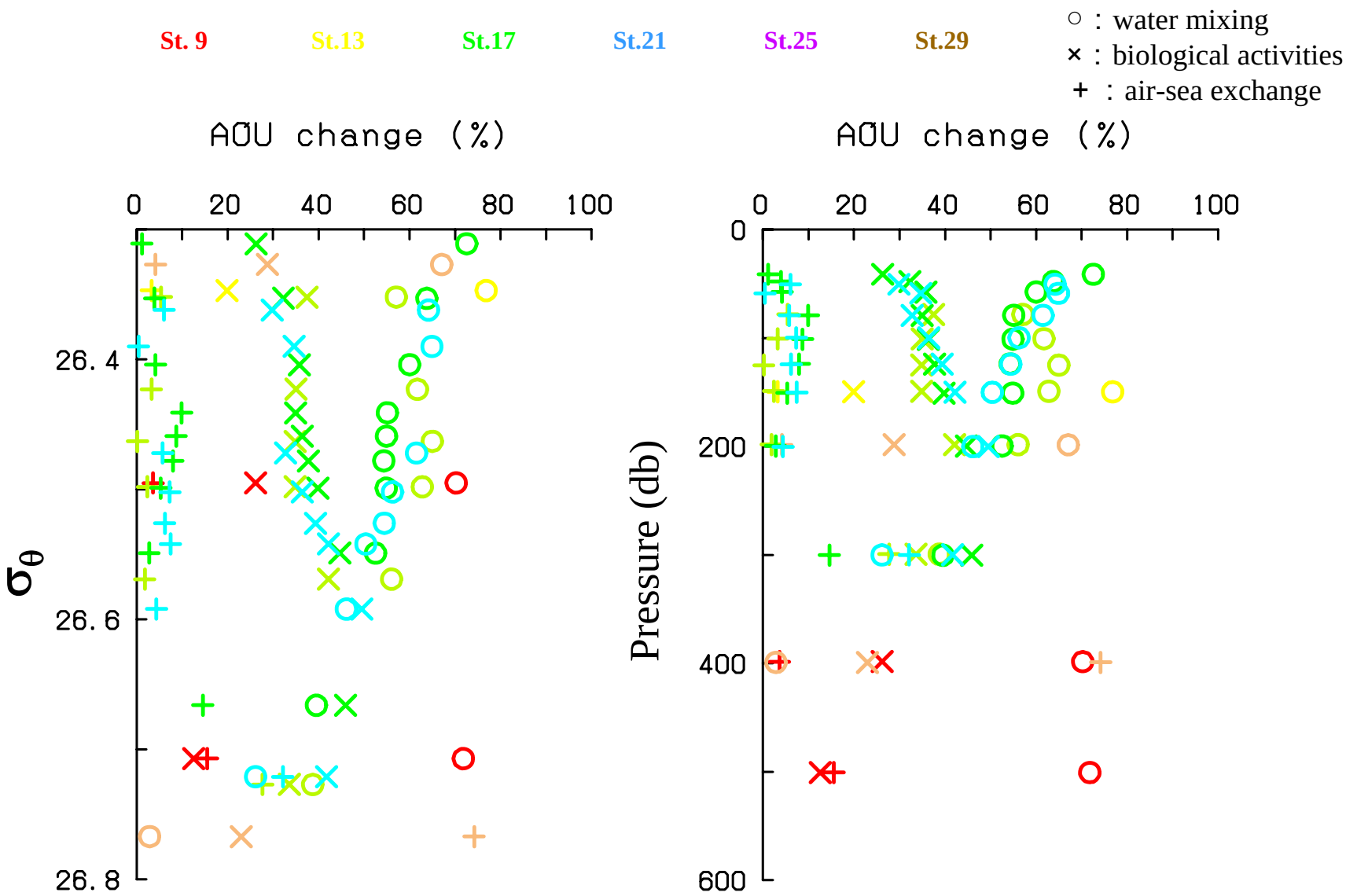
Calculated from $NO_{2,3}$



Calculated from PO_4



Profiles of AOU change ratios (%) by water mixing, biological activities and air-sea exchange upper than 26.8σ_θ depth.



Conclusions

The processes of AOU changes are mainly dependent on water mixing and biological activities (primary production) in the mixed water regions.

The water mixing is the dominant processes in whole water column. Especially in the deeper layer, of which upper boundary is $26.7\sigma_\theta$ depth, changes of AOU and nutrients are explained only by the water mixing processes. This implies that AOU and nutrients are conservative in the deeper layer.

In the upper layer, AOU and nutrients showed lower value than those calculated from mixing process. This implies non-conservative change is also affected. The ratio of non-conservative change of $NO_{2,3}$ and PO_4 consists with Redfield ratio. The process of decreasing nutrients is considered to be primary production (biological activities). While, the ratio of non-conservative change of AOU and nutrient is different from it. **Non-conservative AOU change depends on biological activities** and **air-sea exchange** is implied.

We estimated biological change of AOU from non-conservative change of nutrients with Redfield ratio. AOU change by **biological activities** is lager than by air-sea exchange.

The AOU change ratios by water mixing, biological activities and air-sea exchange are estimated at 50-80, 20-50 and less than 10 percent, respectively.

Thank you!