Southeast Asian Fisheries Development Council
Training Department

The 65th Short-term Training Course for University Students

"Ecosystem-Based Fisheries for Sustainable Fisheries Resources Management"

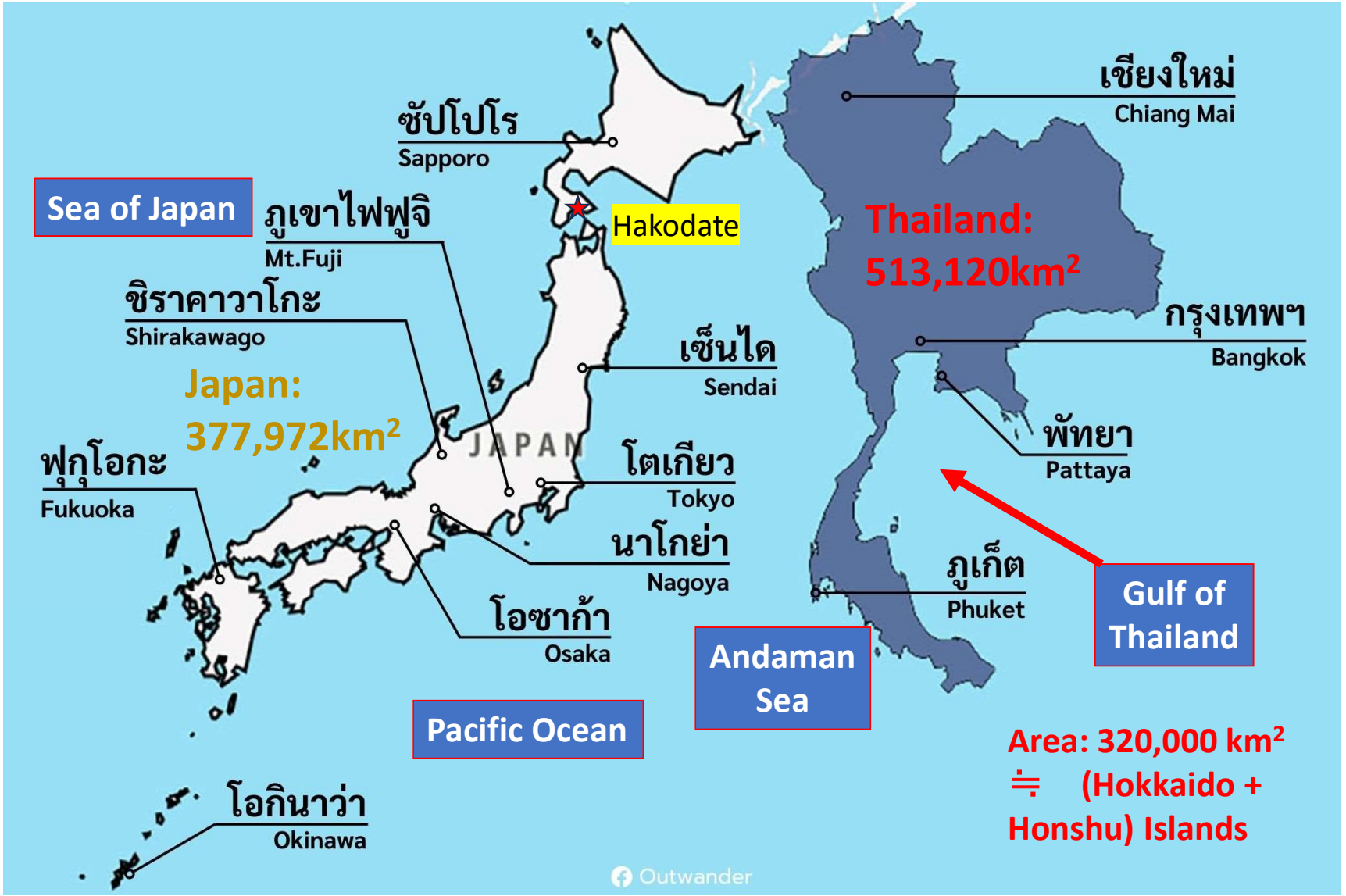
Hokkaido University
Fisheries

Oceanography in the Gulf of Thailand

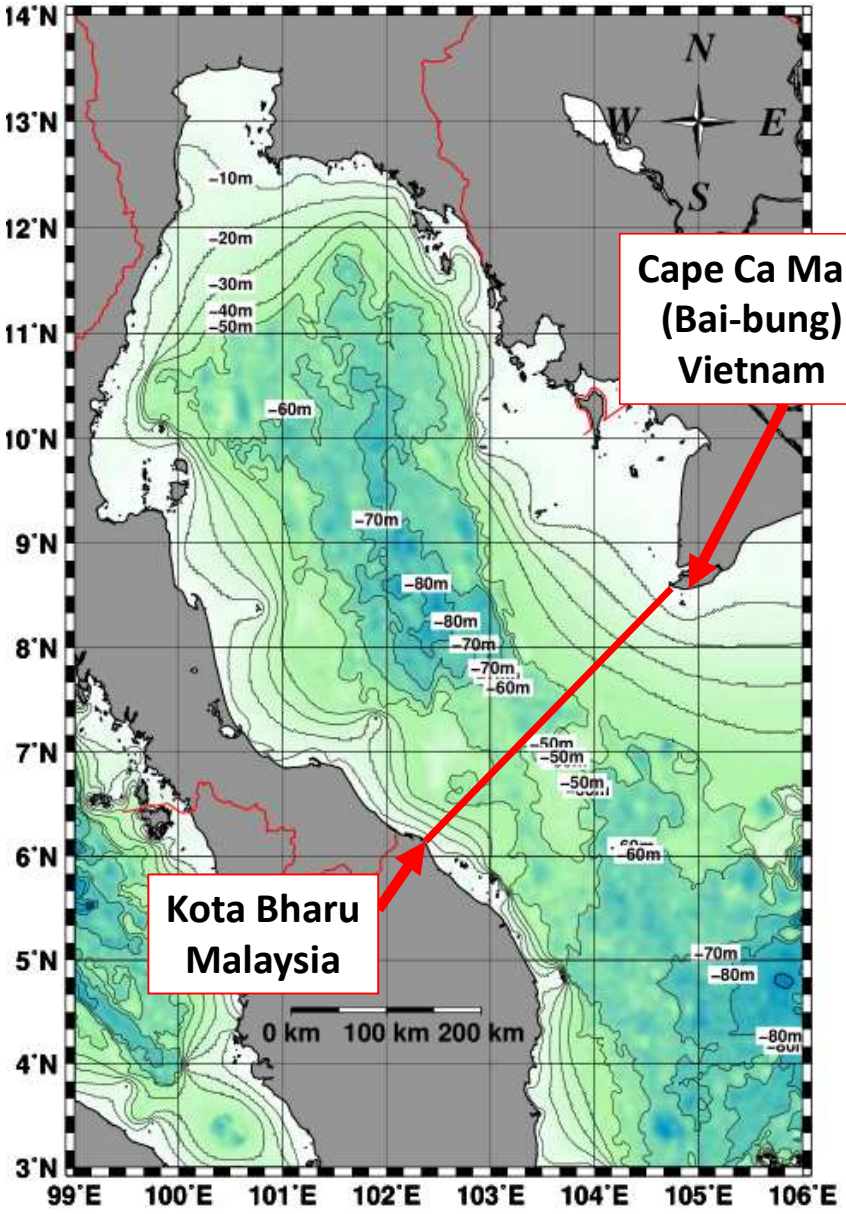
Hiroji Onishi

20th of May 2025, 13:00~14:30

onishi@fish.hokudai.ac.jp


เชียงใหม่
Chiang Mai
ซัปโปโร
Sapporo
Sea of Japan
ภูเขาไฟฟูจิ
Mt.Fuji
Hakodate
Thailand:
513,120km²
ชิราคาวาโกะ
Shirakawago
กรุงเทพฯ
Bangkok
เซ็นได
Sendai
Japan:
377,972km²
JAPAN
พัทยา
Pattaya
ฟุกุโอกะ
Fukuoka
โตเกียว
Tokyo
นาโกย่า
Nagoya
ภูเก็ต
Phuket
Gulf of
Thailand
โอซาก้า
Osaka
Andaman
Sea
Pacific Ocean
Area: 320,000 km²
≒ (Hokkaido +
Honshu) Islands
โอกินาว่า
Okinawa
Outwander

Gulf of Thailand



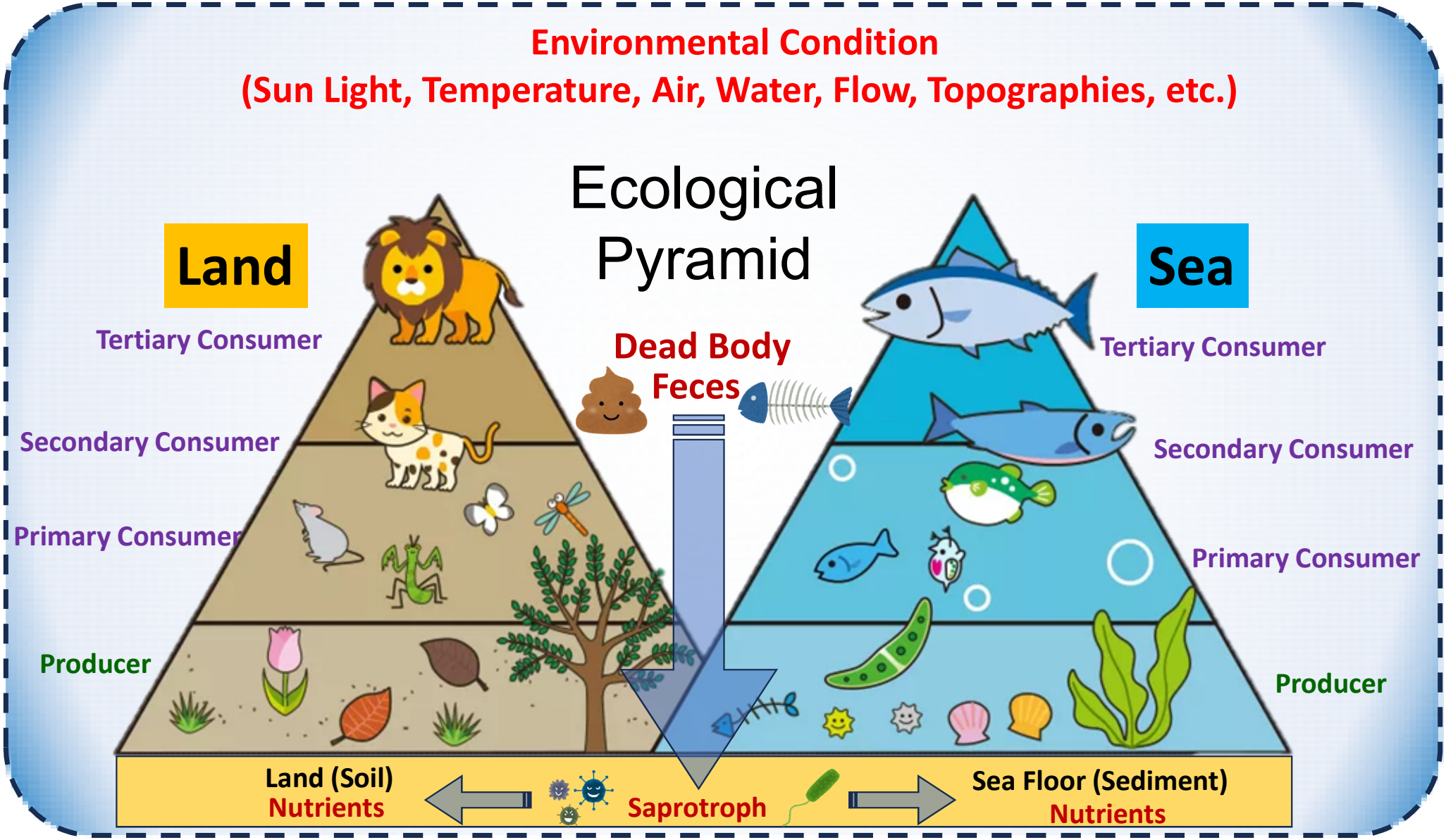
Many Tourist Spots

Many
Fishing Products

Geographical Feature

Area: 320,000 km^2
Length: 800 km
Width: 560 km
Max. Depth: 85 m
Ave. Depth: 58 m
Water Vol.: 12,510 km^3
(Stansfield & Garrett 1997)

Gulf of Thailand ⇔ South China Sea


Environmental Condition
(Sun Light, Temperature, Air, Water, Flow, Topographies, etc.)
Ecological Pyramid
Land
Sea
Tertiary Consumer
Secondary Consumer
Primary Consumer
Producer
Dead Body
Feces
Tertiary Consumer
Secondary Consumer
Primary Consumer
Producer
Land (Soil)
Nutrients
Saprotroph
Sea Floor (Sediment)
Nutrients

Producer
(Primary Production) ≒ Plants (Photosynthesis)

On Land

In Water

Periphyton

Algae

Phytoplankton

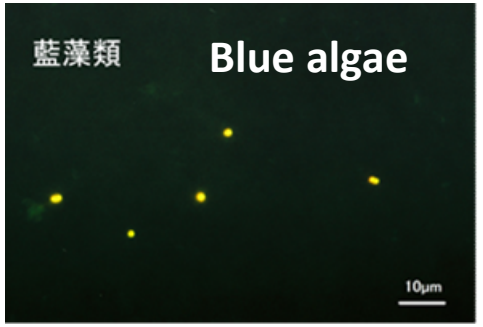
Land Tree

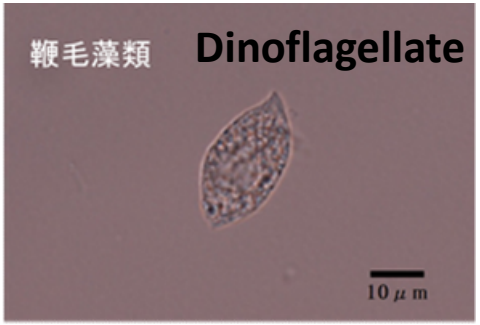
Seed Plants

Land Grass

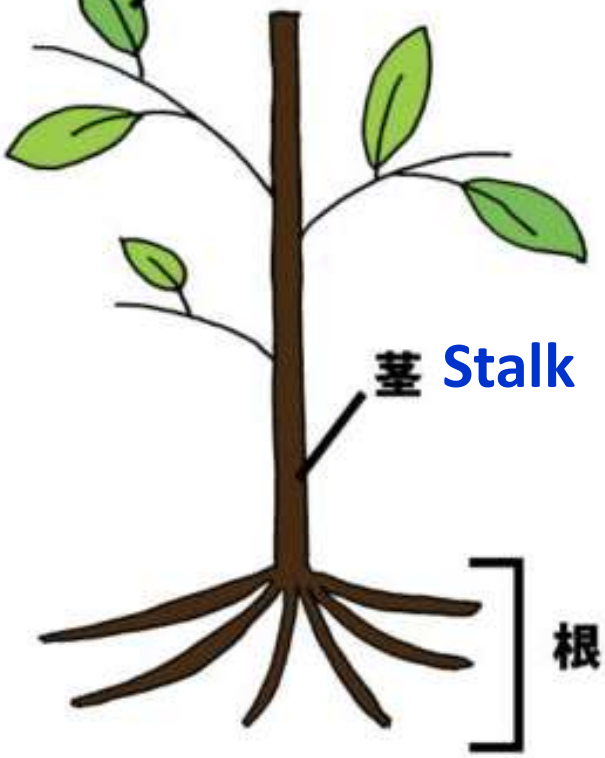
Seaweed (Giant Kelp)

Seagrass





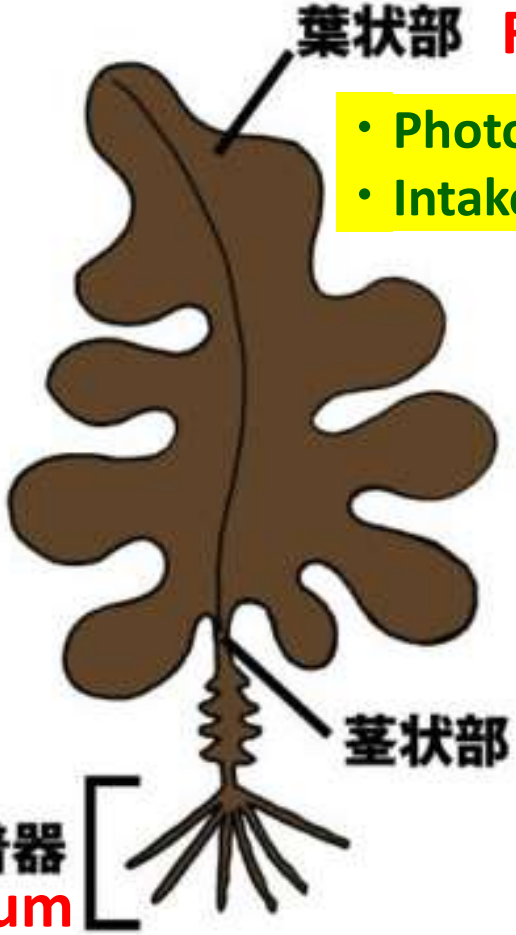
Plant on Land



- Holding Land
- Intake Water & Nutrients

≠

Sea alga / Seaweed

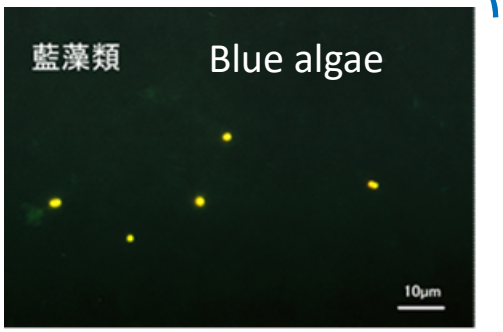


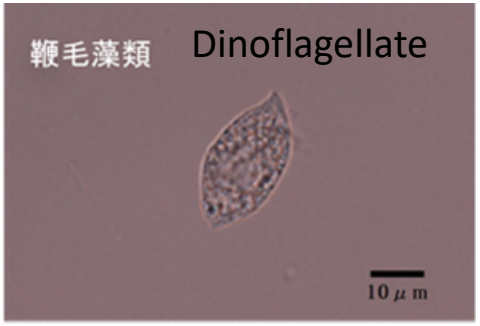
- Photonic Synthesis
- Intake Water & Nutrients

Holding sea floor

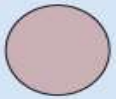
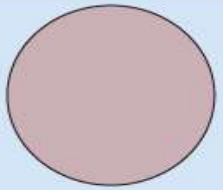
Why the phytoplankton is so small ?

Phytoplankton





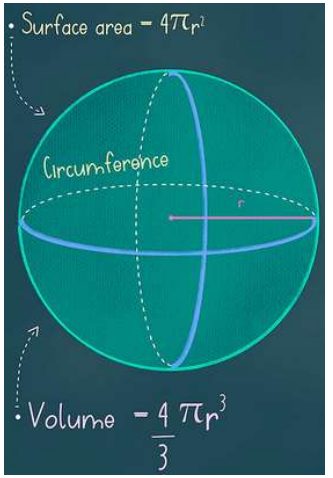
Area-to-Volume ratios

Relative Size			
Radius [L: unit]	1	2	4
Area [L^2: $unit^2$]	$1^2 = 1$	$2^2 = 4$	$4^2 = 16$
Volume [L^3: $unit^3$]	$1^3 = 1$	$2^3 = 8$	$4^3 = 64$
Area / Volume	1/1 = 1	4/8 = 1/2	16/64 = 1/4
Conclusions	1. Most area per unit volume 2. Most drag per unit volume 3. Slowest rate of settling	← ← →	Least area per unit volume Least drag per unit volume Fastest rate of settling

To keep staying in surface layer Large surface area par unit volume

Sink Slower

Sink Faster



Sphere's Projected Area $=\pi r^2$

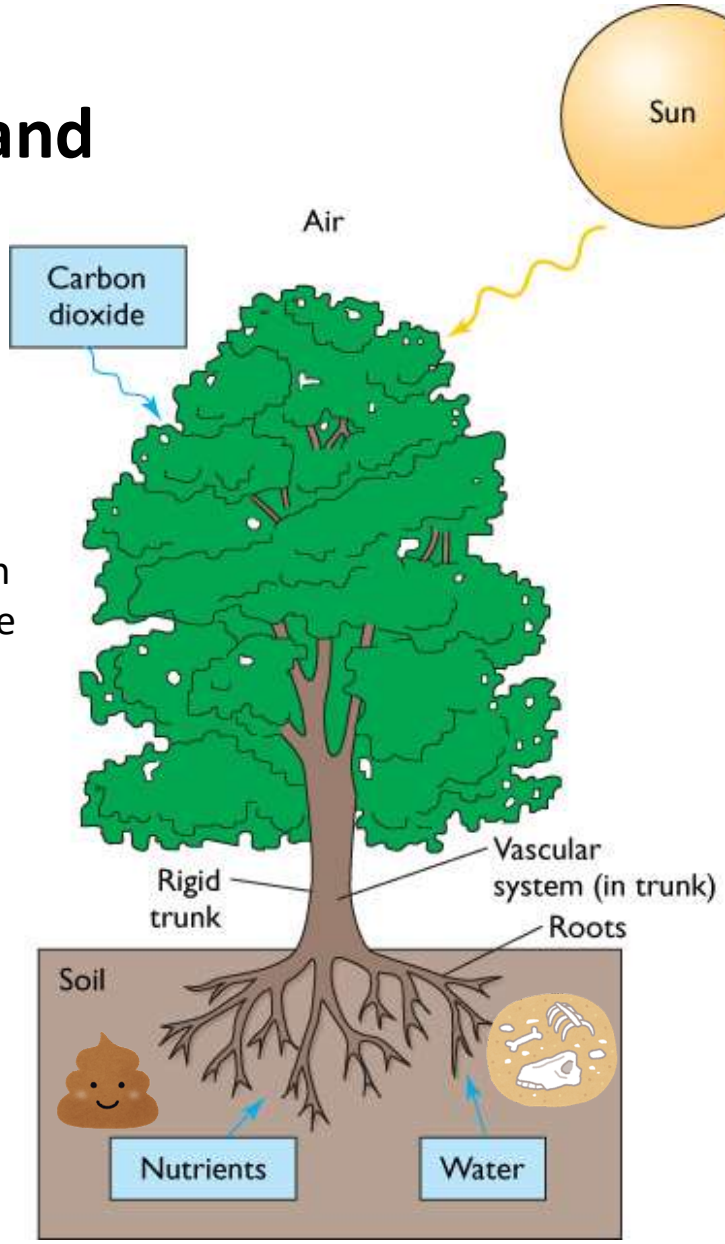
Surface Area $=4 \times \pi r^2$

Volume $=4/3 \times \pi r^3$ (≈Mass) when same density

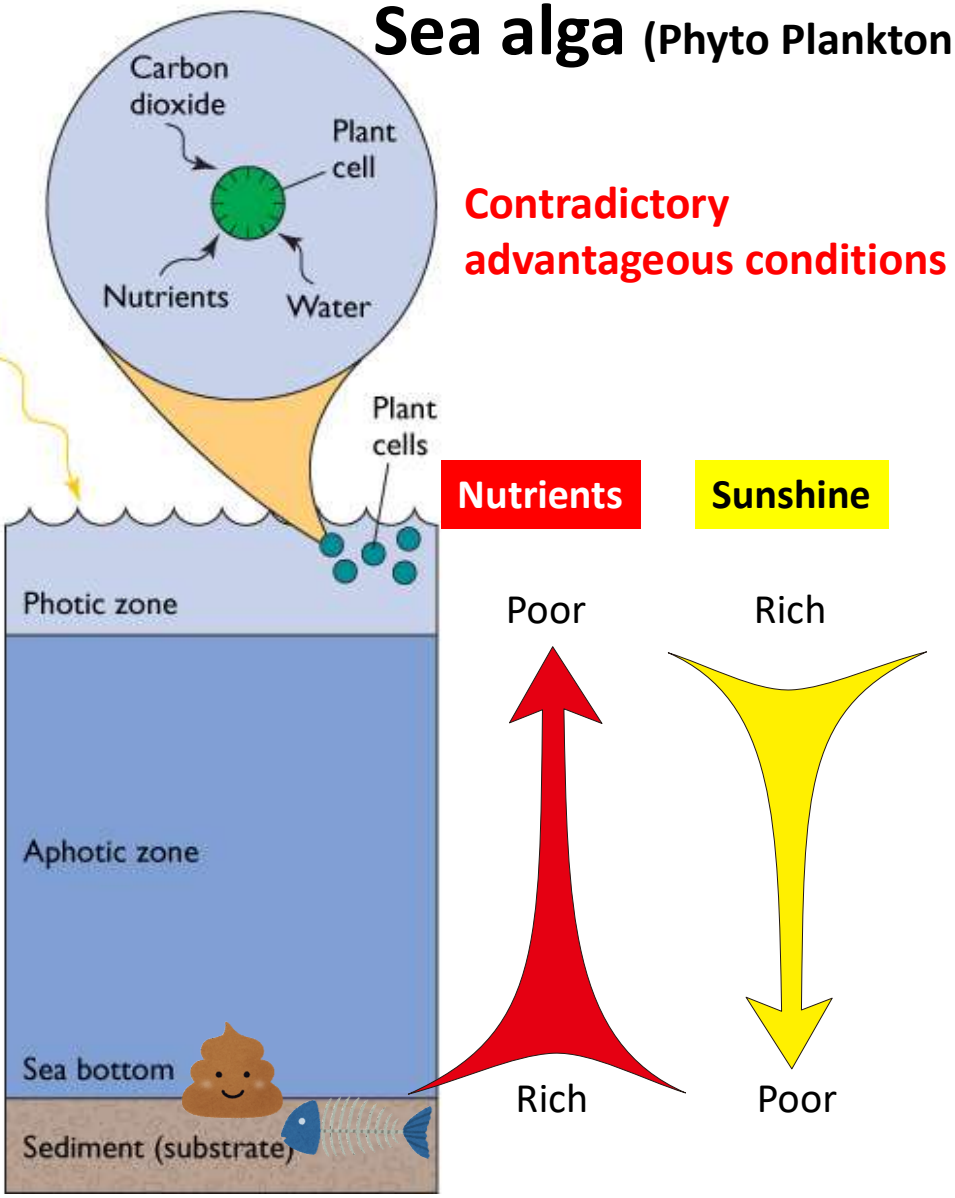
Plant on Land

Tall tree can take a lot of Sunshine on the reaves, and take Nutrients (water) from its root.

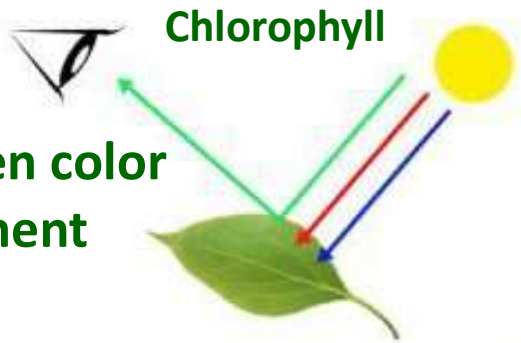
Easy to make photosynthesis



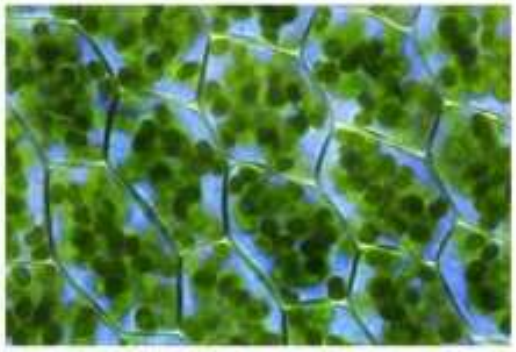
Sea alga (Phyto Plankton)



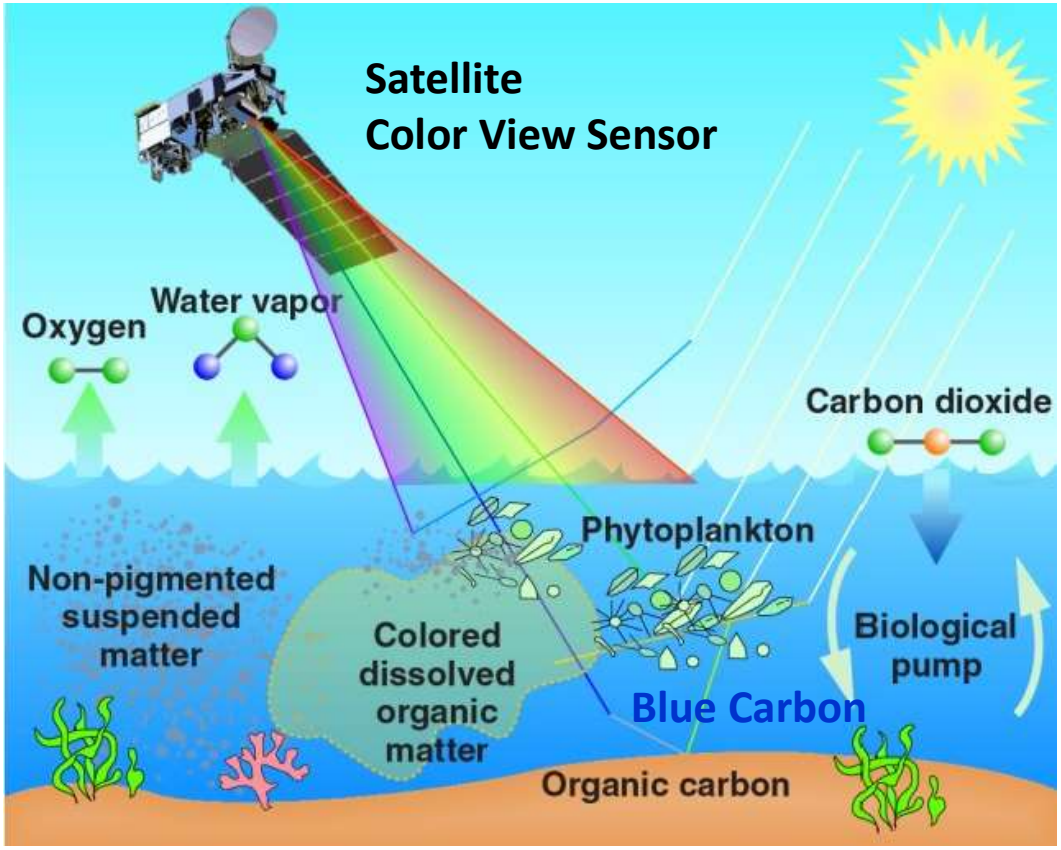
Contradictory advantageous conditions

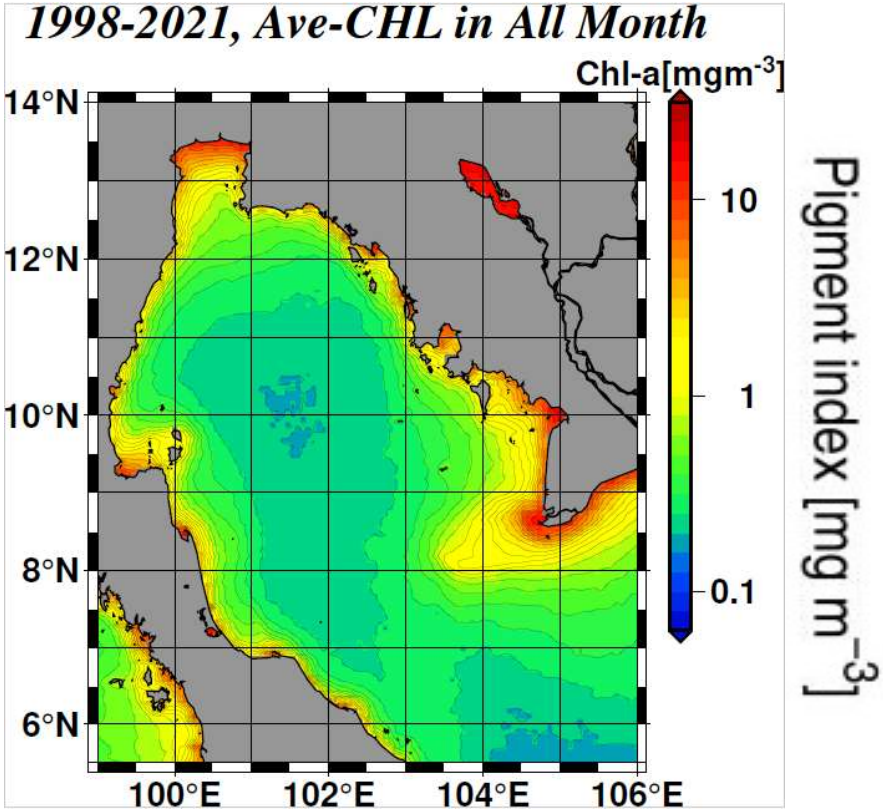


Plant's
Leaf



Phyto-
Plankton

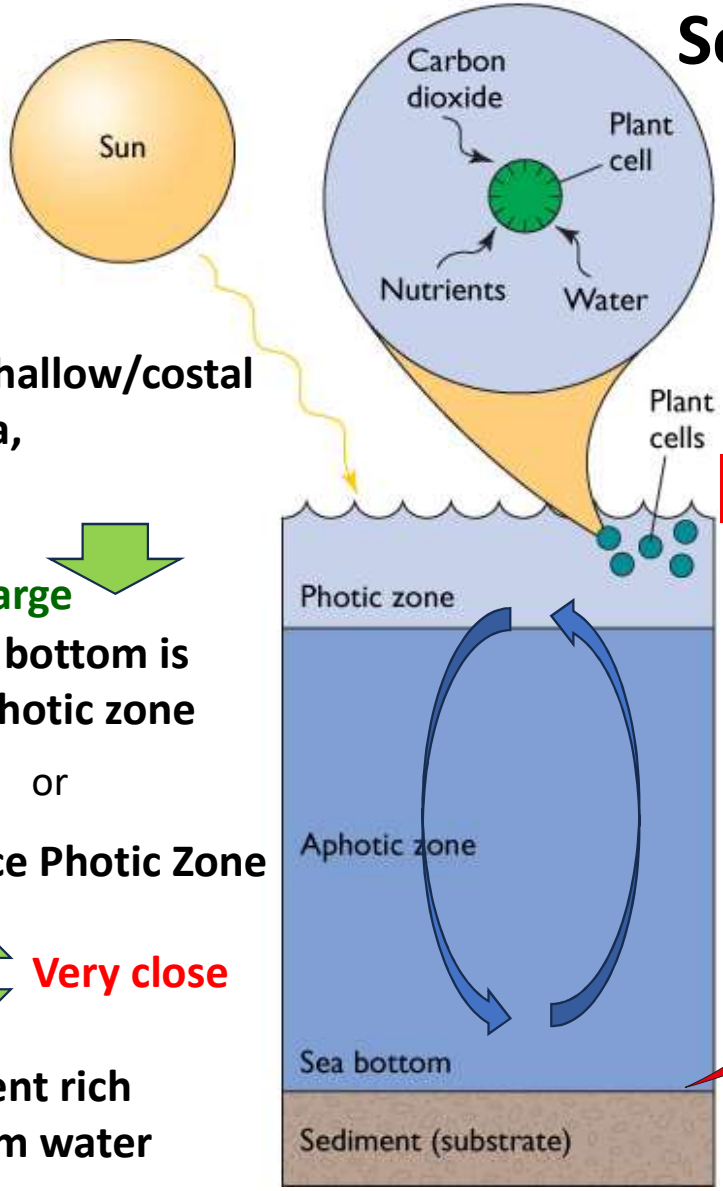




Sea alga (Phyto Plankton)

Contradictory advantageous conditions

Sunshine(Light) can not penetrate into deep layer,
Even in very clear sea water…



In shallow/costal area,

River Discharge

Sea bottom is in Photic zone

or

Surface Photic Zone

Very close

Nutrient rich bottom water

Nutrients

Poor

Rich

In deep/offshore area,

Nutrients rich water must be supplied to Photic surface zone

Water Movement

- Vertical Mixing
- Upwelling

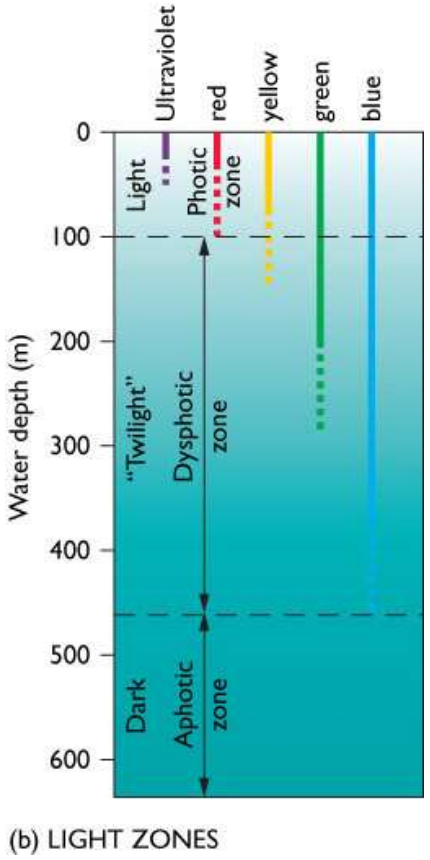
Physical Process

Wind Mix. Winter Mix.
Tidal Mix. Eddy Mix. etc.

Sunshine

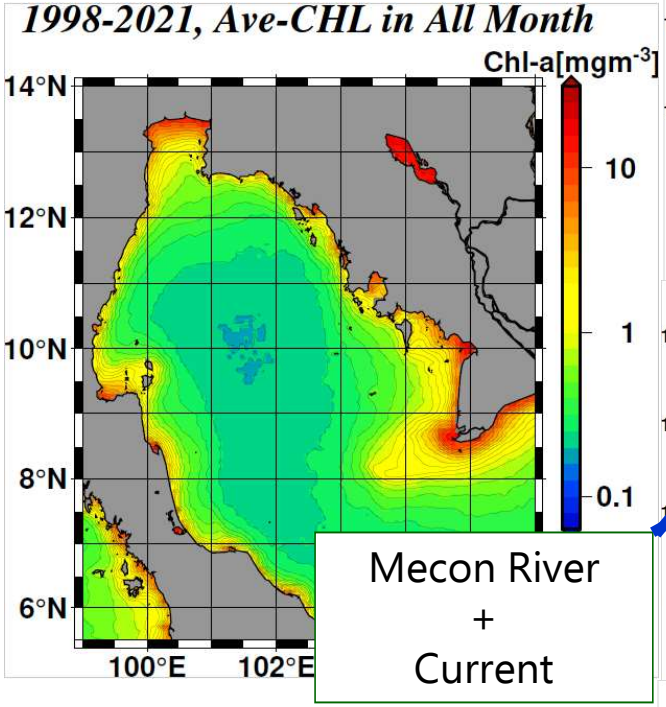
Rich

Poor

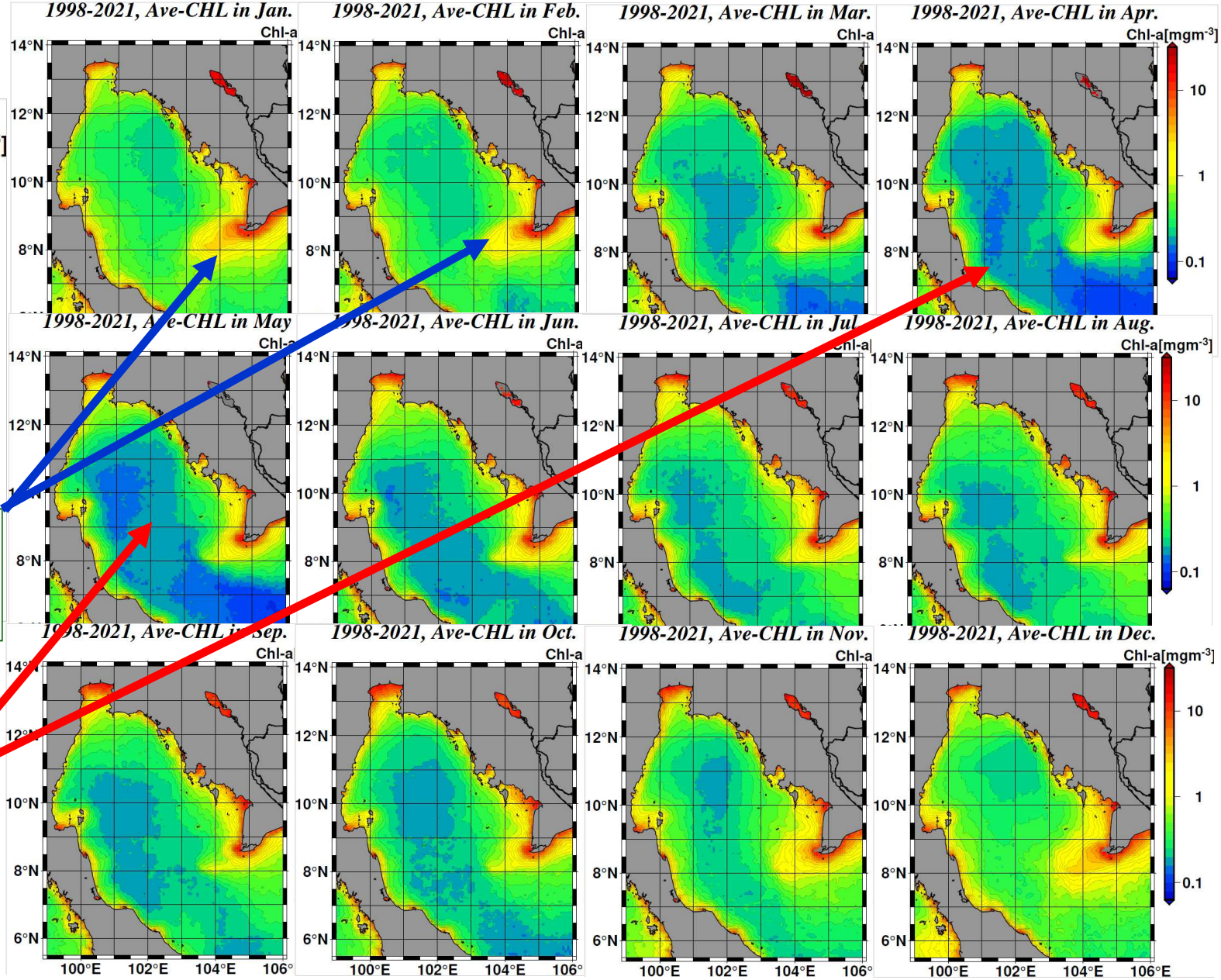


(b) LIGHT ZONES

All month average Chlorophyll



Mecon River
+
Current



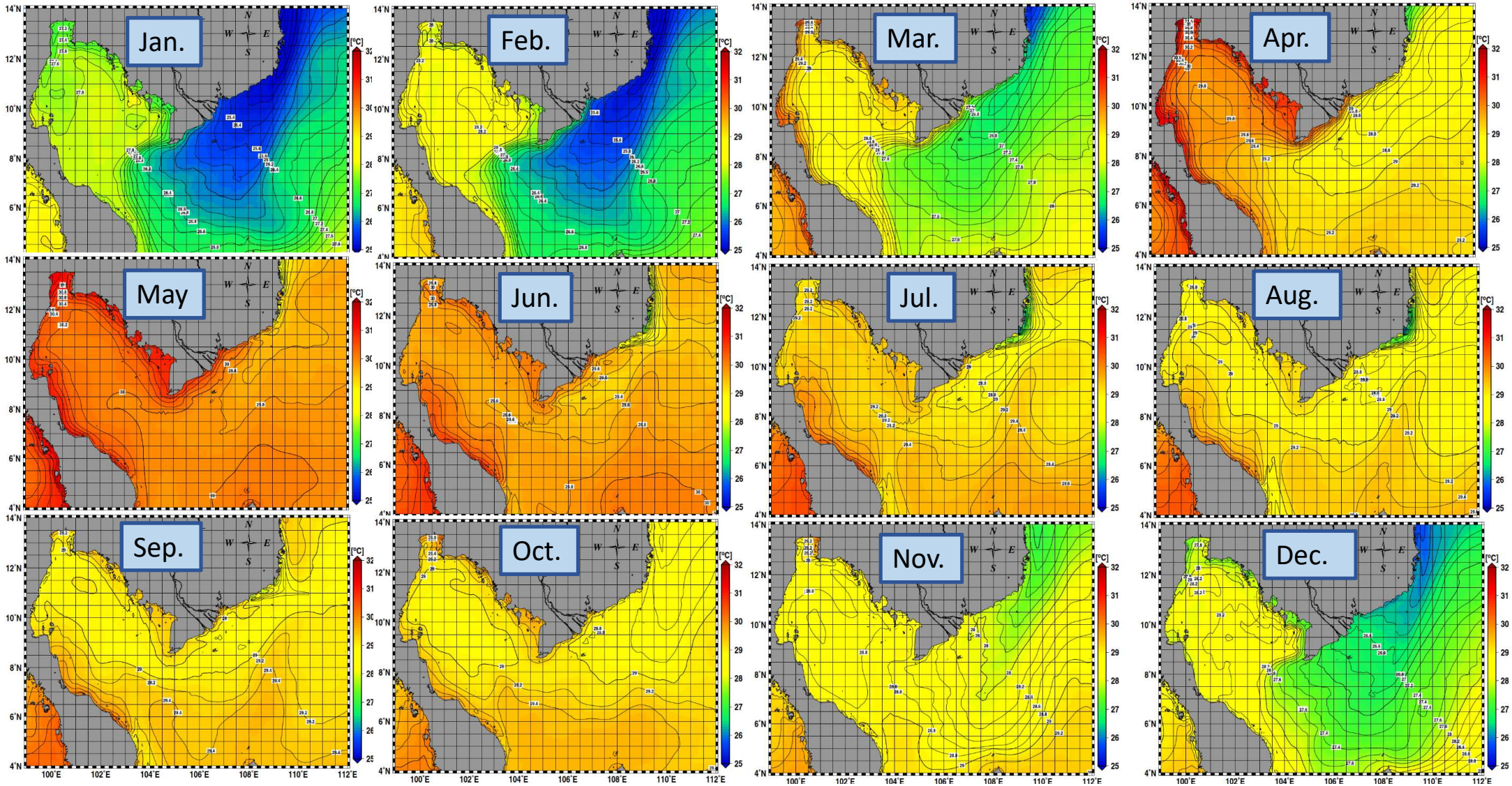
Smaller products in April & May than other months,
Because of very strong water stratification by very warmer surface temperature

Sea Surface Temperature(°C)

Averaged Monthly data through the 26 years(1993-2018)

Dec. Jan. Feb.
⇒ Cold water

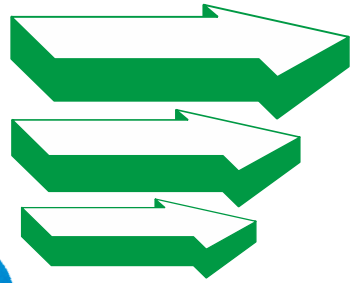
Apr. May
⇒ Hottest



Water Stratification

Global Warming

Wind and/or Cooling



○ Stable

× Unstable

× Stable

Light Density

Warm
Low Salinity

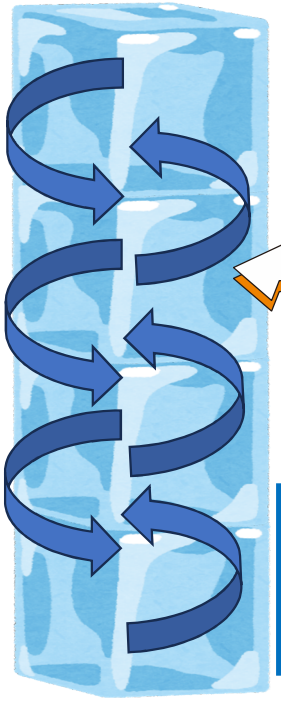
Hard
to
Mixing

Heavy Density

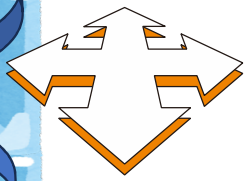
Cold
High Salinity

○ Unstable

Almost Same Density



Tidal Flow



Easy
to
Mixing

For sustainable primary production (Phytoplankton growth), we must think….

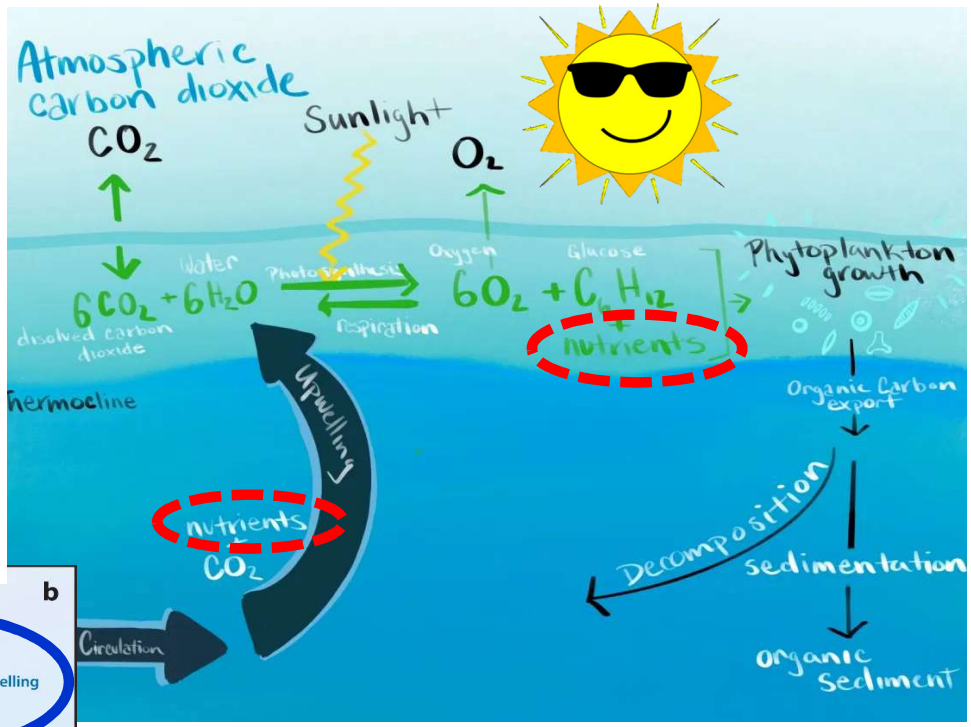
- Sun Energy ⇒ ….Maybe too much in Thailand
- CO_2 + H_2O ⇒ … Enough in sea water

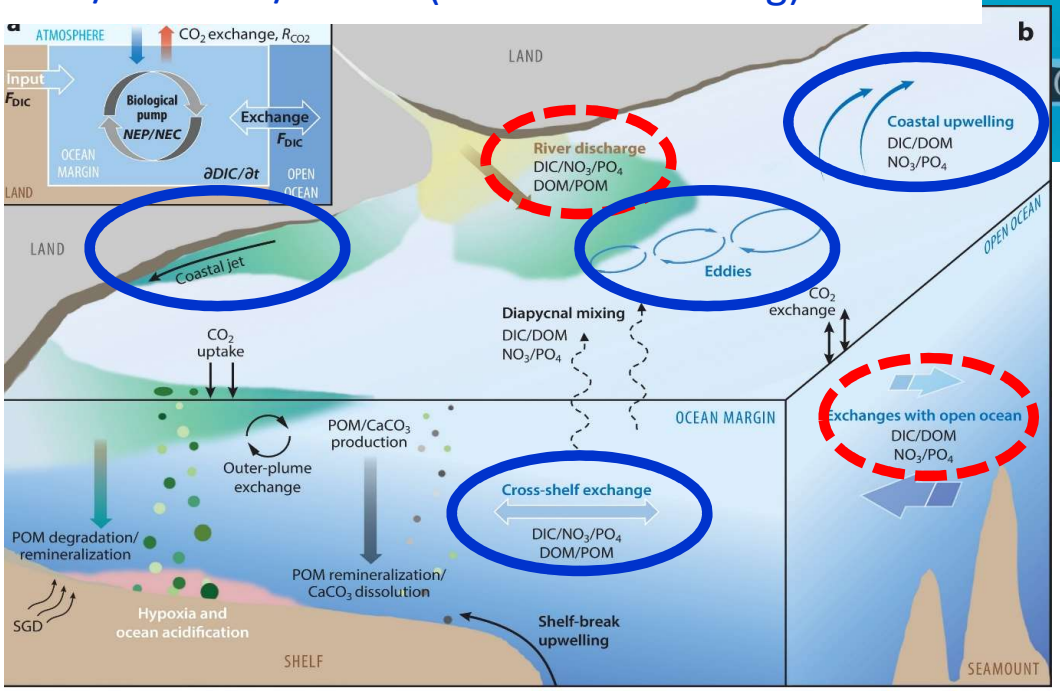
} Photonic Synthesis

- Nutrients Supply …. Only slightly controllable by human

⇒Water moving

- ☐ River discharge (Human effects on Land)
- ☐ Water stratification (Mixing)
- ☐ Upwelling (Vertical moving)
- ☐ Tides/Currents/Eddies (Horizontal moving)

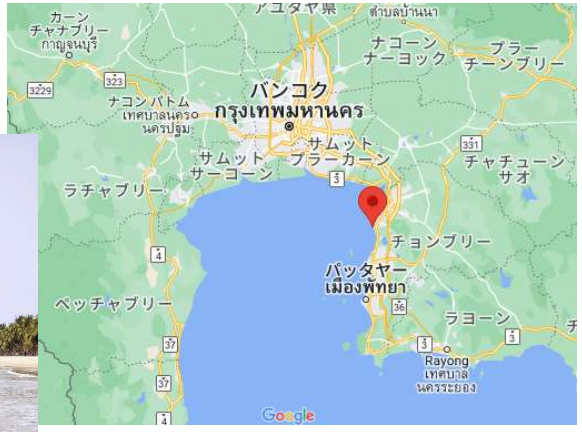


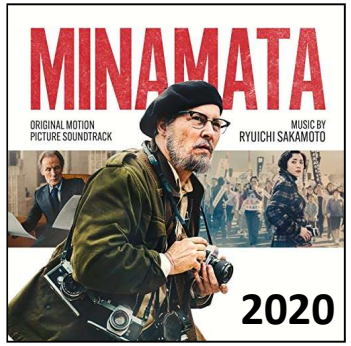


If we fail in control nutrients supply…

If we fail in control nutrients supply…

2024, 2, 27
at Ban Sean Beach



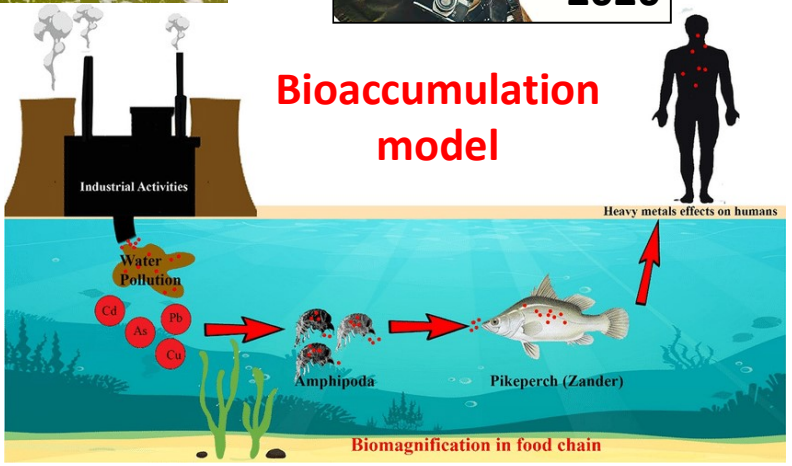


In Japan, there were disease caused by environmental contamination
(4 Big Pollution Diseases)

- **Itai-Itai Disease: 1910-**
- **Minamata Disease: 1956-**
- **Yokkaichi Asthma : 1961-**
- **Niigata Minamata Disease:1965-**

Water pollution
-> Polluted Plankton
-> Polluted Fish
-> Human Disease

Bioaccumulation model



In Japanese dictum,

「過ぎたるは、およばざるが如し」

Sugitaruha, Oyobazaruga, gotoshi

“Too much is as bad as too little.”

In Thai,

ノックナイムハムライテンポートワ

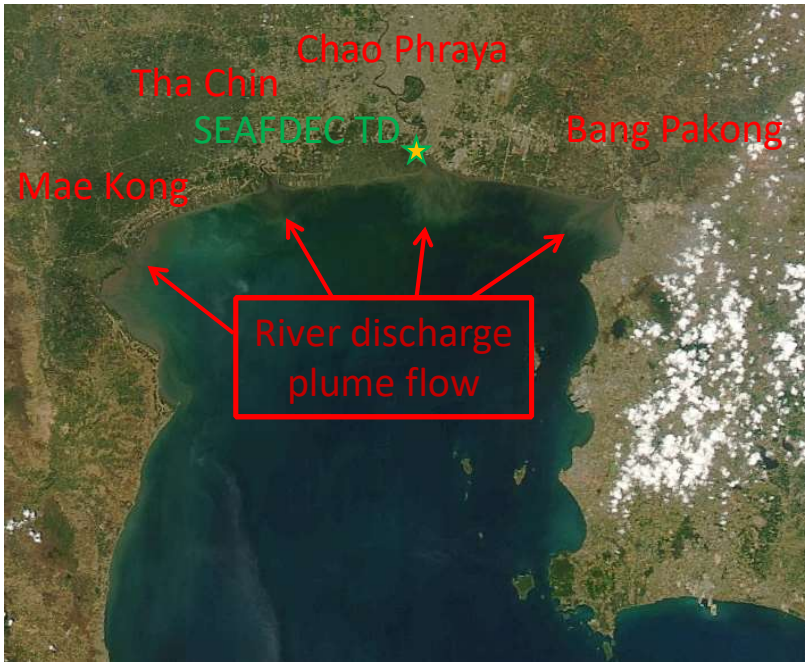
นกน้อยทำรังแต่พอตัว

“Little bird makes small nest”

Too clear sea water (poor nutrients) ,
it is difficult to keep
a productive ecosystem

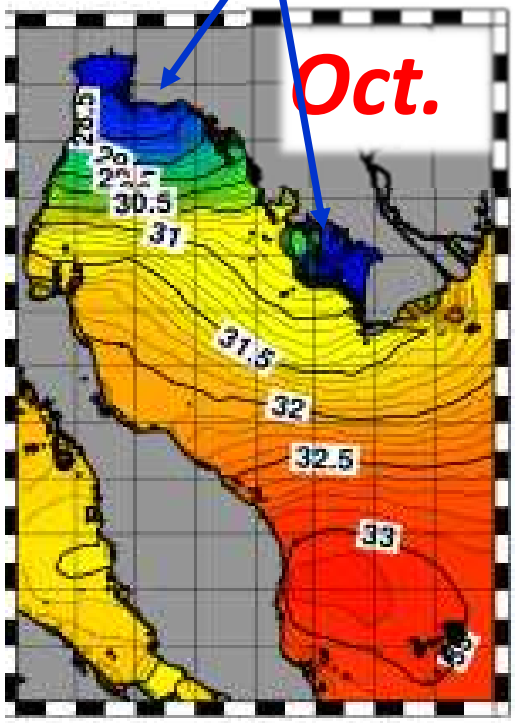
Too much nutrients
(overweight condition),
it is difficult to keep
a healthy ecosystem

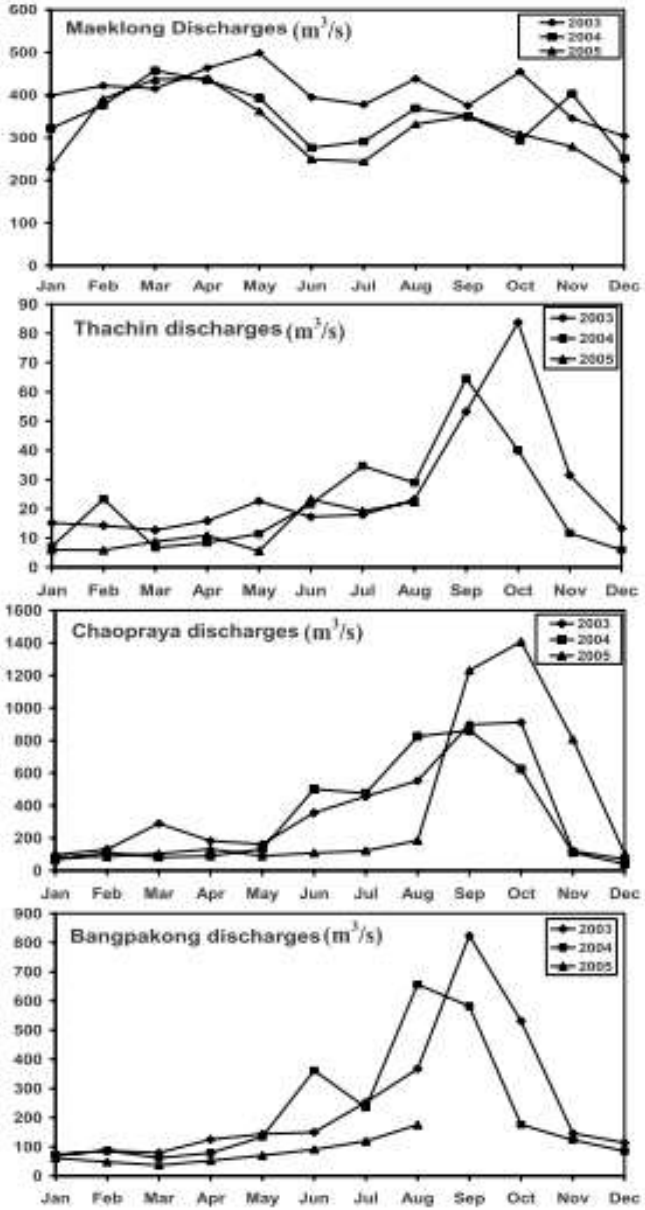
River Discharges (Flow-out)



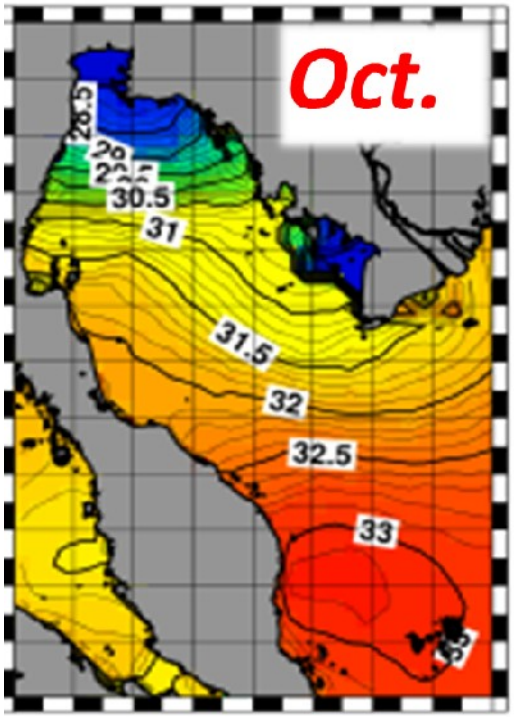
There are 4 big rivers flow out in the upper Gulf of Thailand

Very low salinity water (under 30) can be seen

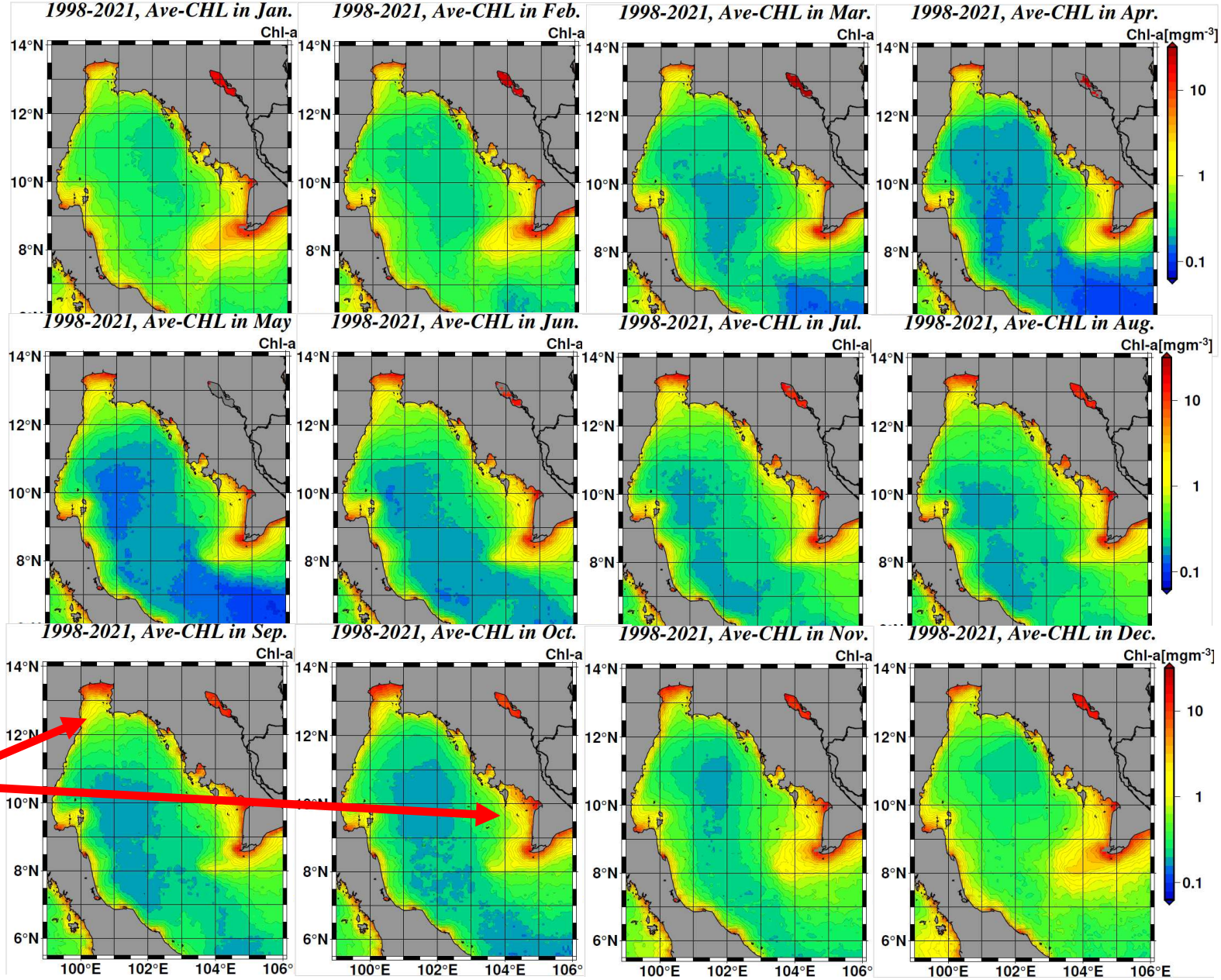




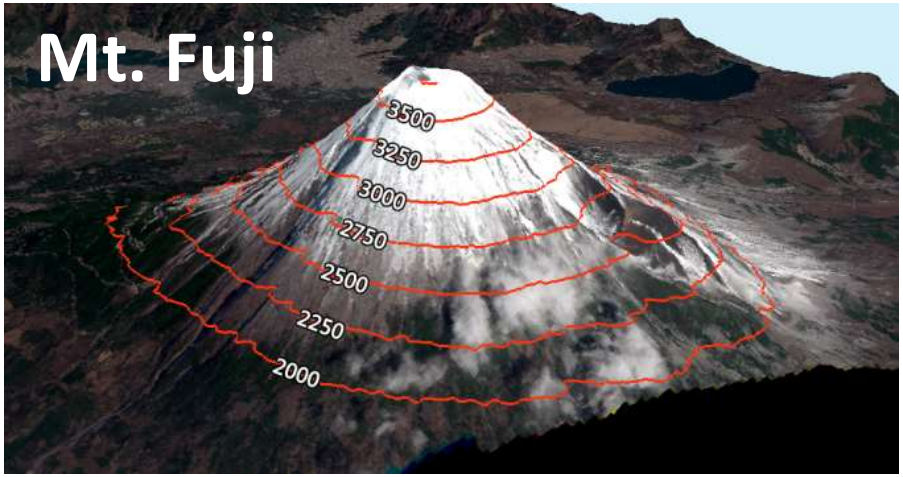
BURANAPRATHEPRAT et al. 2008

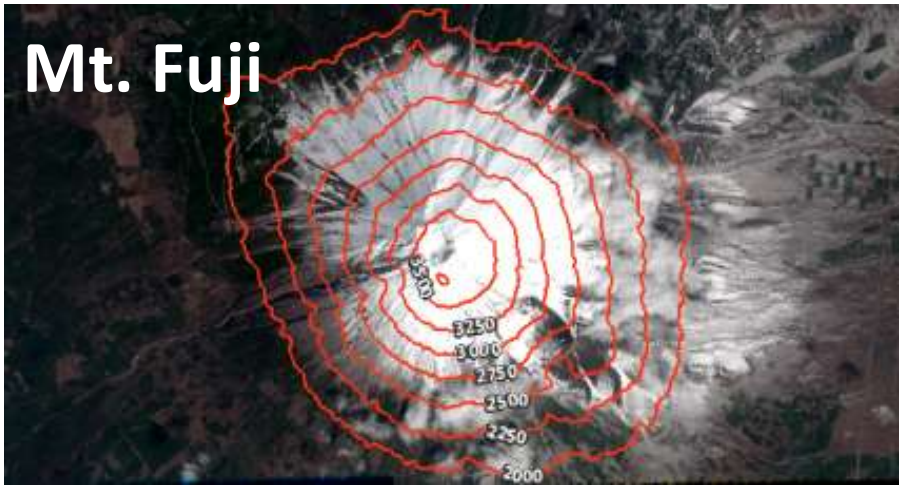


Non effect can be seen
in lower salinity area
by river discharge
in September & October,
Because in costal shallow
area, there is enough nutrients
by mixing



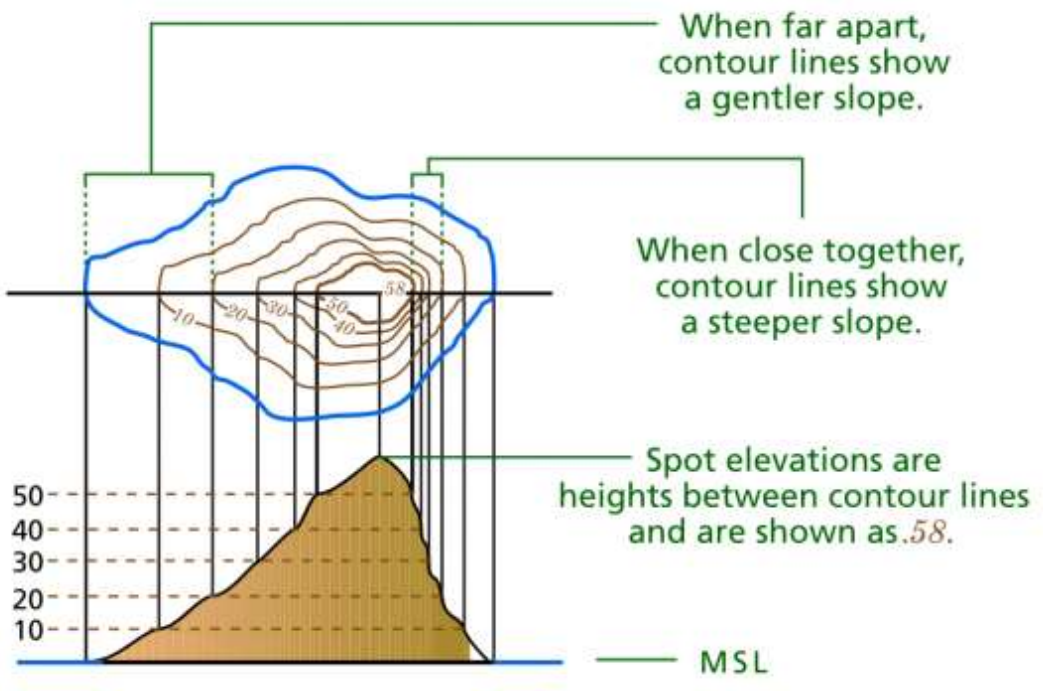
To understand about water distribution in the Gulf of Thailand,
Let's draw contour lines of water temperature…





Contour Line:
a line drawn on a map connecting points of equal height

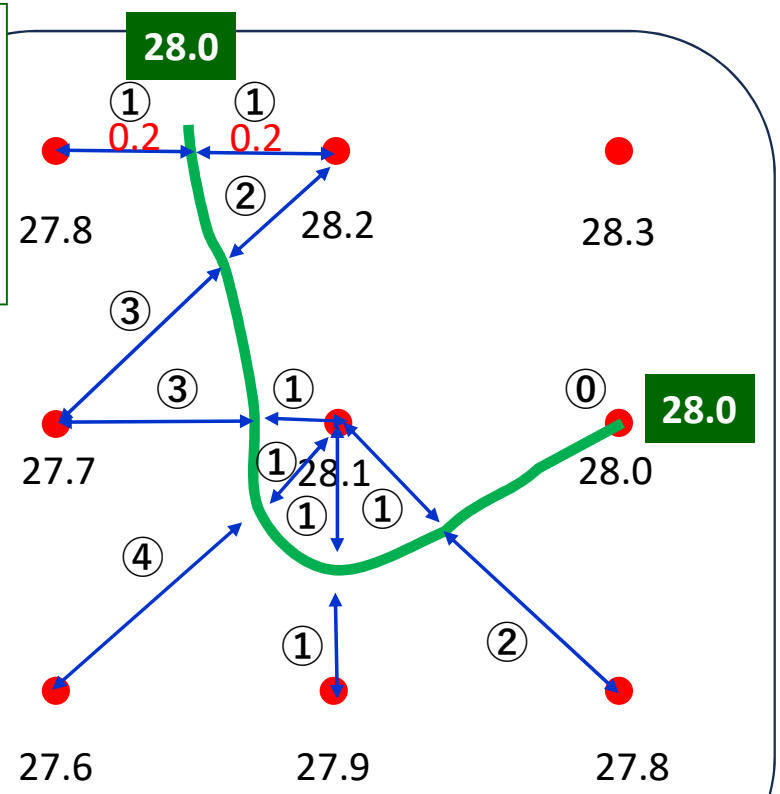
On Temperature map ⇒ Equal Temperature
On Salinity map ⇒ Equal Salinity
Close together Contour lines ⇒ Front area



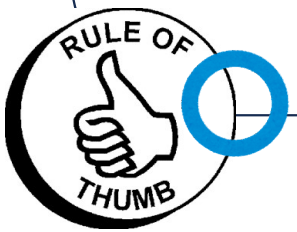
● : Grid Point/Observation Point

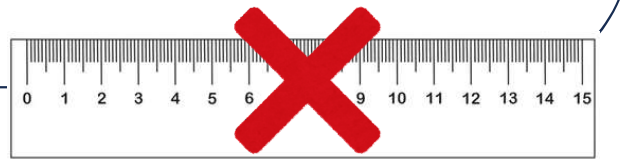
27.8 : Numerical Value at the Point (Temperature: ºC)

At first, You must find border points



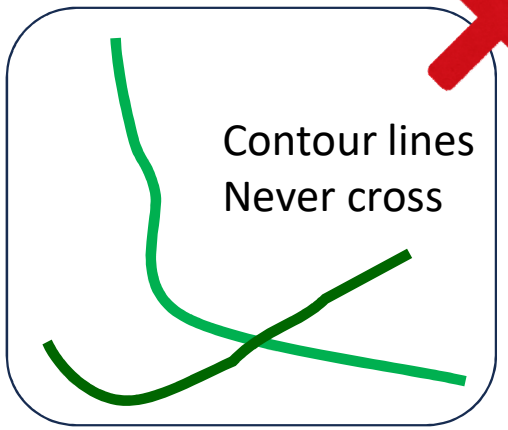
By Rule of Thumb

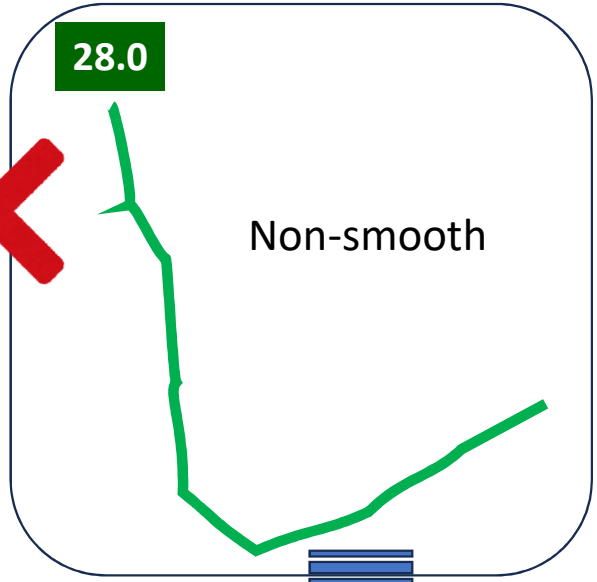


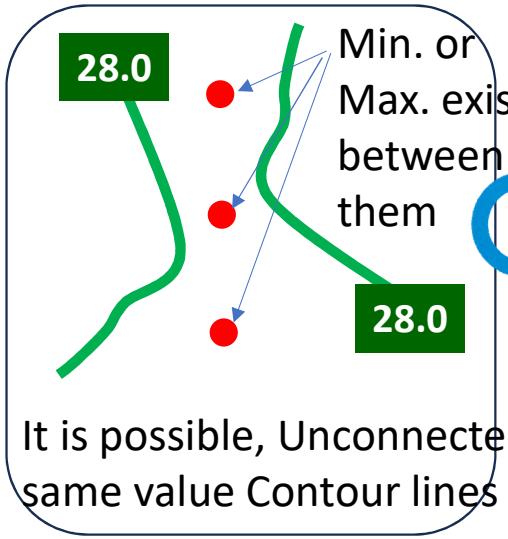


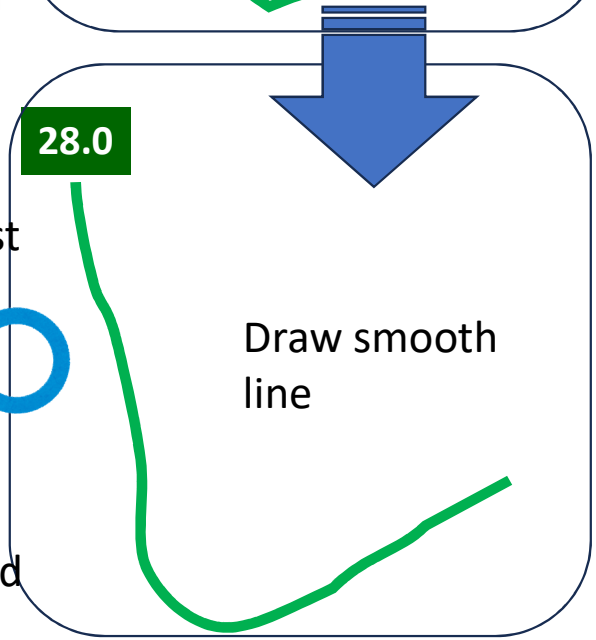
No need to use ruler

Note

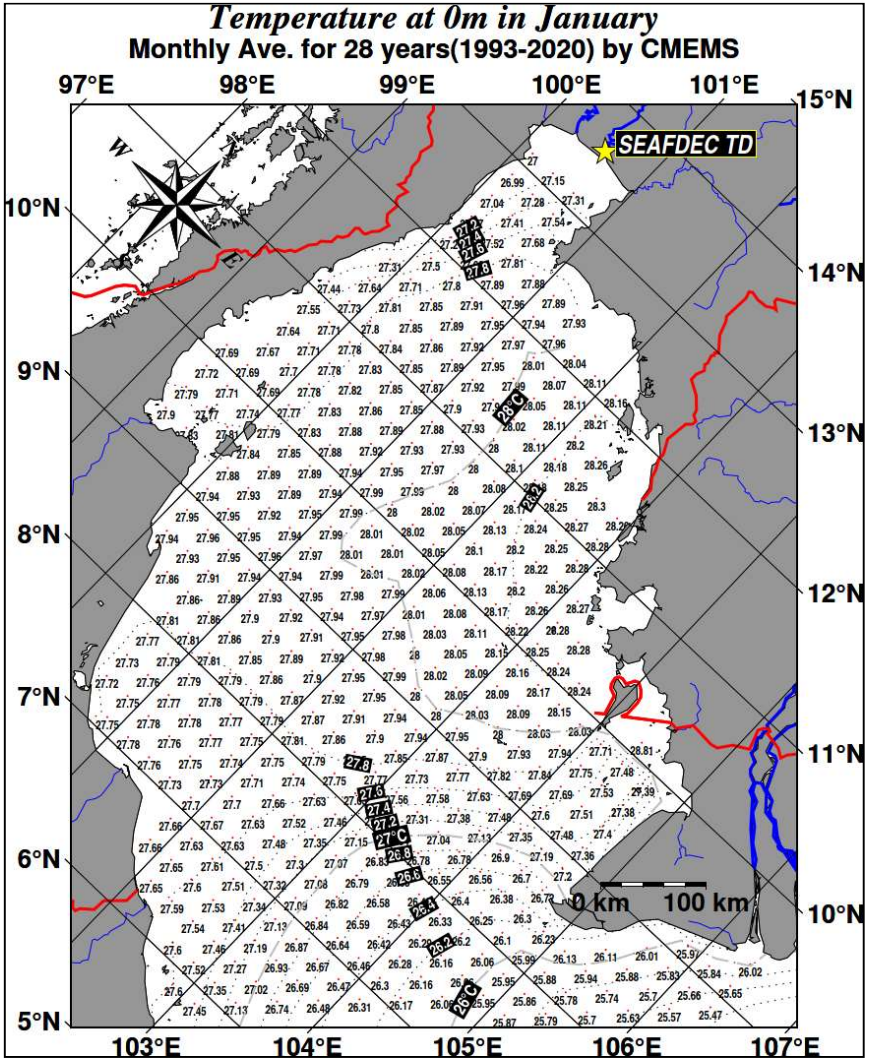








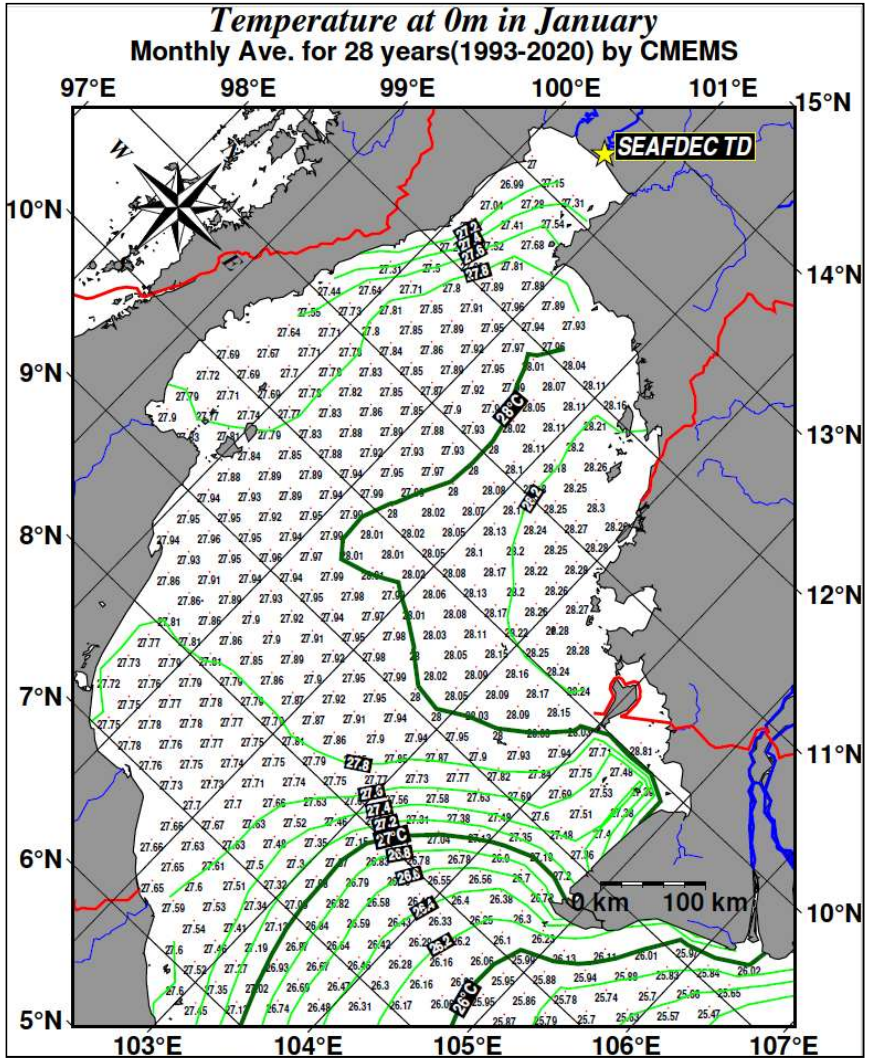
You can see dot line and dash line…



Let's draw Counter Lines Map

As a first step,
Draw 1 °C interval
Conter lines
(26, 27, 28 °C)

Next step,
Draw 0.2 °C interval
Conter lines
(x.2, x.4, x,6, x.8 °C)

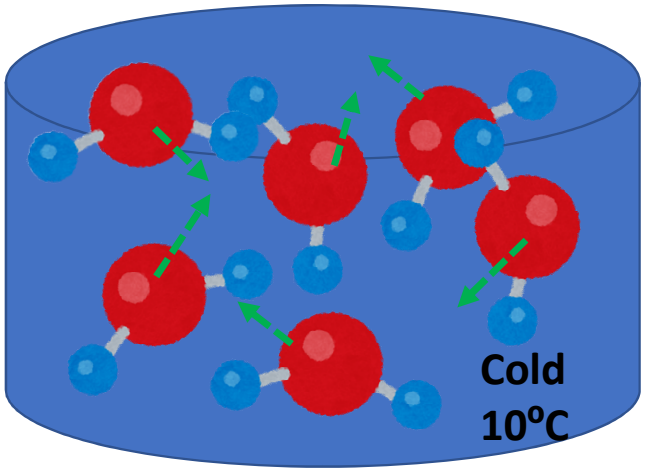


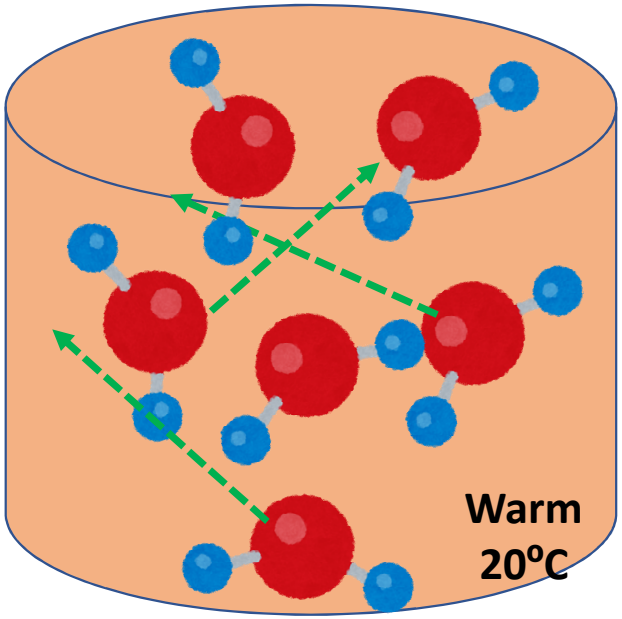
H_2O molecule

Moving Speed

Warmer condition =>
Higher Sea Surface

At same weight (mass),
Warmer water is bigger volume
(Water level is higher)





Molecules: Low-speed moving
Spans between molecules is narrow
High content of molecules
⇒
High Density
⇒
Heavy Weight/Volume

Molecules: High-speed moving
Spans between molecules is wide
Low contest of molecules
⇒
Low Density
⇒
Light Weight/Volume

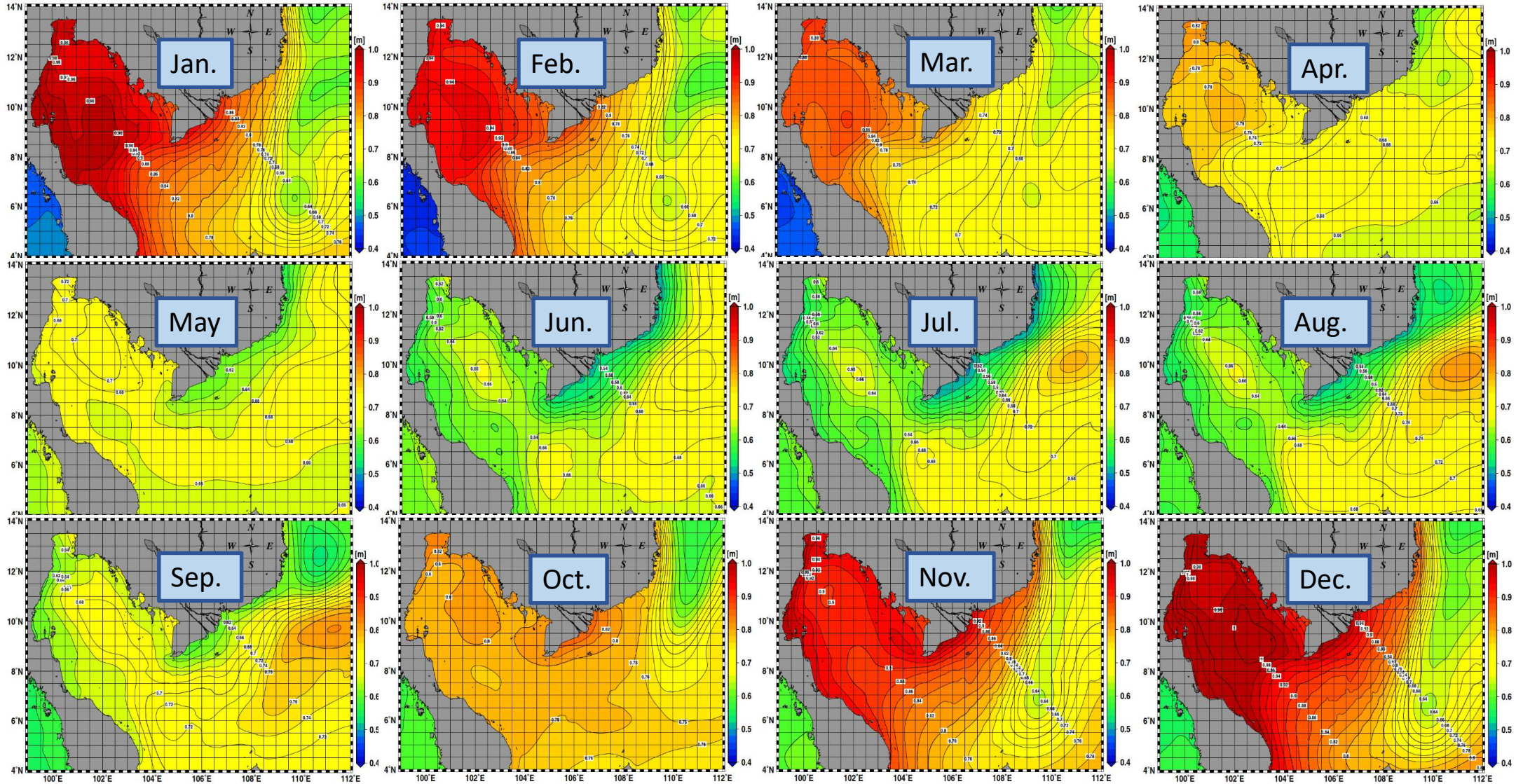
By Global warming
Sea water level is rising…

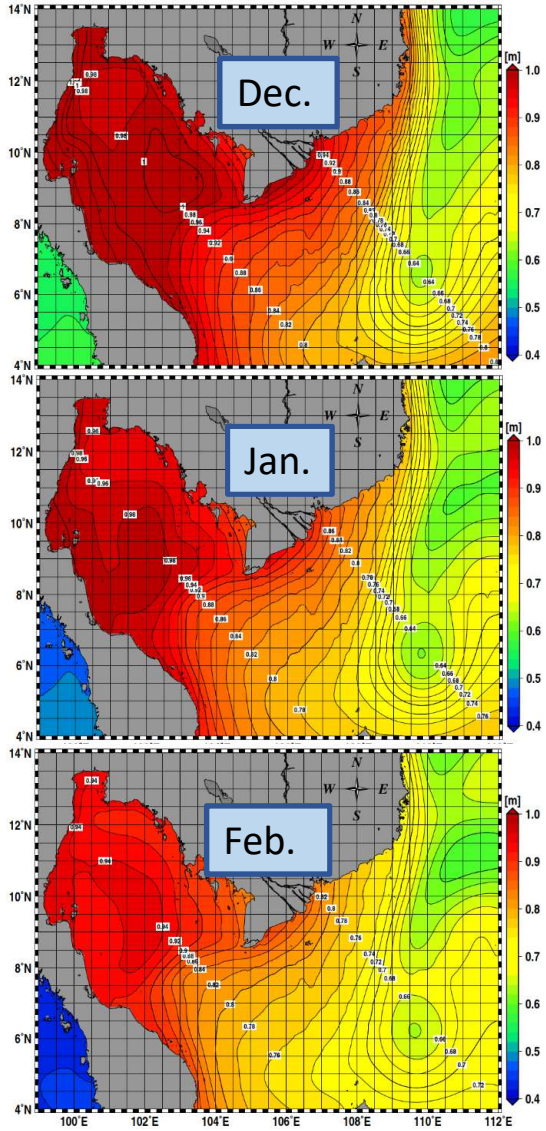
Sea Surface Height(m)

Averaged Monthly data through the 26 years(1993-2018)

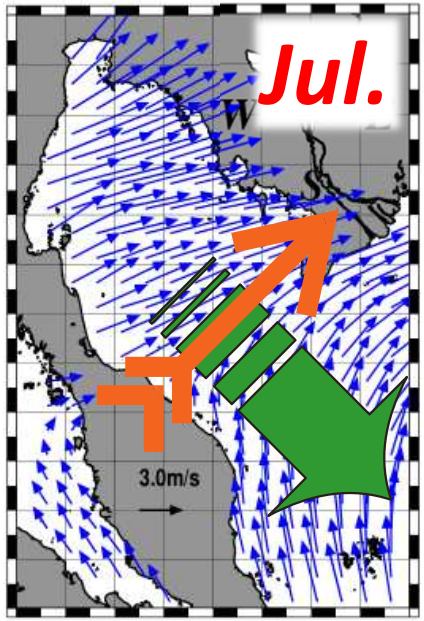
Nov. Dec. Jan. Feb.
⇒ High Level

Jun. Jul. Aug. Sep.
⇒ Low Level

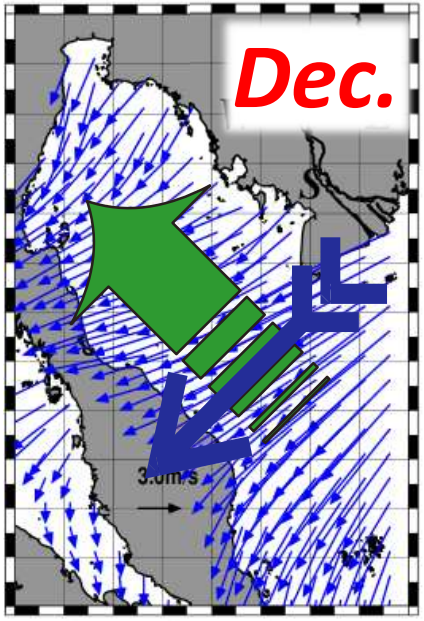




SW Monsoon wind

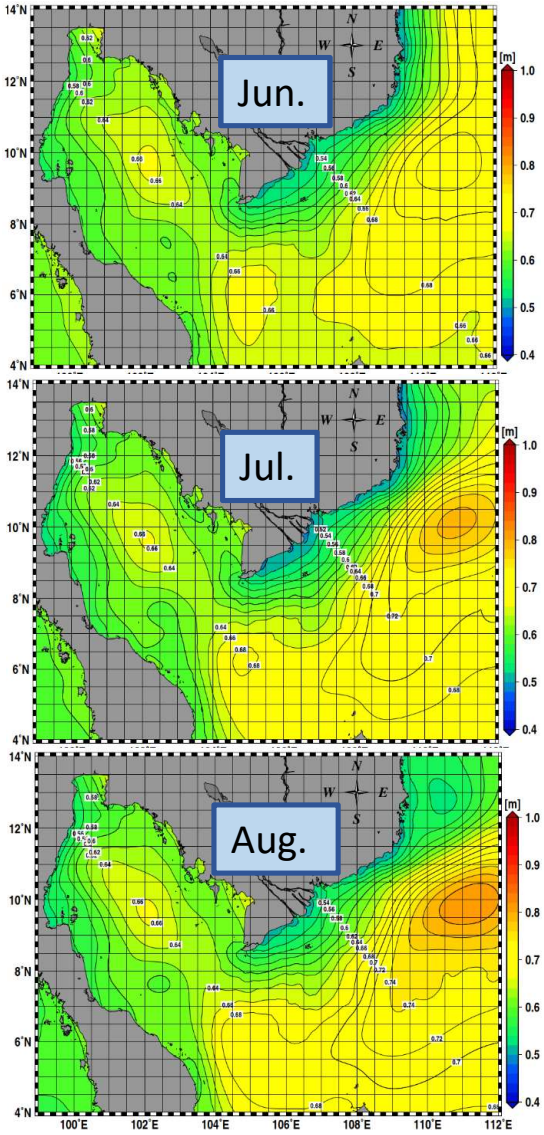


Outward Ekman Transport



Inward Ekman Transport

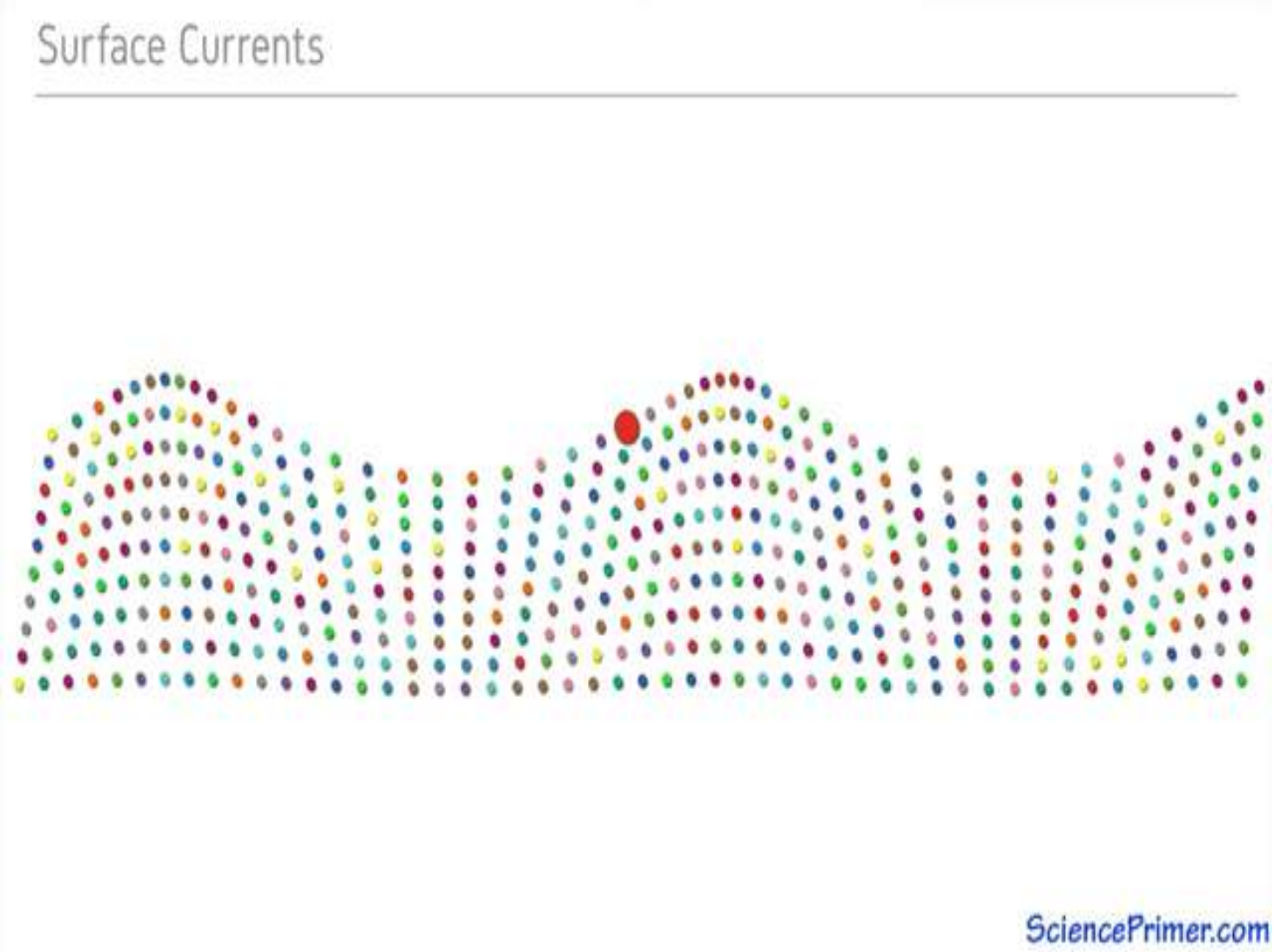
NE Monsoon wind



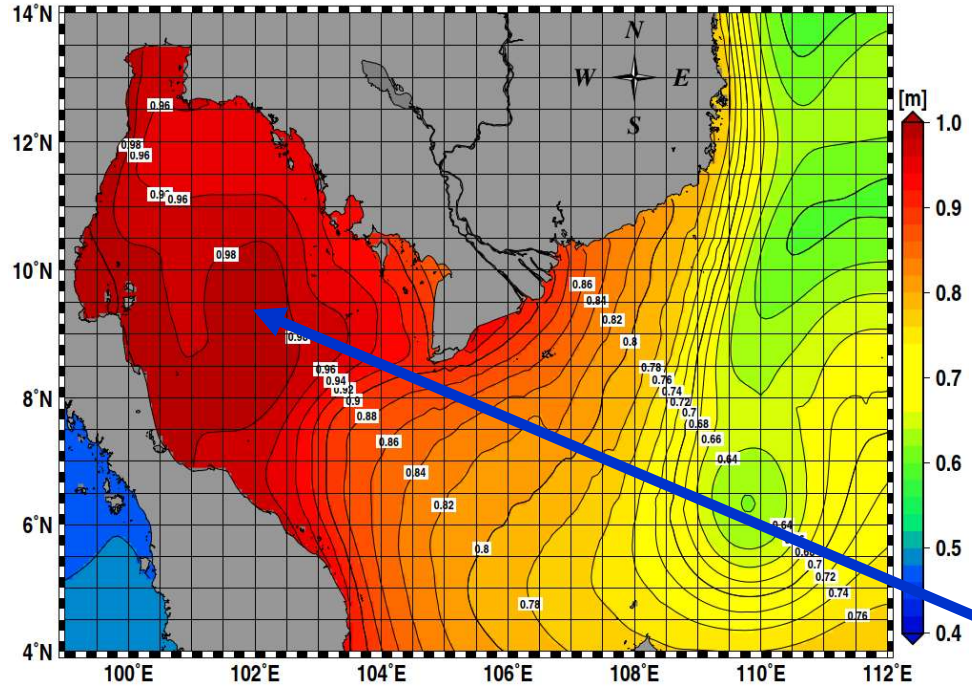
What is “Ekman Transport”

https://youtu.be/KBKmKI3tl4Q

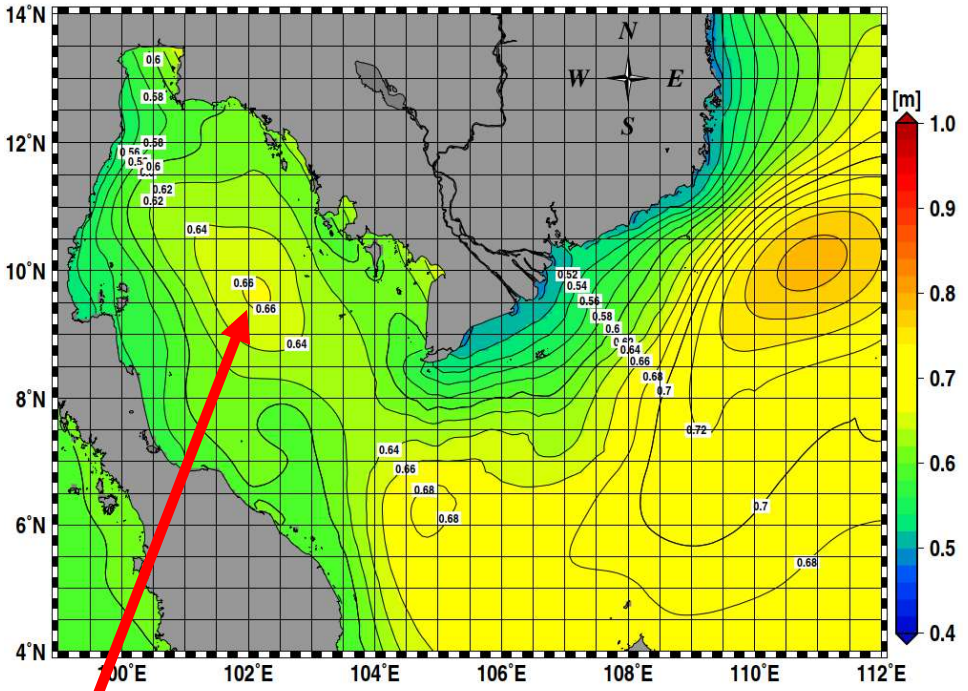
Vagn Walfrid Ekman
(1874-1954)
was a Swedish oceanographer. In 1905, Ekman published his theory of the Ekman spiral which explains the phenomenon in terms of the balance between frictional effects in the ocean and the Coriolis force, which arises from moving objects in a rotating environment, like planetary rotation.



January



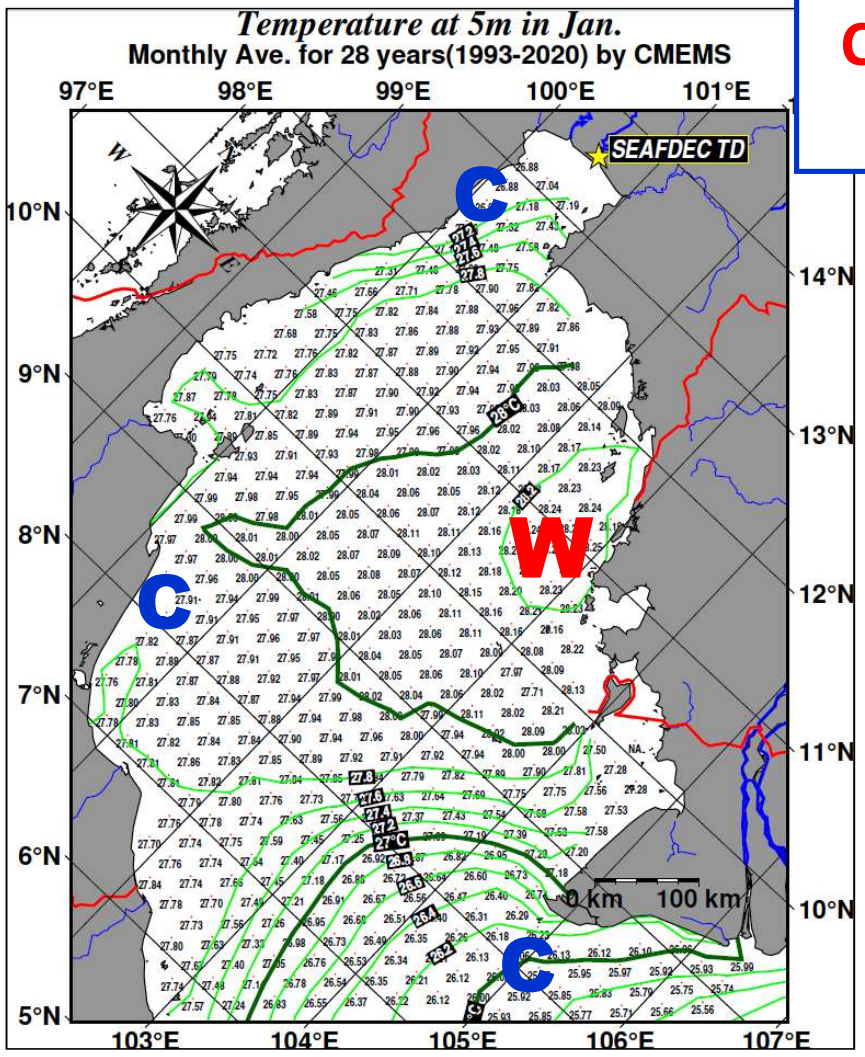
July



Even in both season, Highest point locates at central area in the Gulf.

Why?

5m depth in January

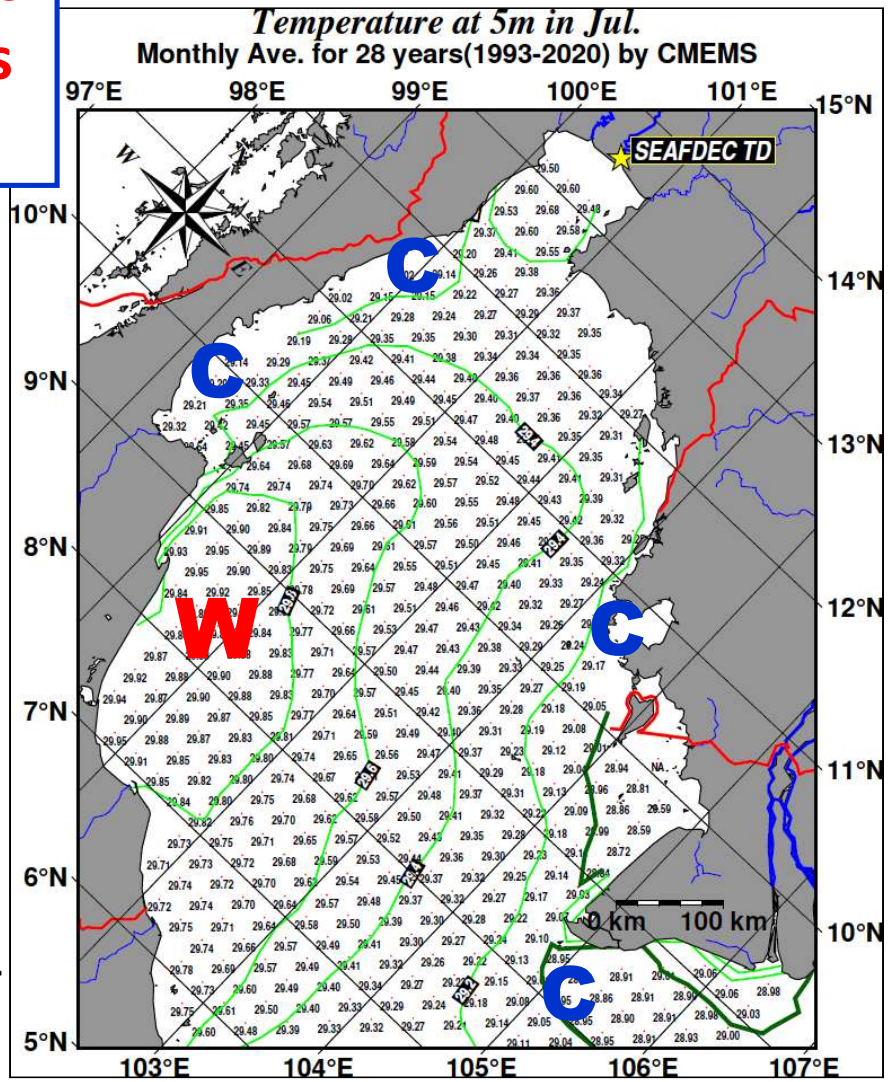


Compare 2 seasons Conter lines Maps At 5m Depth

Temperature values are different.
In the central area, Warmest point exists.
In the costal area, Colder points exist.

In both season, Warmer & High level Water exist at the center

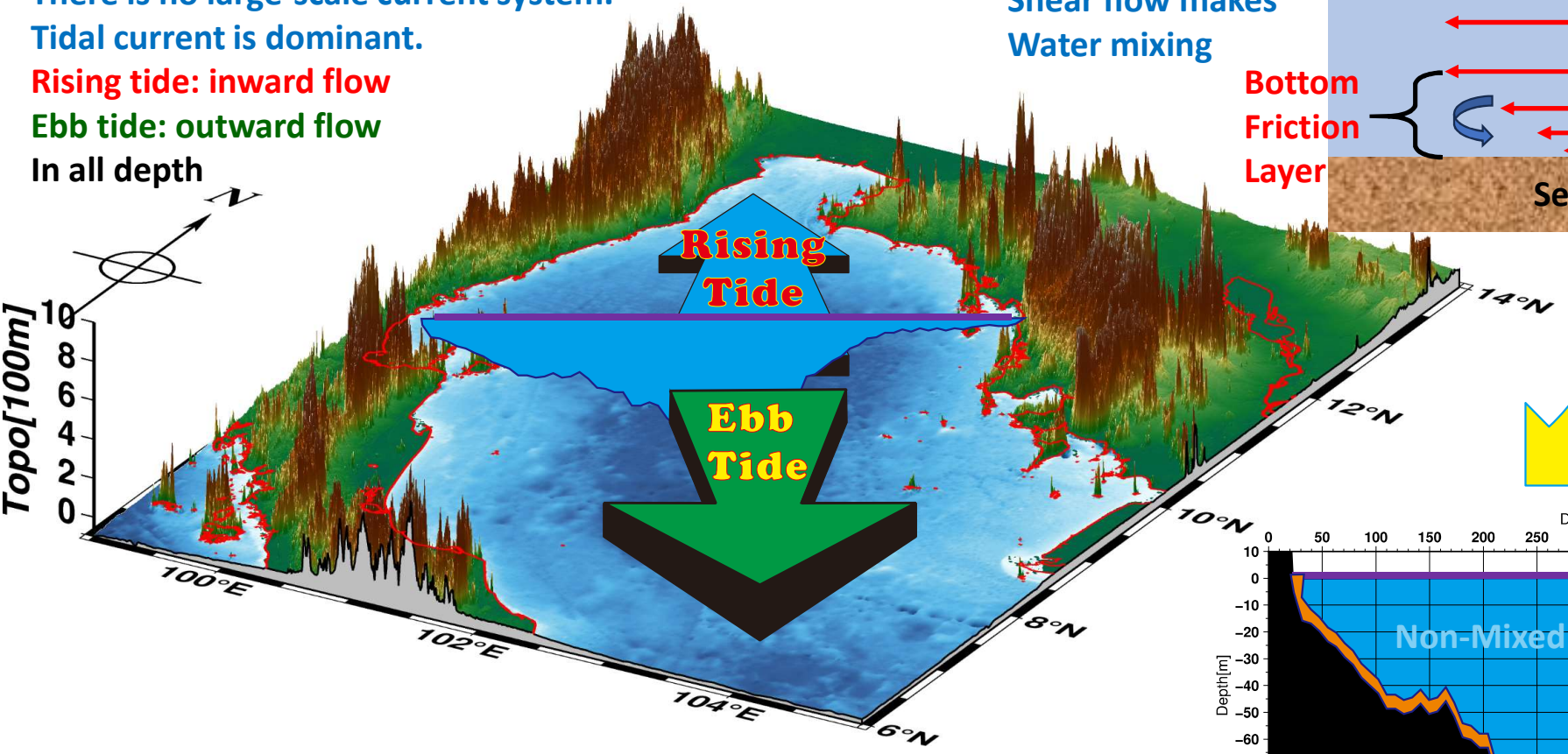
5m depth in July



We must think about tidal motion effects

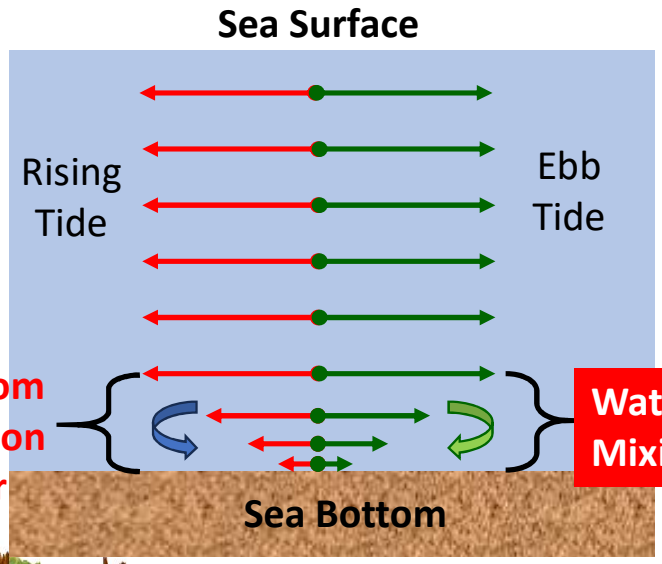
Effect of Tide (Tidal Current)

In the Gulf of Thailand
There is no large-scale current system.
Tidal current is dominant.
Rising tide: inward flow
Ebb tide: outward flow
In all depth

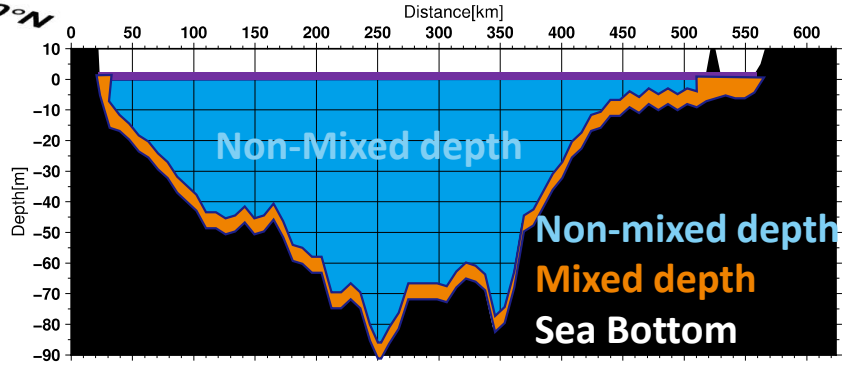


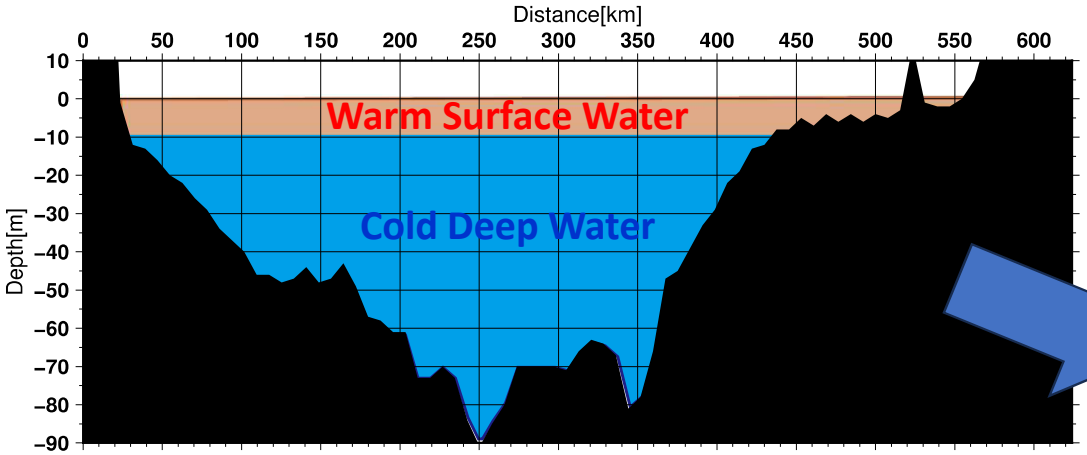
Back-and-Forth Motion
No Water Mixing

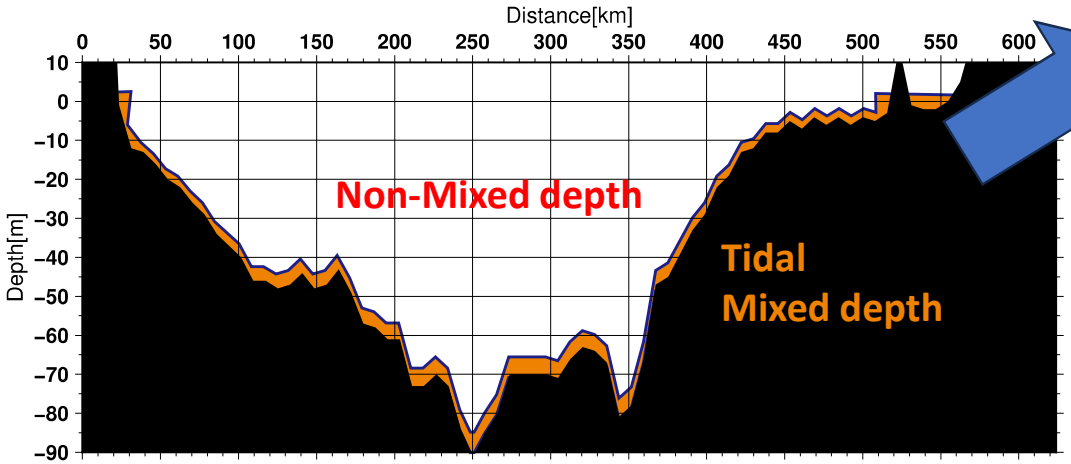
Shear flow makes Water mixing



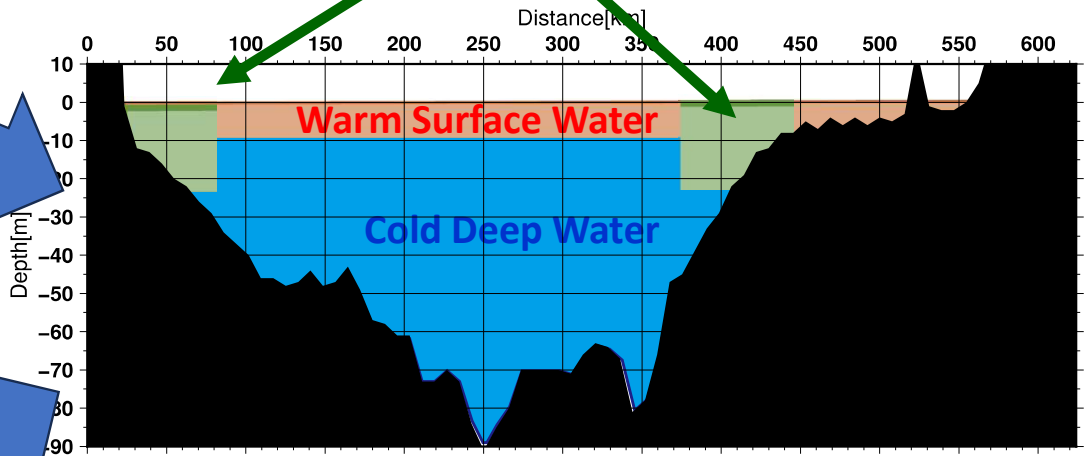
Mixed layer is formed along the bottom line







Mixed Water
(Middle range temp, Nutrients content)

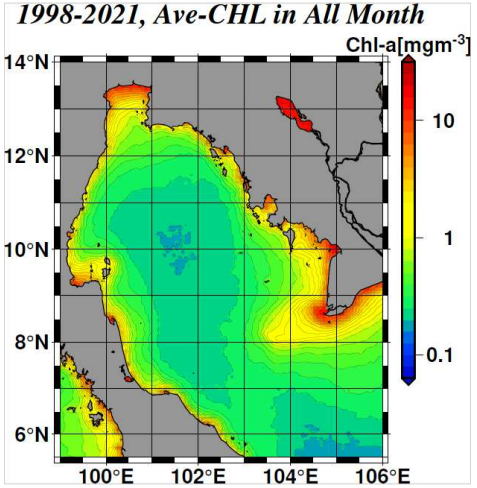


In coastal area and shelf edge area, surface warm water and deep nutrient-rich water will be mixed by tidal friction bottom layer.

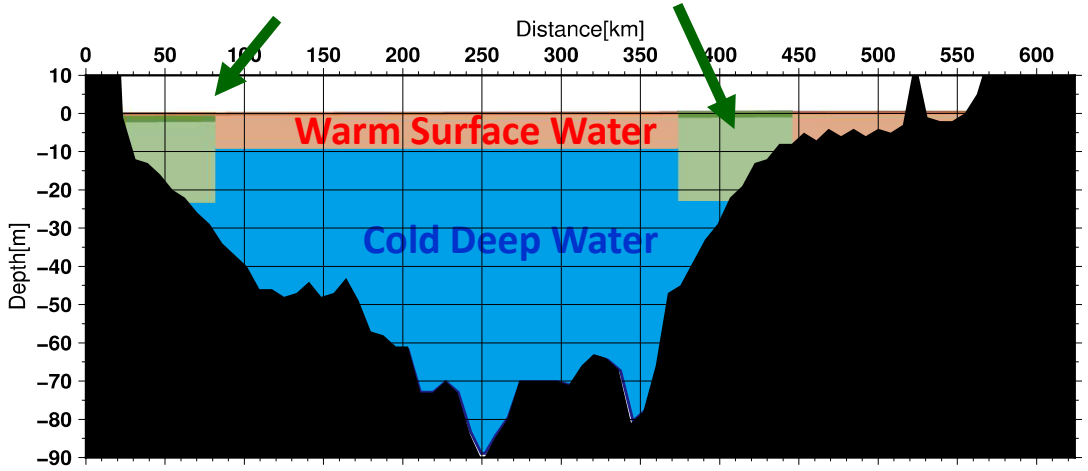
⇒

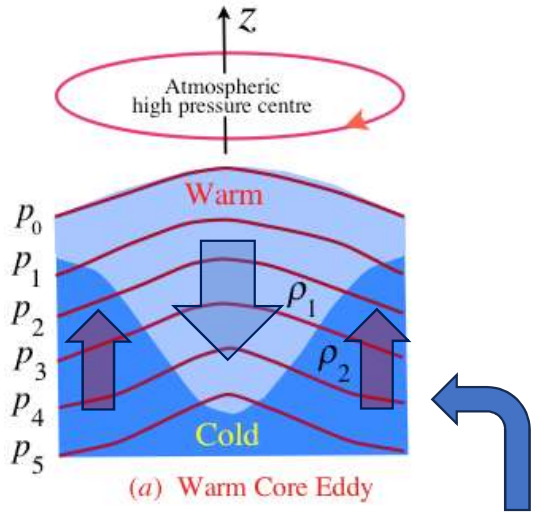
Good condition to make primary production

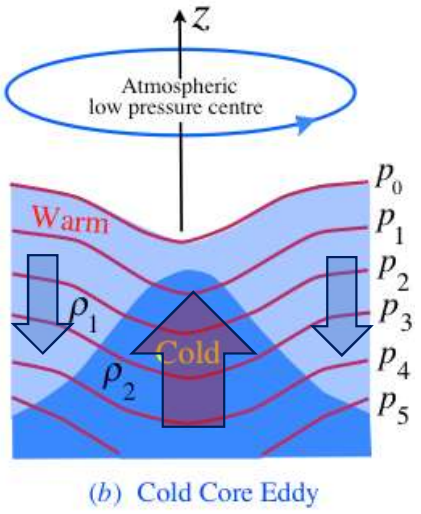
Another reason

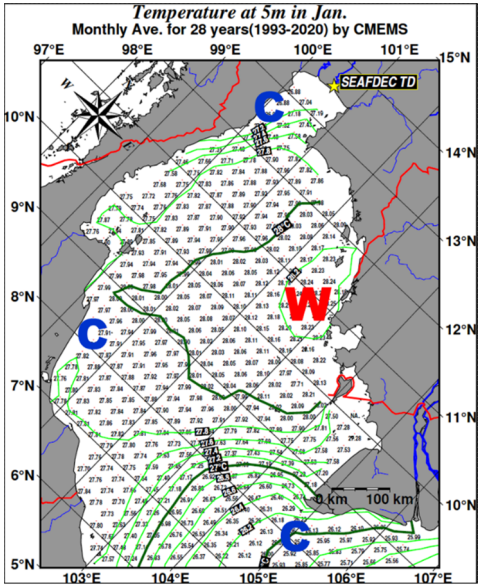


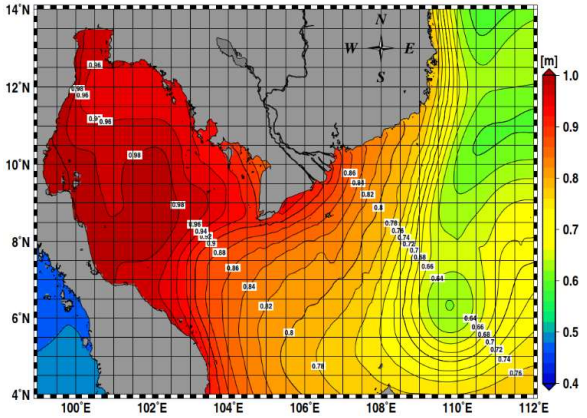
Mixed Water
(Middle range temp, Nutrients content)



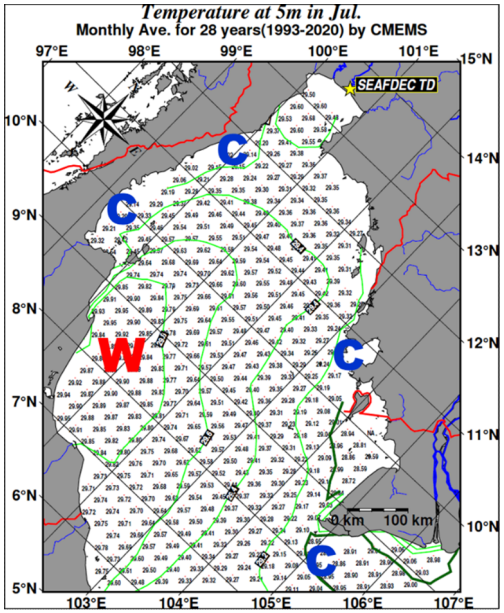


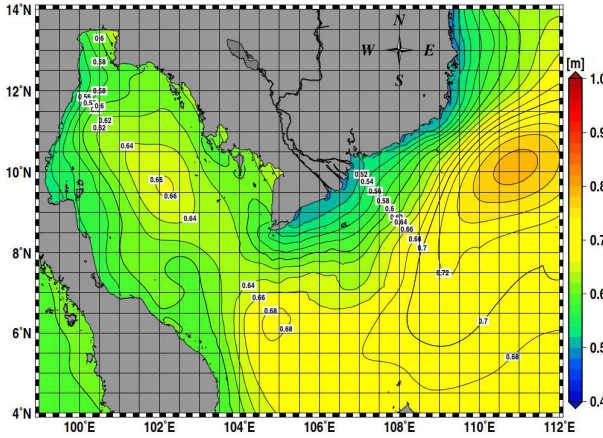






Warmer & High level
Water exist at the center



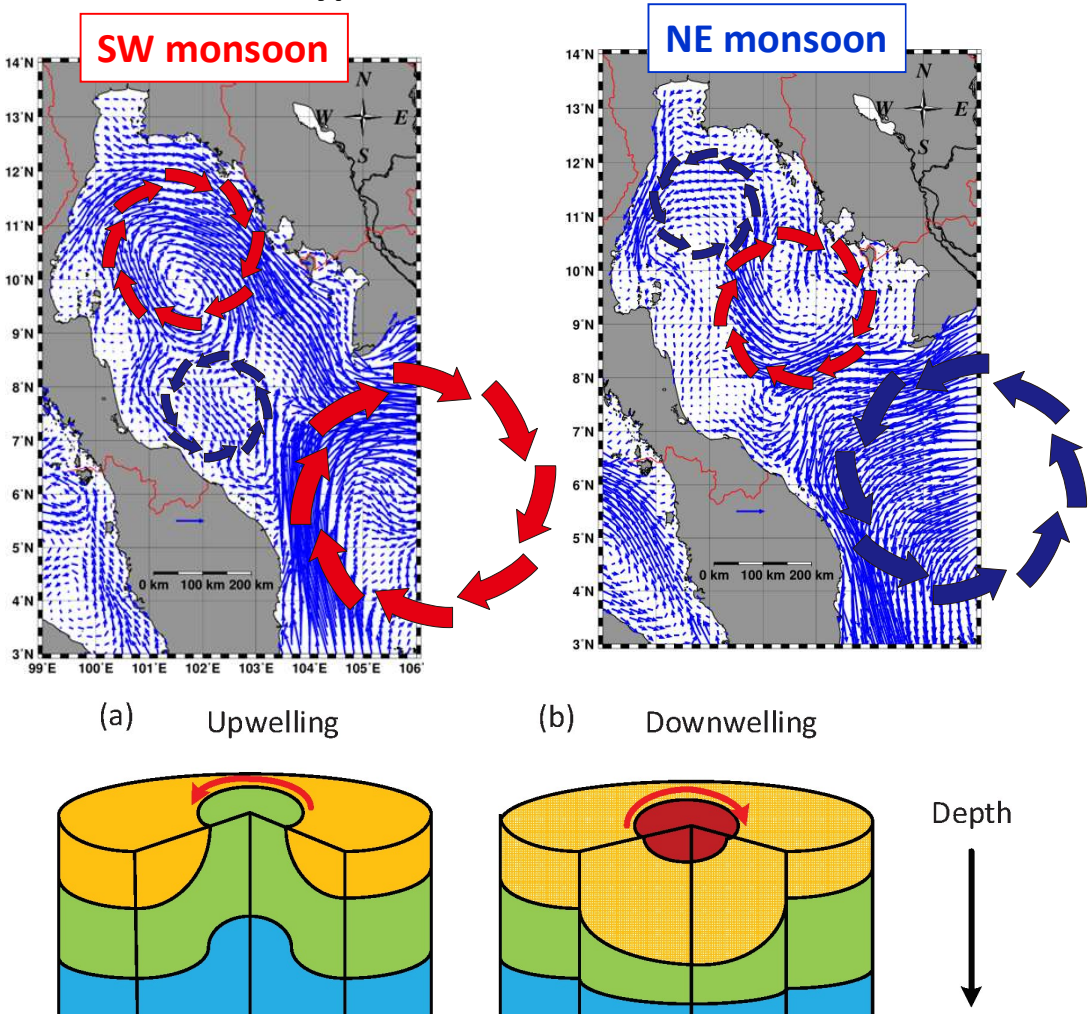


Warmer & High level
Water exist at the center

Effect of Eddies

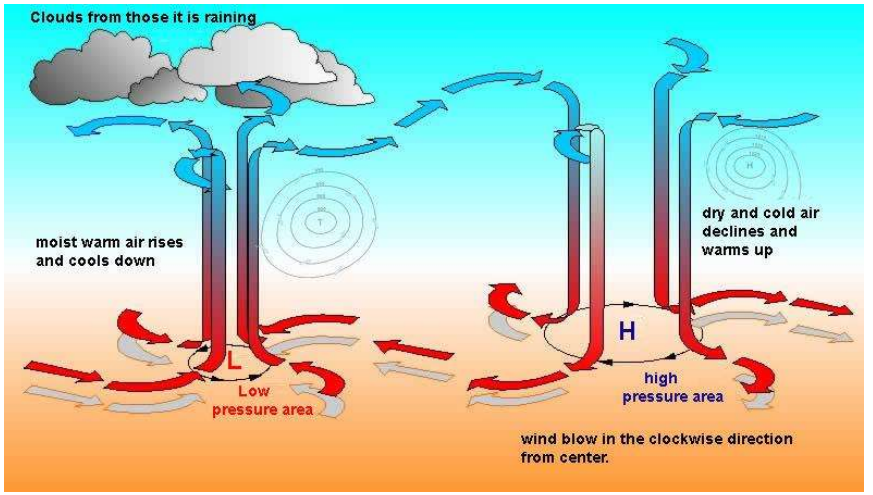
Typical Flow Pattern

Clockwise Eddies are dominant



(a) Upwelling (b) Downwelling

Low Pressure & High Pressure



Upward Air-flow

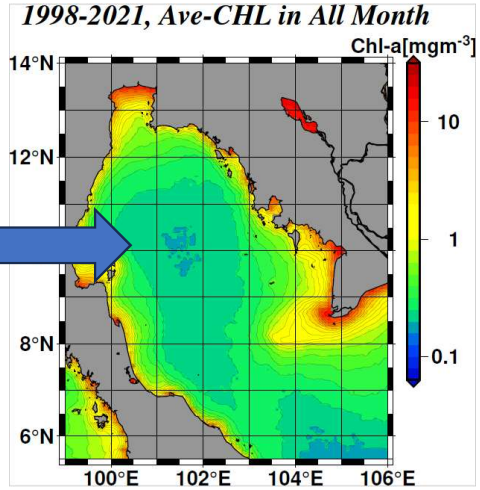
Lifted-up moisture-air makes cloud & rain

Downward Air-flow

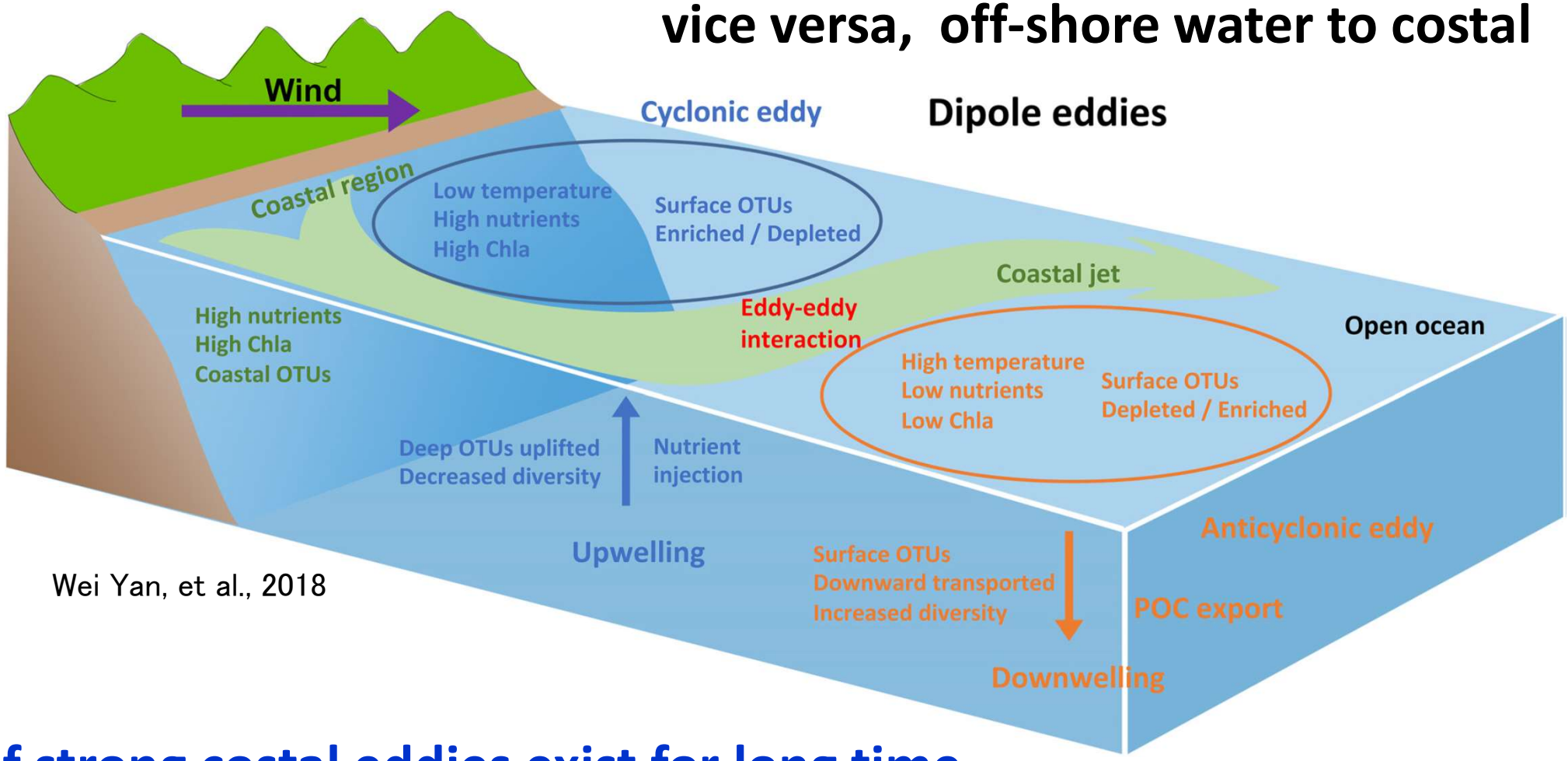
Downward dry-air makes fine weather

Clockwise Eddies and downwelling are dominant in Central area of the Gulf

Another reason



Eddies can carry costal water to off-shore vice versa, off-shore water to costal



Wei Yan, et al., 2018

If strong costal eddies exist for long time…

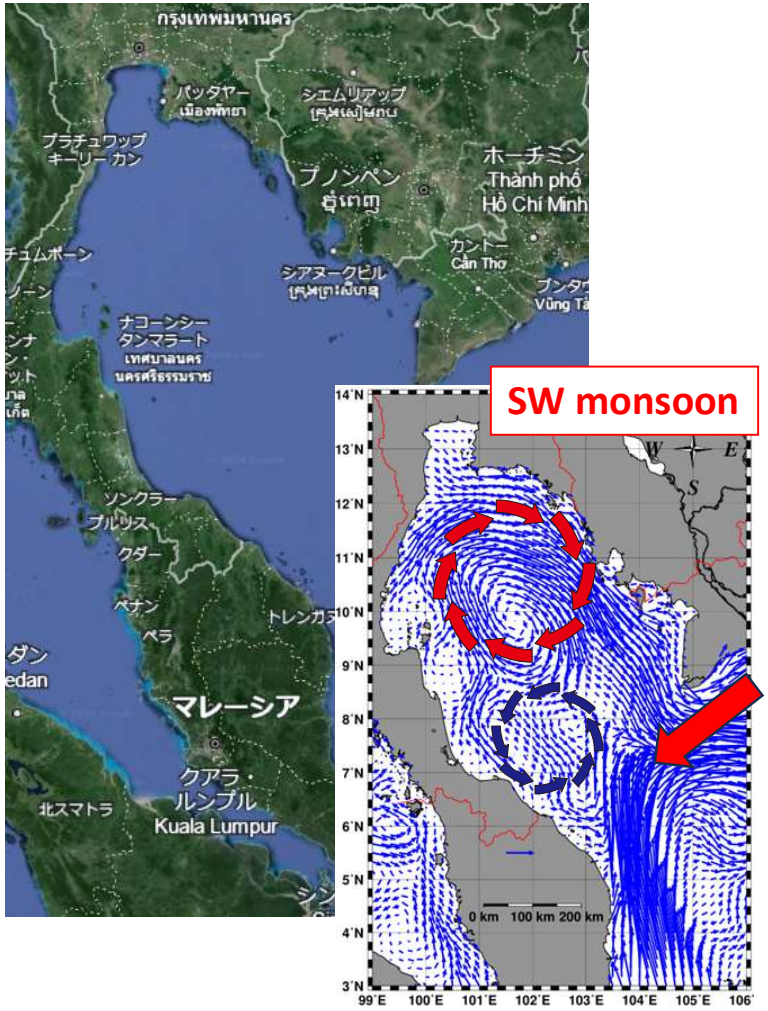
It makes effect to costal topography…

Gulf of Siam

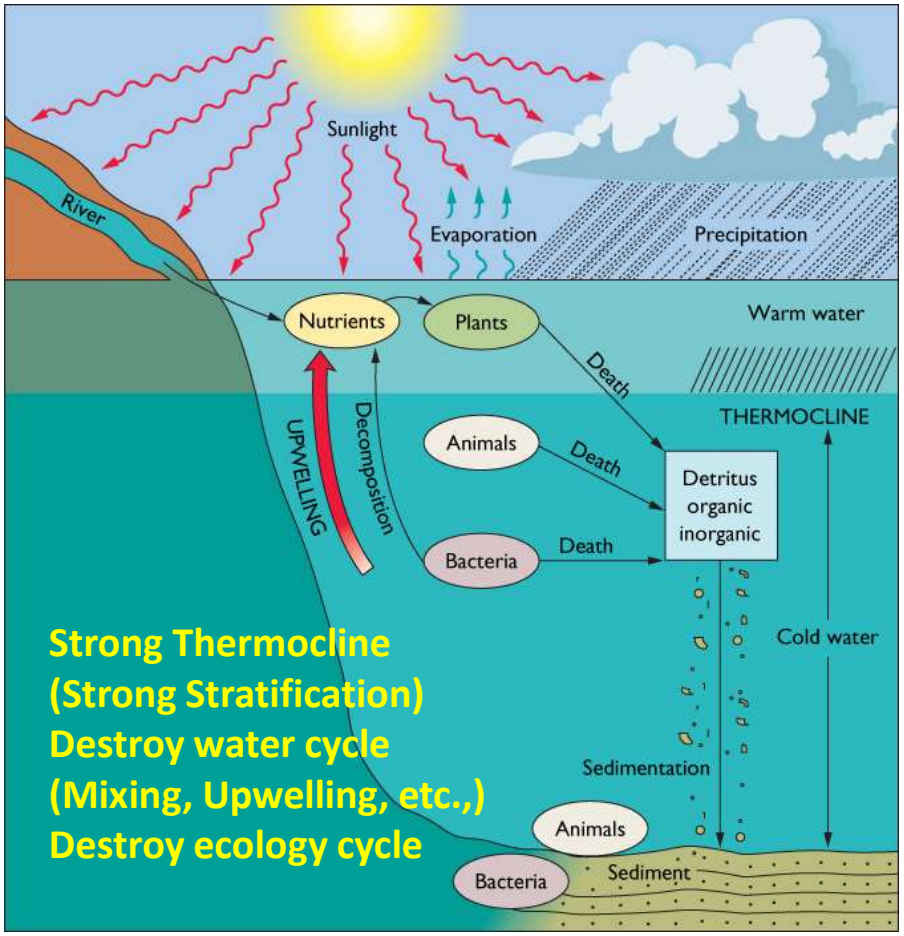
A.D.1686 (2229)

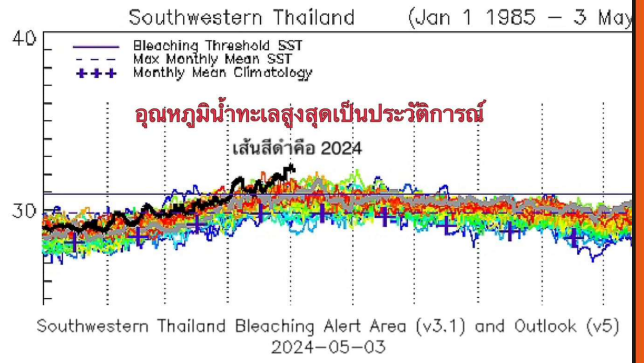
Gulf of Thailand

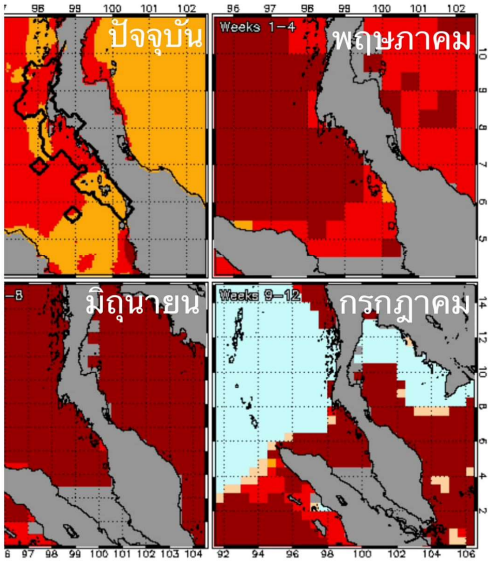
Present 2025 (2568)

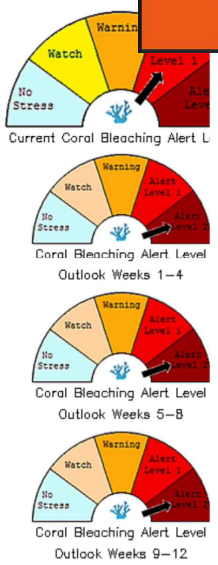


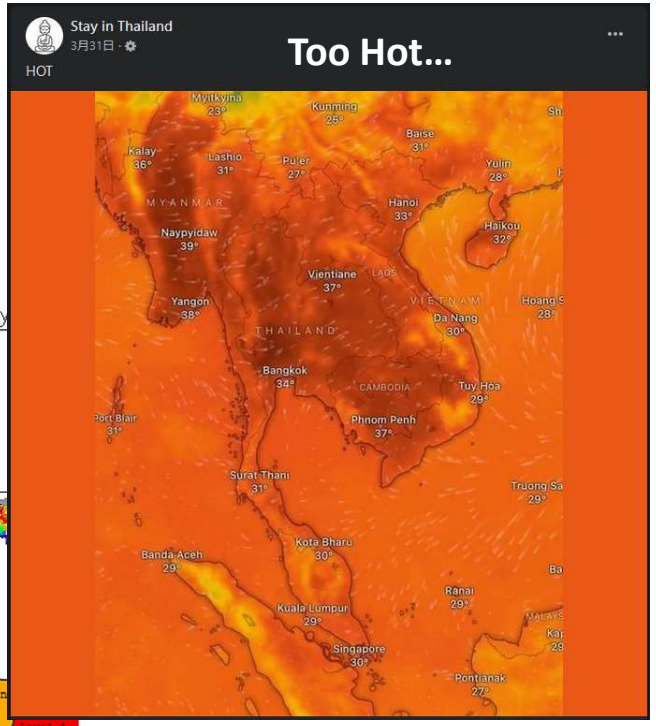
Healthy ecology cycle….will be destroyed by too warmer surface water, too much nutrients.











Coral bleaching
Alert level
Over 32°C sea water

By Global warming…　⇒　Sea water level is rising …

Thailand will melt?

Flooding in Bangkok at High Tide (2021 Nov.)

Bangkok will move?

Road at front of SEAFDEC/TD
2024/1/25
By Dr. Koki Abe

In 2005, Capital city of MYANMAR, has moved from Yangon to Nay Pyi Taw.

Most of reasons…
Military government…

One of reasons…
High tide disaster of Cyclone

In 2024,
Capital city of Indonesia, Jakarta will move to East Kalimantan.

A lot of area of Jakarta, is under 0m height

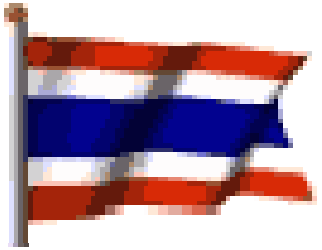
Jakarta, 2007 Feb.

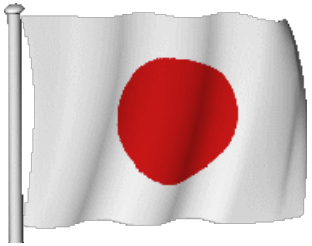
Summary of my lecture

- In the sea, Phyto Plankton is in contradictory advantageous conditions (Surface: rich Sunshine ⇔ Deep: rich Nutrients).
- Water movement (Mixing, Upwelling, Tide, Eddy, River Discharge, etc.) must be need to solve this contradictory condition.

◆ Too warmer surface condition, Too strong water stratification,
⇒ Stop water mixing, Stop nutrient supply, Stop primary production
⇒ Water level: rise, Flooding risk: higher (NE monsoon season)

◆ Too much nutrient supply by river discharge from human effects
⇒ Too heavy bloom, Red tide, Blue-Green Algae, etc. ….





Thank you very much!

ขอบคุณมากครับ

コップン　マーク　クラッ

Good Luck!

โชคดีนะ

チョーク ディー ナ

See you again.

พบกันใหม่นะ

ポップ ガン マイ ナ