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Effects of nutrient transport through the Korea Strait on the seasonal and interannual variability in the East Sea ecosystem

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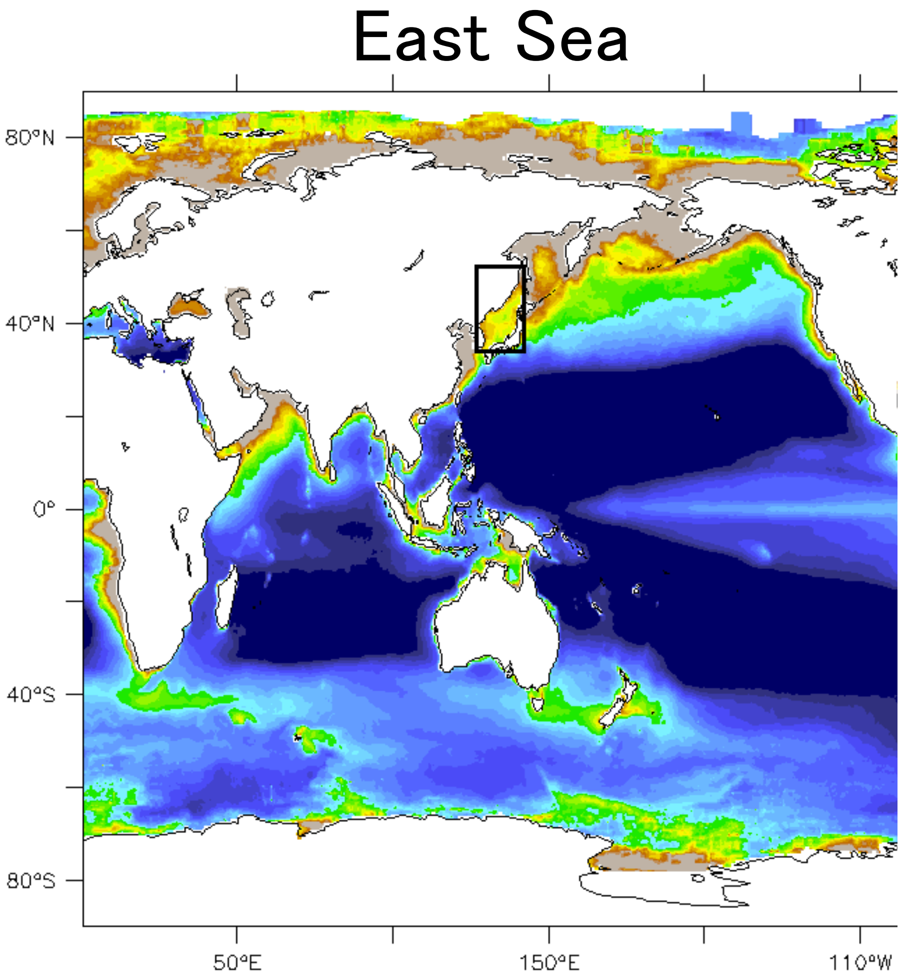
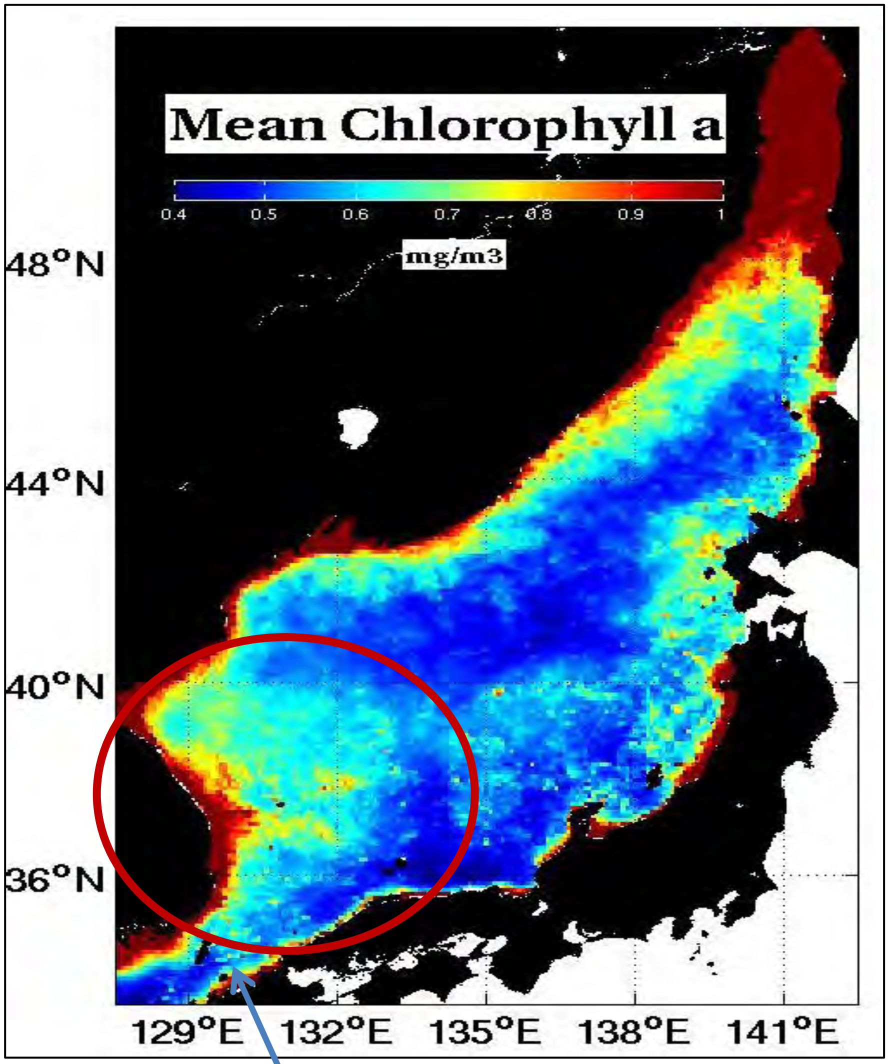
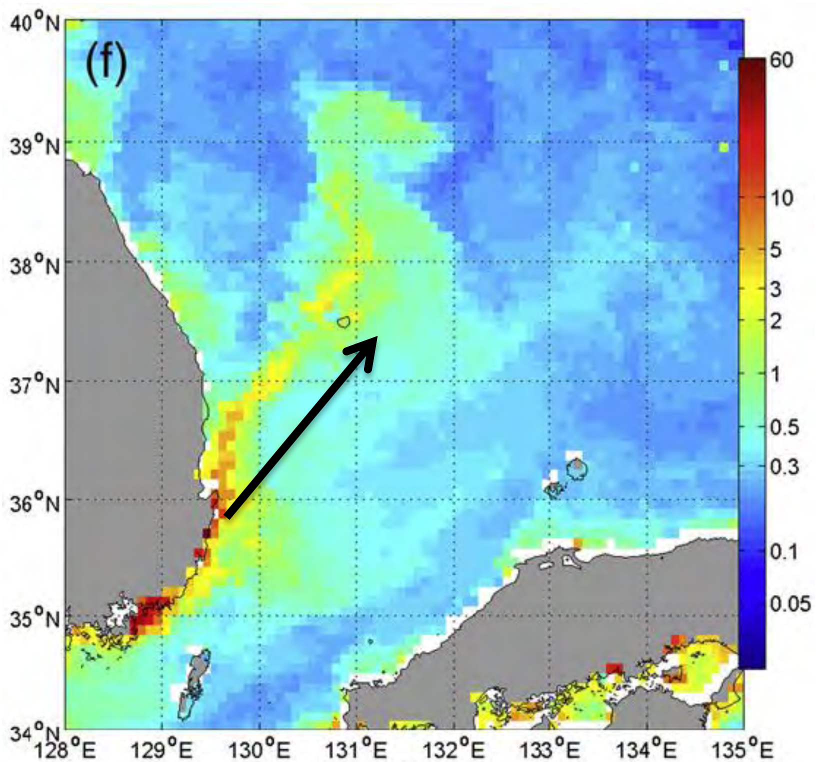
Long-Term Mean Chlorophyll-a

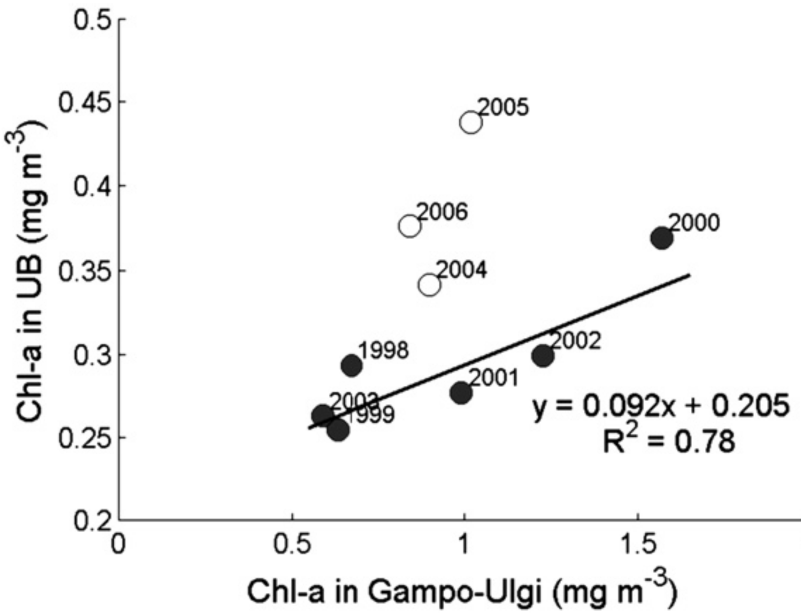




Coastal Upwelling

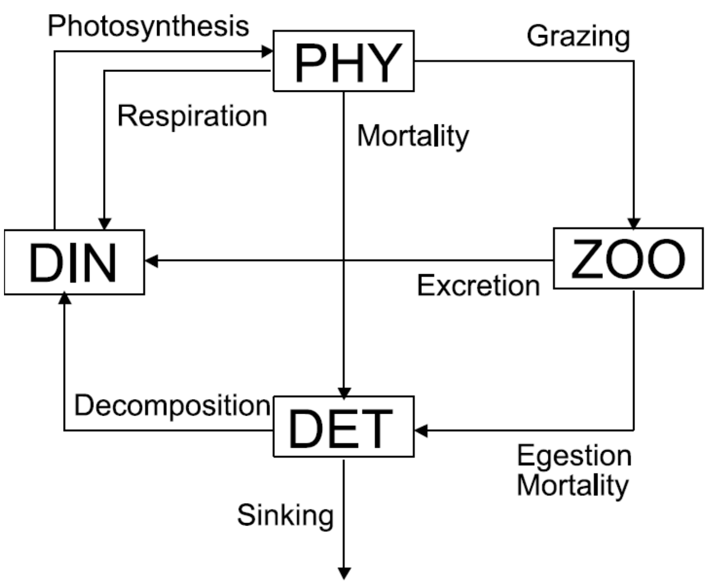
(Yoo & Park, 2009)

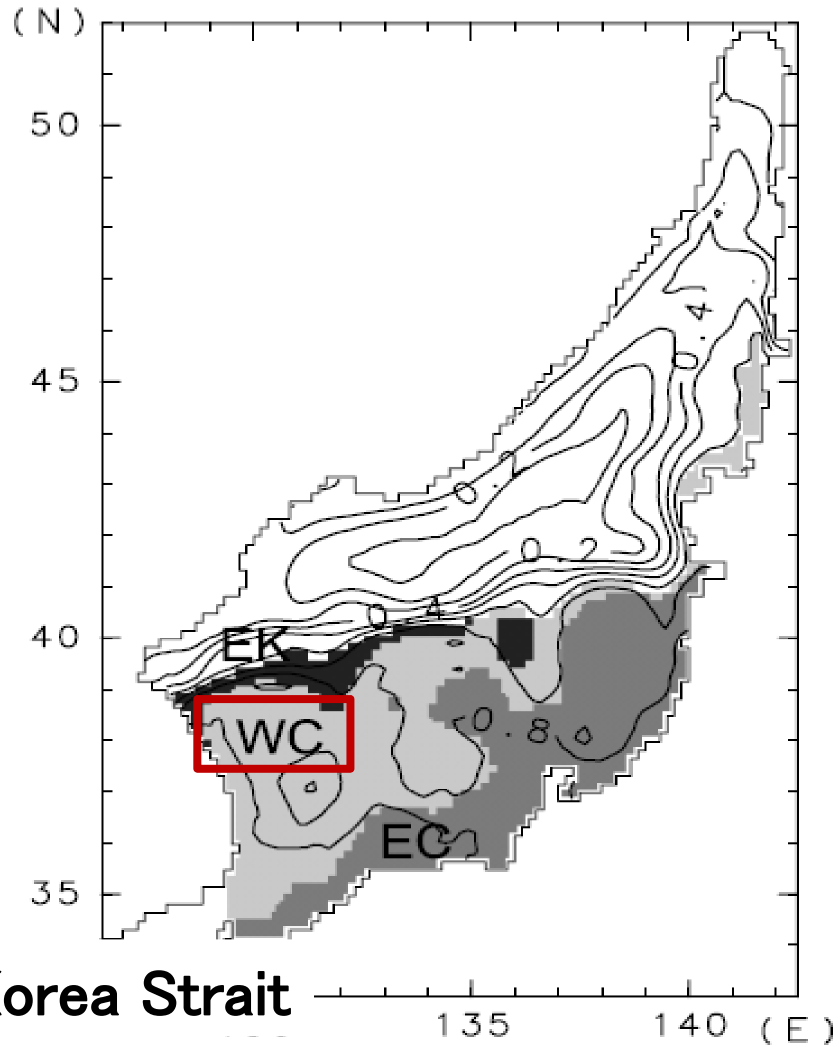




Nutrient Supply through the Korea Strait

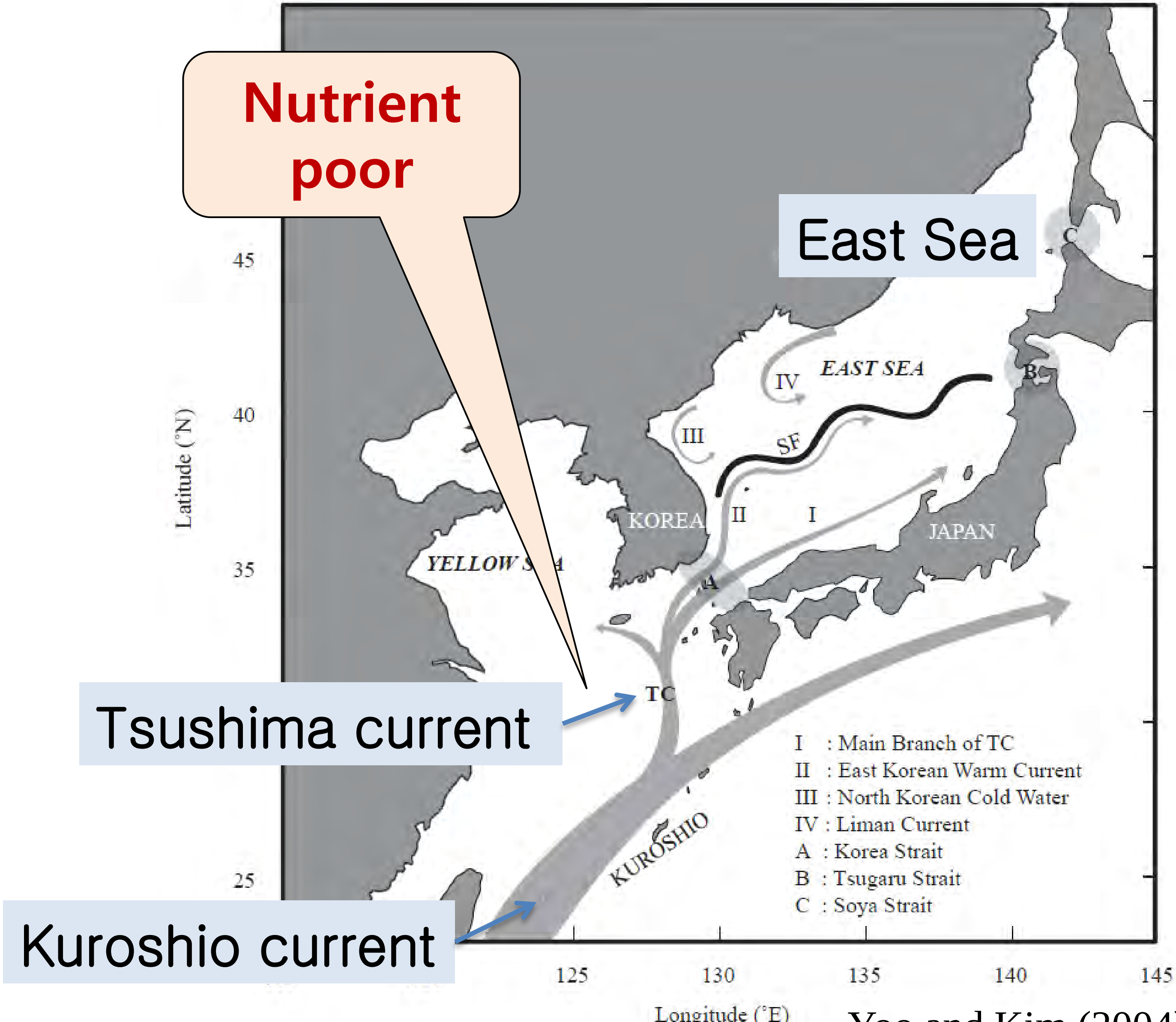
(Onitsuka et al 2007)





EK: upwelling along the East coast of Korea
WC: Western Channel of Korea Strait
EC: Eastern Channel of Korea Strait

Nutrient Transport through the KS



Yoo and Kim (2004)

Nutrient Transport through the KS

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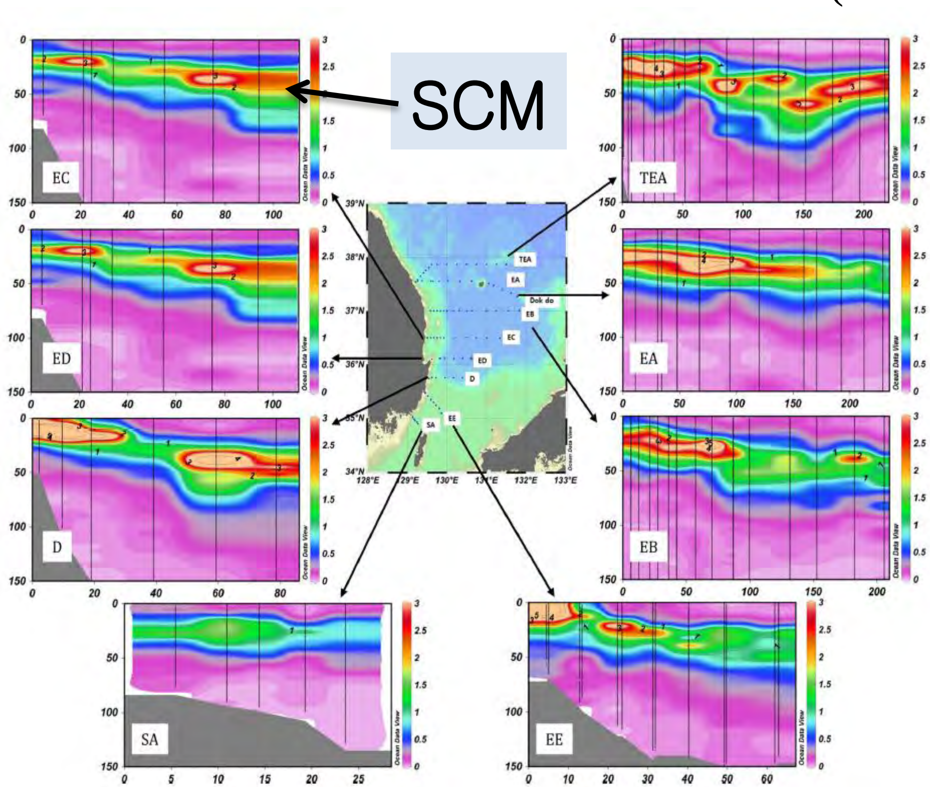
Tsushima intermediate water supplies nutrient to the SCM layer

vertical cross sections of fluorescence (Aug 2008)

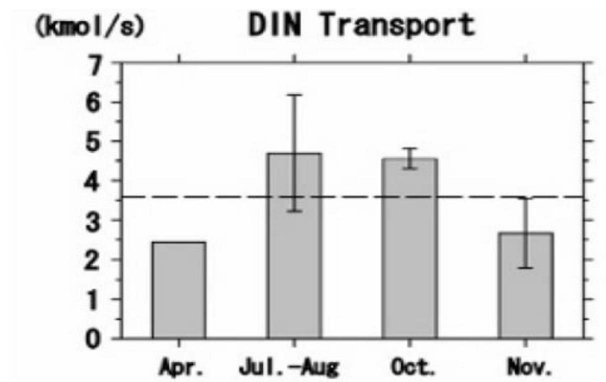
Roh et al. (2012)



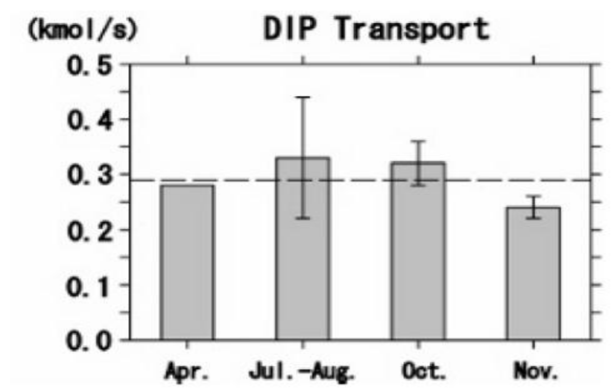
SCM layer : Subsurface Chlorophyll Maximum layer

Large amount of nutrient

Morimoto et al. (2009)



total 3.59 kmol/s



total 0.29 kmol/s

DIN : Dissolved inorganic Nitrogen
DIP : Dissolved inorganic phosphorus

Objective

To investigate how the nutrient transport through the KS affects the low trophic ES ecosystem.

Three Numerical Experiments

Hypothesis:
Nutrient transport through the KS contributes to the seasonal and interannual variations of the ES ecosystem

3 numerical experiments with different nutrient transport

1) nutrient flux with seasonal variation only
2) no nutrient flux
3) nutrient flux with seasonal/interannual variations

Methodology:

A 3D physical-biological coupled model

Assumption:

No other nutrient supplies (from atmosphere, river discharge etc)

3D Physical–Biological Coupled Model

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ROMS + Low trophic biological model **NPZD model**

N
$$\frac{\partial N}{\partial t} + \mathbf{u}\cdot\nabla N = \delta D + \gamma_n GZ - UP + \frac{\partial}{\partial z}\left(k_v \frac{\partial N}{\partial z}\right), \quad (1)$$

P
$$\frac{\partial P}{\partial t} + \mathbf{u}\cdot\nabla P = UP - GZ - \sigma_d P + \frac{\partial}{\partial z}\left(k_v \frac{\partial P}{\partial z}\right), \quad (2)$$

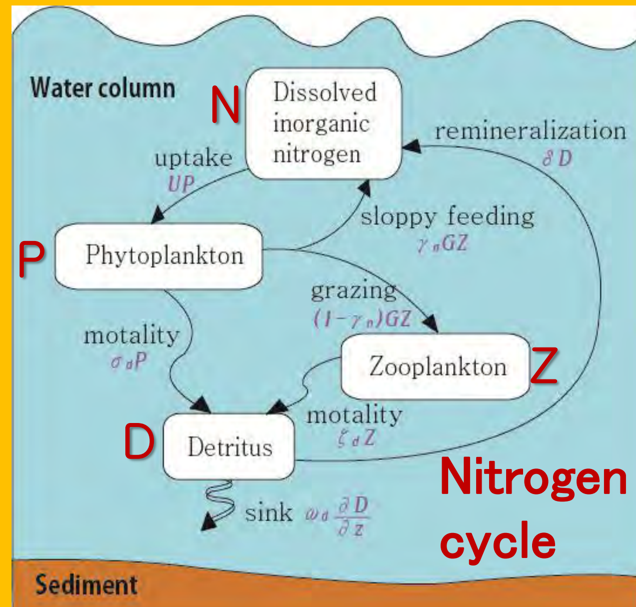
Z
$$\frac{\partial Z}{\partial t} + \mathbf{u}\cdot\nabla Z = (1-\gamma_n)GZ - \zeta_d Z + \frac{\partial}{\partial z}\left(k_v \frac{\partial Z}{\partial z}\right), \quad (3)$$

D
$$\frac{\partial D}{\partial t} + \mathbf{u}\cdot\nabla D = \sigma_d P + \zeta_d Z - \delta D + w_d \frac{\partial D}{\partial z} + \frac{\partial}{\partial z}\left(k_v \frac{\partial D}{\partial z}\right), \quad (4)$$

$$G = R_m\left(1 - e^{-\Lambda P}\right), \quad (5)$$

$$I = I_0 \exp\left(k_z z + k_p \int_0^z P(z')dz'\right), \quad (6)$$

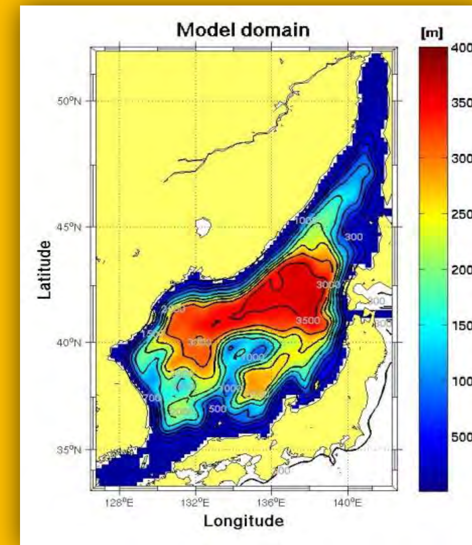
$$U = \frac{V_m N}{k_N + N}\frac{\alpha I}{\sqrt{V_m^2 + \alpha^2 I^2}}. \quad (7)$$



Powell et al. (2006)

Table 1. Parameter Values

Parameter Name	Symbol	Value	Dimension
Light extinction coefficient	k_z	0.067	m^{-1}
Self-shading coefficient	k_p	0.0095	m^2 mmol-N^{-1}
Initial slope of P-I curve	α	0.025	$m^2 W^{-1}$
Surface irradiance	I_0	158.075	$W m^{-2}$
Nitrate uptake rate	V_m	1.5	d^{-1}
Uptake half saturation	k_N	1.0	mmol-N m^{-3}
Phytoplankton senescence	σ_d	0.1	d^{-1}
Zooplankton grazing rate	R_m	0.52	d^{-1}
Ivlev constant	Λ	0.06	m^3 mmol-N^{-1}
Excretion efficiency	γ_n	0.3	
Zooplankton mortality	ζ_d	0.145	d^{-1}
Remineralization	δ	1.03	d^{-1}
Detrital sinking rate	w_d	8.0	$m d^{-1}$



Topography : ETOPO5
Horizontal resolution: 1/6°
Vertical layers: 30 layers

Experiment Results

1) nutrient flux with seasonal variation only
2) no nutrient flux
3) nutrient flux with seasonal/interannual variations

	(seasonally varying) Nutrient flux	No flux
Initial condition	N : WOA2005 P, Z, D : 1.0 $mmolN/m^3$	
Biological boundary condition (at KS)	N : WOA2009 P : SeaWiFS chlorophyll (50%)* Z, D : SeaWiFS chlorophyll (20%)* *corresponding to the ratio with chl-a	closed (boundary value = inner value)
Spin-up	10 years	
Forcing	ECMWF interim (climatology, bulk formula)	

Surface Chl-a (mg/m^3) in Spring and Fall

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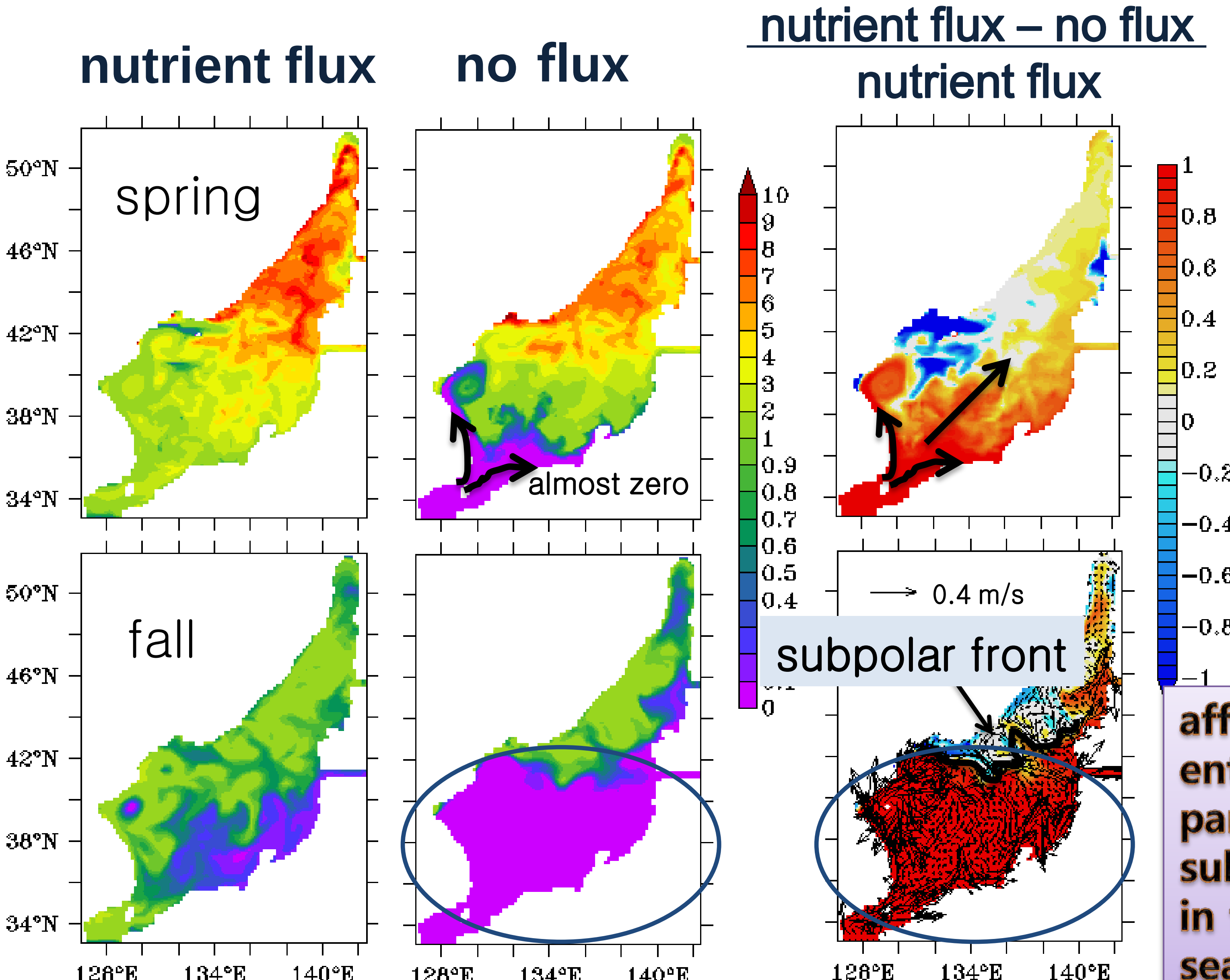
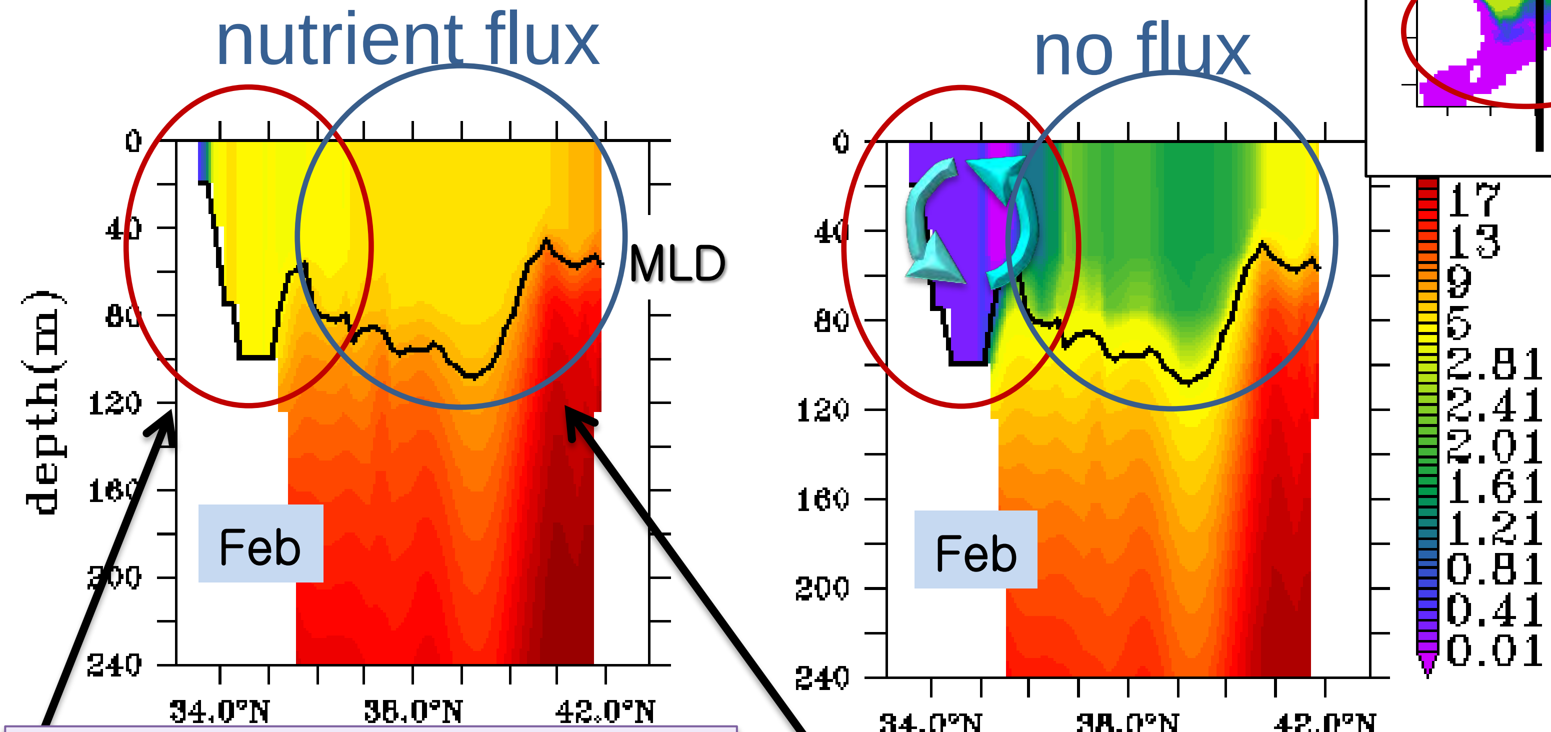


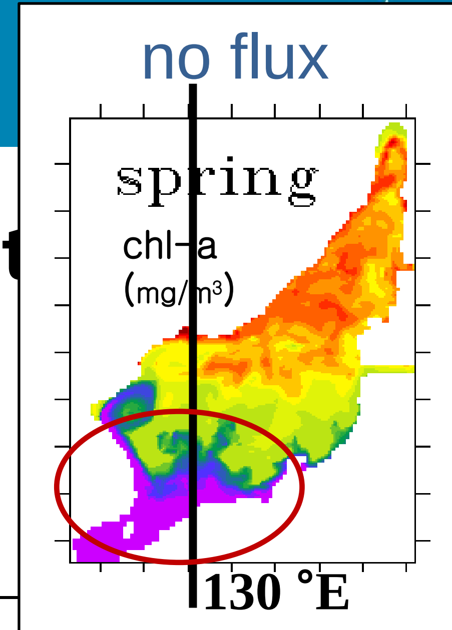
positive effect decreased gradually toward the northern ES in the spring bloom season

affected in the entire southern part of the subpolar front in fall bloom season

Nutrient Poor Water in the Southern ES

nutrient concentration (mmolN/m^3) along t
in Feb





nutrient transport through the KS only

nutrient through the KS + other supplies

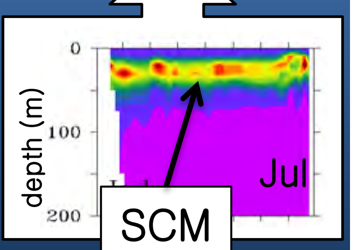
Annual Mean Chl-a (mg/m³) in Surface & Subsurface Layers

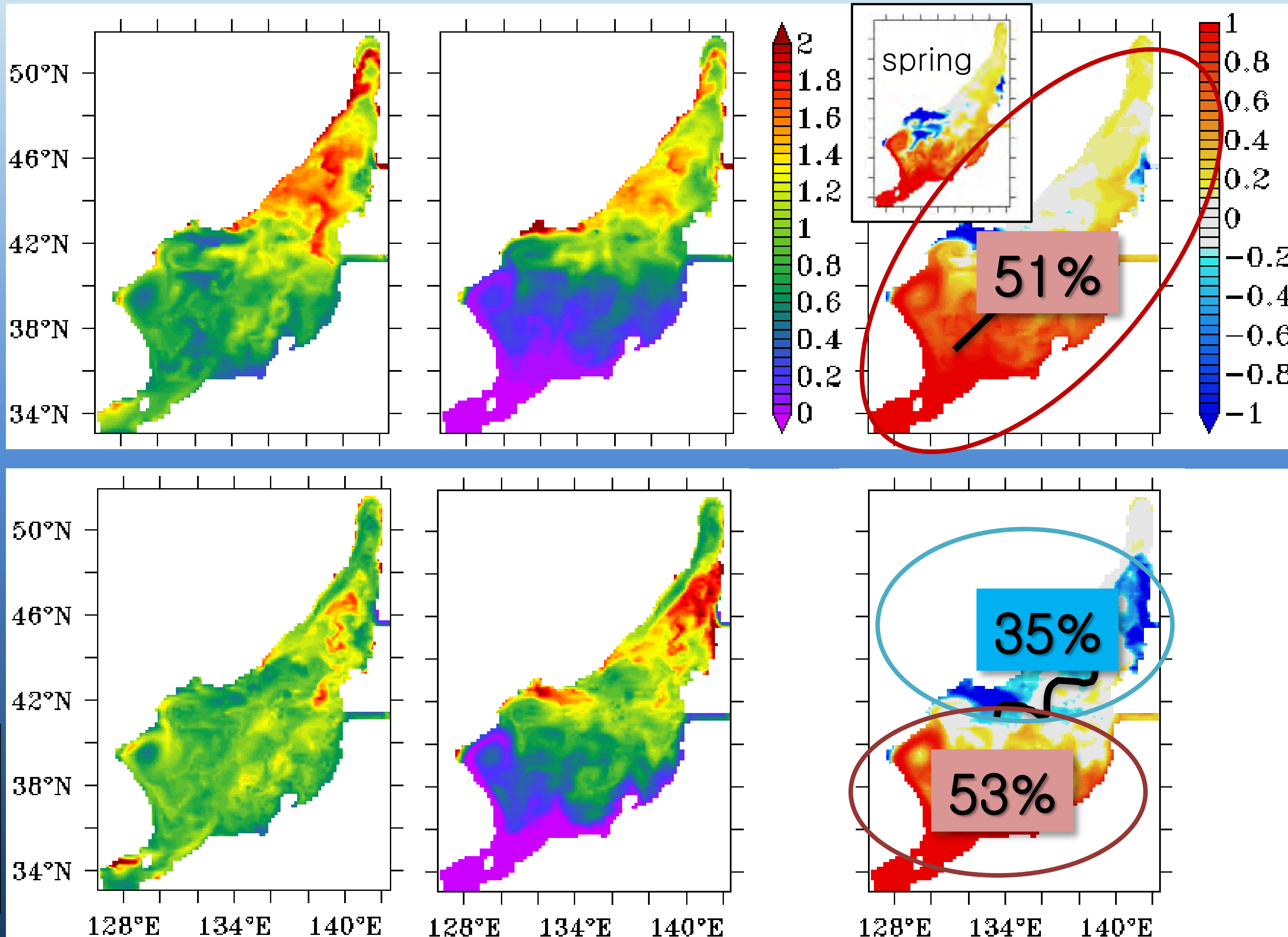
nutrient flux | no flux | (nutrient flux – no flux) / nutrient flux

surface
0-5m

spring bloom
fall bloom

subsurface
20-40m





Experiment Results

1) nutrient flux with seasonal variation only
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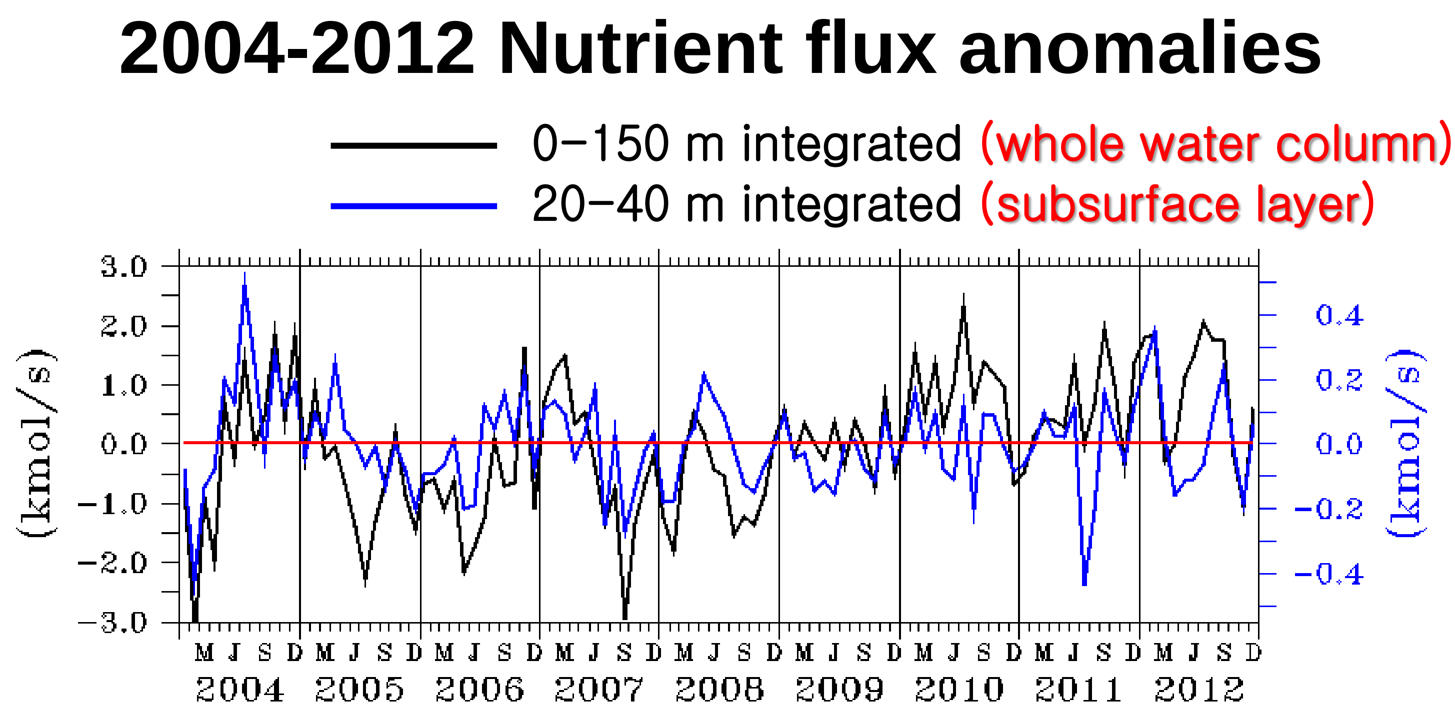
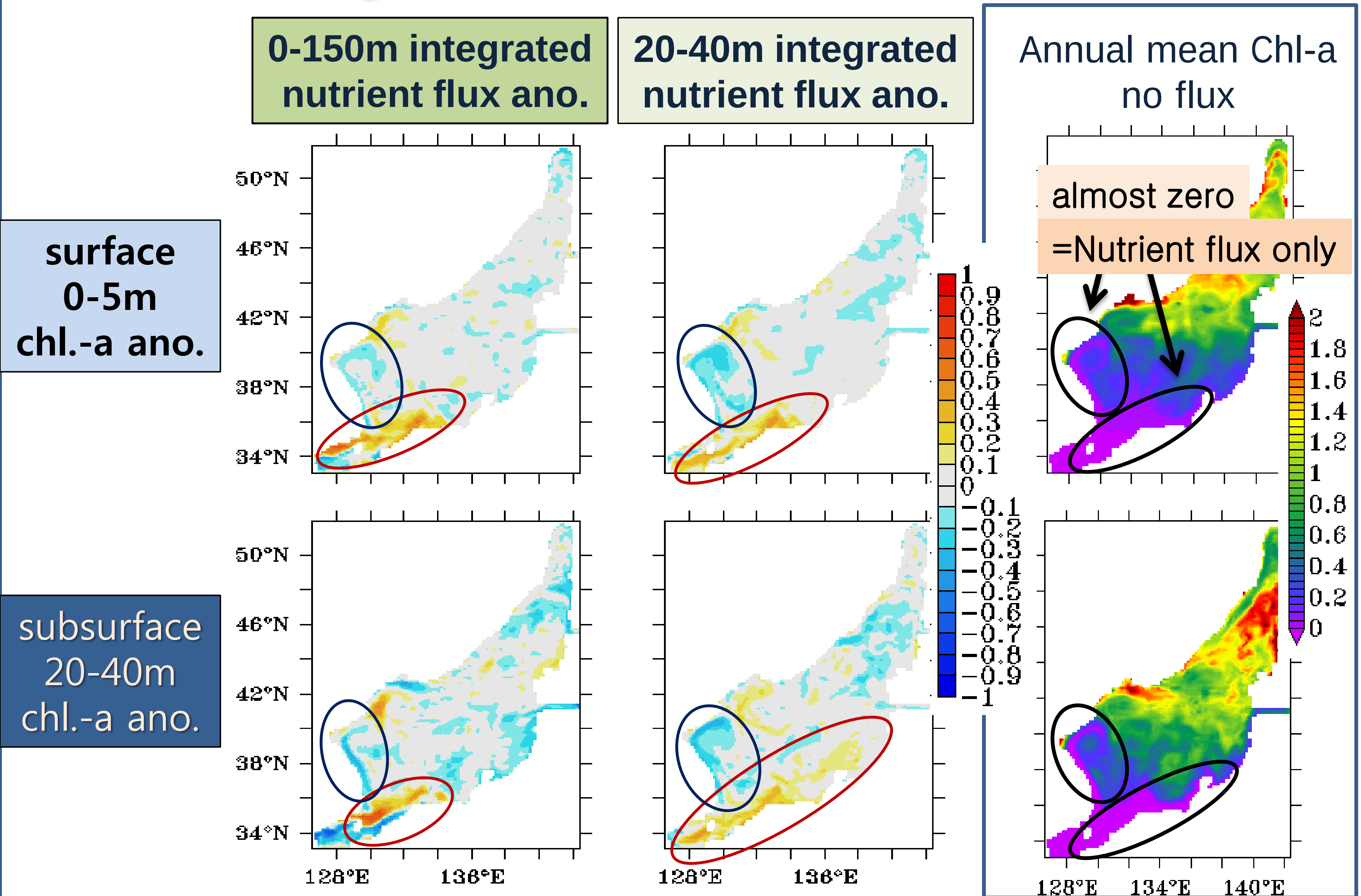
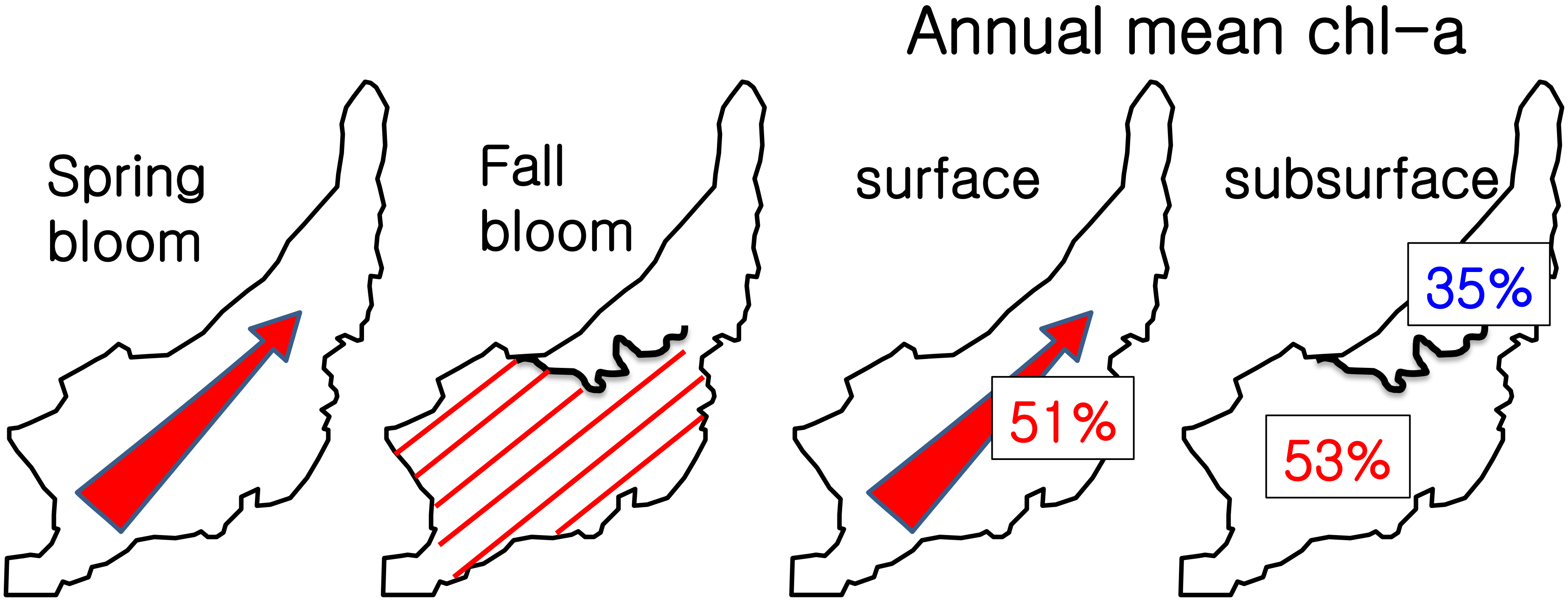


Correlations of Nutrient flux (kmol/s) Anomalies with Chl-a (mg/m³) Anomalies



Summary

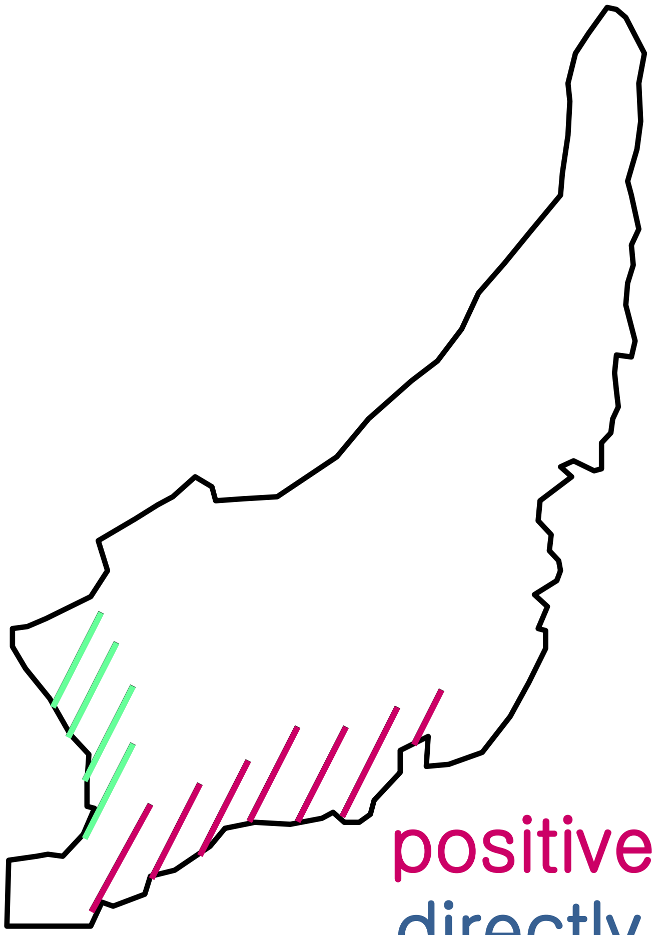
The effect of nutrient transport through the Korea Strait …



Summary

The downstream areas of the Tsushima current show good correlation of nutrient flux with chlorophyll-a concentration.

The interannual variation of nutrient transport through the KS affects the variation of the chlorophyll-a concentration



Future Study
- Limitations -

- Low resolution-1/6
  - EKWC overshooting
  - UWE, upwelling
- NPZD model …
  - Only one compartment of Phyto. & Zoo.
  - T dependency (photosynthesis, grazing etc.) ignored
  - biological BC & parameters poorly known

Thank you very much