5th (2021) NOWPAP training course
on remote sensing data analysis
Webinar 2 Monitoring and assessment of
water quality by ocean color remote sensing

Institute for
Space-Earth Environmental Research

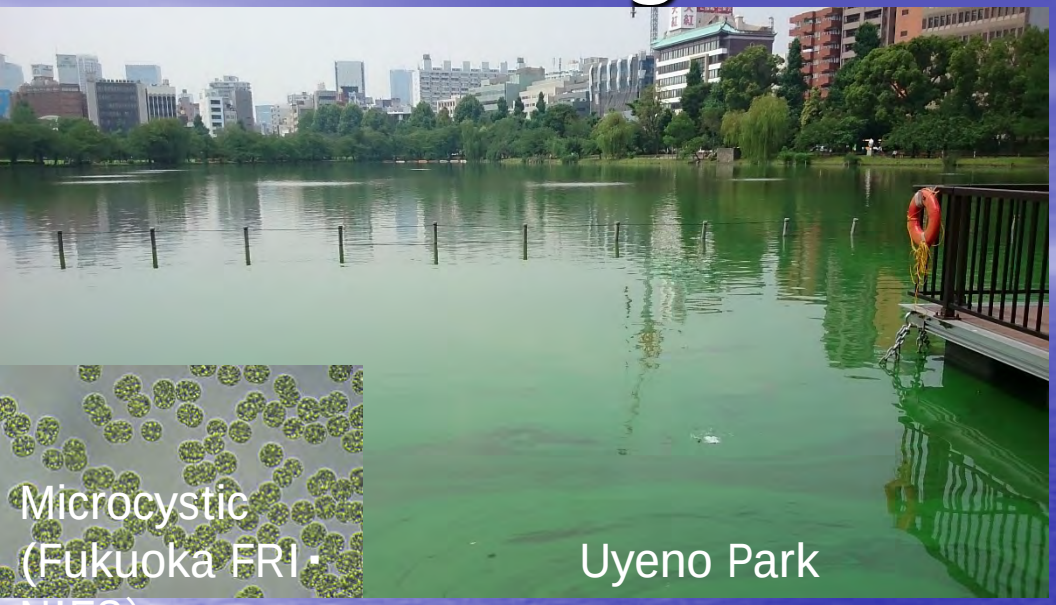
Introduction to satellite biological oceanography and ocean color remote sensing

Joji Ishizaka
Nagoya University,
Institute for Space-Earth Environmental Research（ISEE）
jishizaka@nagoya-u.jp

Contents

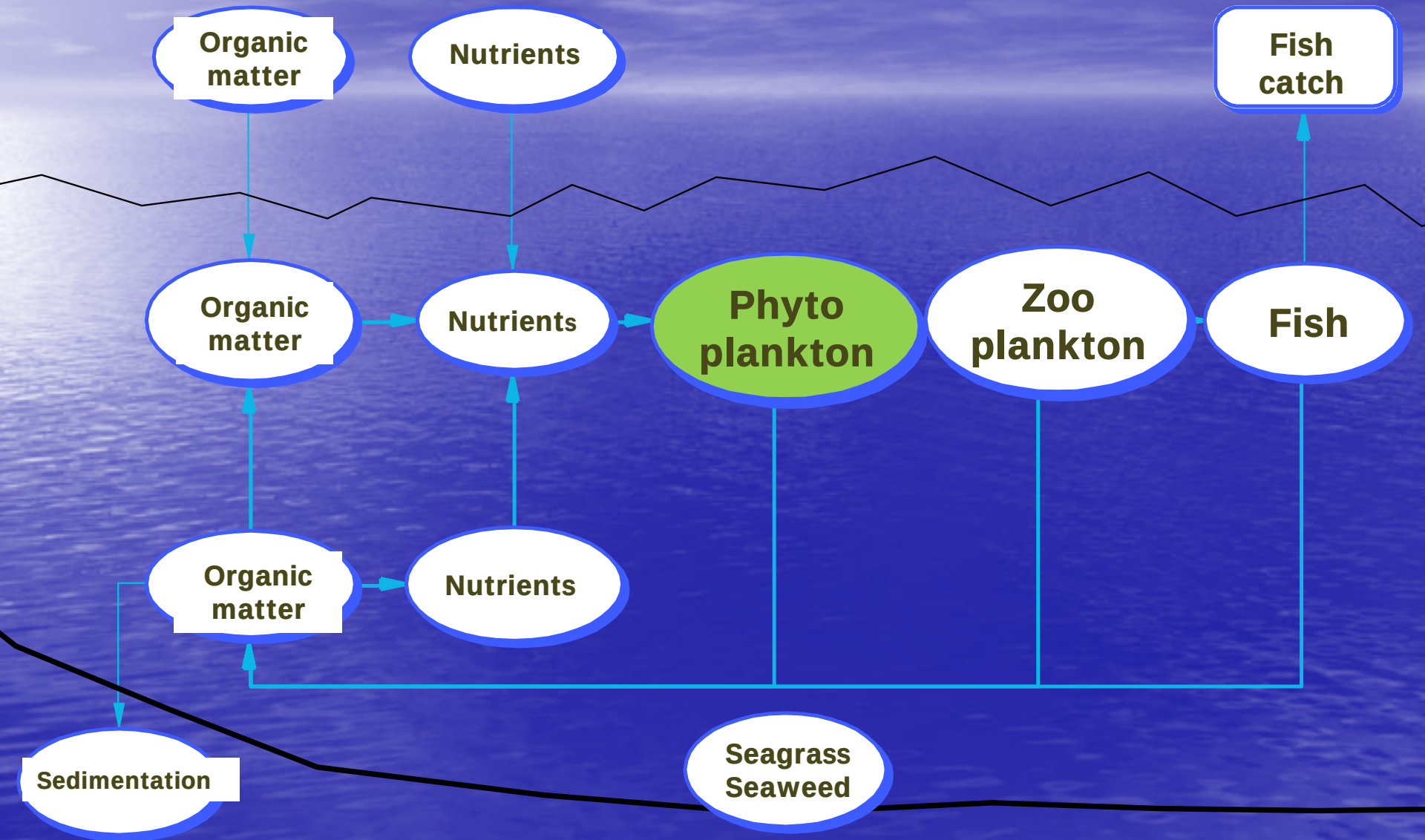
- Eutrophication
- Global Phytoplankton Distribution
- Satellite Detection of Chlorophyll-a
- Seasonal Variation
- Primary Production
- Change in the East China Sea
- Phytoplankton Group Identification

Harmful Algal Blooms



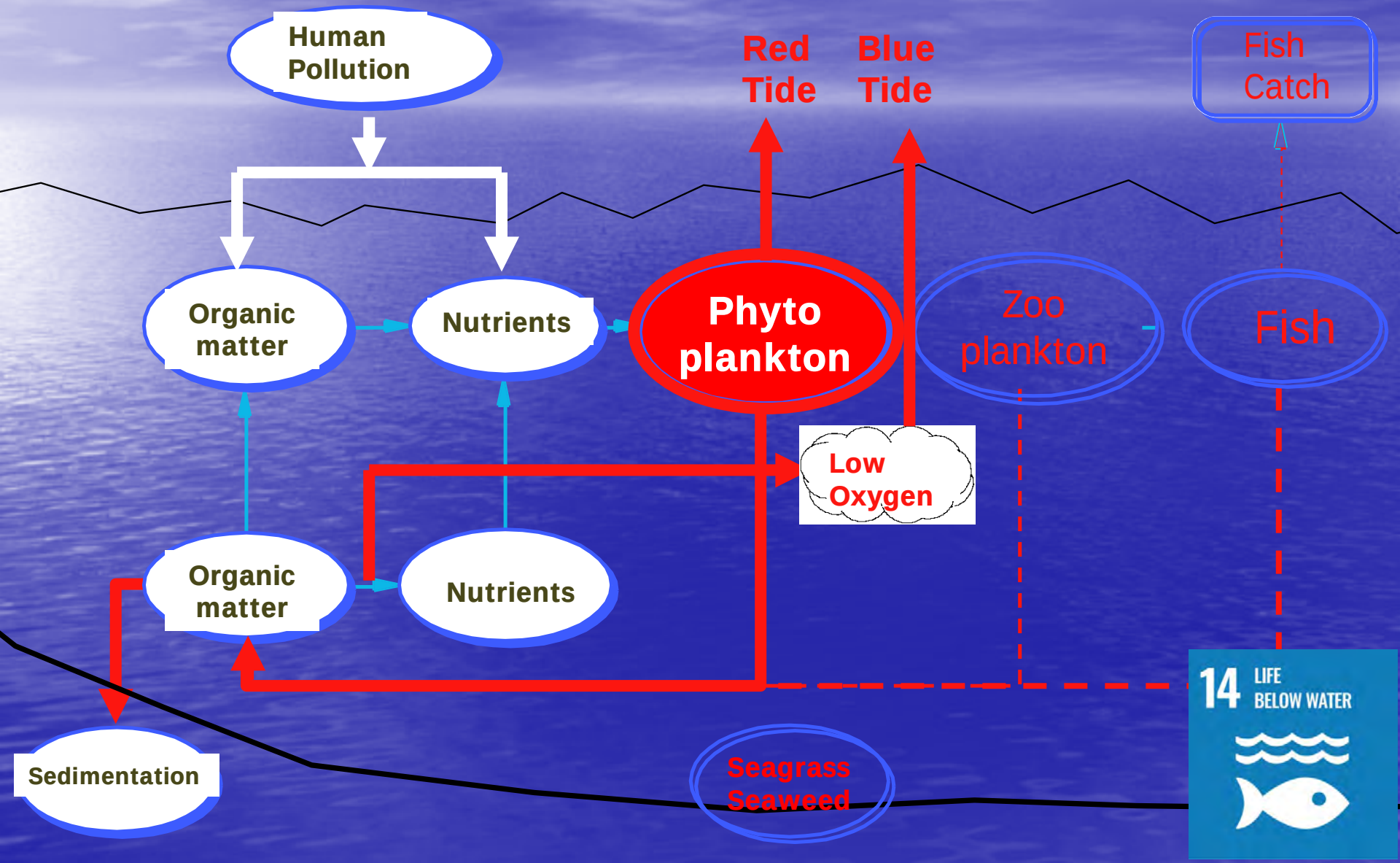
Phytoplankton Blooms often cause Harmful Algal Bloom （HAB） （including Fish Kill）

Before Eutrophication



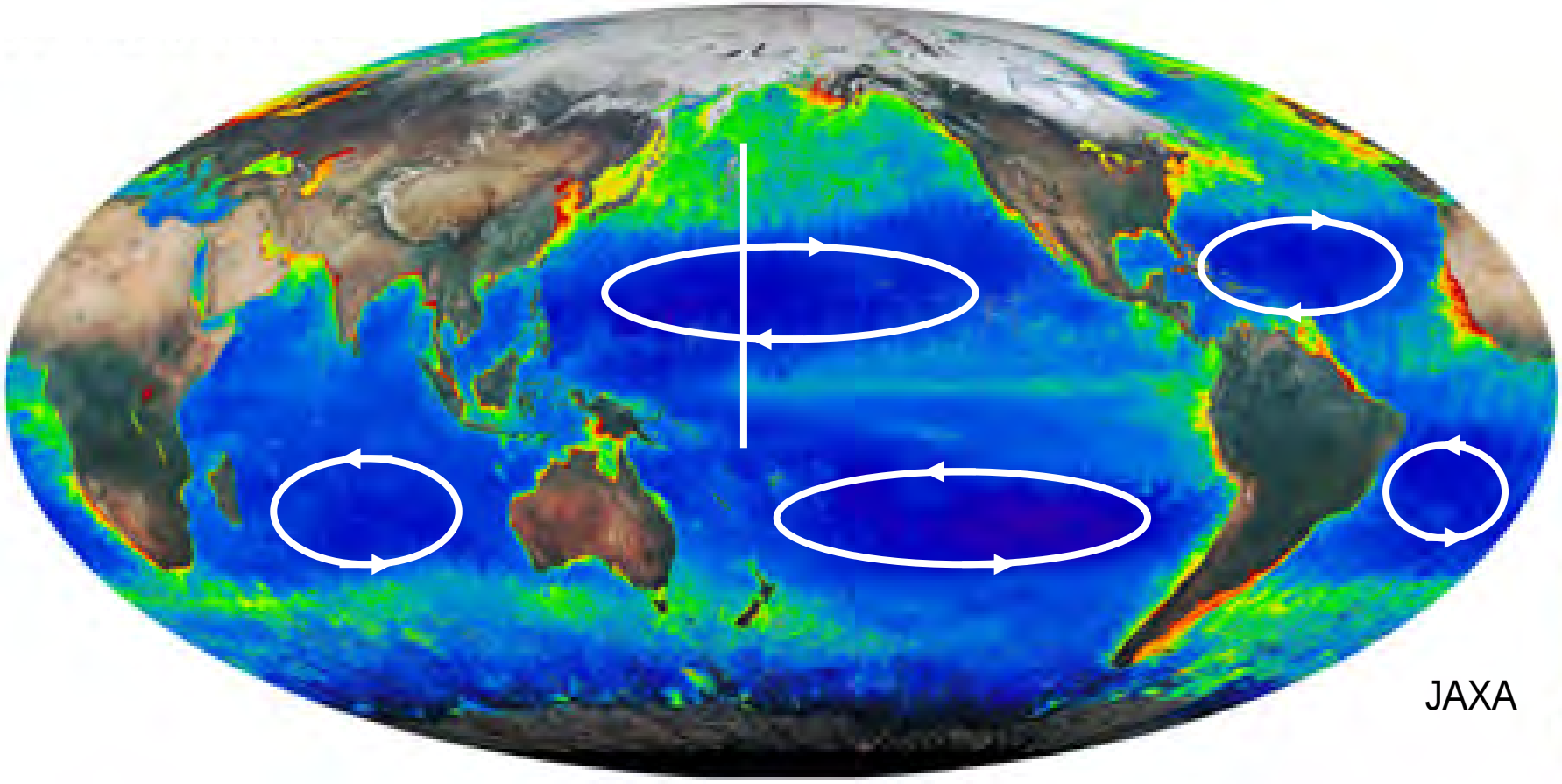
14.1.1(a)
Index of coastal eutrophication

After Eutrophication



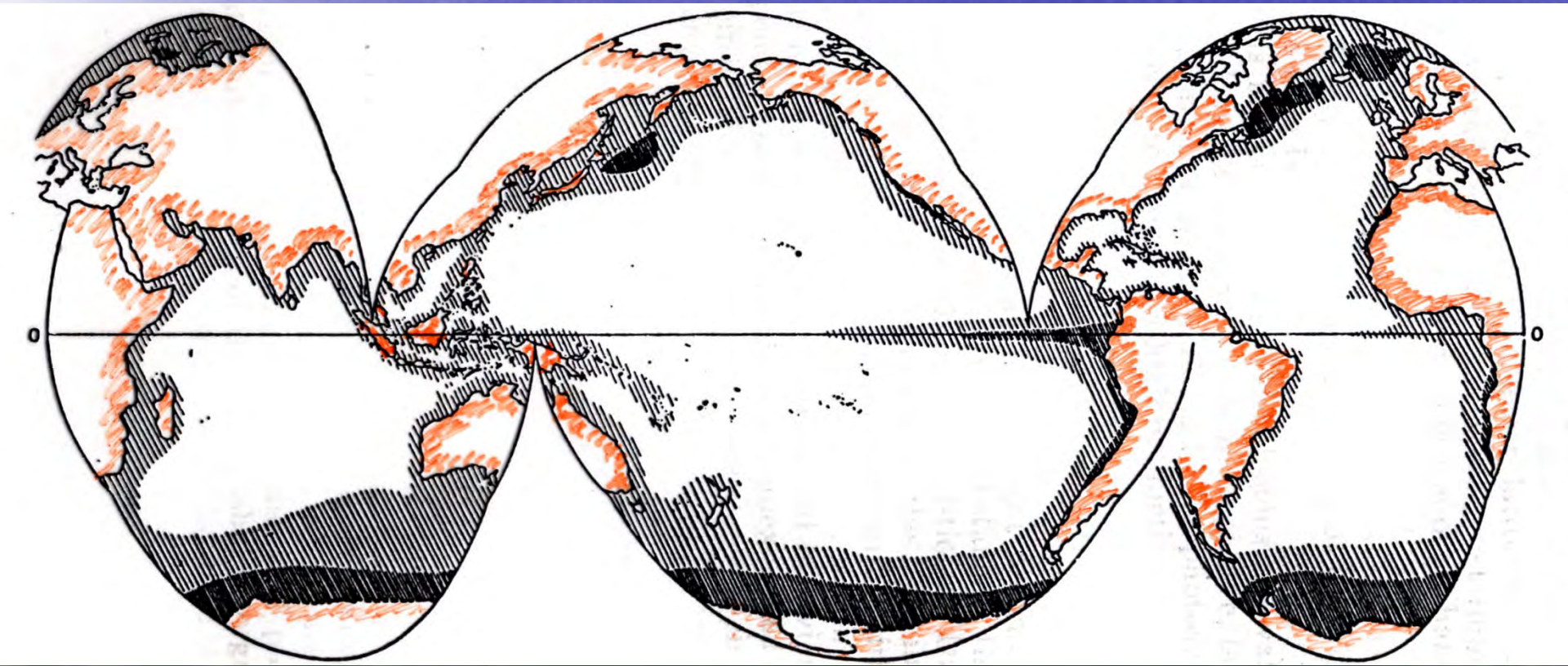
Global Phytoplankton (Chlorophyll-a) Distribution

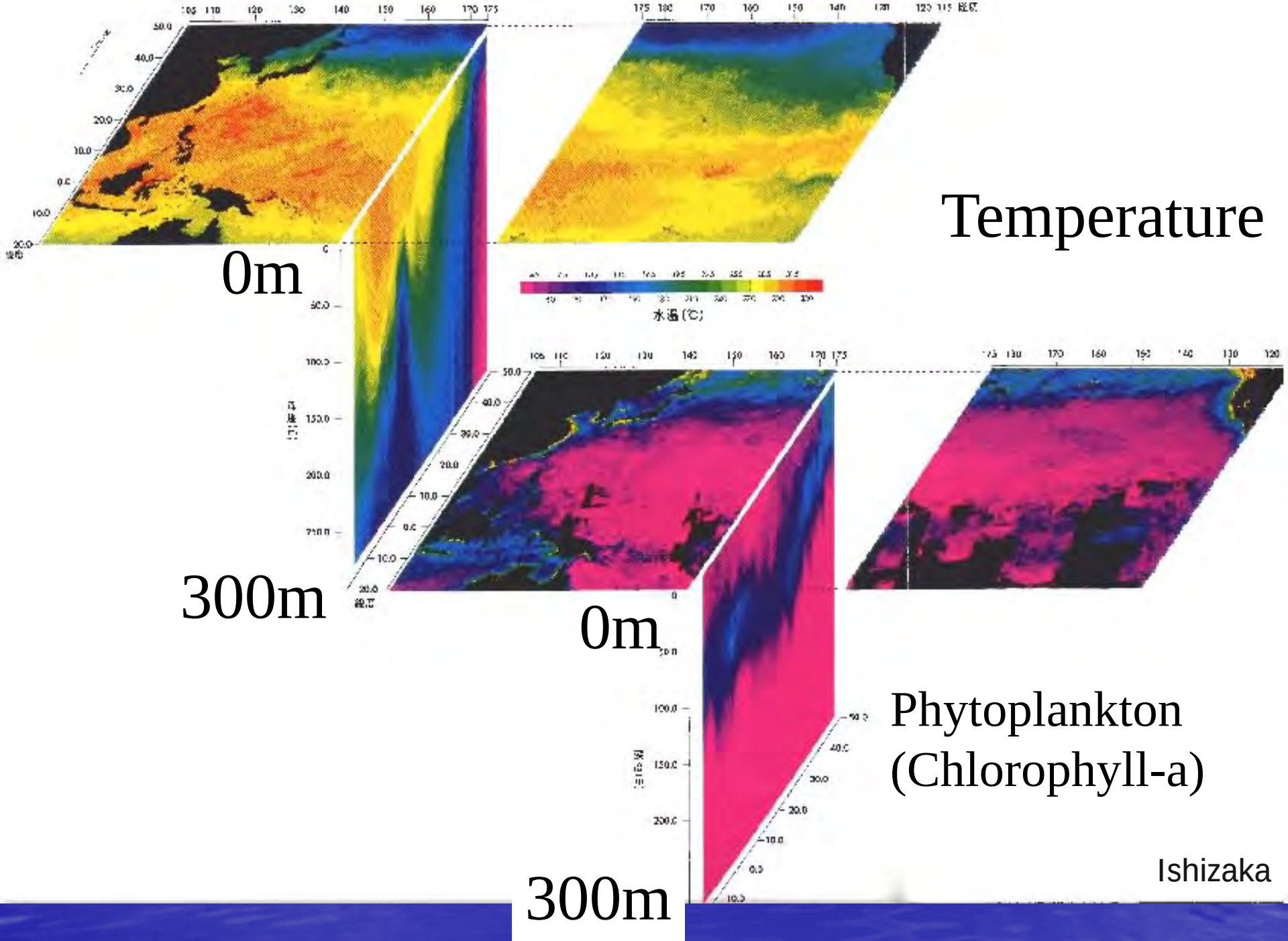
Wind Driven Surface Currents: Nutrient Supply



CI Photosynthetically available radiation

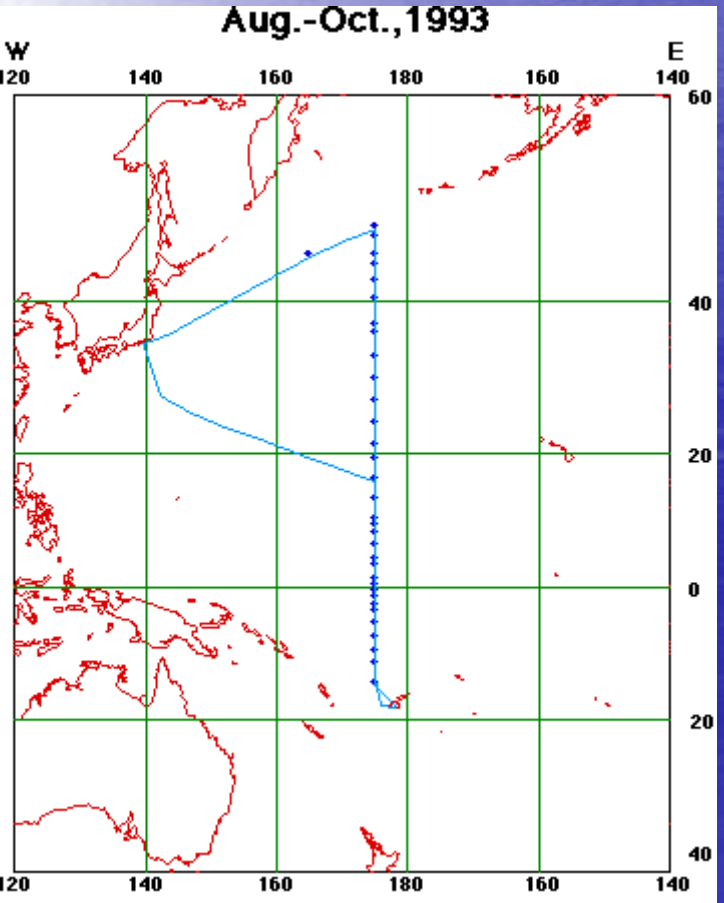
Sverdrup (1955)
Place of Physical Oceanography in the Oceanographic Research

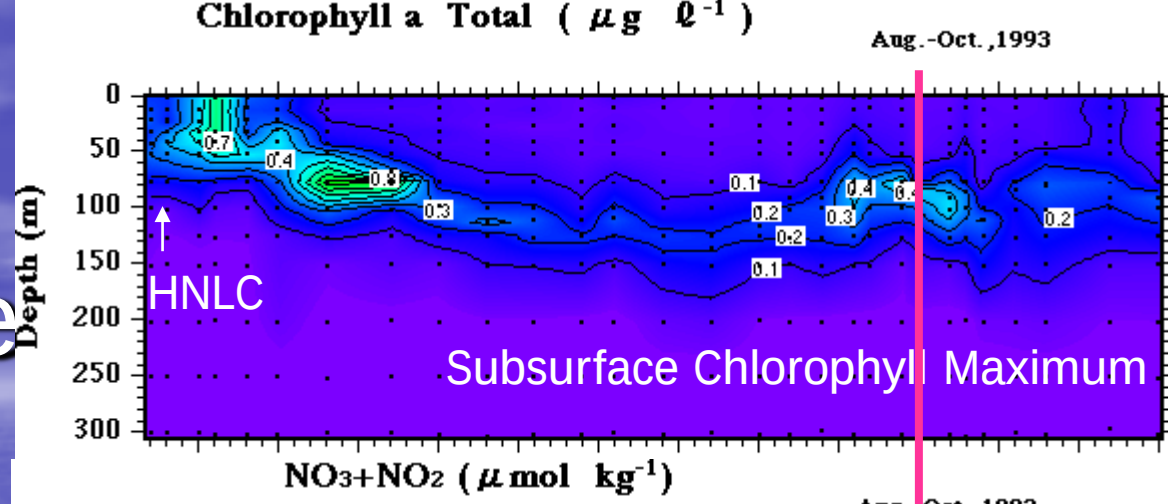


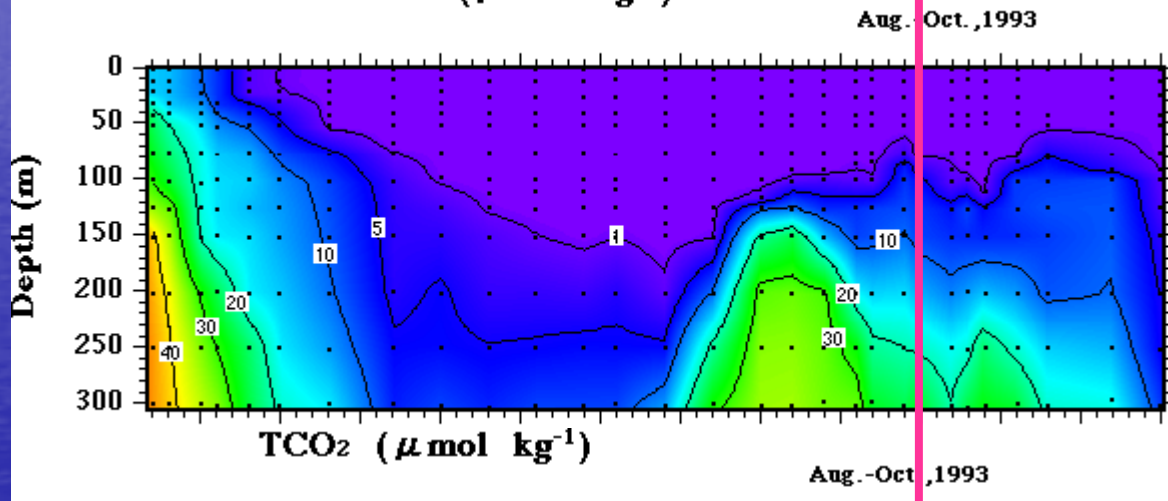

Temperature
0m
300m
0m
300m
Phytoplankton
(Chlorophyll-a)
Ishizaka

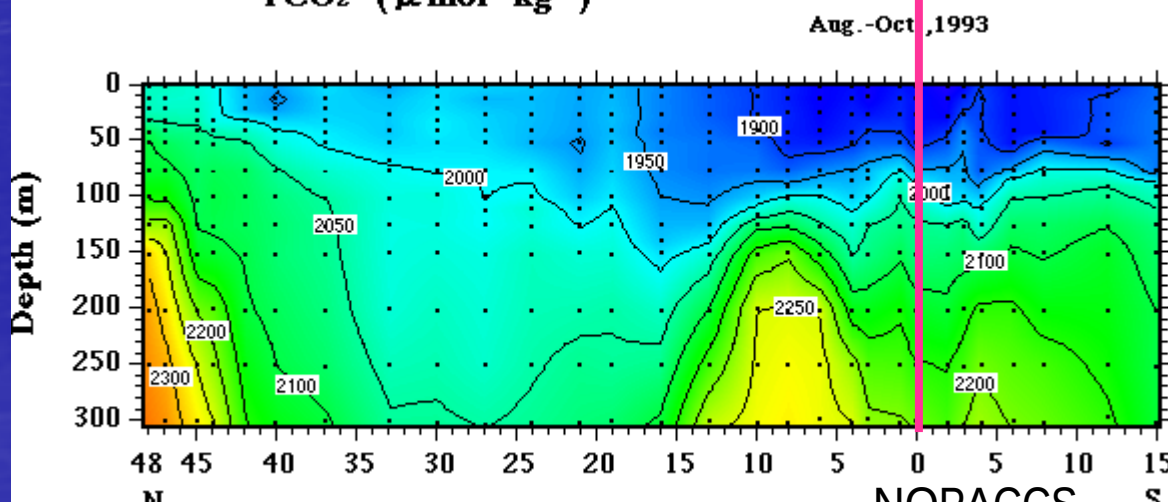
CHL-a
Nitrate+Nitrite
Total Carbonate

Biological Pump
Solubility Pump

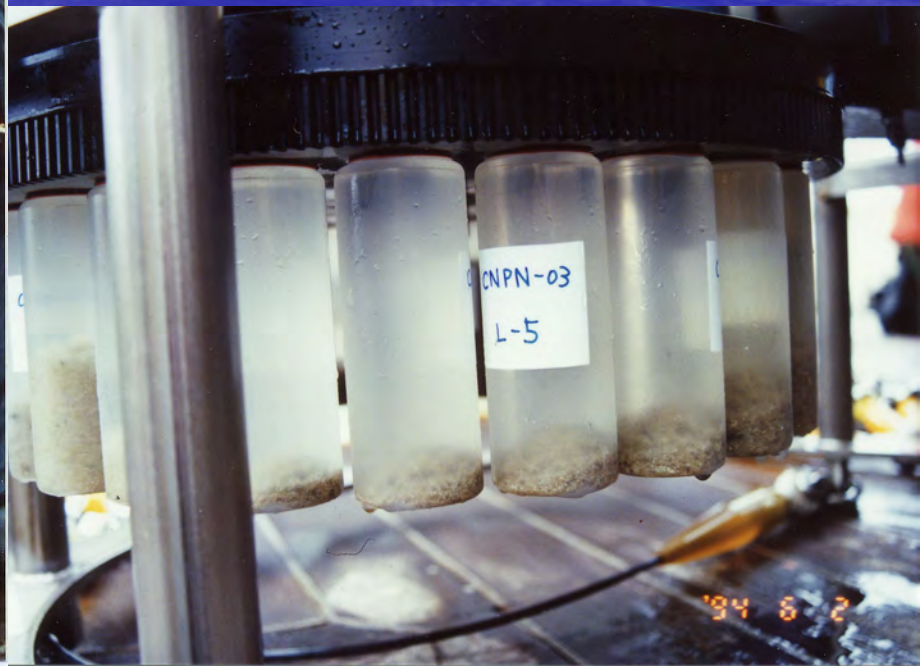








Sediment trap Sinking Particle Evaluation of Biological Pump

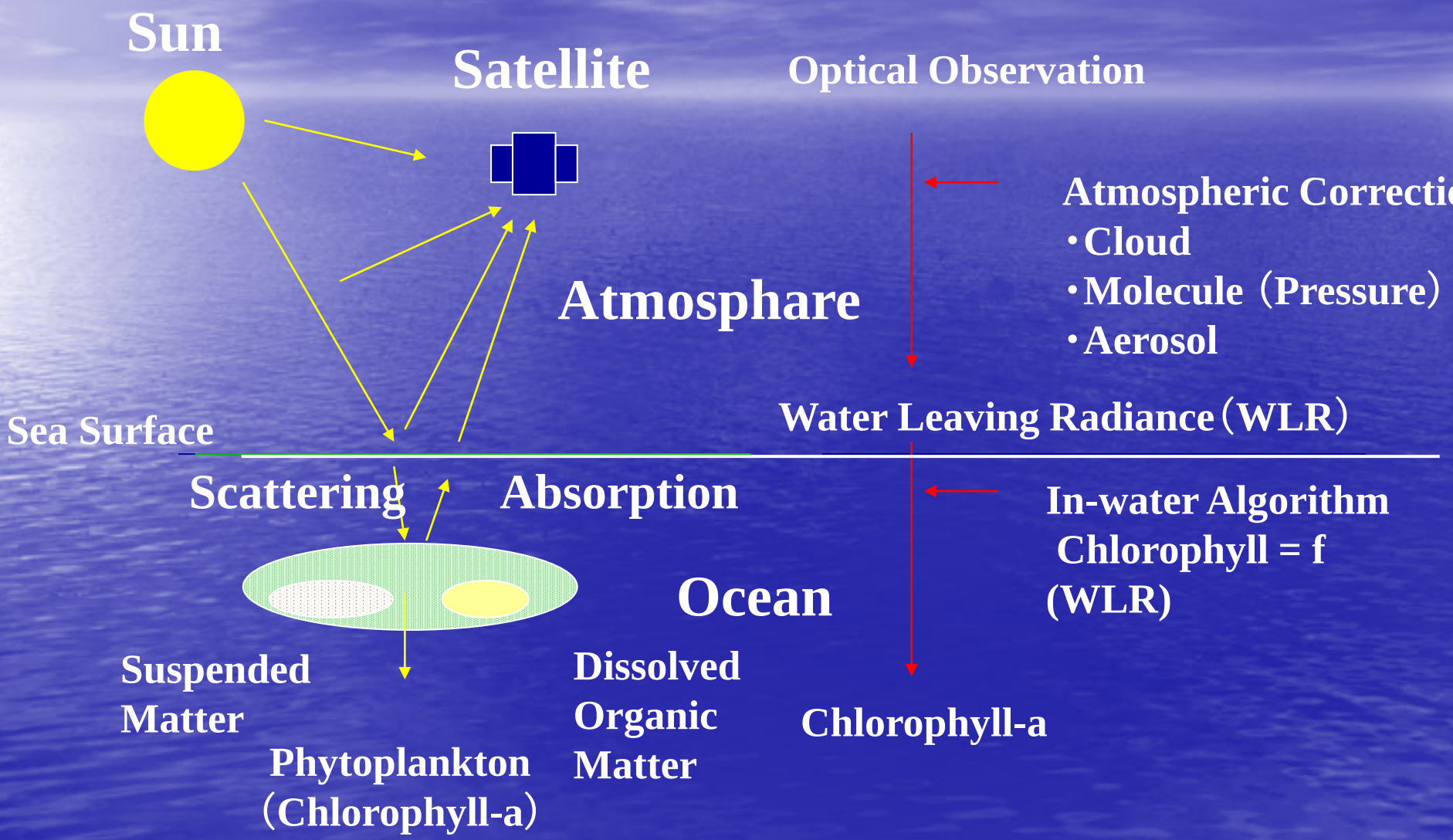


Controlling factors of Phytoplankton Growth

- Nutrients (Material Source)
- Light (Energy Source)
- Temperature (Rate Controlling)

- Physical factors (including wind, current, stratification)
- Influence from land (including river, aerosol)
- Influence of climate change and anthropogenic factors

Ocean Color


Sun
Satellite
Optical Observation
Atmosphere
Atmospheric Correctio
・Cloud
・Molecule（Pressure）
・Aerosol
Sea Surface
Water Leaving Radiance（WLR）
Scattering
Absorption
In-water Algorithm
Chlorophyll = f
(WLR)
Ocean
Suspended
Matter
Dissolved
Organic
Matter
Chlorophyll-a
Phytoplankton
（Chlorophyll-a）

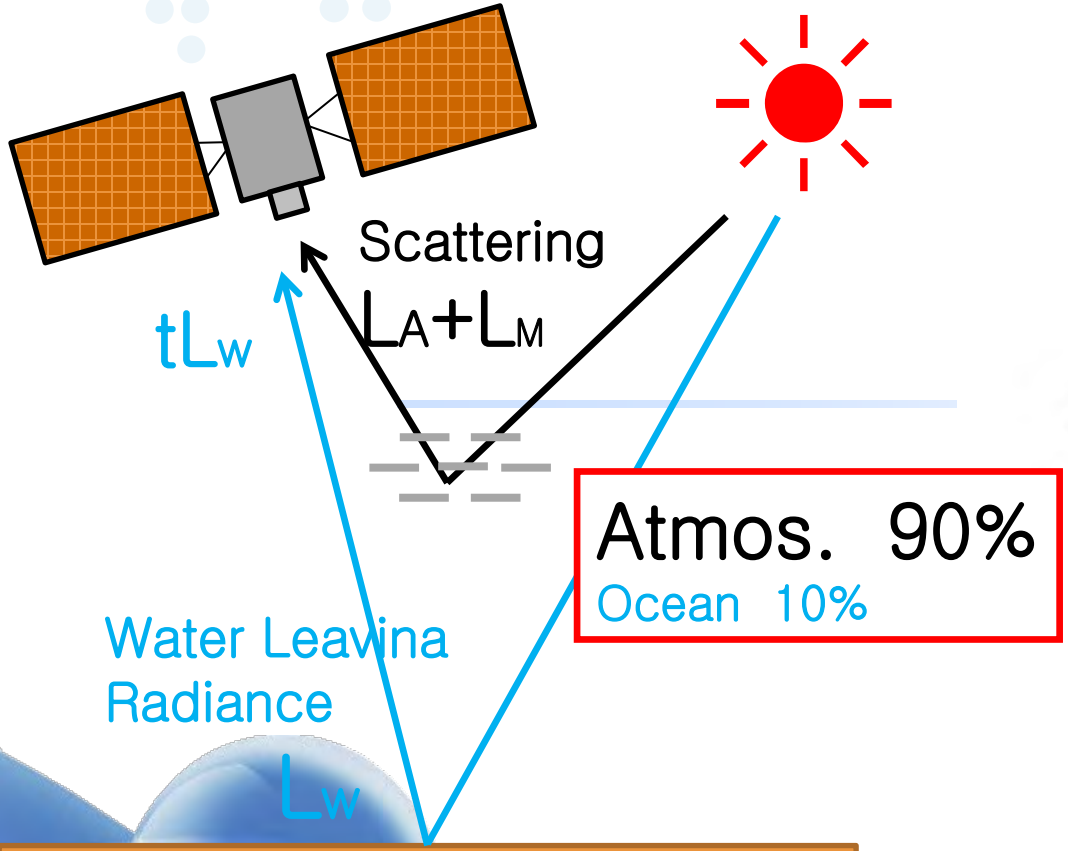
Bands of Ocean Color Sensors

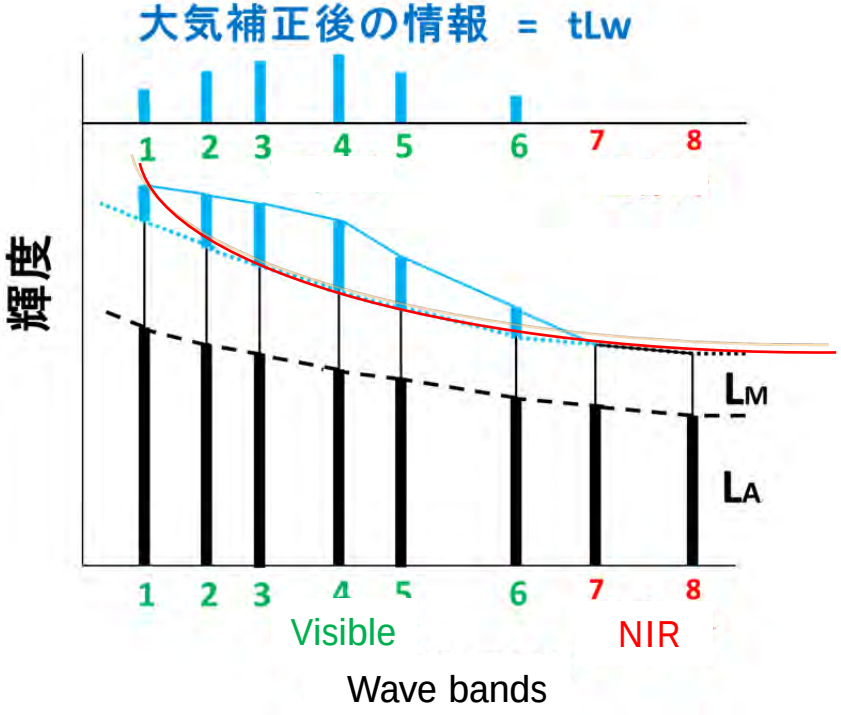
CZCS	OCTS	SeaWiFS	GLI	MODIS	MERIS	S-GLI
			380			380
			400			
	412	412	412	412	412.5	412
443	443	443	443	443	442.5	443
			460			
	490	490	490	488	490	490
520	520	520	520	531	510	530
			545	547		
550	565	555	565	555	560	565
			625	645	620	625
670	670	670	666	667	665	
			680	678	681	673.5
			710		705	
750	765	765	749	748	775	763
	865	865	865	870	865	868.5

Visible

Near Infrared (NIR)

Atmospheric Correction





L_A: Scattering by Aerosol

L_M: Scattering by Molecule

t: Diffuse Attenuation

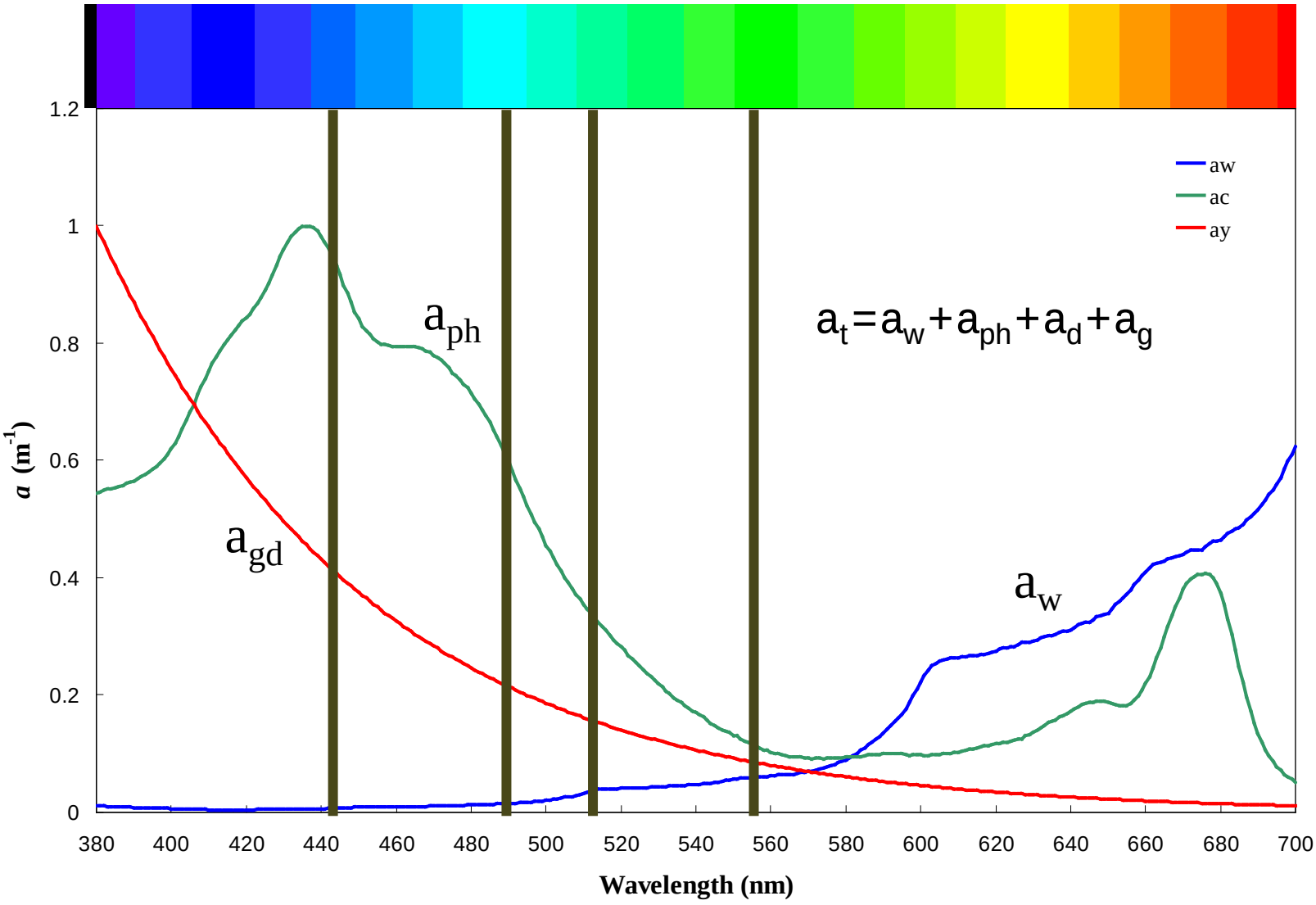
Estimate atmospheric radiance assuming no radiance from Ocean

↓

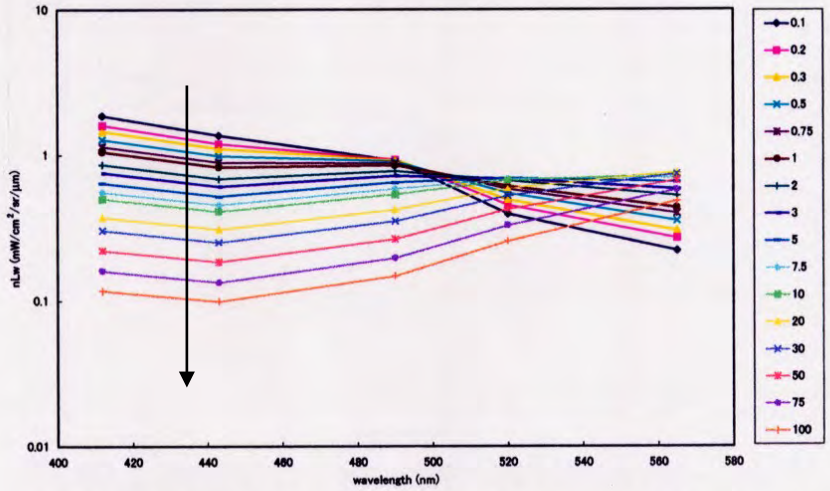
Overestimation of Atmoshare

➡Underestimation of Ocean

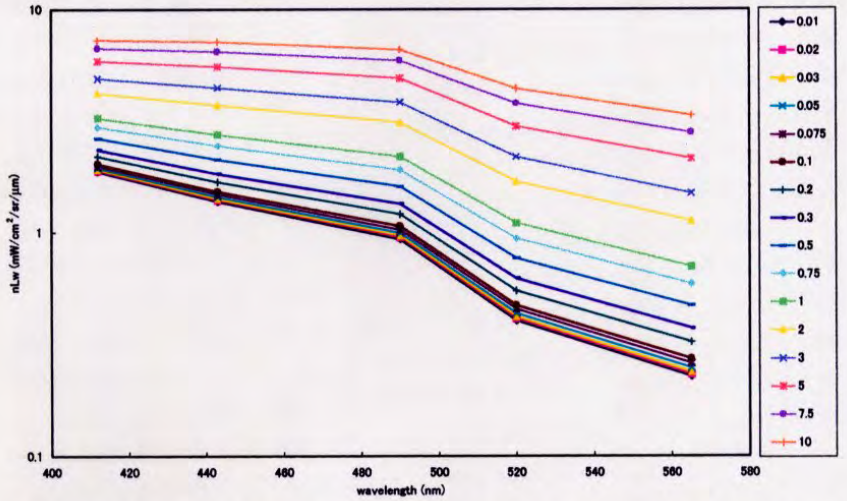
Absorption Spectra



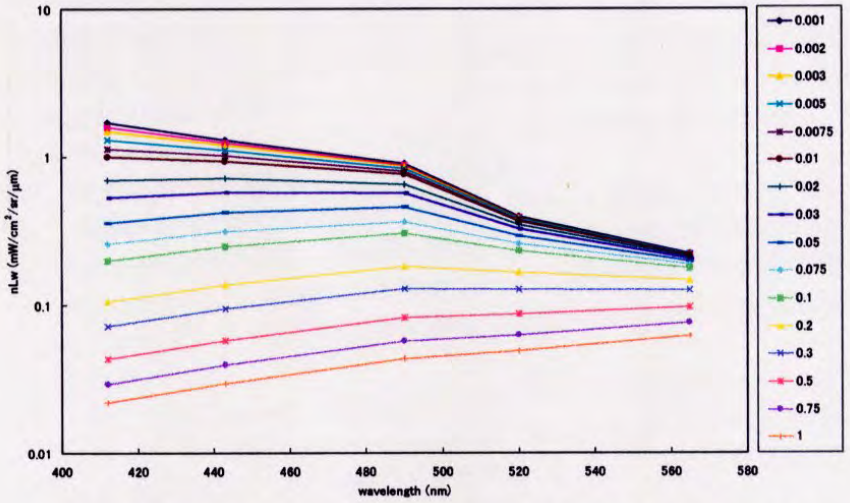
Coastal Waters with SS and CDOM



Chlorophyll a



Suspended Solid (SS)



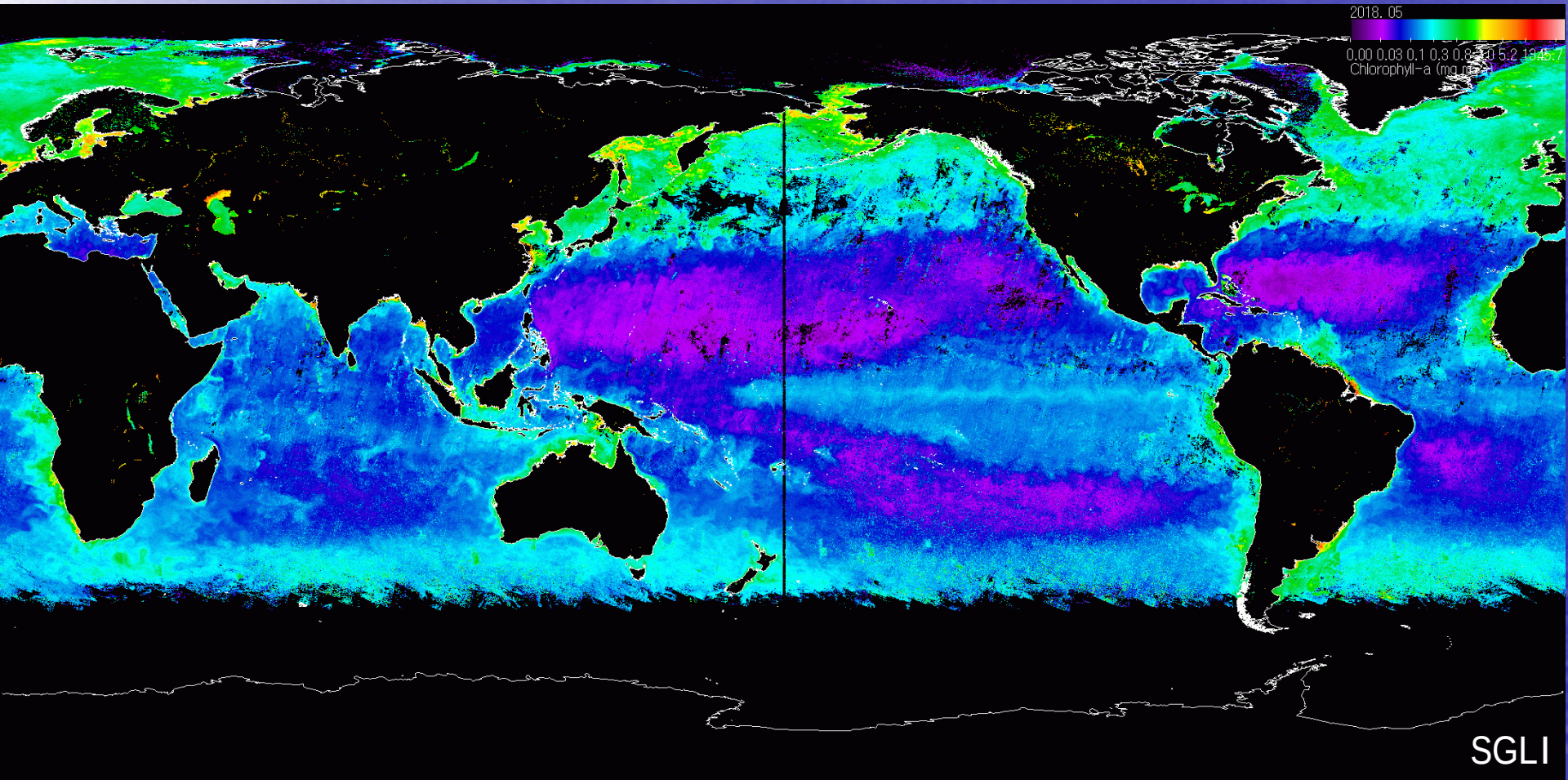
Colored Dissolved Organic Matter (CDOM)

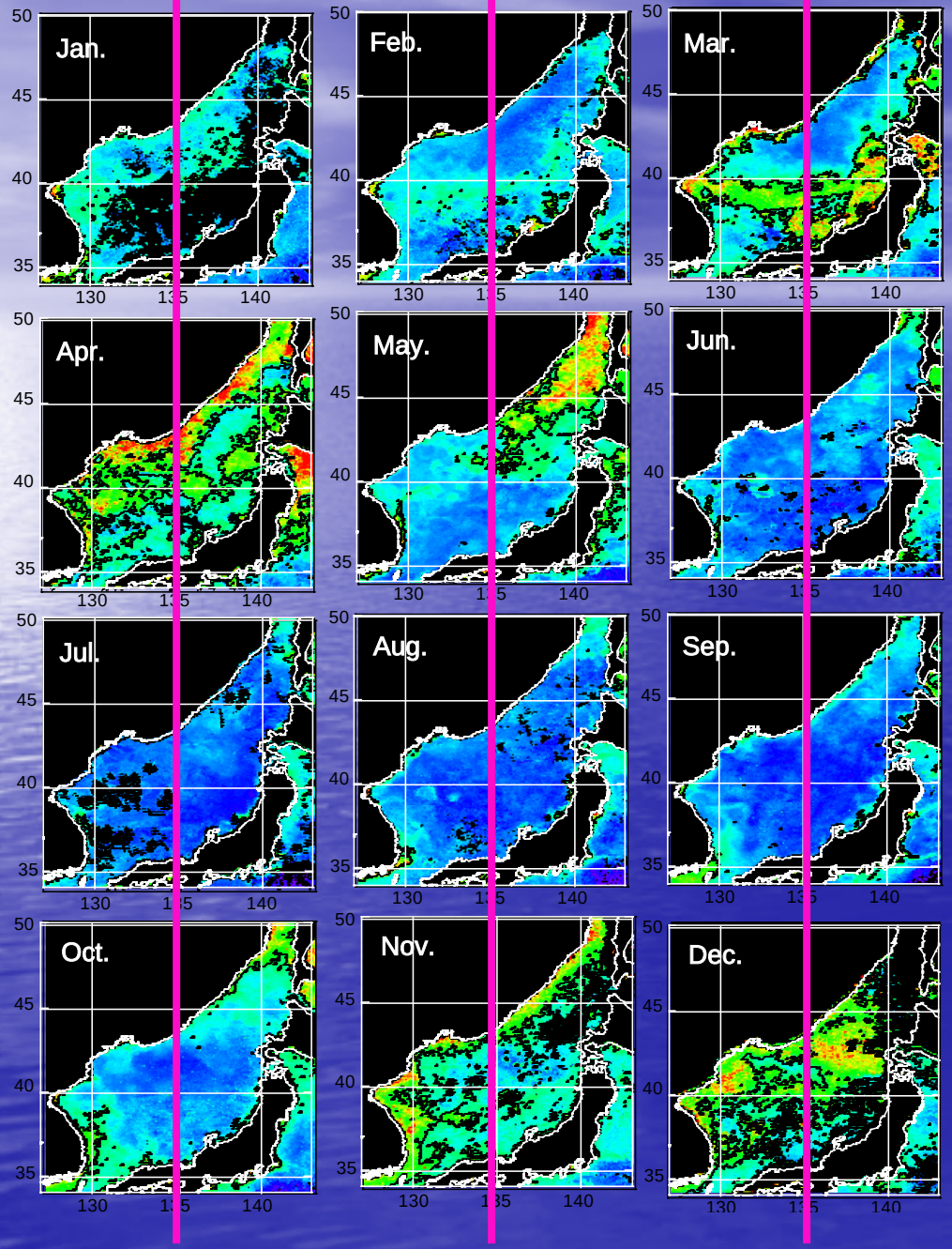
Problems

Optical Properties are different in different area.

It also affects to (NIR) atmospheric correction.

Seasonal Variation of Chl-a



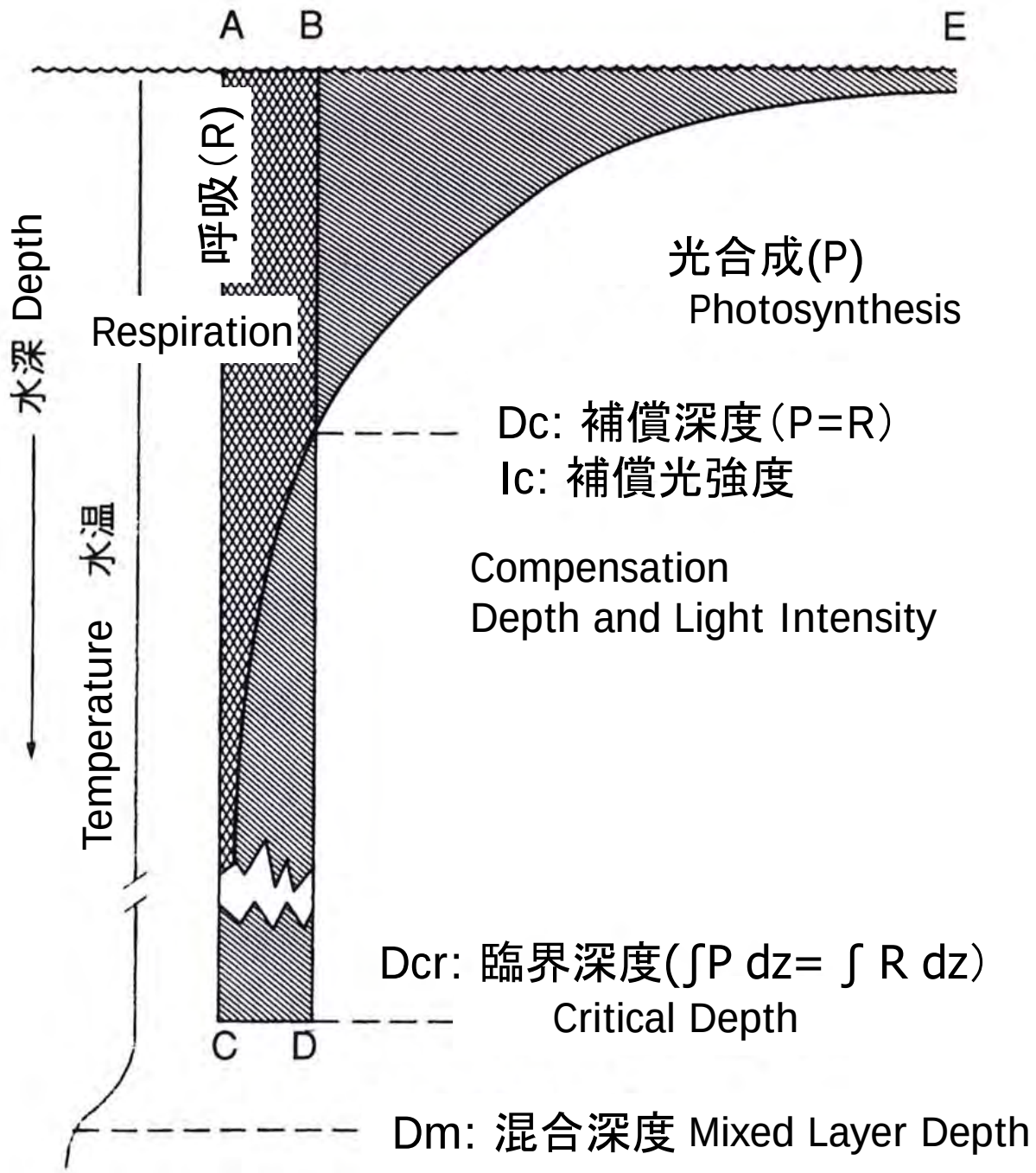


Seasonal Change of Chlorophyll in Japan Sea (1998)

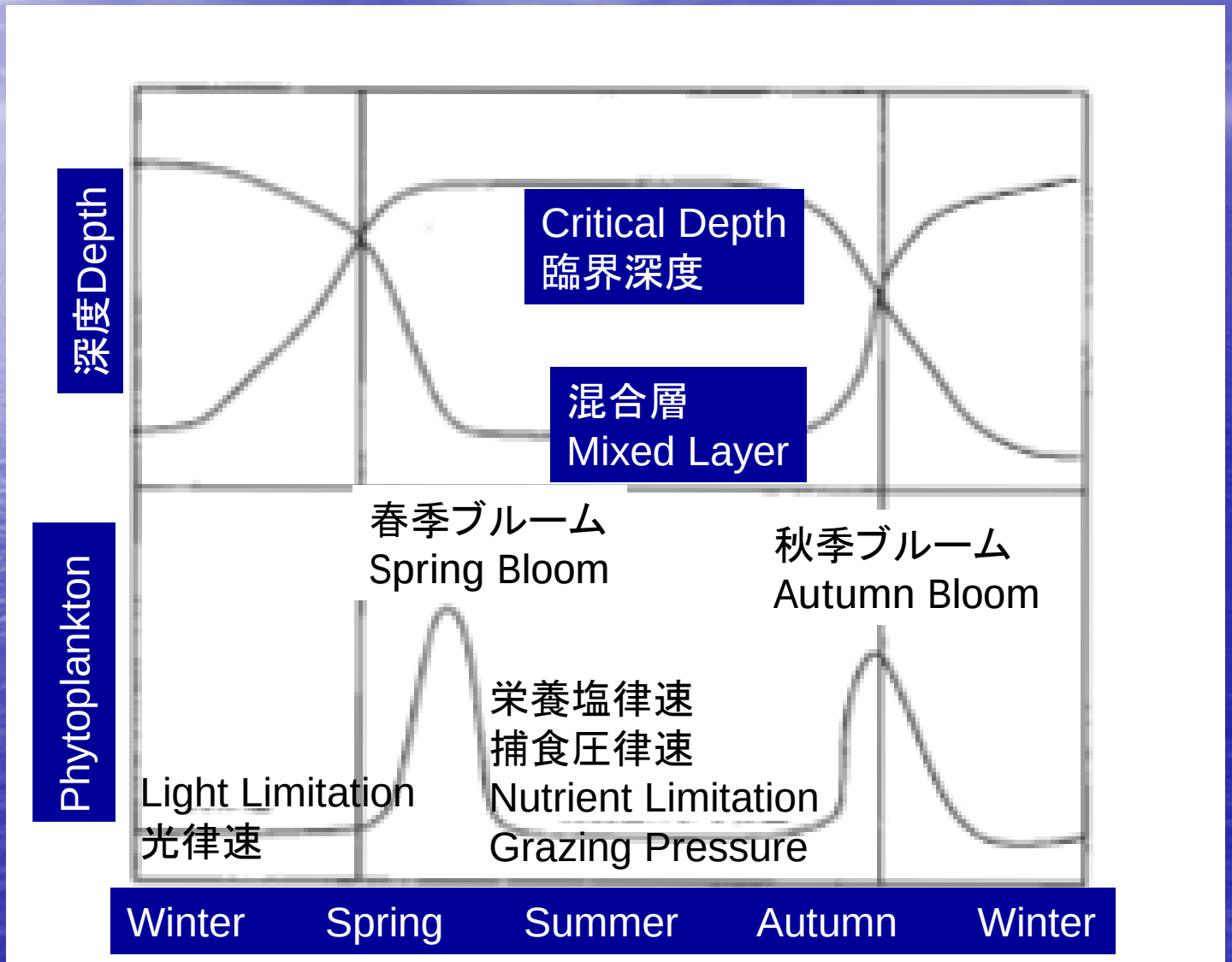
Chlorophyll a (mg m^{-3})

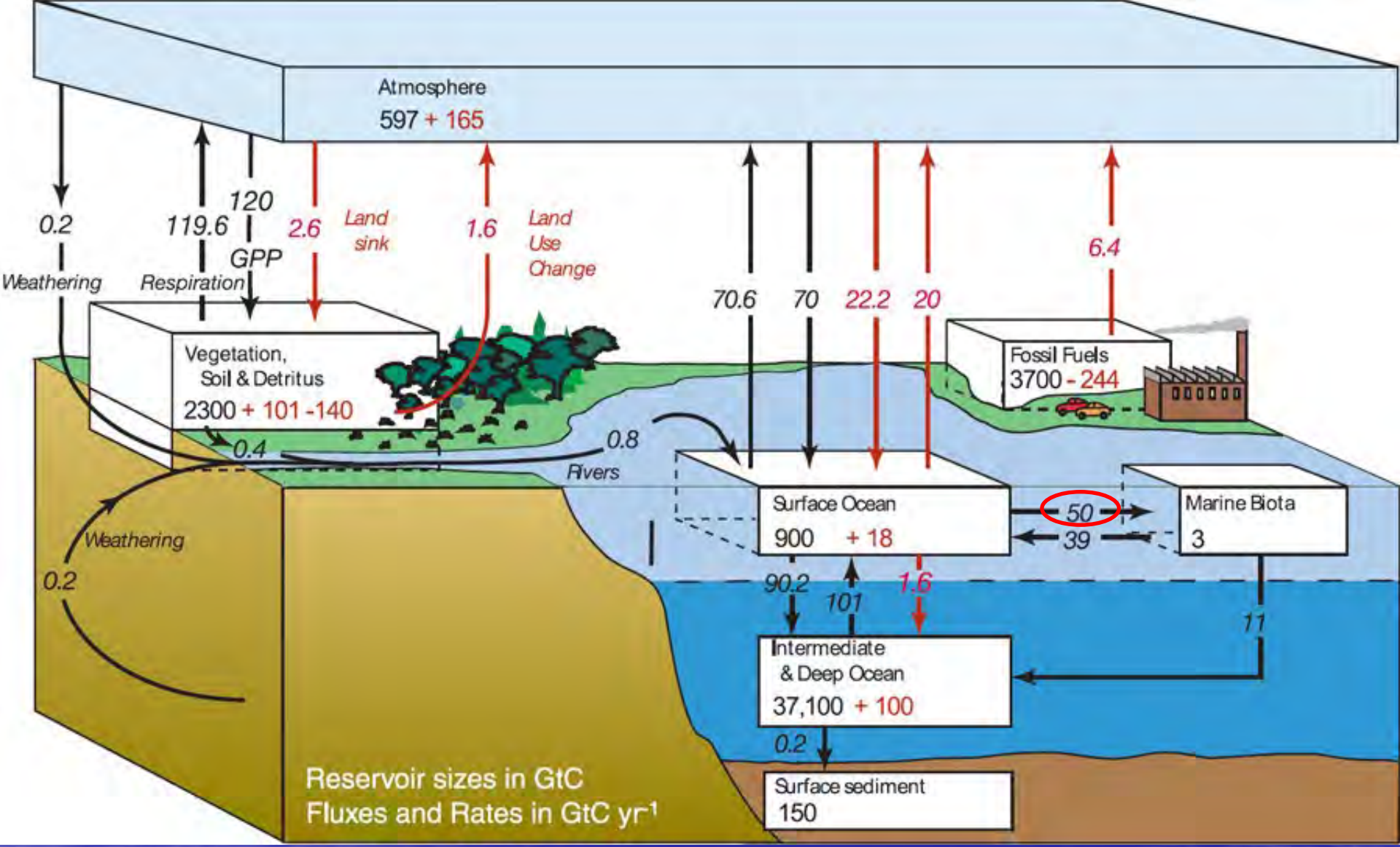
(Yamada and Ishizaka)

Critical Depth Theory



Spring and Autumn Bloom and Critical Depth/Mixed Layer Depth

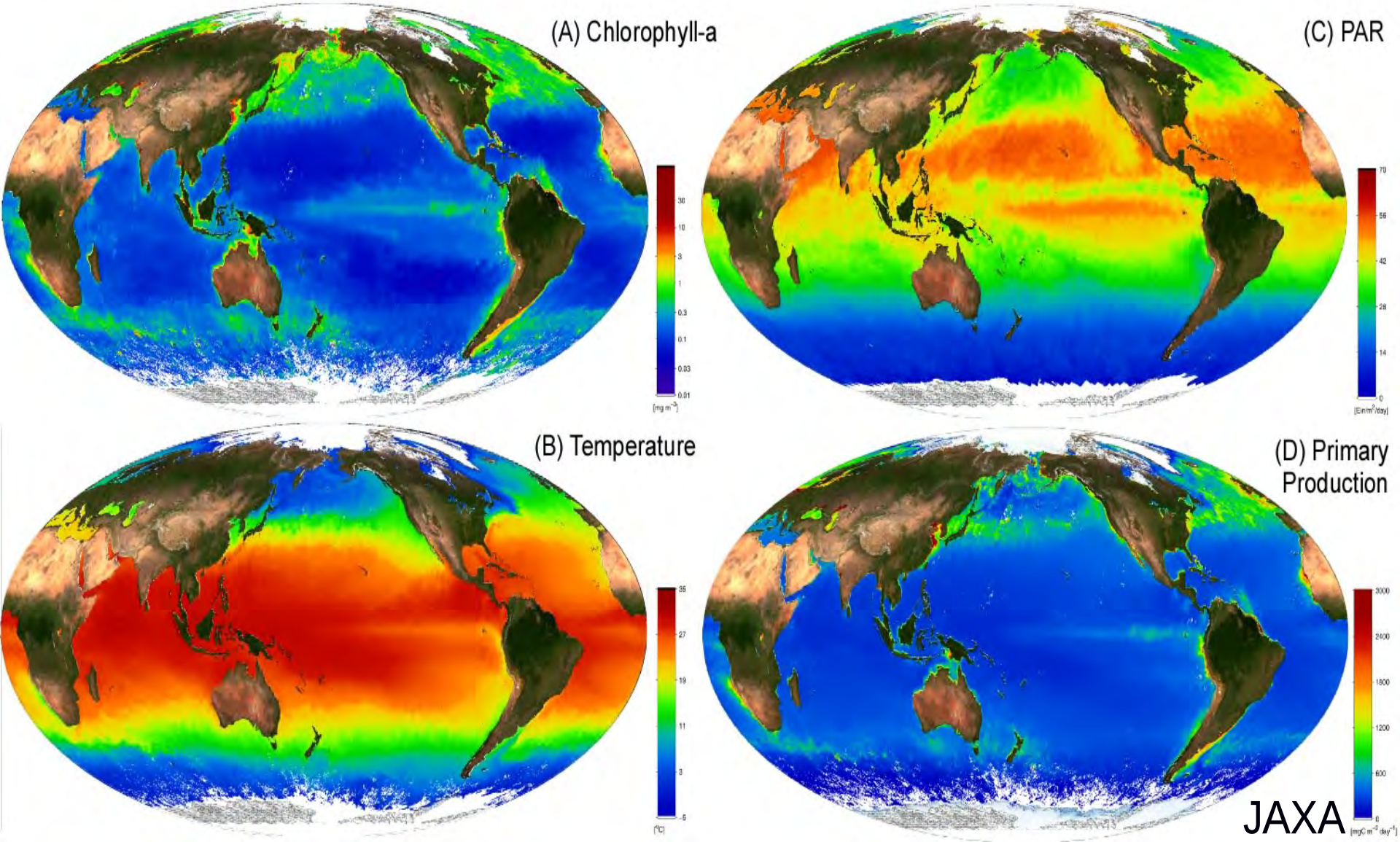




Global Carbon Cycle
Pre-industrial + 90's

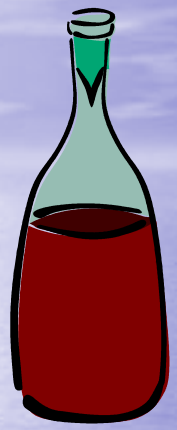
UCAR (2021) ⇐ IPCC (2007)

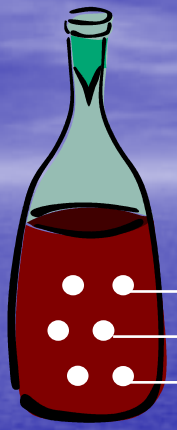
Chl-a, SST, PAR → Primary Production (April-June 2004)



Sampled water in bottle
Add ^{14}C or ^{13}C(HCO_3^-)
hrs～1day incubation
（Same Light Condition）
Carbon in Organic Matter

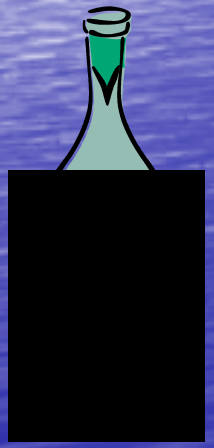
Light Bottle



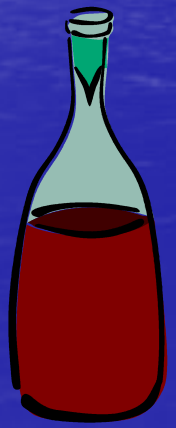


Organic ^{14}C・^{13}C

+$NaH^{14}CO3$ **Net Primary Production**



Dark Bottle



Blank

Measurements of Primary Production by $^{14}C/^{13}C$

Measurement of Primary Production

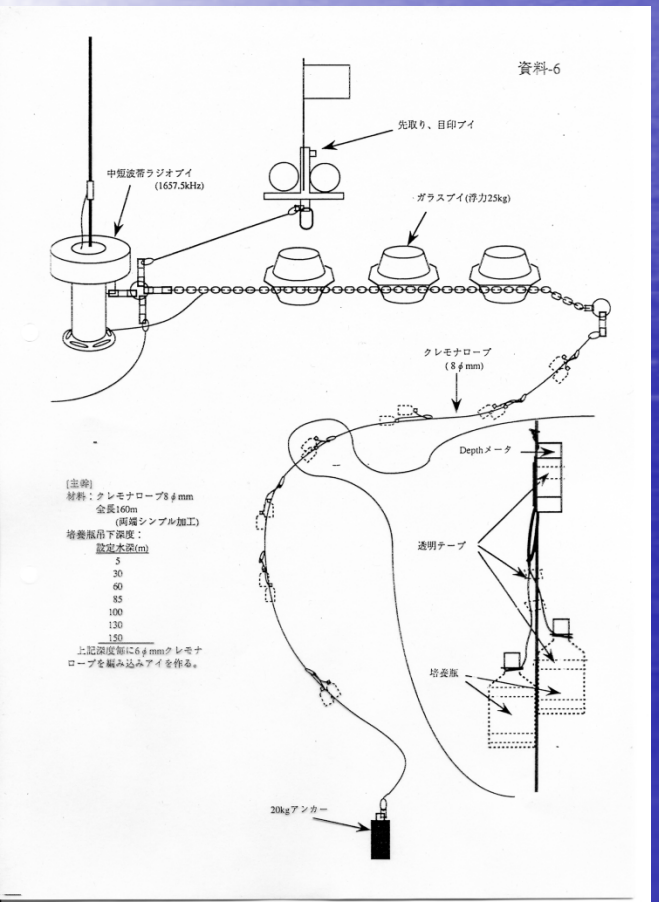
Incubation of water with ^{14}C or ^{13}C HCO_3^-

Hours to 1 day under same light (temp.) condition to field

Determine how much carbon accumulated to particles

（Production of oxygen）

In situ (**現場法**)



Simulated In Situ (**擬似現場法**)

Estimation of Global Primary Production

Riley (‘46)	126	DO method, several stations
Steemann Nielsen (‘55)	15	^{14}C methods
Ryther (‘69)	20	Ocean:Coast:Upwelling= 90:9.9:0.1
Koblentz-Mishke et al.(‘70)	23	7000 data
Lieth and Whittaker (‘75)	18.6	Fleming (‘57)
Platt and Sabbarao (’75)	31	Summaries areal data
Eppley and	19.1	Modified Koblentz-Mishke et al. (‘70)
Peterson (‘79)	23.7	Modified Platt and Subba Rao (‘75)
Romankevich(‘84)	25	Modified Koblentz-Mishke et al. (‘70)
Shushkina (‘85)	56	130 stations (‘68-’82)
Berger et al. (‘87)	26.9	8000 stations (mostly ‘70-)
Martin et al. (‘87)	51	Ryhter (‘69) method + Clean Method
Longhurst et al. (‘95)	45-51	Satellite data (CZCS) + biological provinces

2008- Gree Tide

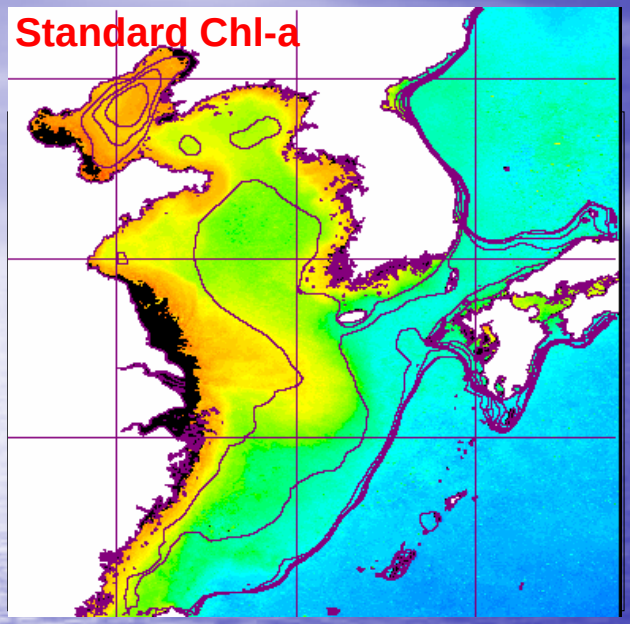
2002-
Giant
Jellyfish

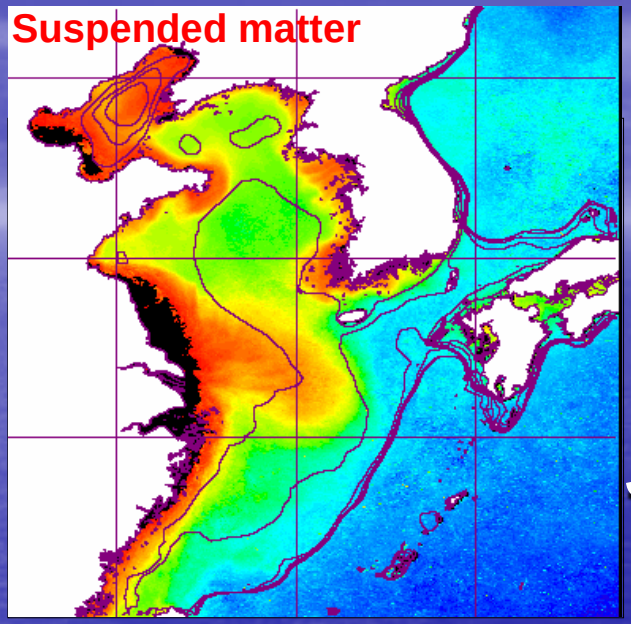
2000-
Red tide

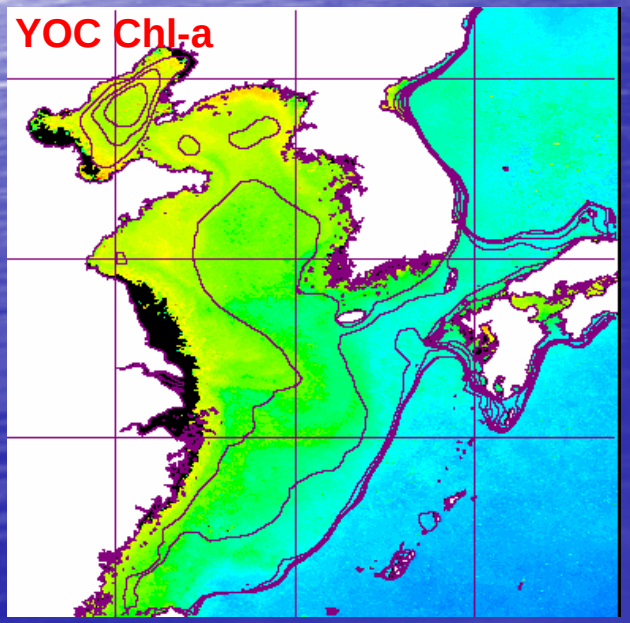
Three Gorge Dam
1993-

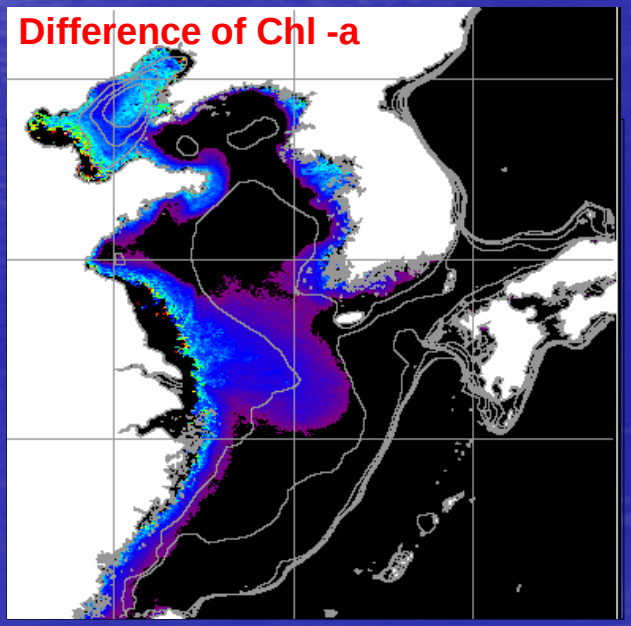
(Siswanto et al, JO-11,
Yamaguchi et al. CSR-13)

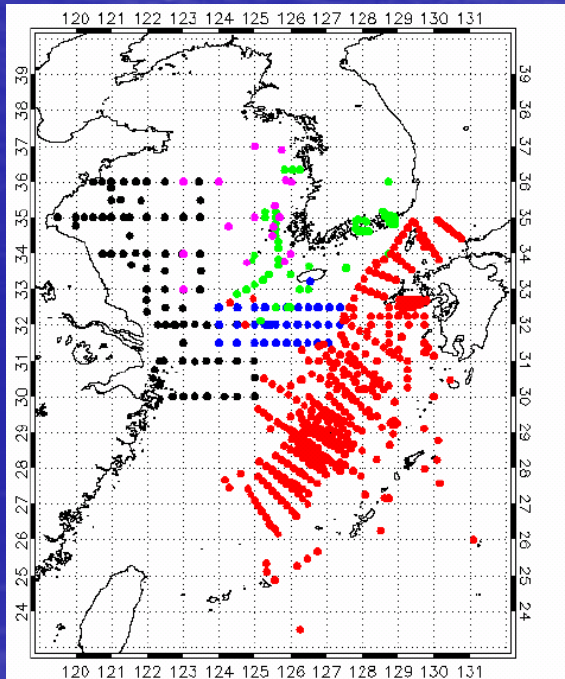
Development of New Chl-a Algorithm with Collaboration of Japan-Korea-China





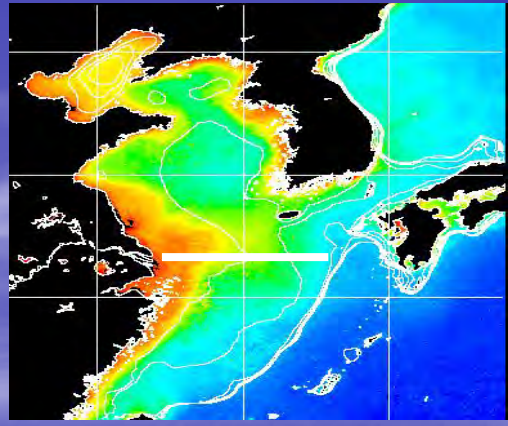


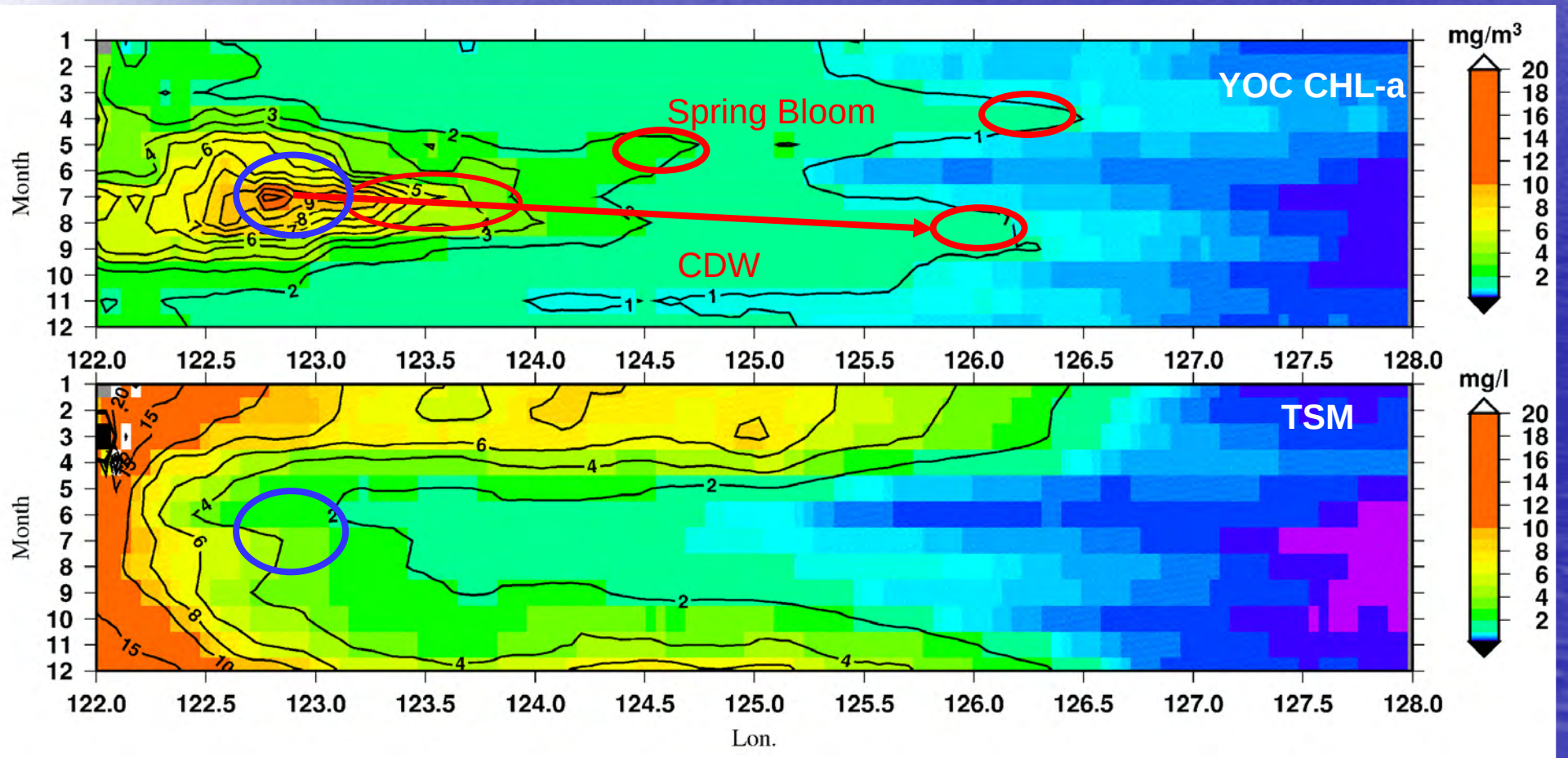




Seasonal Changes of Chl-a and TSM in ECS

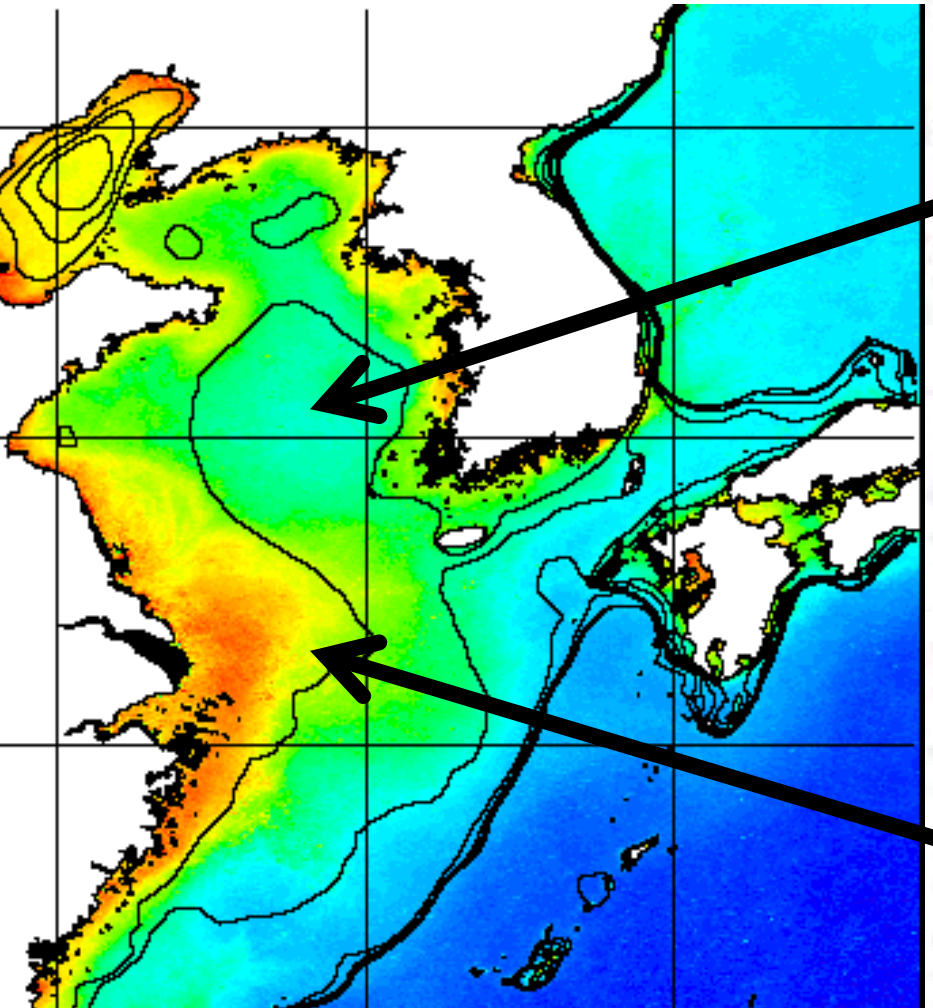
(Yamaguchi et al. CSR-13)

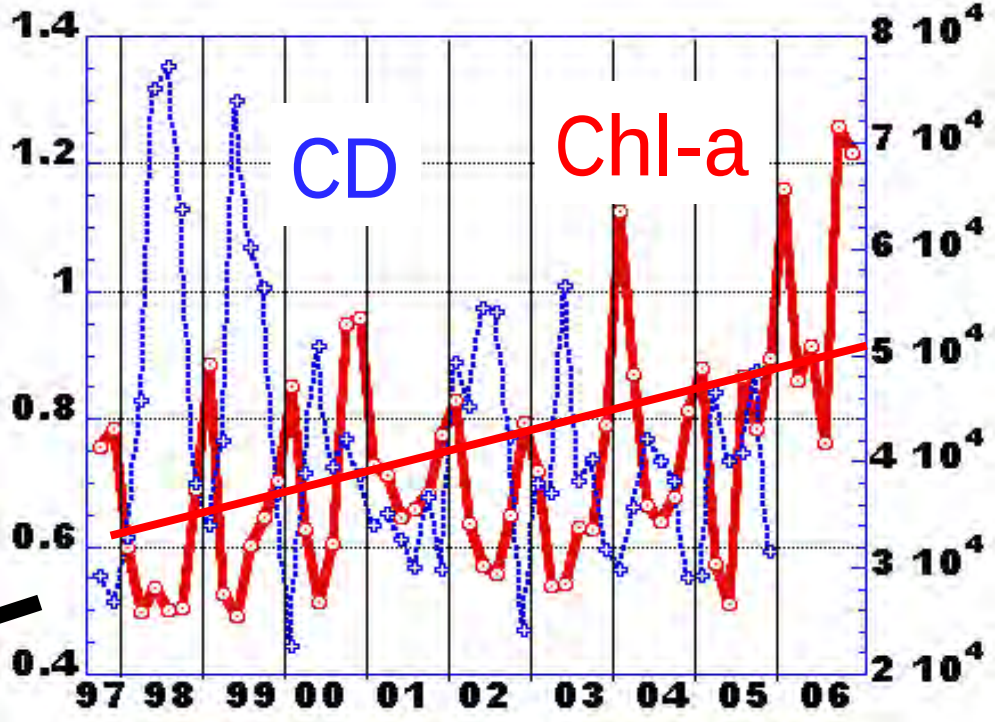


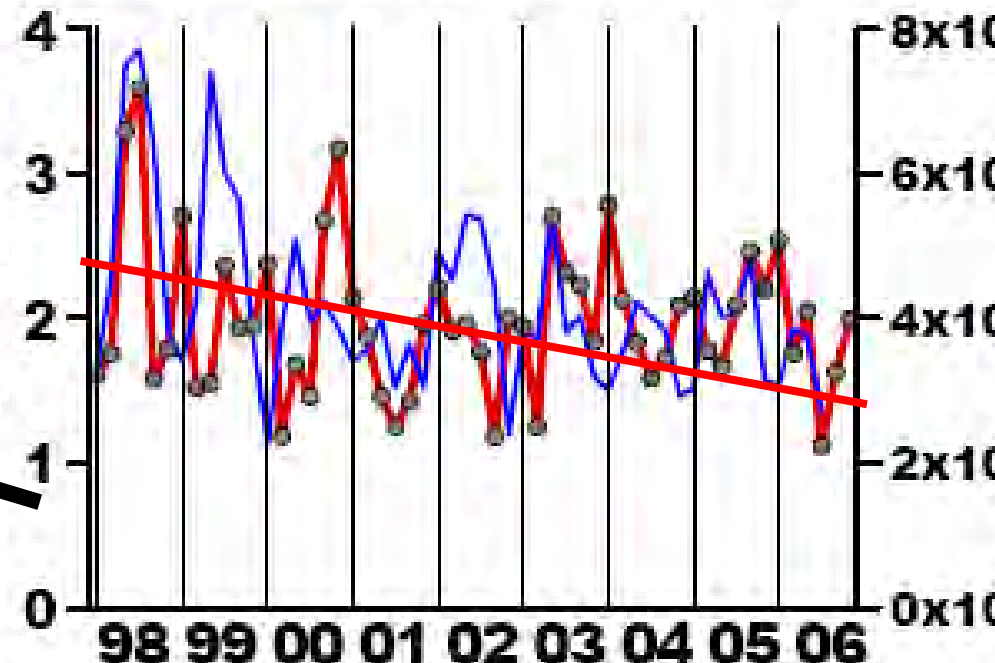


erannual Chang of Chl-a nd Changjian Discharge

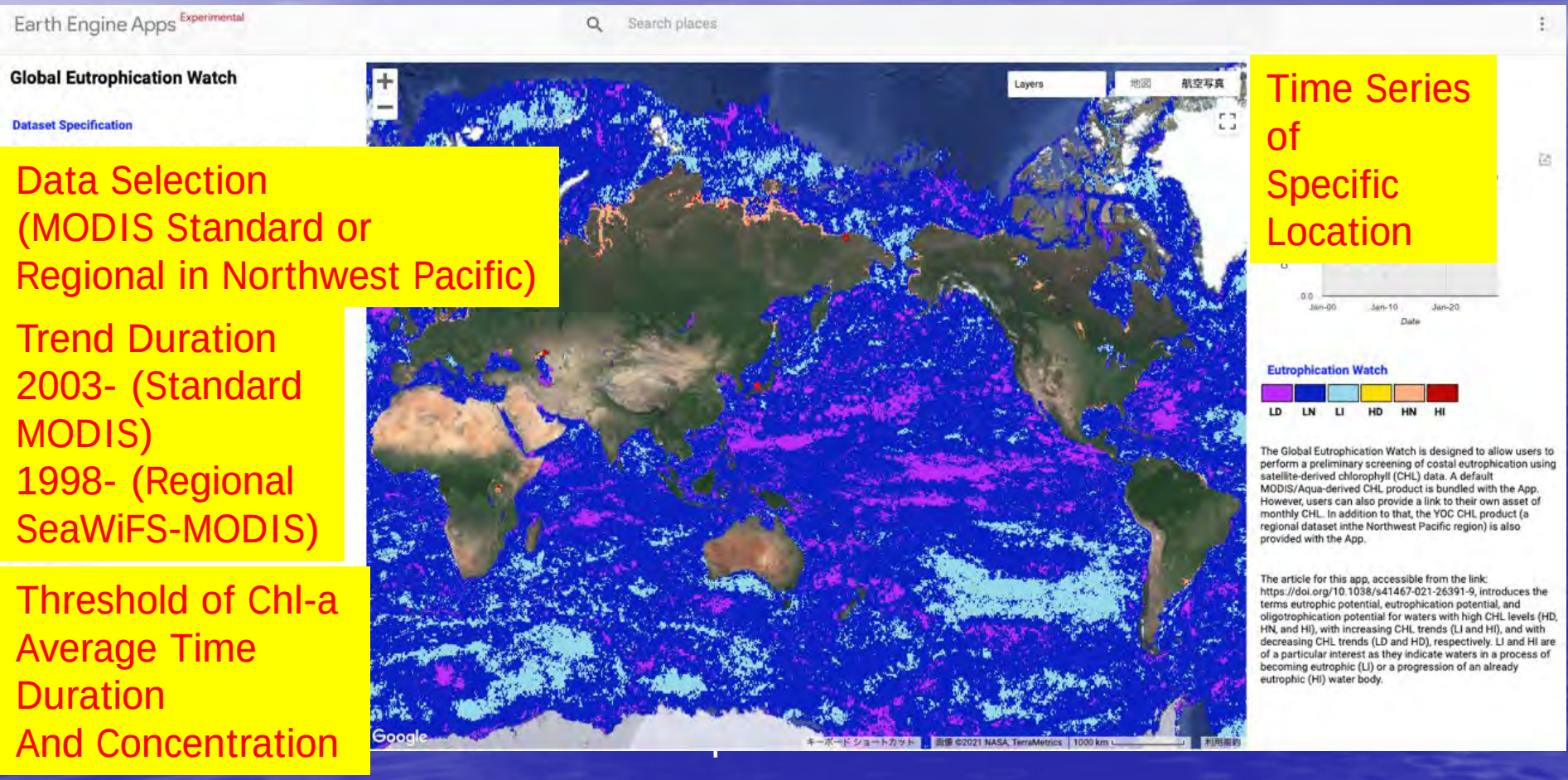
(Yamaguchi et al. Prog.Oceanogr. 2012)







Global Eutrophication Watch



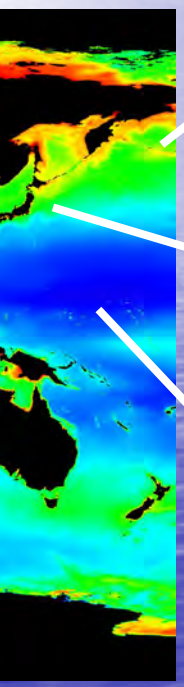
Data Selection
(MODIS Standard or
Regional in Northwest Pacific)

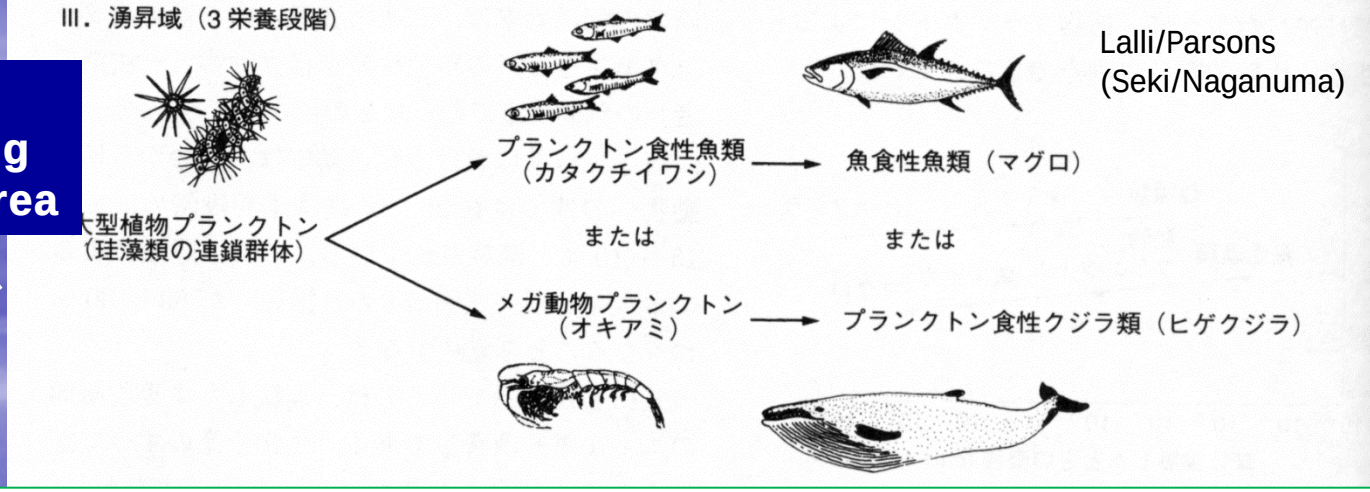
Trend Duration
2003- (Standard MODIS)
1998- (Regional SeaWiFS-MODIS)

Threshold of Chl-a
Average Time Duration
And Concentration

Warming?

Polar Upweling Small Area

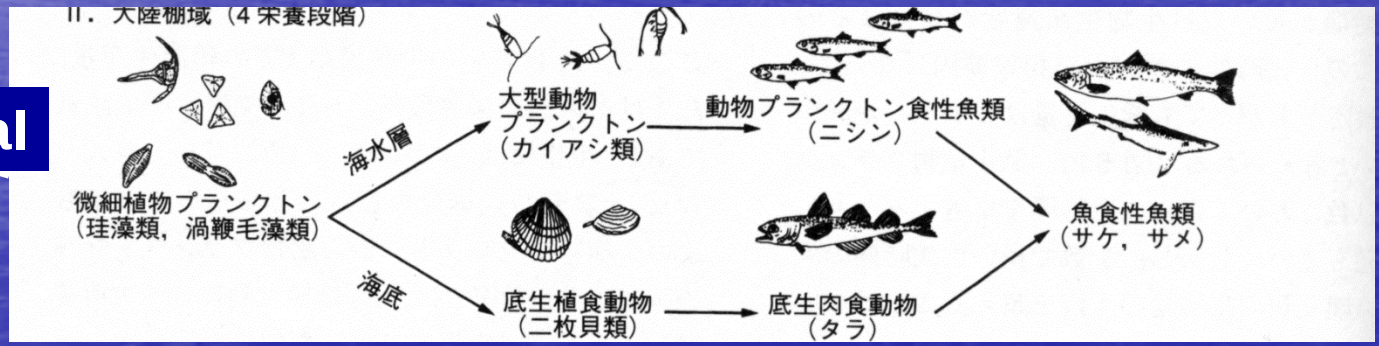




Lalli/Parsons
(Seki/Naganuma)

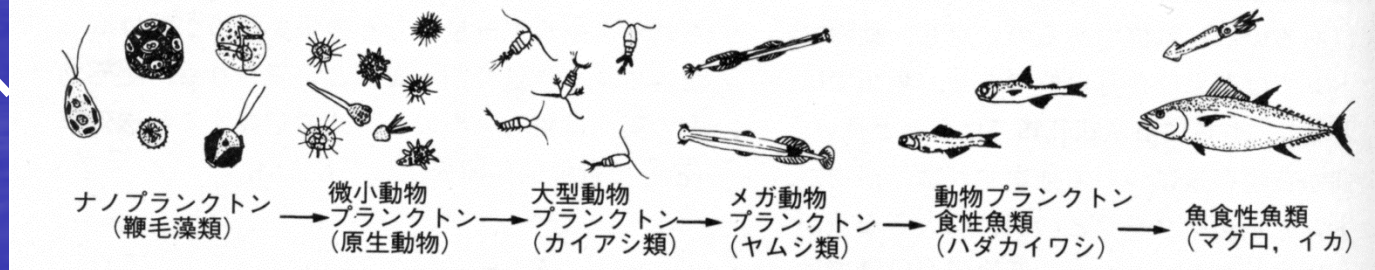
Rich N⇒Much, Large Phytoplankton ⇒High Fish Prod

Coastal



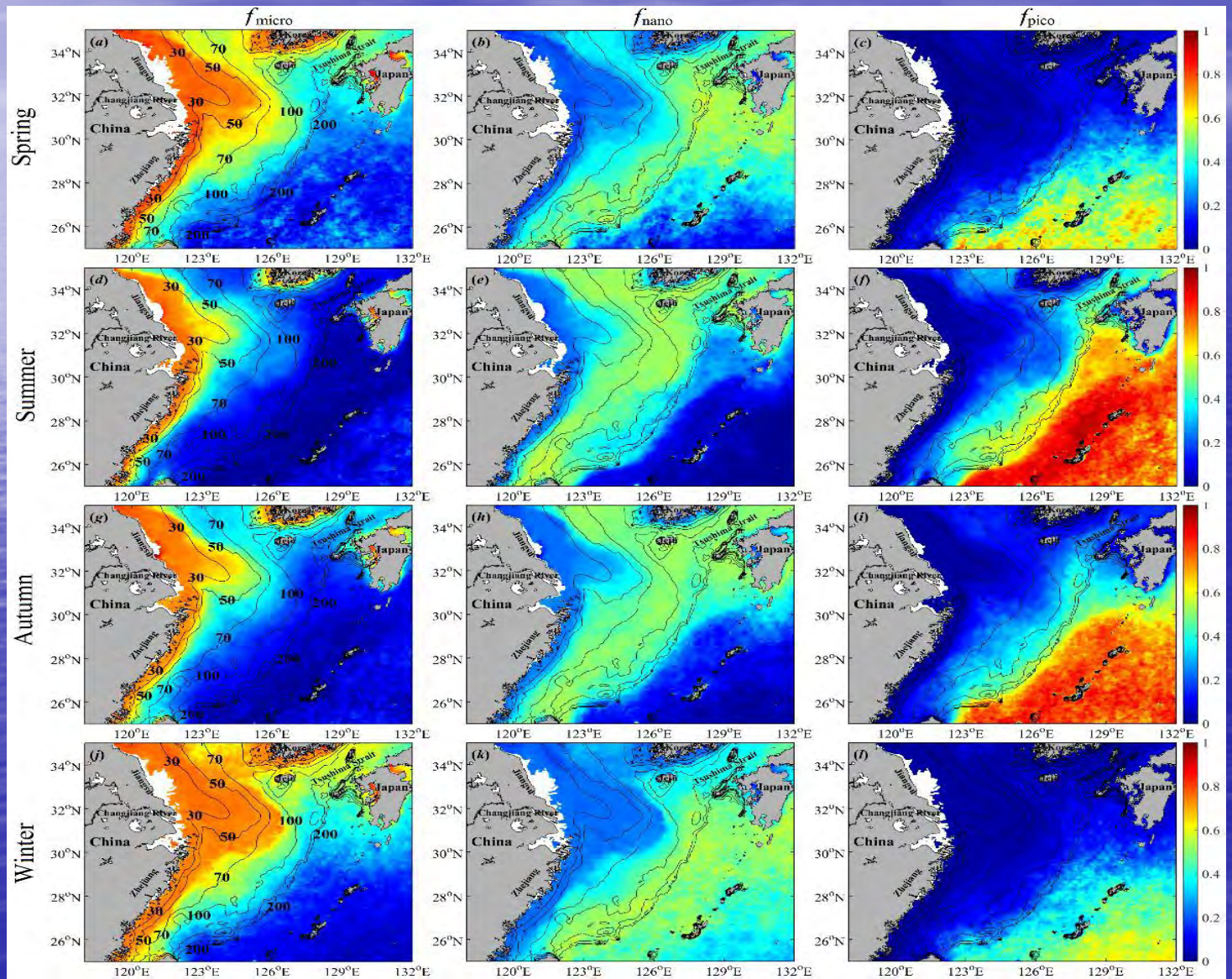
Open Ocean Large Area

Pool N⇒Less, Small Phytoplankton ⇒Low Fish Prod



Different Ecosystem

Phytoplankton Size in the East China Sea (Zhang et al., 2018)



Questions

- What is the good relation between human and ocean?
- We do not know much about ocean.
- Ocean is definitely changing with the influence of human.
- How to manage?
- What is the best condition?