Decadal salinity variation in the western North Pacific correlated with the North Pacific Gyre Oscillation

Hitoshi Kaneko[1*], Takeshi Okunishi[1], Shinya Kouketsu[2], Sachihiko Itoh[3], Takashi Setou[4], Hiroshi Kuroda[5], and Yugo Shimizu[4]

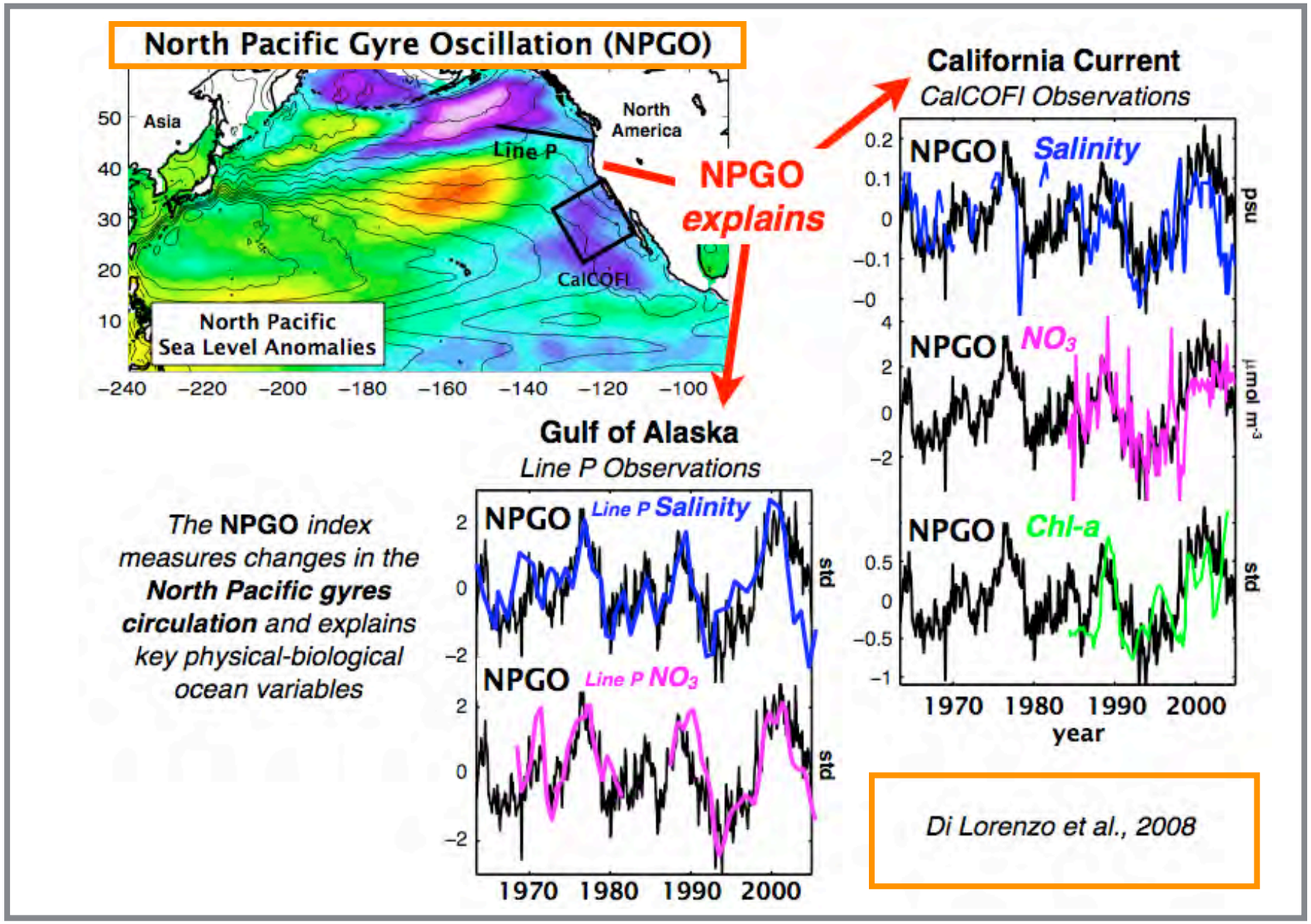
E-mail: jinziren@affrc.go.jp

1 Tohoku National Fisheries Research Institute,
2 Japan Agency for Marine-Earth Science and Technology
3 Atmosphere and Ocean Research Institute
4 National Research Institute of Fisheries Science
5 Hokkaido National Fisheries Research Institute (Kushiro Laboratory)

14:00–14:20 on April 24, 2018

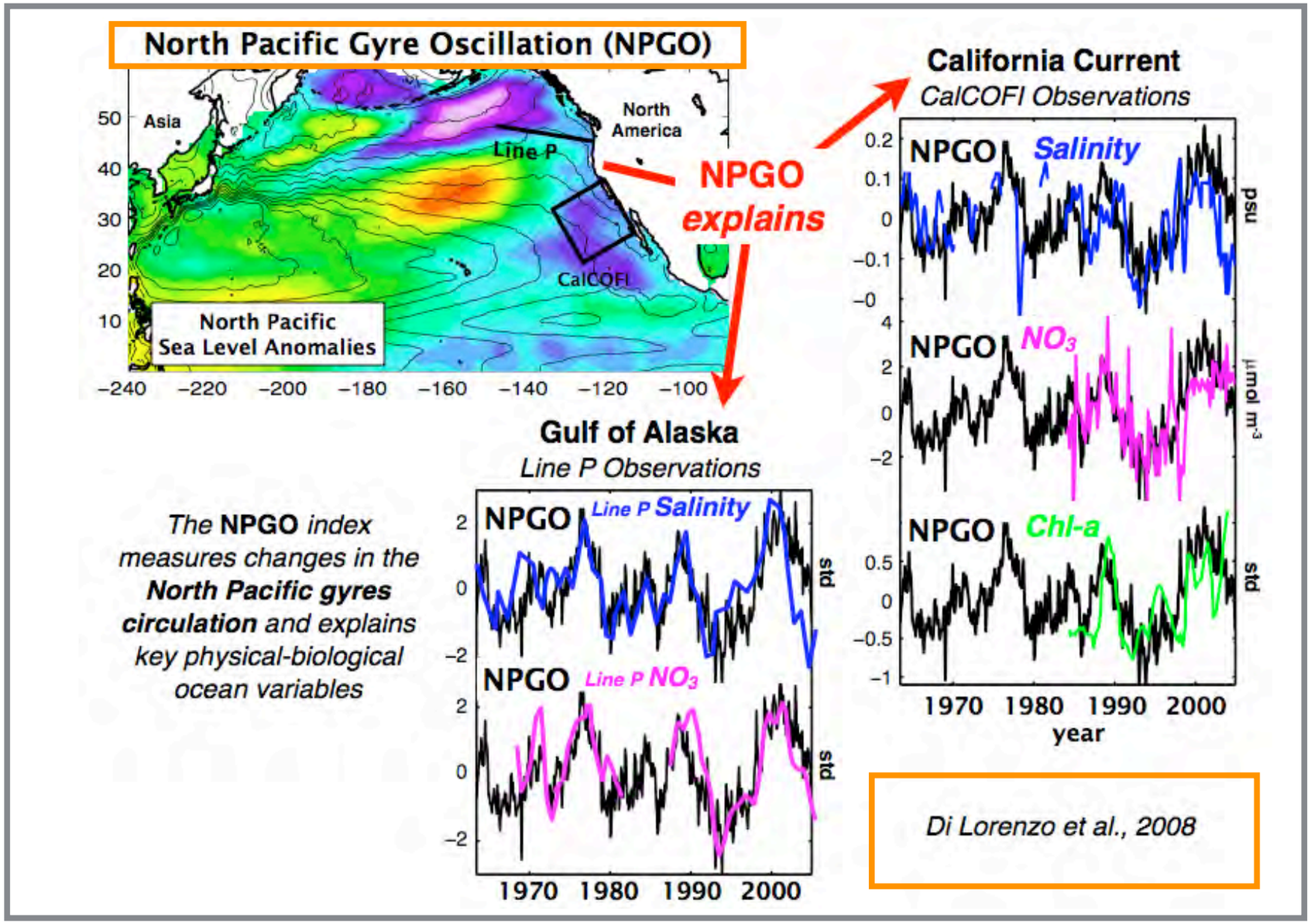
La Paz, Baja California Sur, Mexico

North Pacific Gyre Oscillation (NPGO)



2nd dominant mode of sea surface height variability (**2nd EOF SSH**) in the North Pacific.

North Pacific Gyre Oscillation (NPGO)



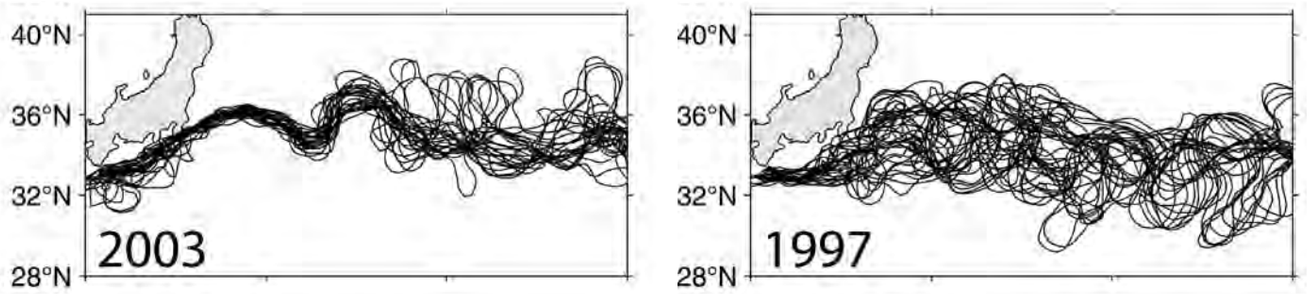
2nd dominant mode of sea surface height variability (**2nd EOF SSH**) in the North Pacific.

It is thought that NPGO is characteristic signals in the eastern North Pacific, however, the signal has deep relationship with decadal variability in the **western** North Pacific.

Decadal variation of KE and NPGO

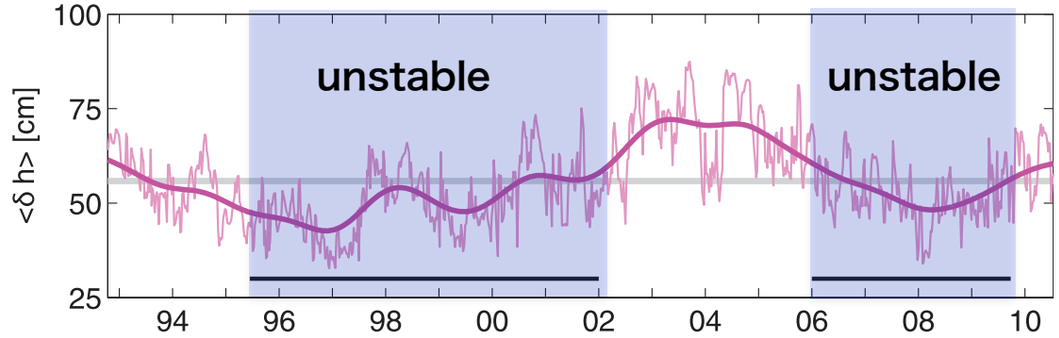
Stable/unstable KE

Qiu and Chen (2005, 2011)



Yearly paths of the Kuroshio and Kuroshio Extension defined by the 170-cm contours in the weekly SSH fields. Here paths are plotted every 14 days. Qiu & Chen (2005)

SSH difference across the KE jet averaged from 140°E to 160°E.
Qiu & Chen (2011)

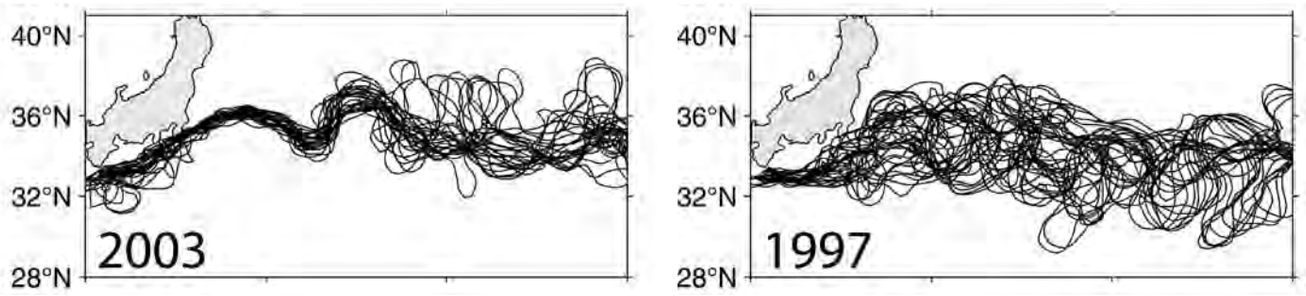


(δh is evaluated at each longitude by first averaging the SSH values over the 1.5° bins centered 1° north and south of the KE's axis.)

Decadal variation of KE and NPGO

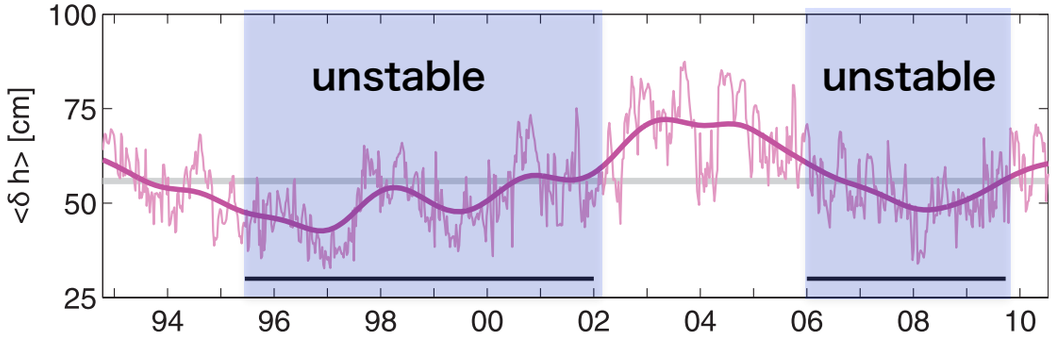
Stable/unstable KE

Qiu and Chen (2005, 2011)



Yearly paths of the Kuroshio and Kuroshio Extension defined by the 170-cm contours in the weekly SSH fields. Here paths are plotted every 14 days. Qiu & Chen (2005)

SSH difference across the KE jet averaged from 140°E to 160°E.
Qiu & Chen (2011)

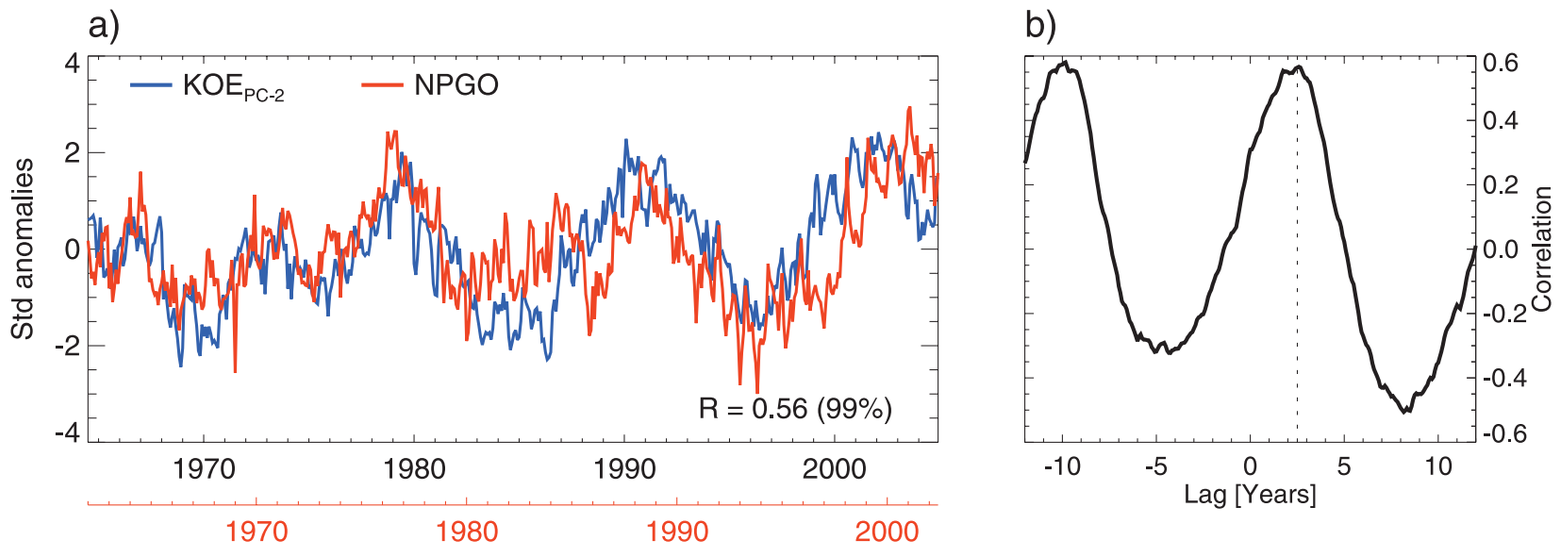


(δh is evaluated at each longitude by first averaging the SSH values over the 1.5° bins centered 1° north and south of the KE's axis.)

Stability of KE corresponds to NPGO with several years lag

Taguchi et al. (2007), Ceballos et al. (2009)

OFES hindcast (1950–2003/4) (Principal component of SSH near KE vs NPGO)



Impact on lower trophic levels

Kouketsu et al. (2016):

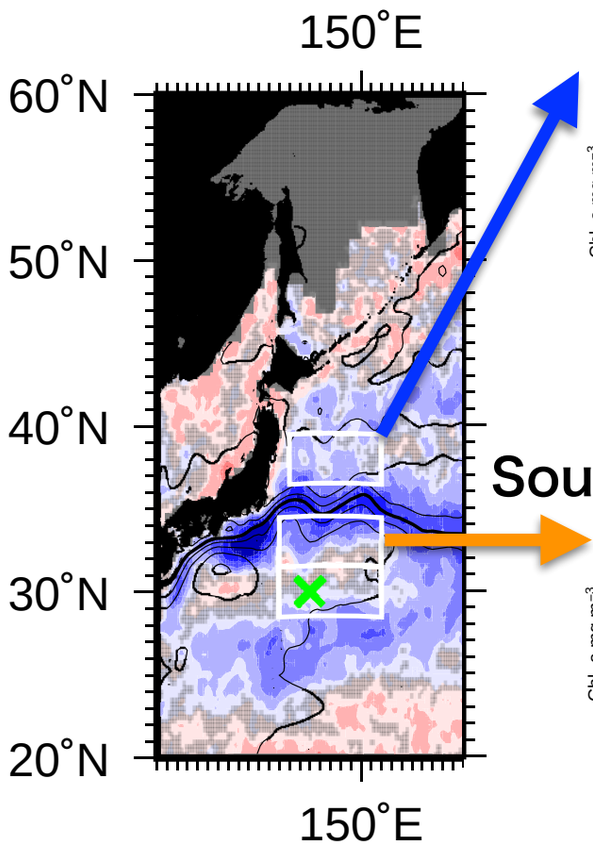
Stability of KE could change subsurface nitrate and Chl-a.

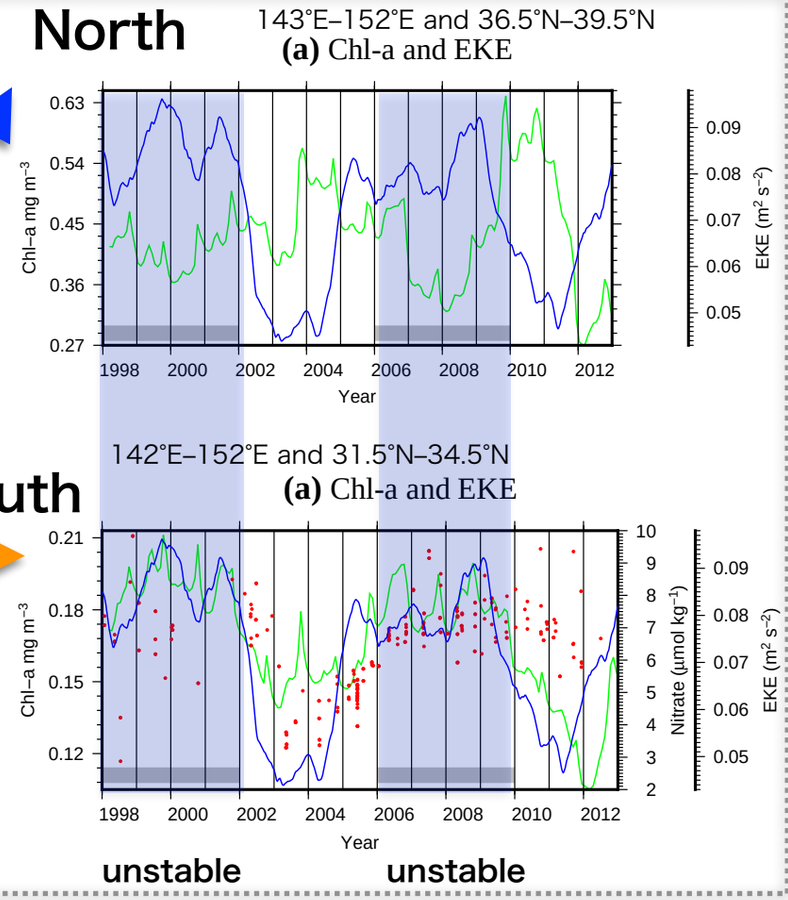
During unstable phase:

North of KE: lower nitrate/Chl-a

South of KE: higher nitrate/Chl-a

→ transport of mesoscale eddies

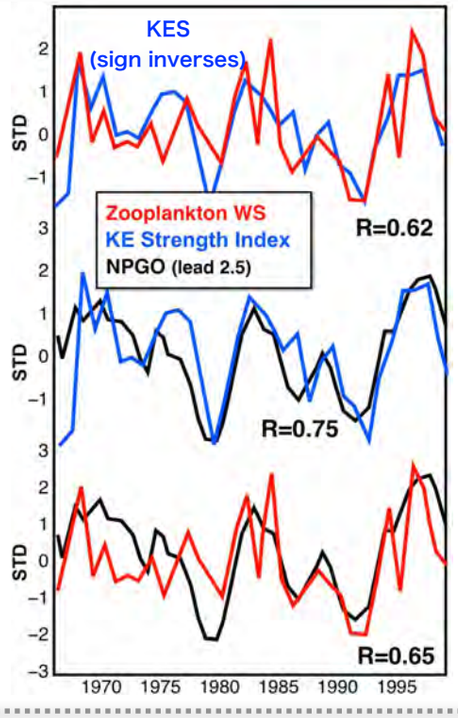


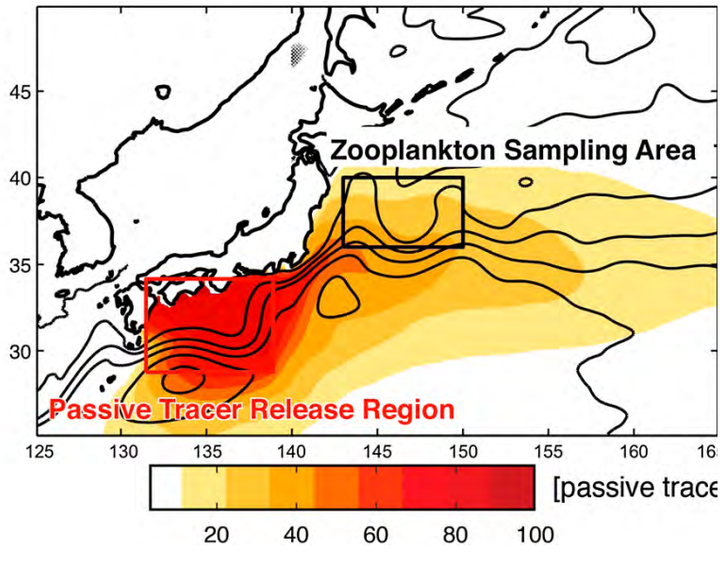


Chiba et al. (2013) :

Negative correlation between KE Strength and abundance of warm-species-zooplankton in the north of KE

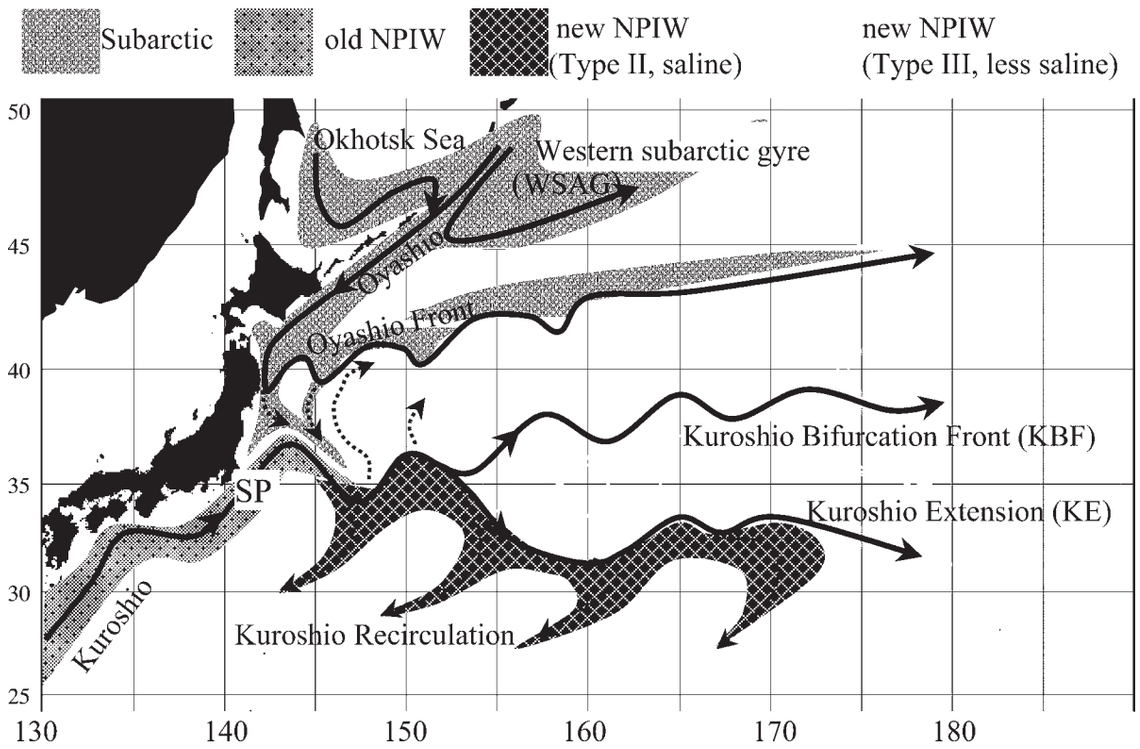
→ **transport of mesoscale eddies**



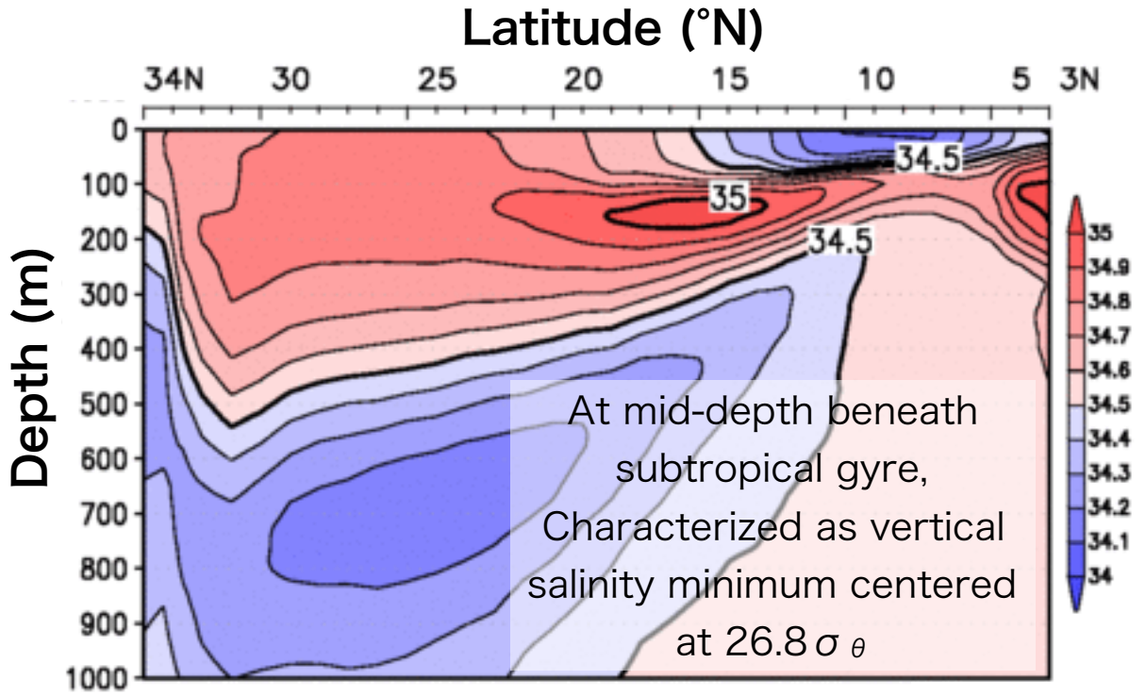


Distribution of NPIW* and its origin water

*North Pacific Intermediate Water



Shimizu et al., 2004

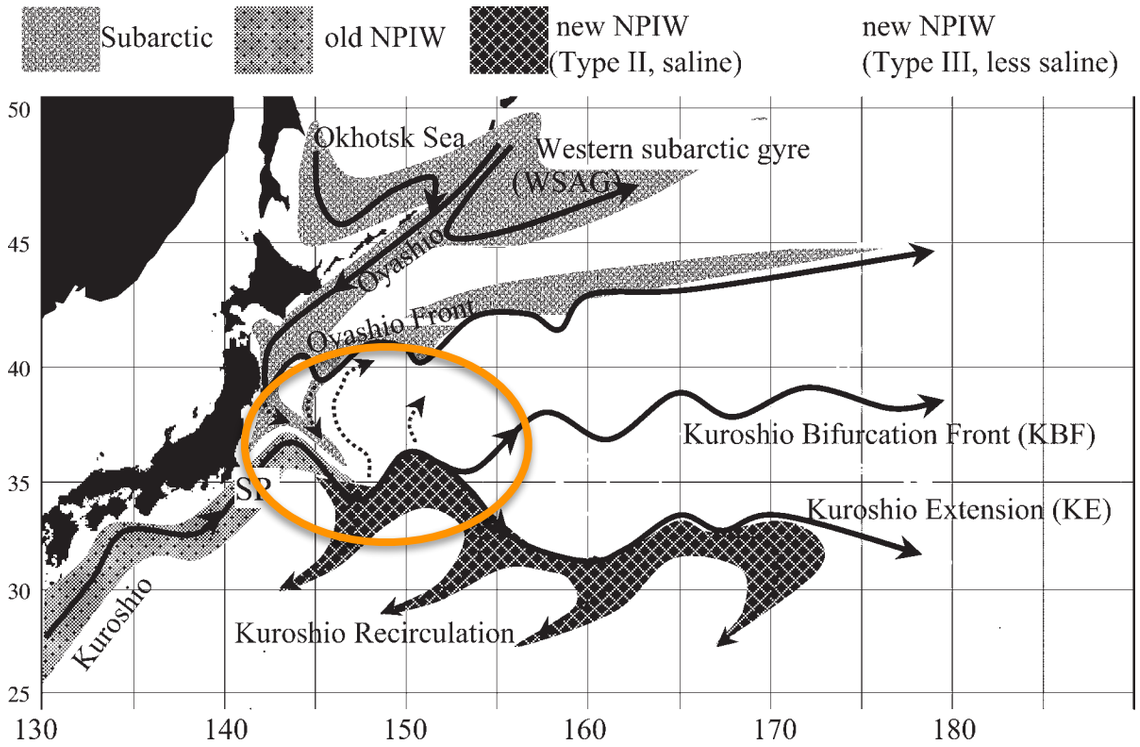


Winter time mean section along 137°E of salinity (lower)
http://www.data.jma.go.jp/kaiyou/db/vessel_obs/hq/ltflobs/137e/ave137.html

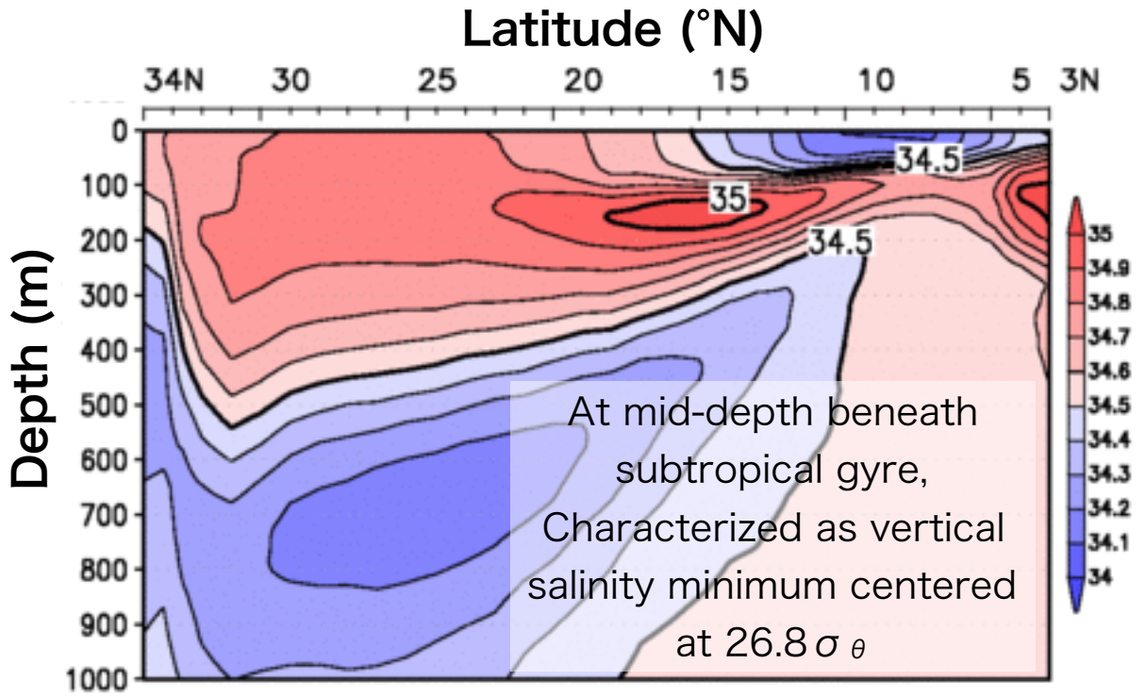
Formation region of NPIW is thought to be the area around KE including transition area (PTA).

Distribution of NPIW* and its origin water

*North Pacific Intermediate Water



Shimizu et al., 2004

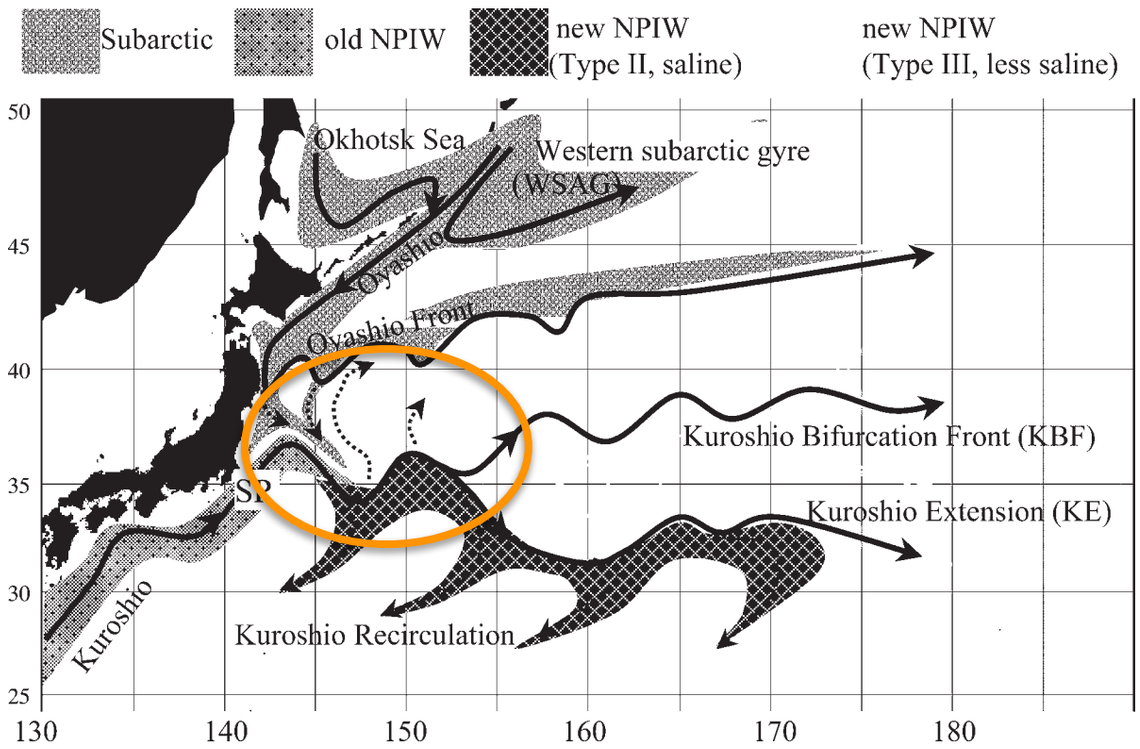


Winter time mean section along 137°E of salinity (lower)
http://www.data.jma.go.jp/kaiyou/db/vessel_obs/hq/ltflobs/137e/ave137.html

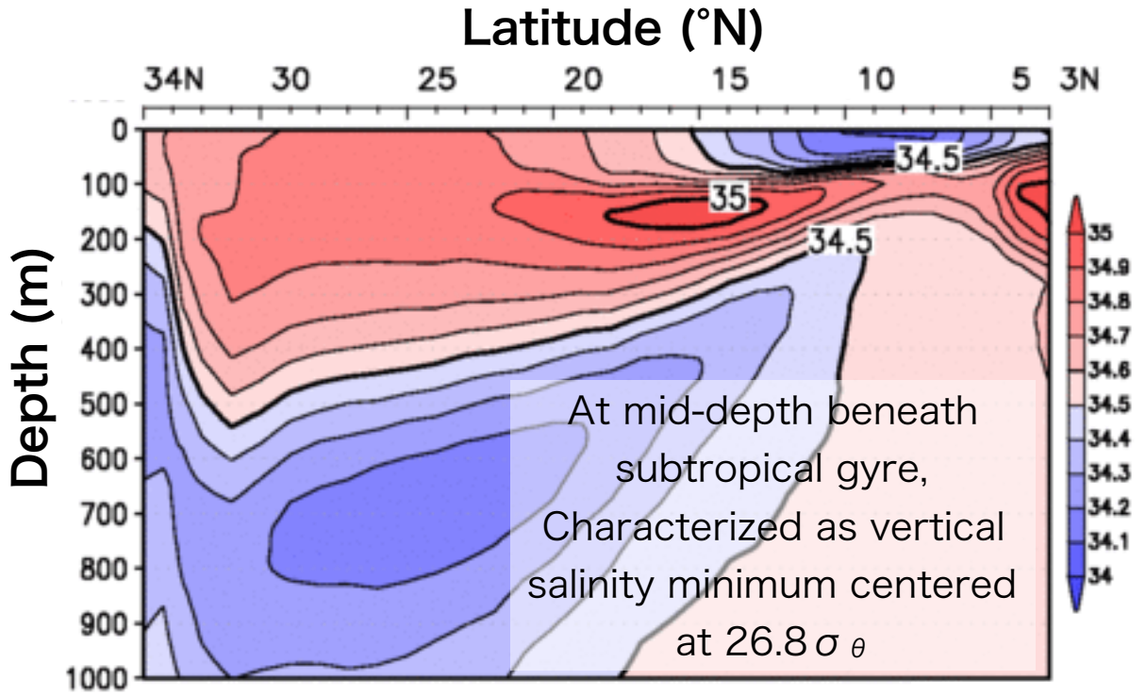
Formation region of NPIW is thought to be the area around KE including transition area (PTA).

Distribution of NPIW* and its origin water

*North Pacific Intermediate Water



Shimizu et al., 2004



Winter time mean section along 137°E of salinity (lower)
http://www.data.jma.go.jp/kaiyou/db/vessel_obs/hq/ltflobs/137e/ave137.html

Formation region of NPIW is thought to be the area around KE including transition area (PTA).

Stability of KE is expected to affect decadal variability of salinity around NPIW density.

Variation of KE stability (correlated with NPGO) would affect water mass distribution around KE including PTA

Target:

Horizontal/vertical structure of relationship between KE stability and property of water mass, such as NPIW

Variation of KE stability (correlated with NPGO) would affect water mass distribution around KE including PTA

Target:

Horizontal/vertical structure of relationship between KE stability and property of water mass, such as NPIW

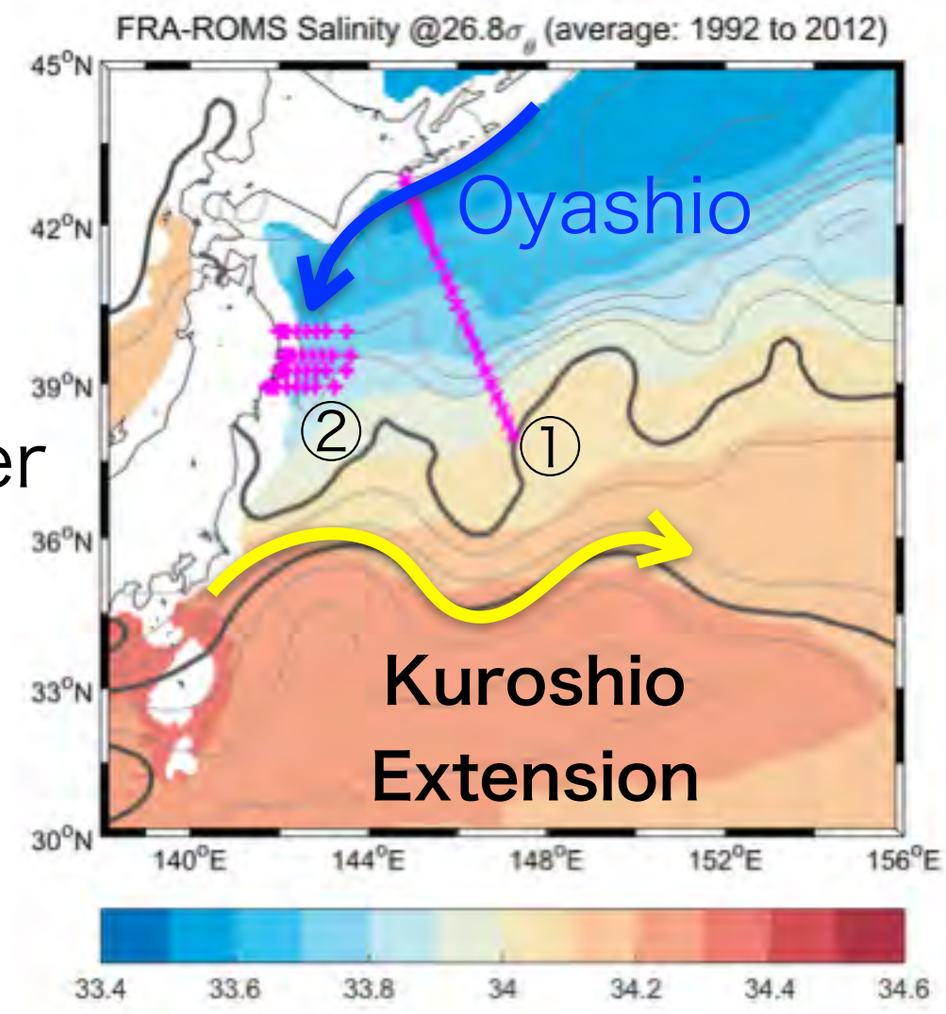
(1) Observational data along monitoring lines
(2) Reanalysis data provided from eddy resolved model

Data & Methods

1. Observational Data

① A-line (1987–2015, seasonal)

② Observational lines of
Iwate Fisheries Technology Center
(1980–2015, monthly)



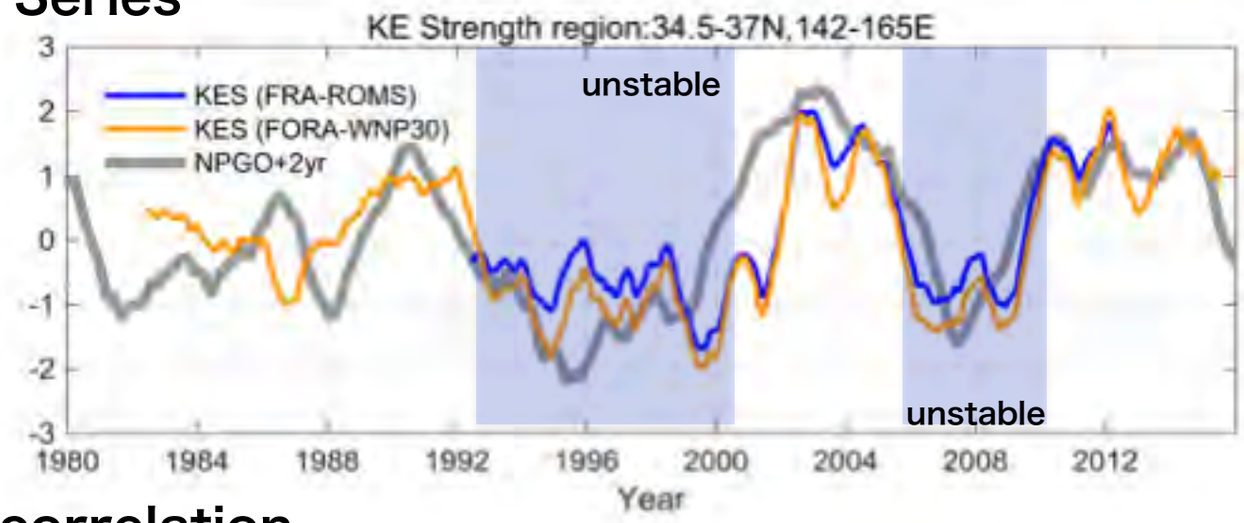
2. Reanalysis Data

① FRA-ROMS
(Japan Fisheries Research and Education Agency,
1/10°, 1992–2012)

② FORA-WNP30 (JAMSTEC, 1/10°, 1982–2015)

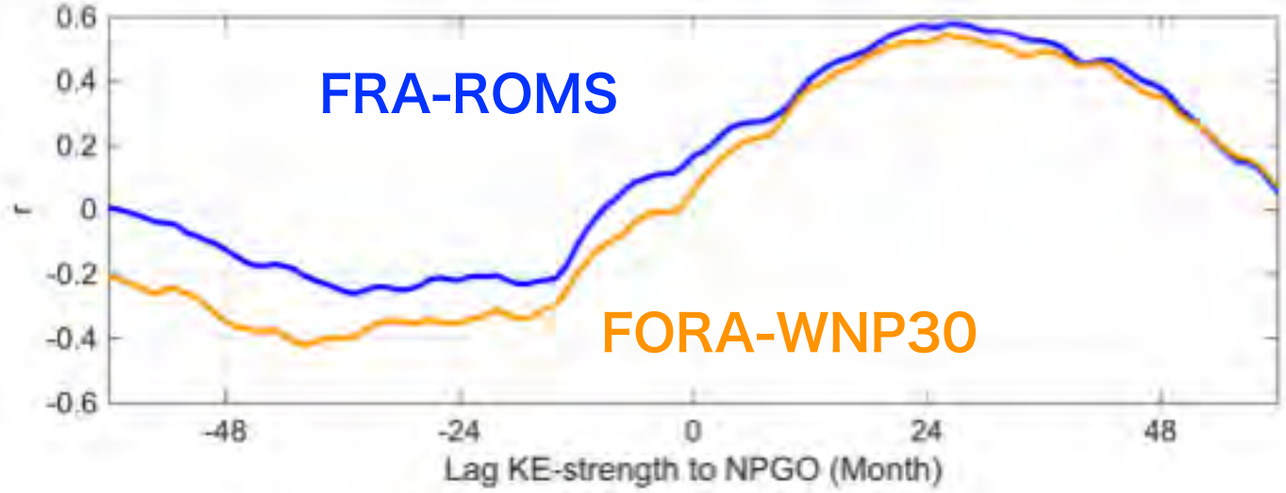
KE Strength (KES) vs NPGO

Time Series



KES:
zonal average (142–165°E) of
meridional difference of
sea surface height
between 34.5°N and 37°N

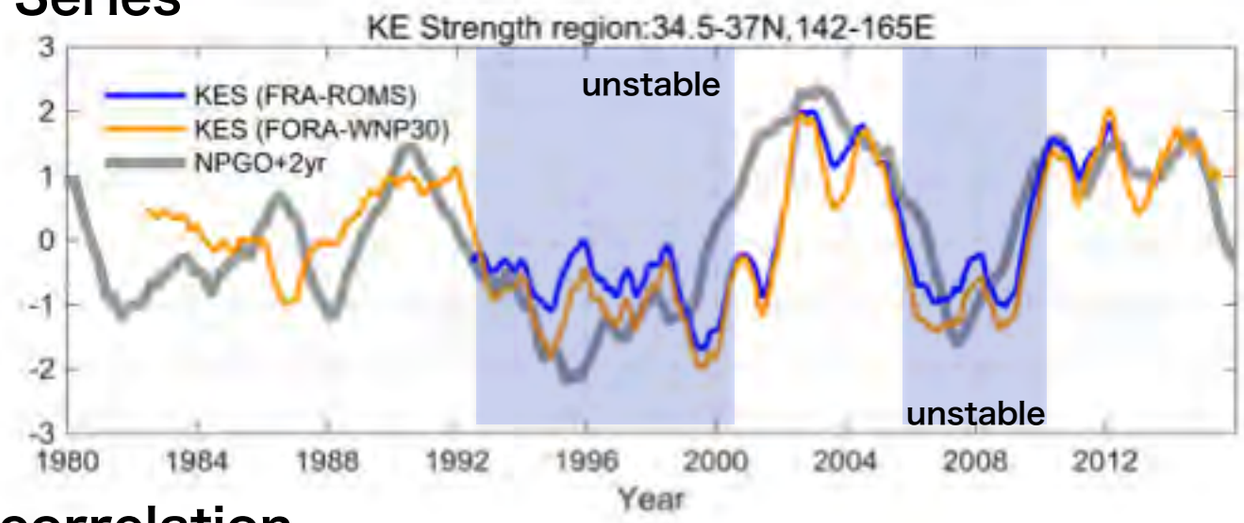
Lag correlation



KES agrees well to NPGO with about 2 years lag.
(c.f. Taguchi et al., 2007; Ceballos et al., 2009)

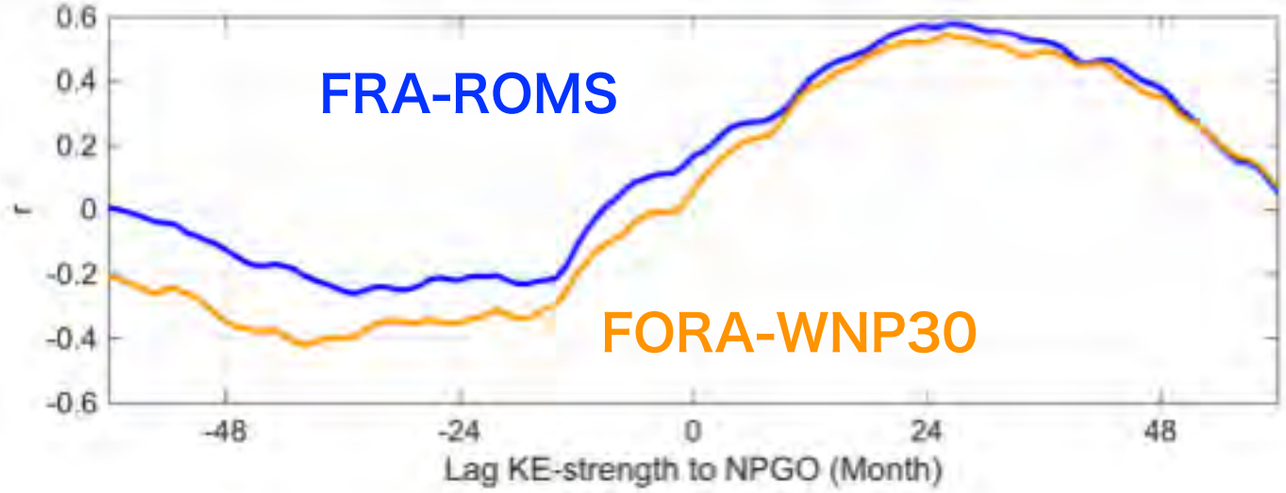
KE Strength (KES) vs NPGO

Time Series



KES:
zonal average (142–165°E) of
meridional difference of
sea surface height
between 34.5°N and 37°N

Lag correlation

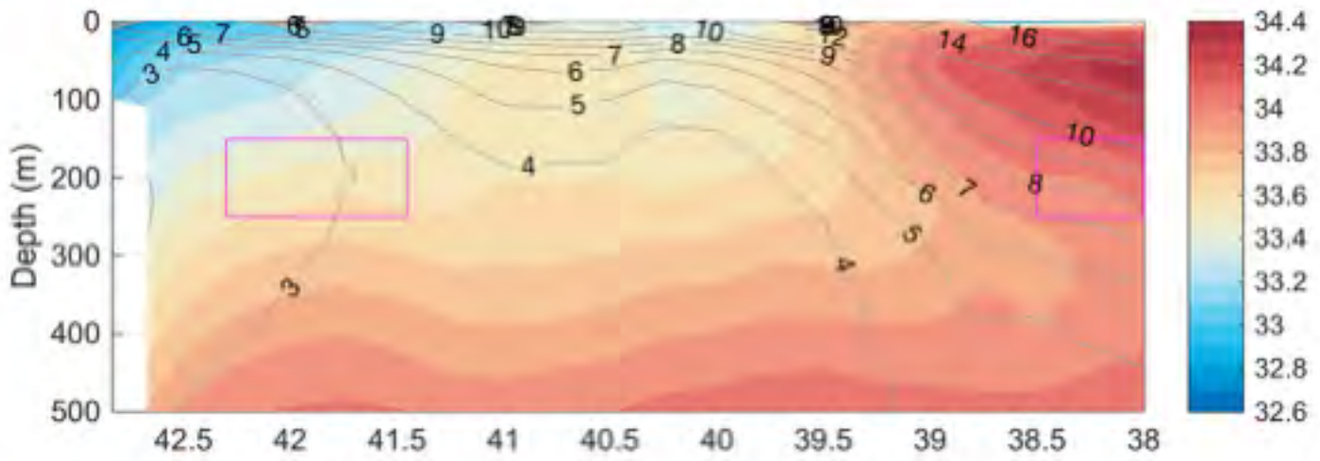


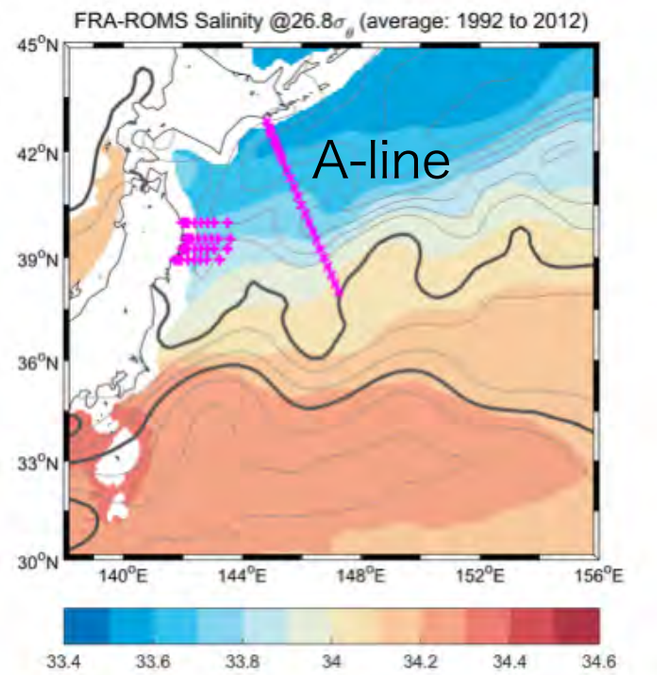
KES agrees well to NPGO with about 2 years lag.
(c.f. Taguchi et al., 2007; Ceballos et al., 2009)

We made a correlation analysis between salinity data and KES instead of NPGO in the present study.

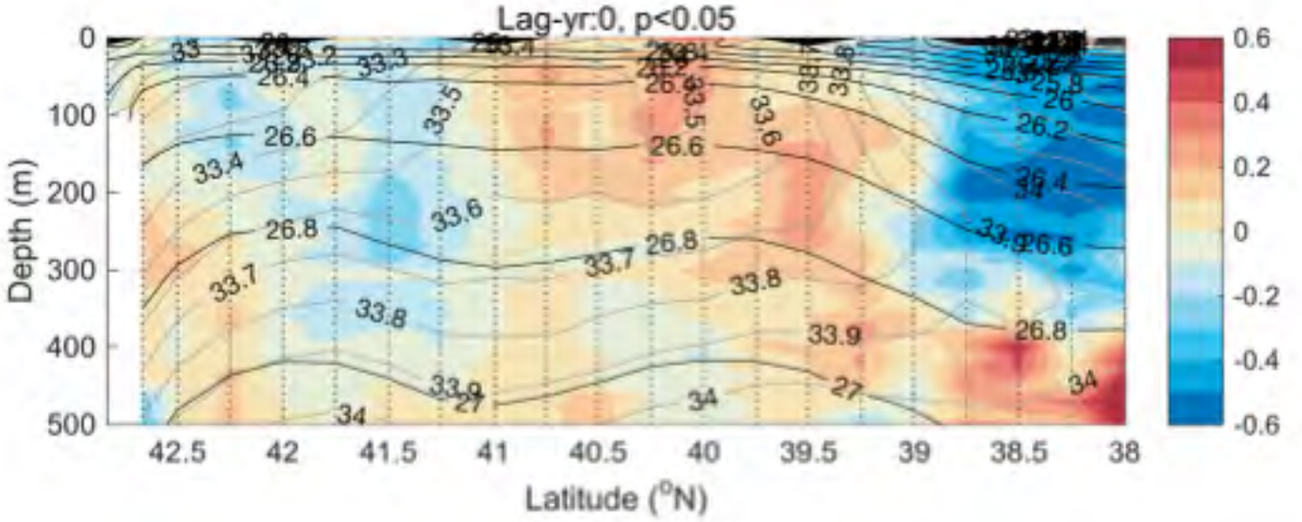
Observational data (A-line)

Mean section of salinity (color) & temperature (contour)





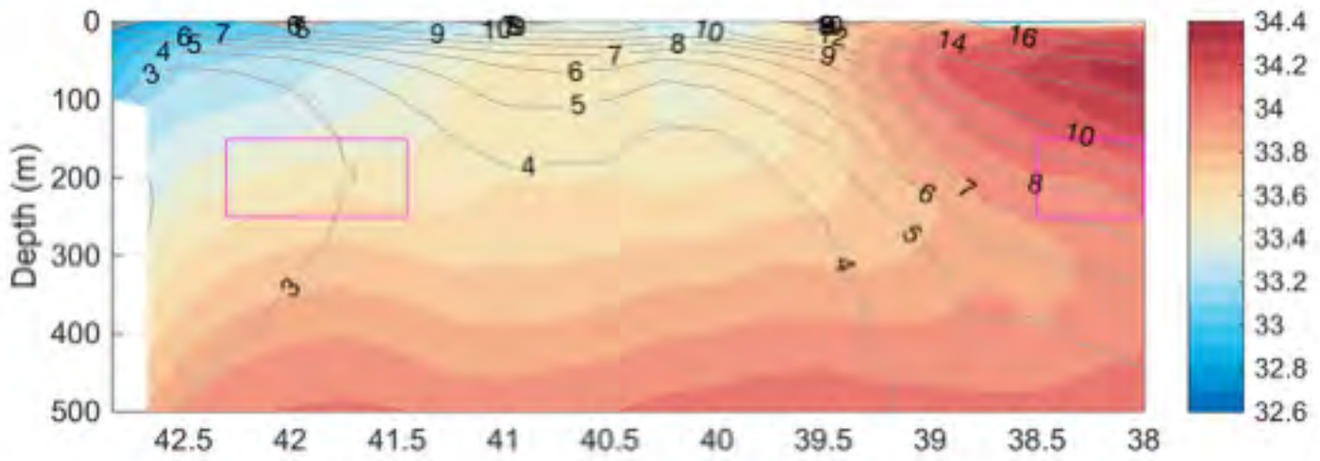
Correlation map of salinity with KES without lag

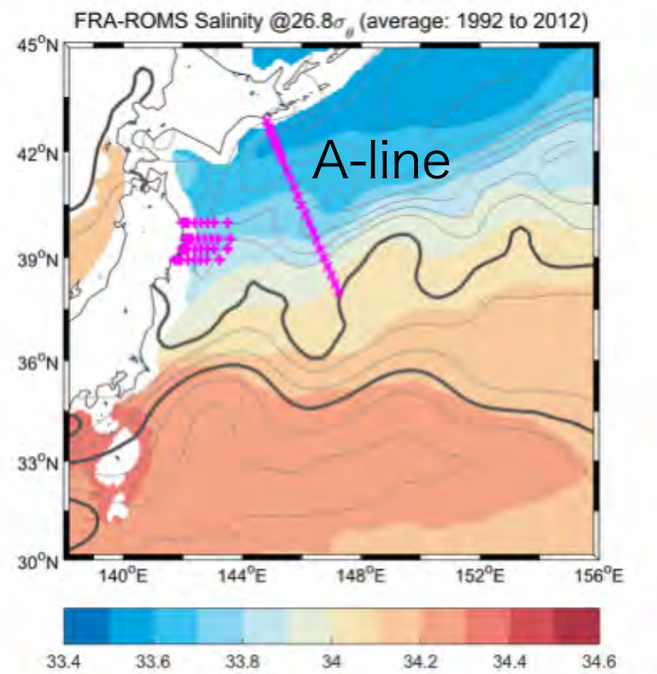


Negative correlation at the mid-depths north of KE

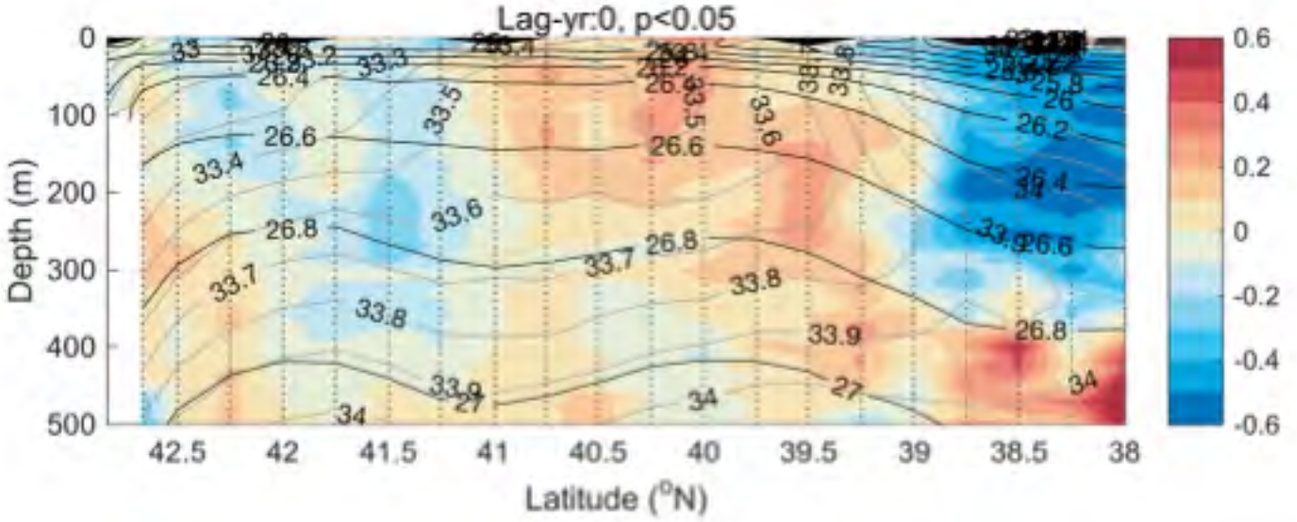
Observational data (A-line)

Mean section of salinity (color) & temperature (contour)





Correlation map of salinity with KES without lag



Negative correlation at the mid-depths north of KE

We also focused on lag correlations.

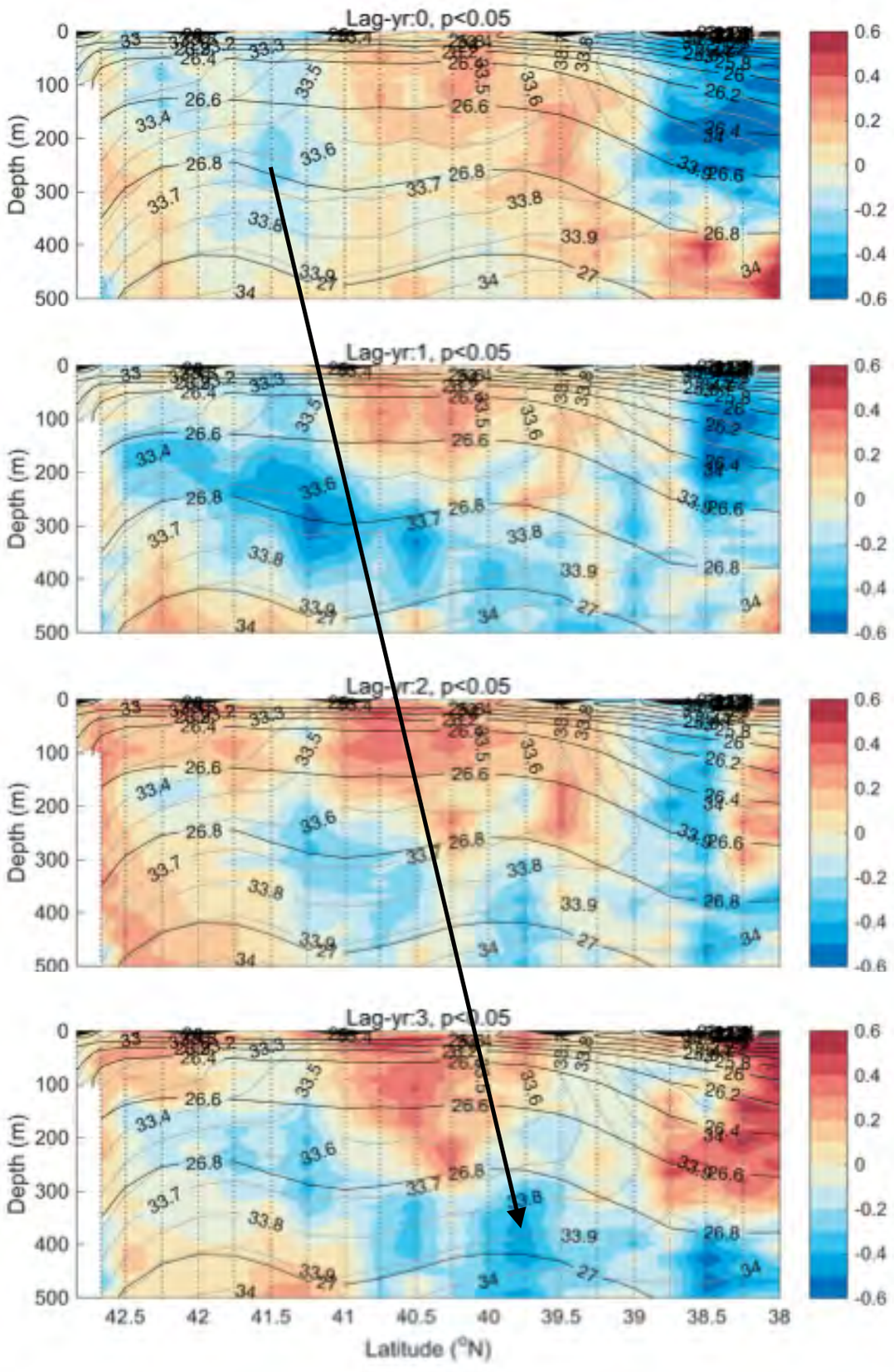
Lag correlation of salinity with KES

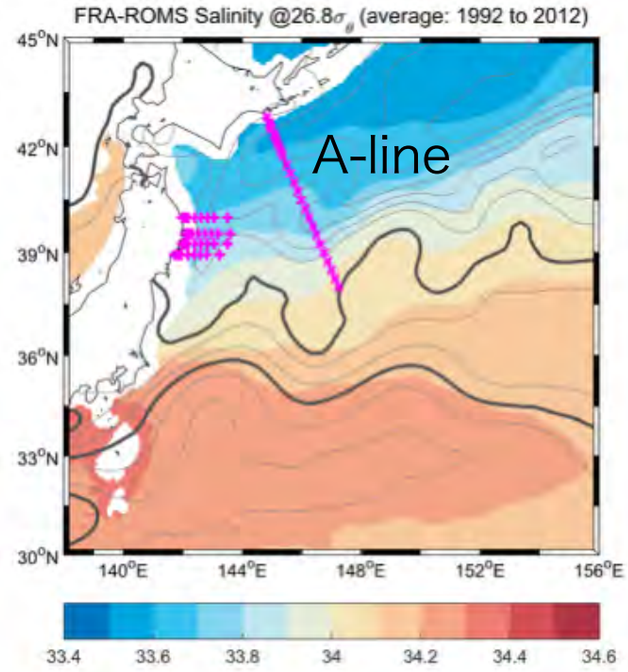
Lag 0 year

Lag 1 year

Lag 2 years

Lag 3 years

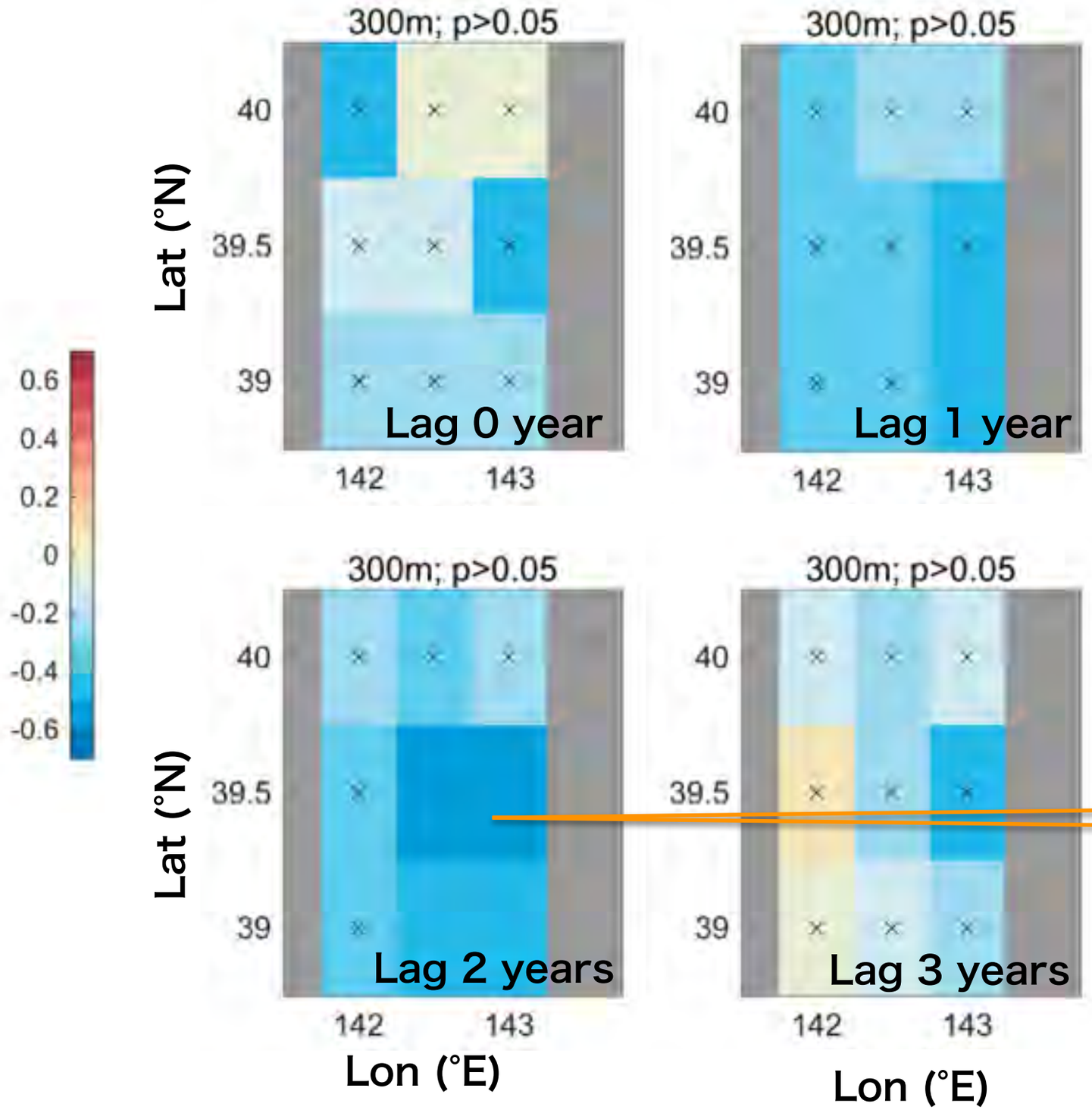


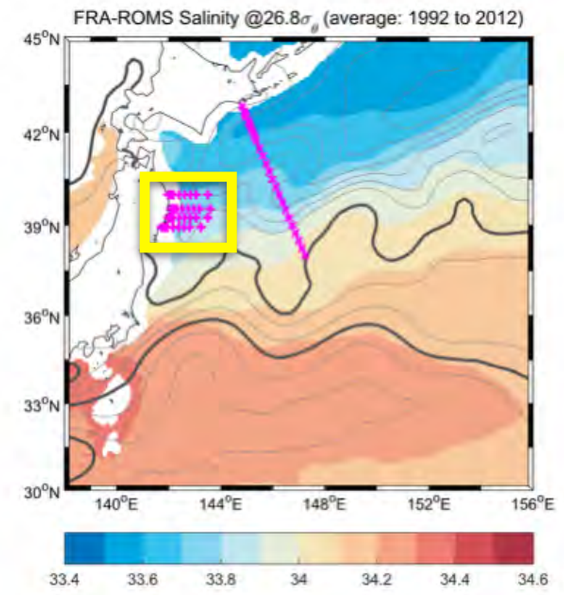


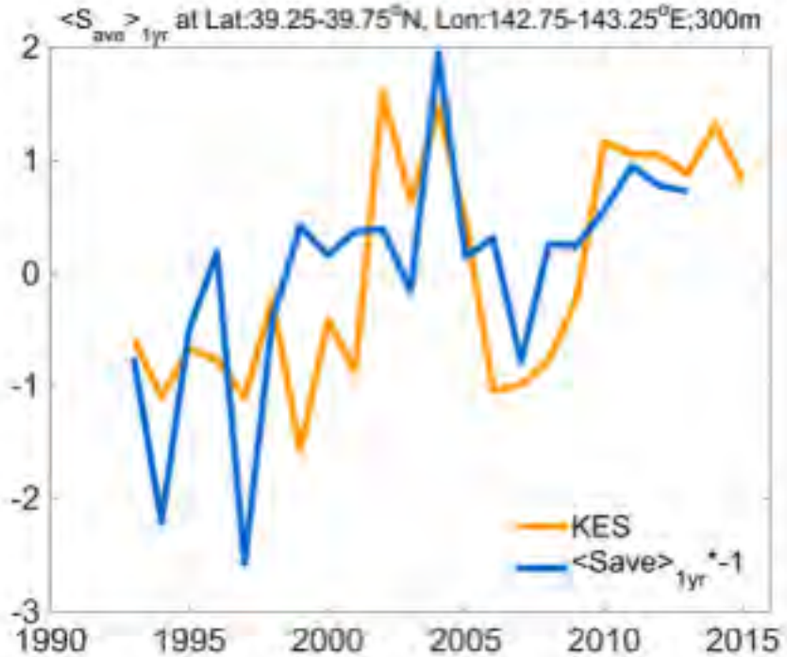
Southward propagation of negative anomaly with increase of lag around 26.8σ_θ, suggesting advection of fresh Oyashio water

Correlation map of S_{300m} and KES in IWATE

Salinity (averaged in 0.5° grids, winter) to KES

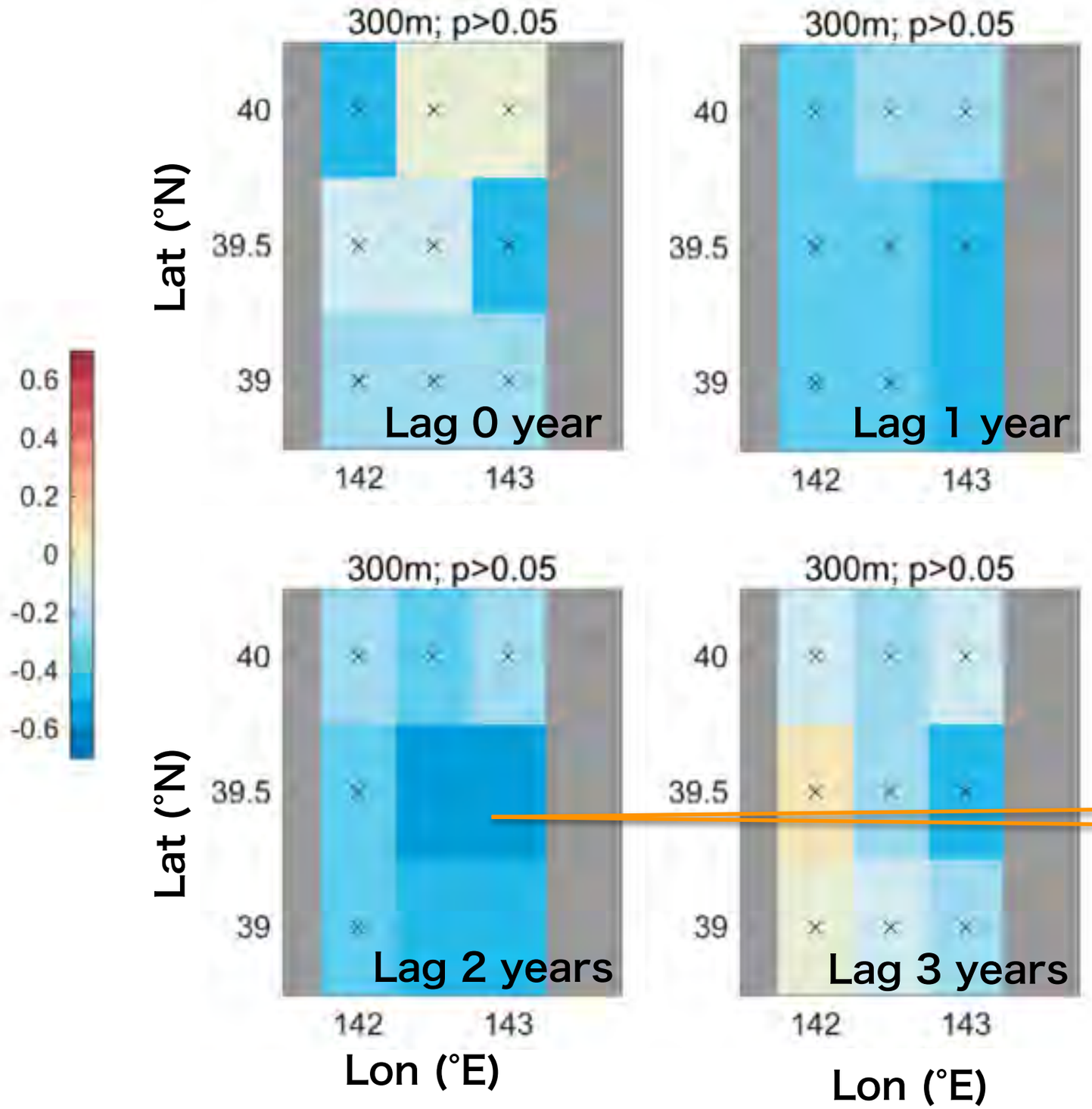


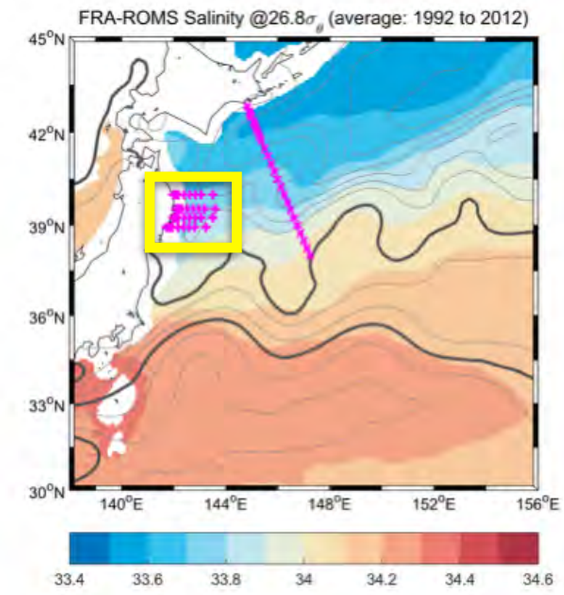


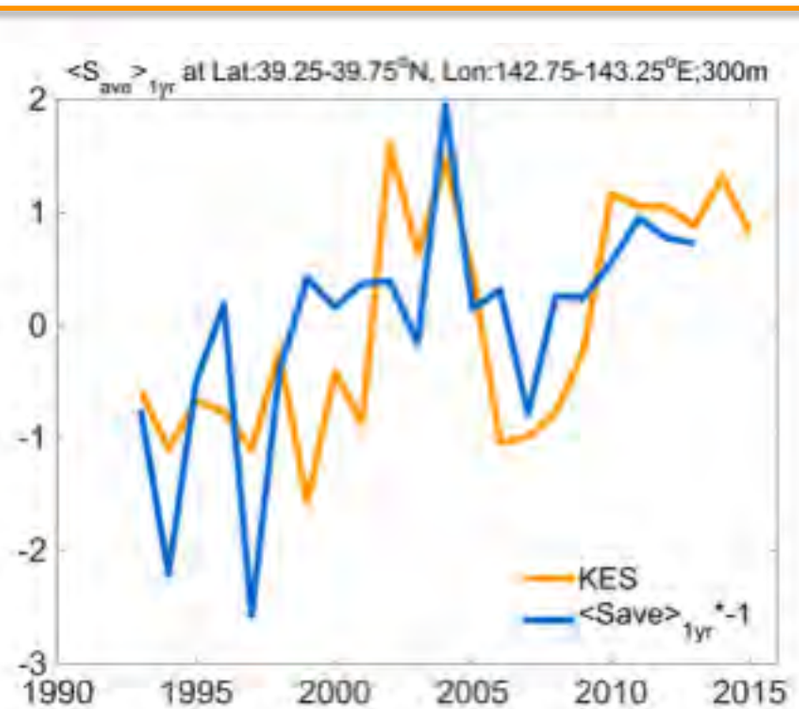


Correlation map of S_{300m} and KES in IWATE

Salinity (averaged in 0.5° grids, winter) to KES



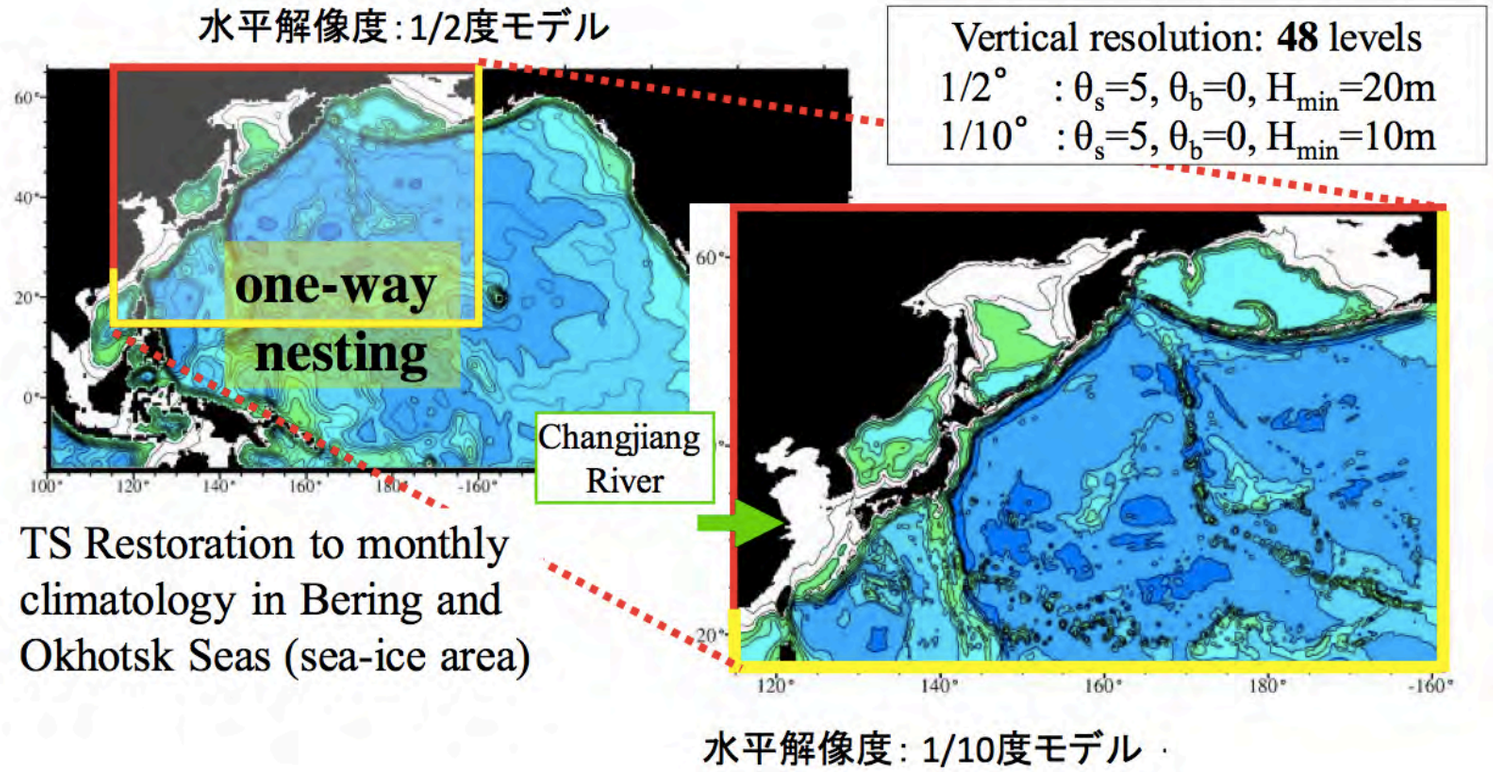




Significant negative correlation appears with lag 1~2 years.

Examination based on reanalysis data

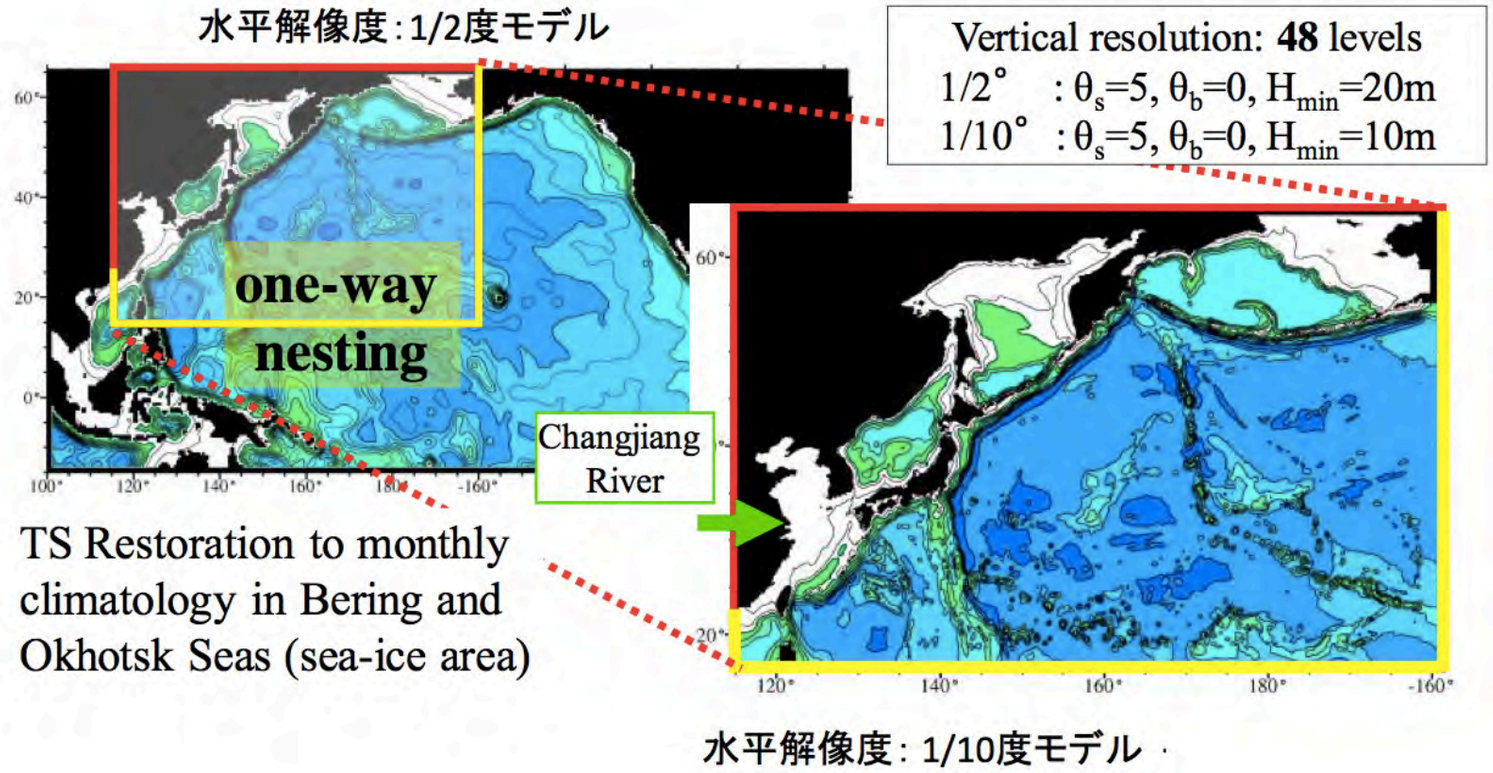
1. FRA : FRA-ROMS 1/10° (1992–2012)



2. JAMSTEC FORA-WNP30 1/10° (1982–2015)

Examination based on reanalysis data

1. FRA : FRA-ROMS 1/10° (1992–2012)



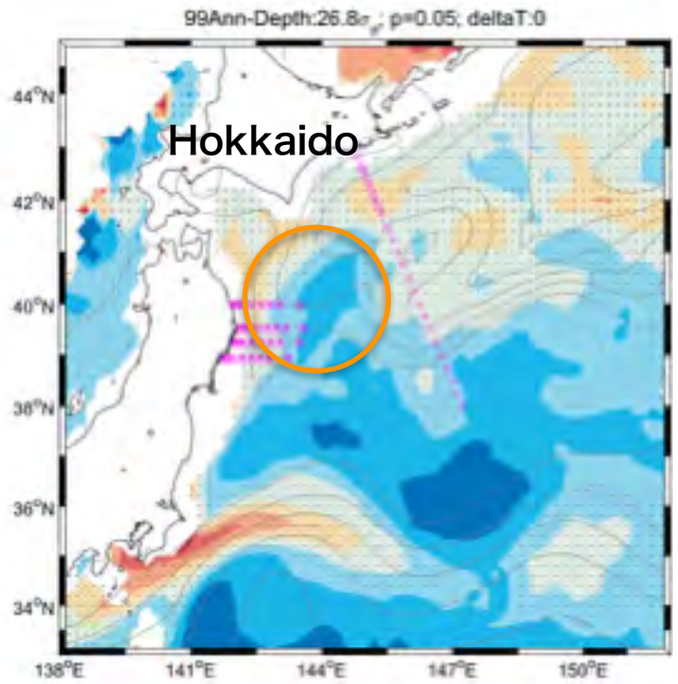
2. JAMSTEC FORA-WNP30 1/10° (1982–2015)

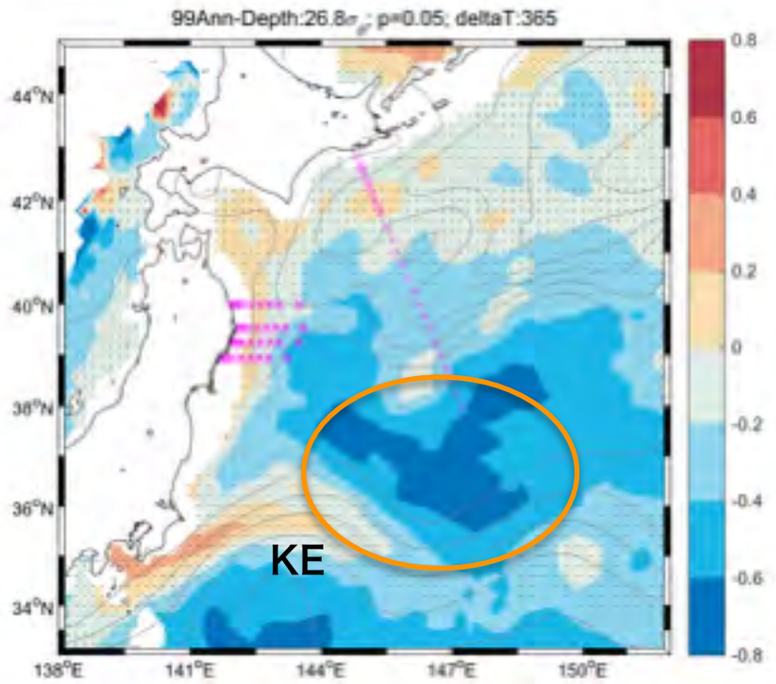
Isopycnal data was estimated by linear interpolation (each 0.2 kg m^{-3}).
Composite data during stable/unstable was made based on KES value.

Correlation map between salinity @ 26.8σ_θ with KES

FRA-ROMS

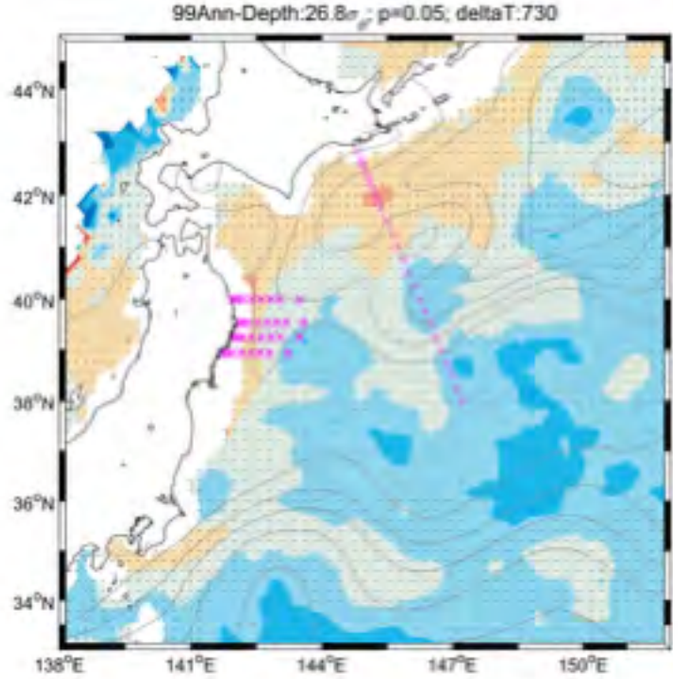
Lag 0

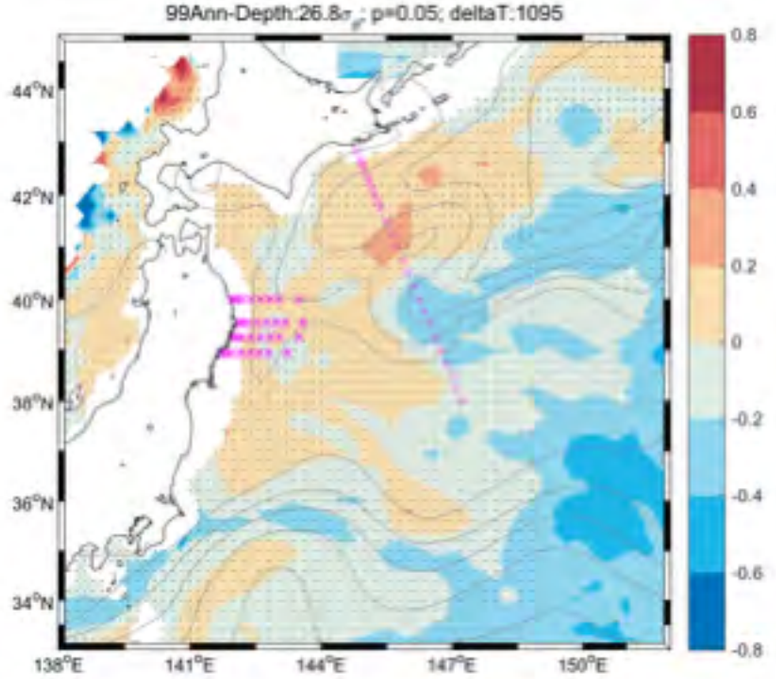




Lag 1 year

Lag 2 years



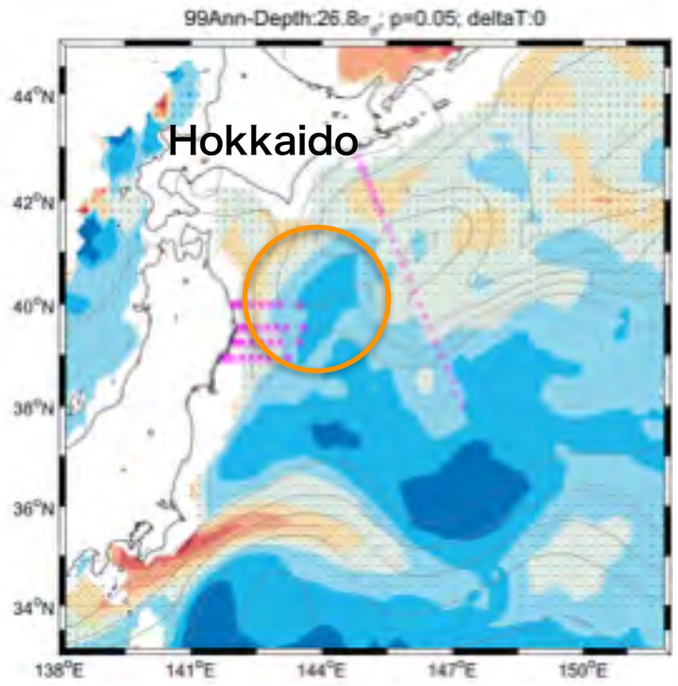


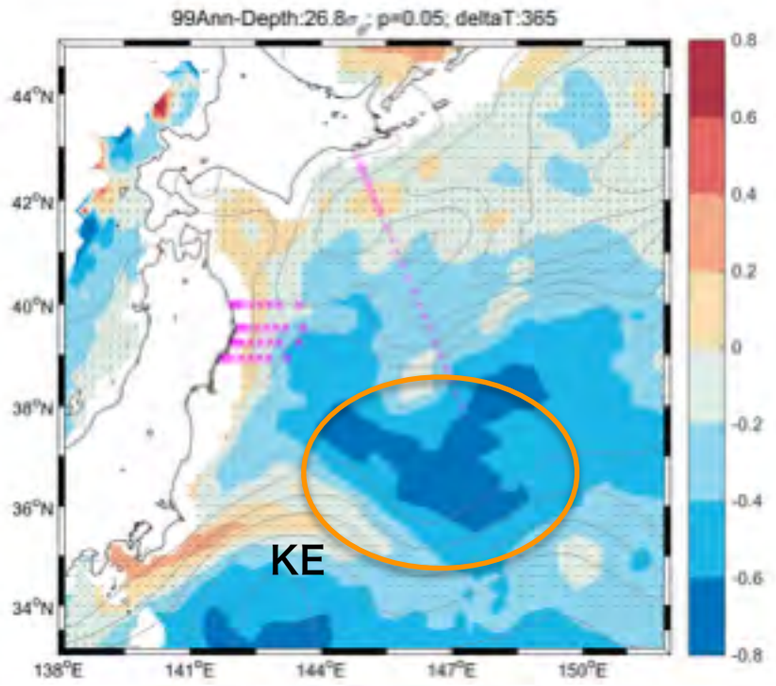
Lag 3 years

Correlation map between salinity @ 26.8σ_θ with KES

FRA-ROMS

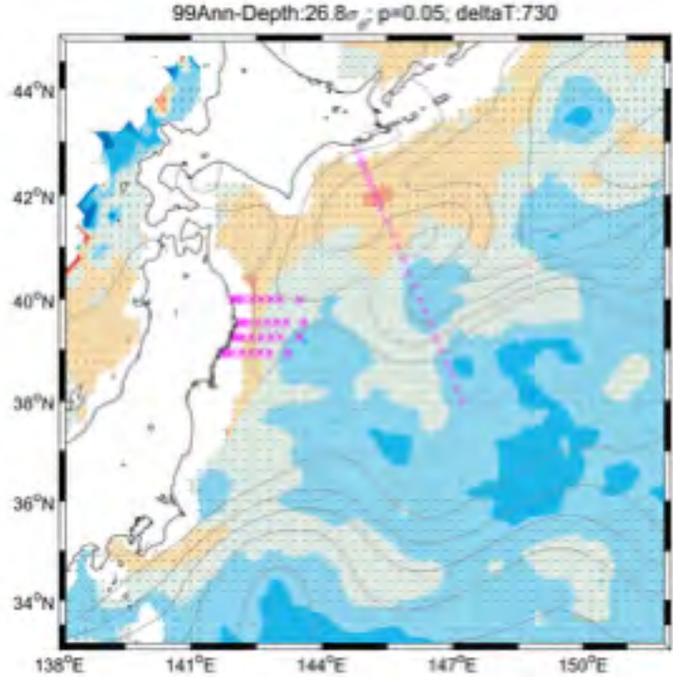
Lag 0

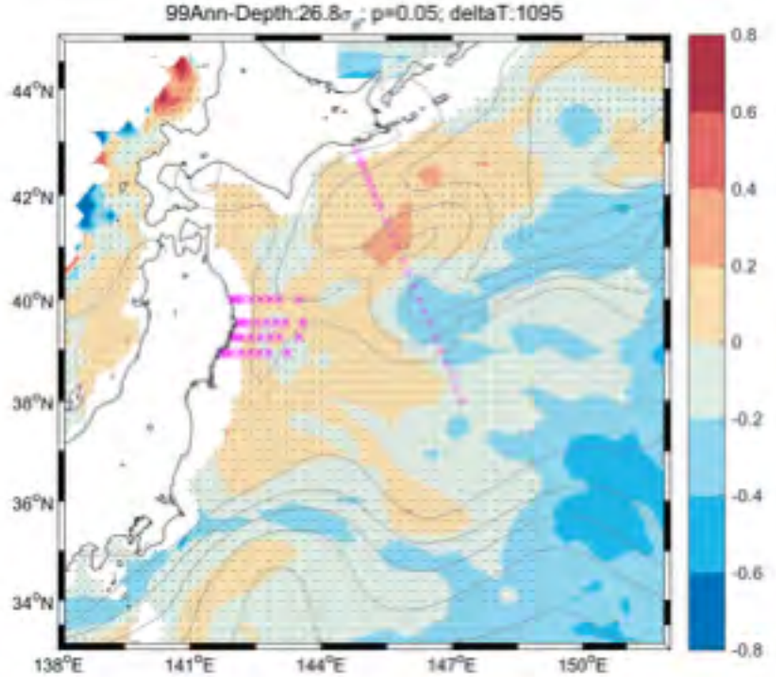




Lag 1 year

Lag 2 years





Lag 3 years

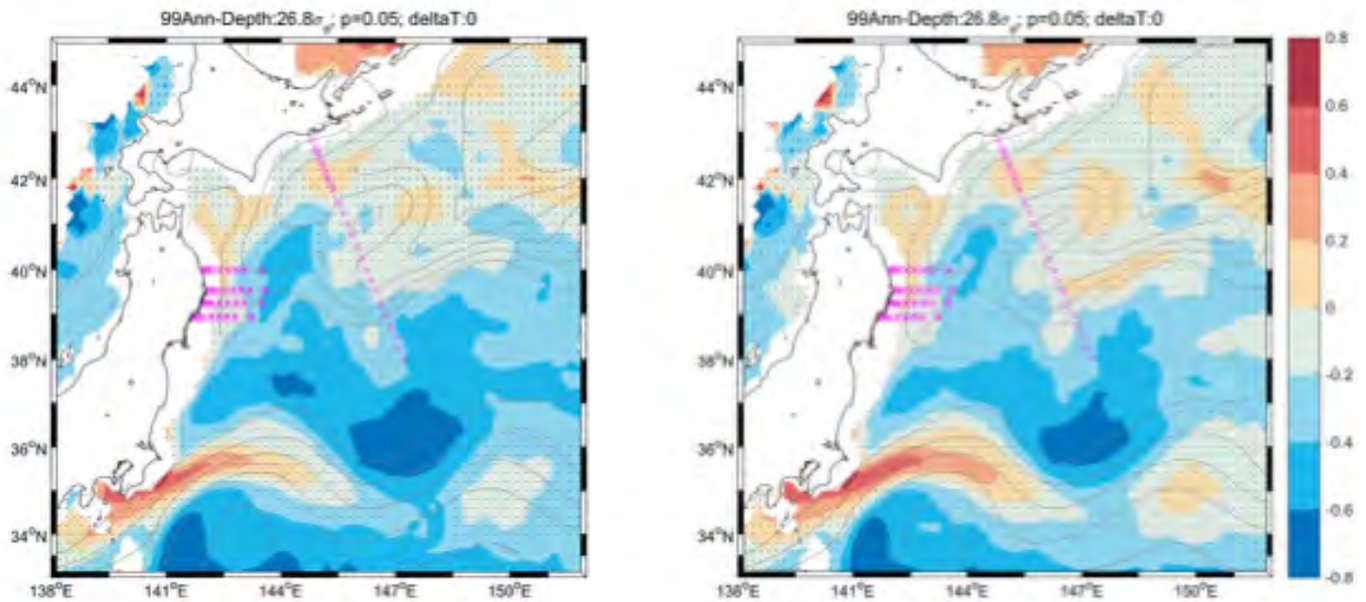
Negative anomaly south of Hokkaido moved southward and anomaly north of KE was enhanced until lag 1 year.

Comparison with FORA-WNP30 & A-line section

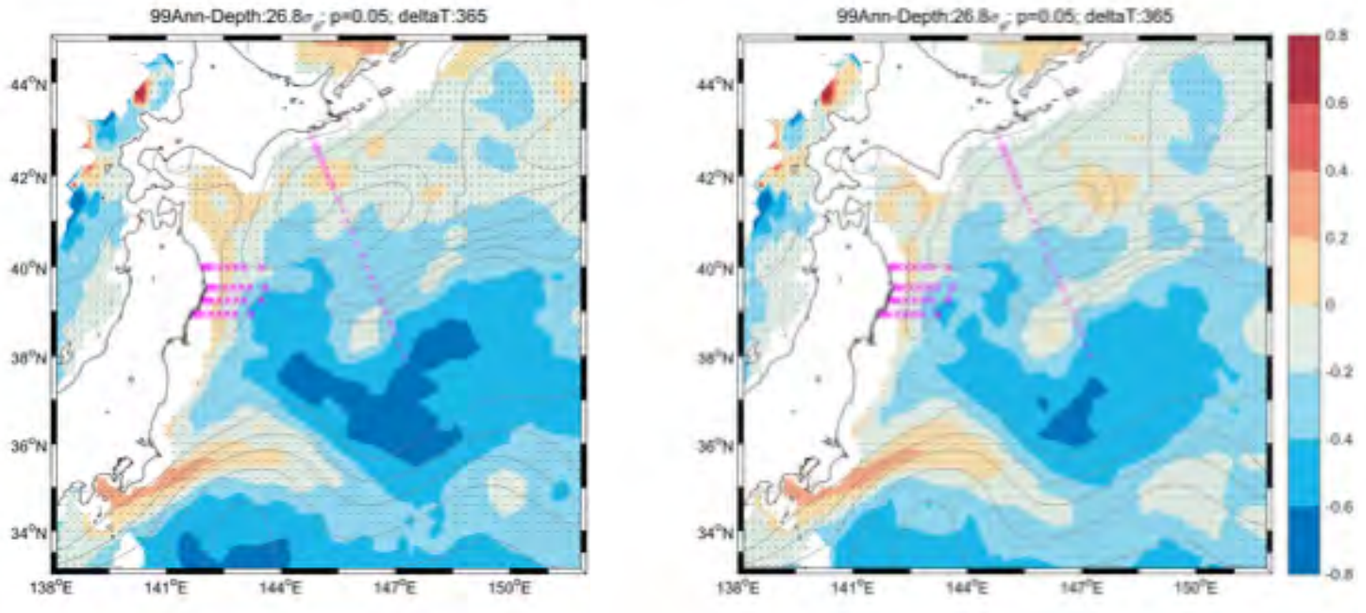
FRA-ROMS

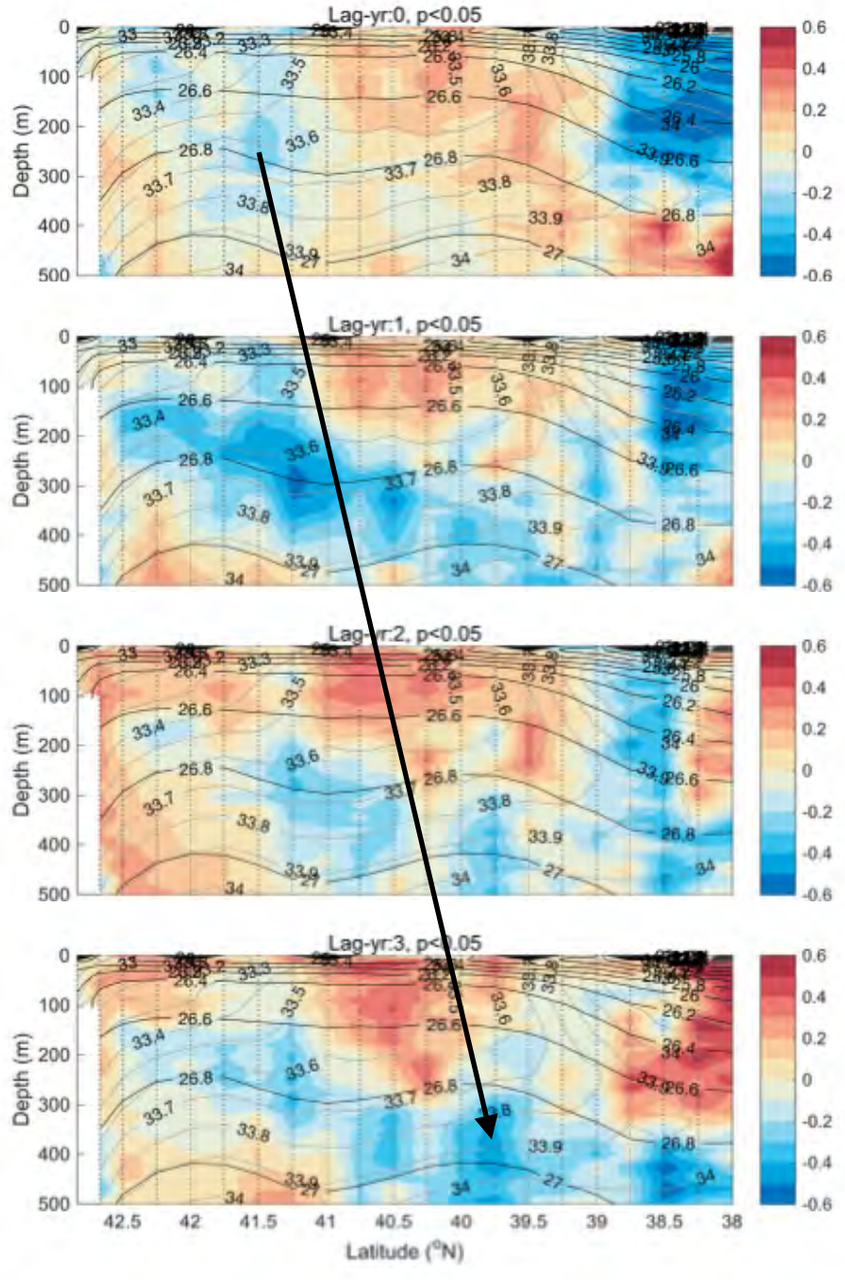
FORA-WNP30

Lag 0



Lag 1 year





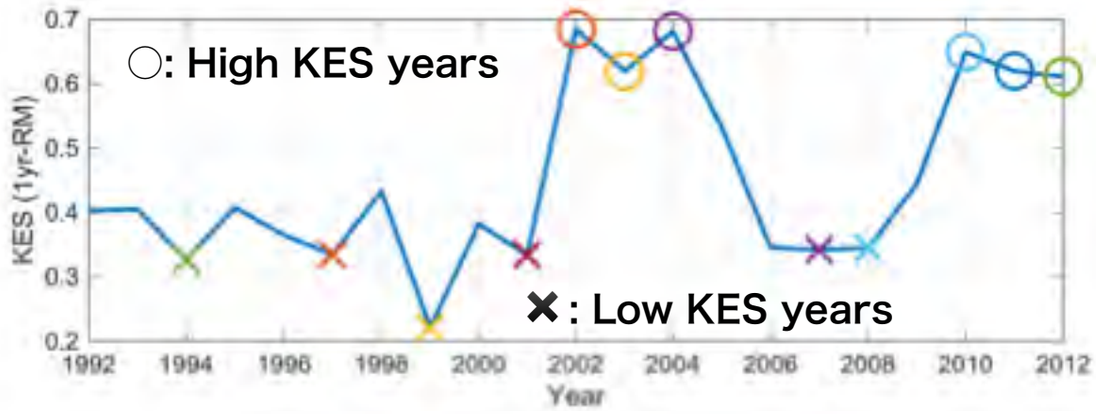
Tendency of southward propagation of negative anomaly is consistent with that of FORA/observational data.

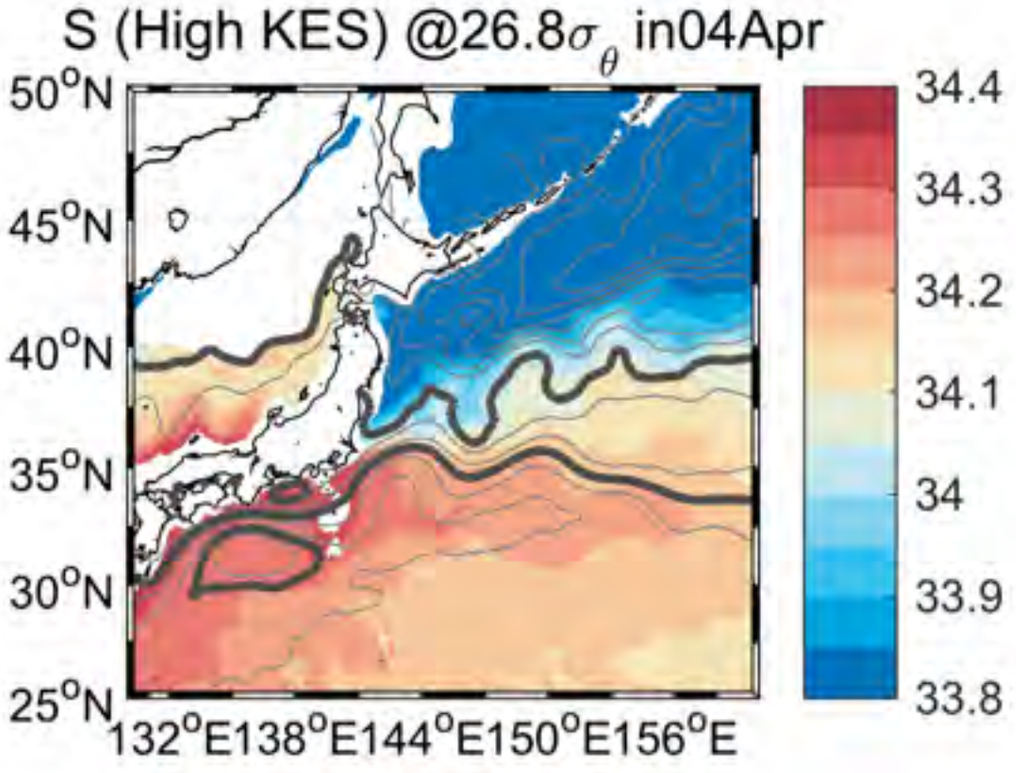
Composite salinity distribution

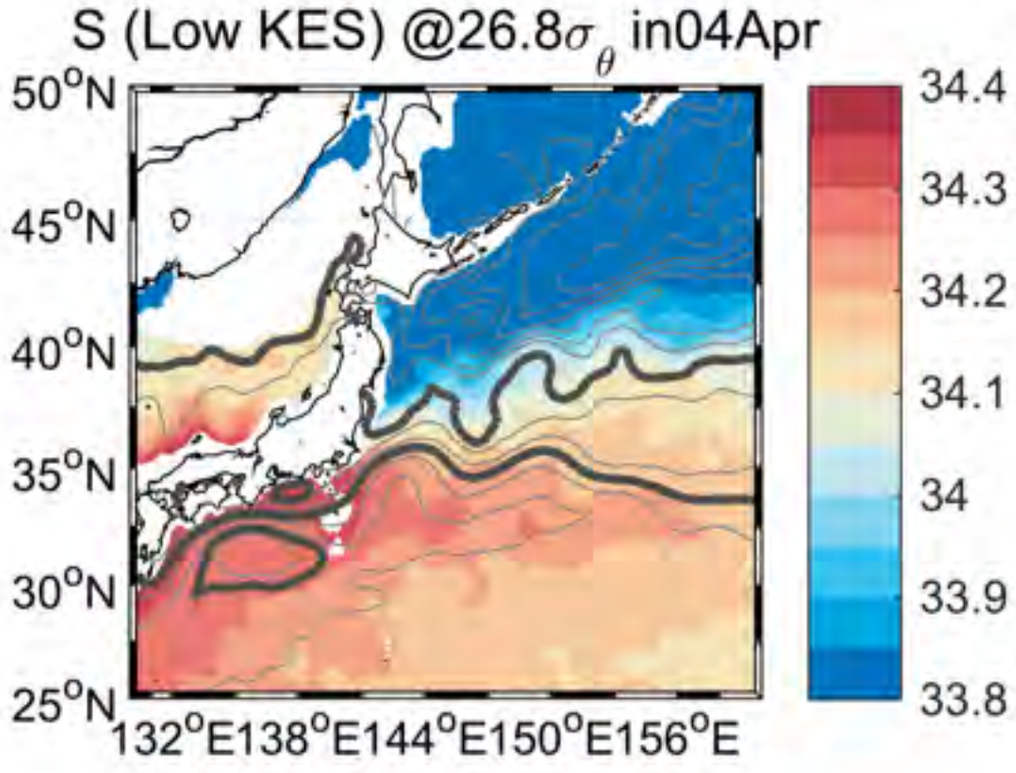
Upper/lower 30% of KES

Monthly mean at 26.8 σ_θ

(FRA-ROMS, Apr. as example)





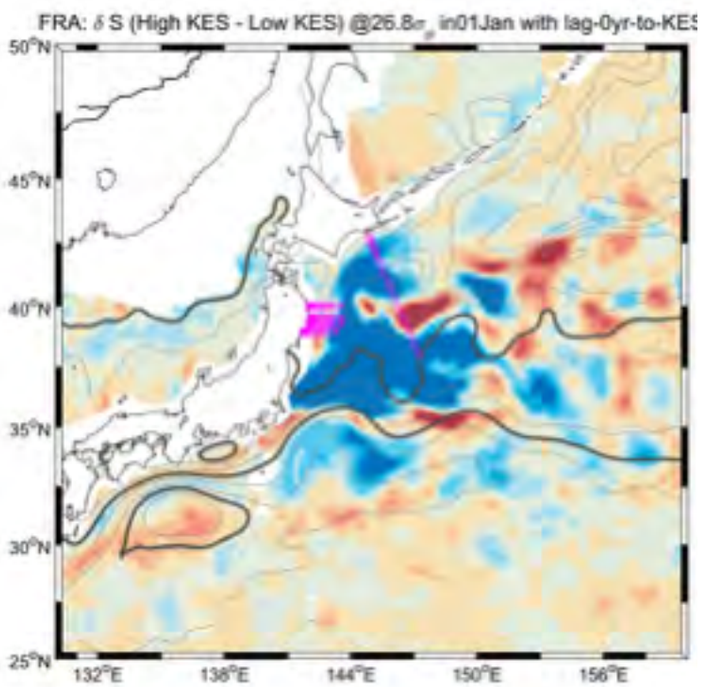


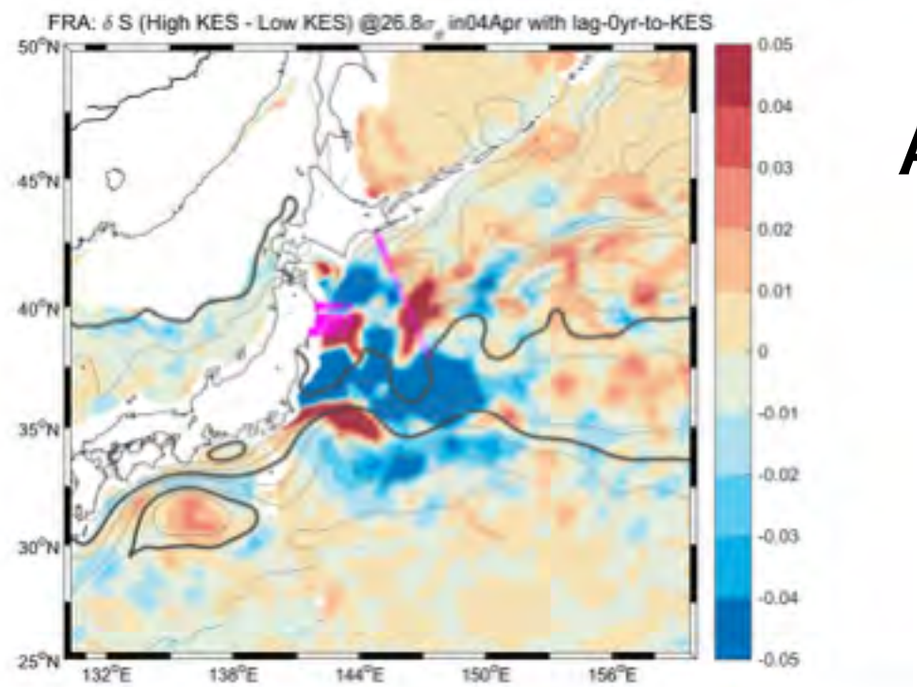
We calculated difference between the composites for each month.

Difference of salinity at 26.8 σ_θ
(High KES year composite – Low KES year composite)

FRA-ROMS

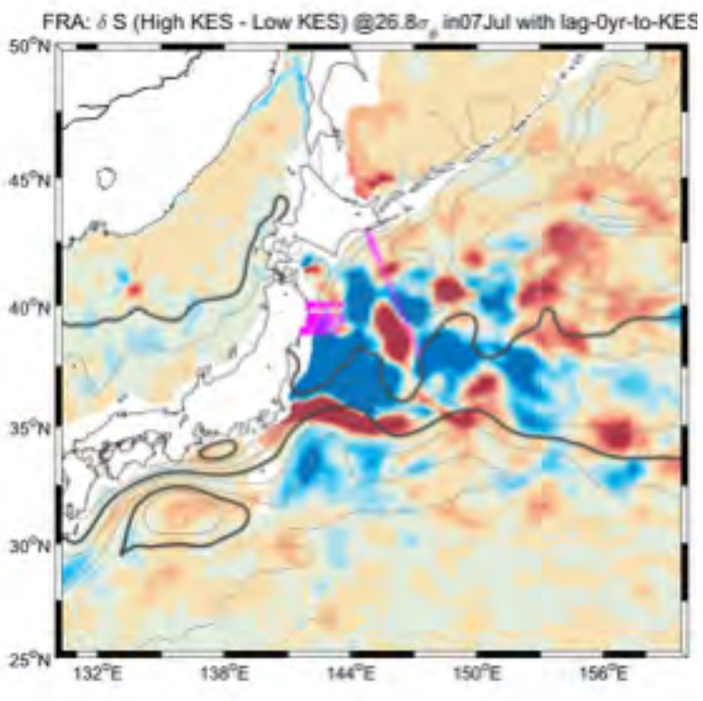
Jan.

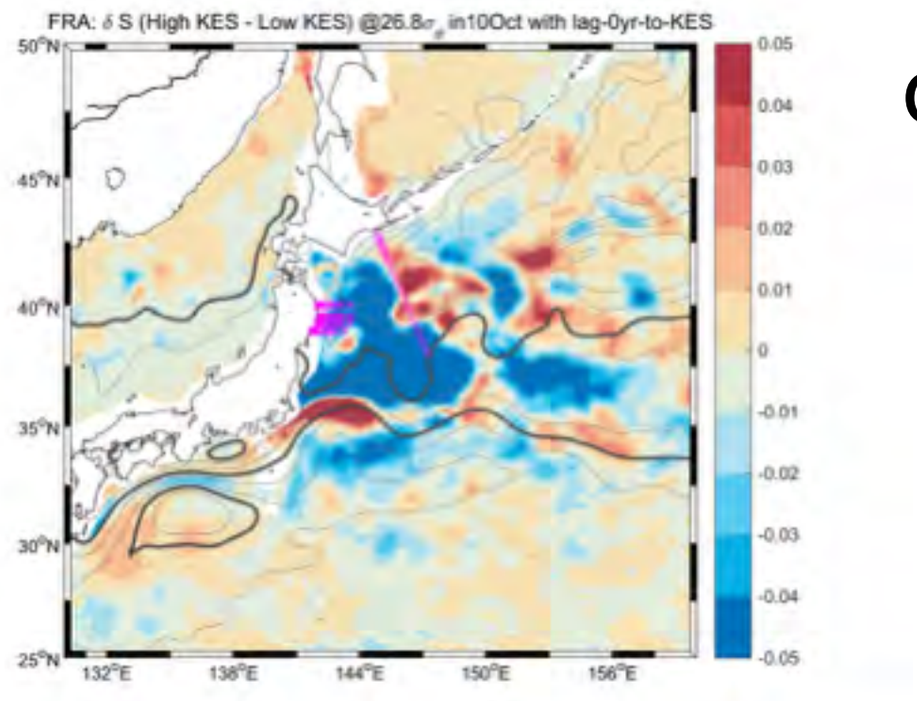




Apr.

Jul.

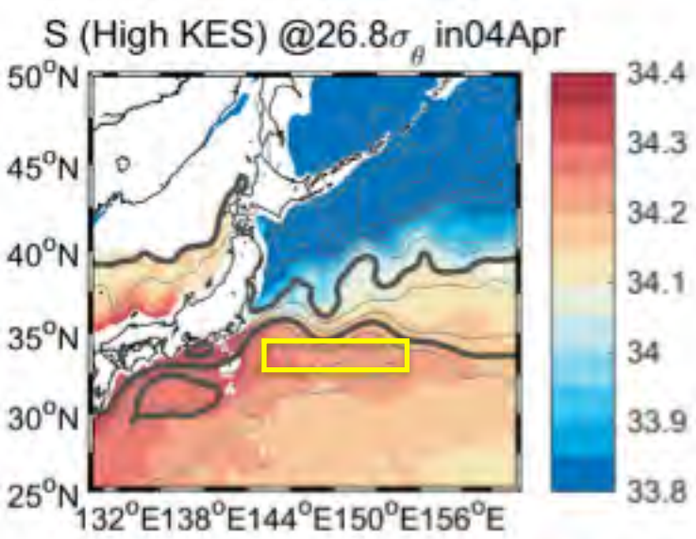


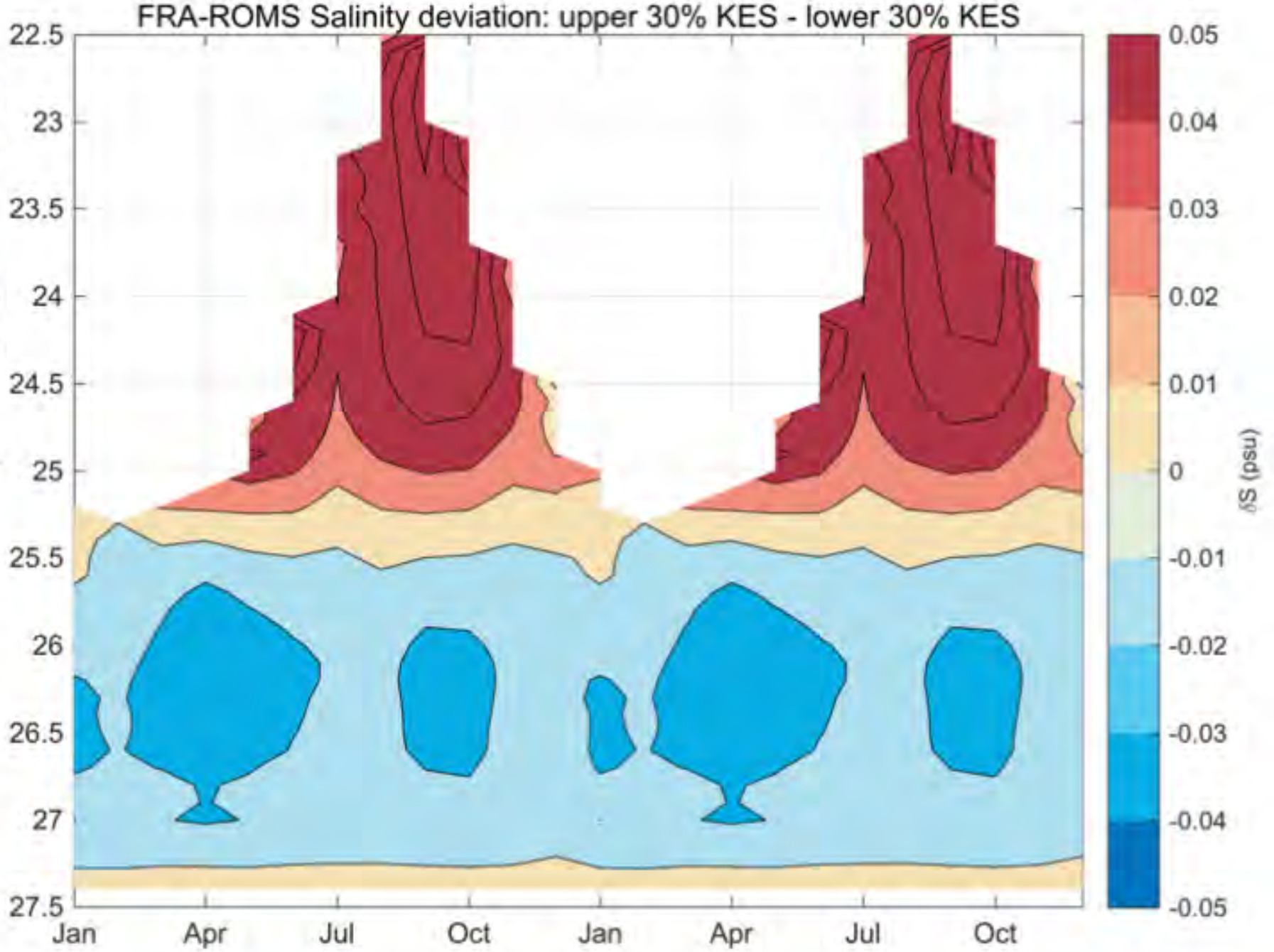


Oct.

Prominent negative anomaly is spread around PTA.

Box average of salinity anomaly (vertical distribution)





Negative anomaly is found from 25.5 to 27.4σ_θ.

negative anomaly > Salinity around KE from subsurface to mid-depths would decrease when KE is stable.

Summary

1. Salinity at NPIW density tends to decrease in PTA from stable to unstable period of KE.
2. KES is correlated with NPGO with ~2 years lag.
3. Around KE, salinity at depths deeper than subsurface might be strongly affected by NPGO.

Future works:

* Mechanism about negative salinity anomaly propagation
* Other decadal/bidecadal variations in the PTA including tidal oscillation and Aleutian low (PDO)
* Relationship between salinity variation at lighter density (such as subtropical mode water) and NPGO

Thank you!