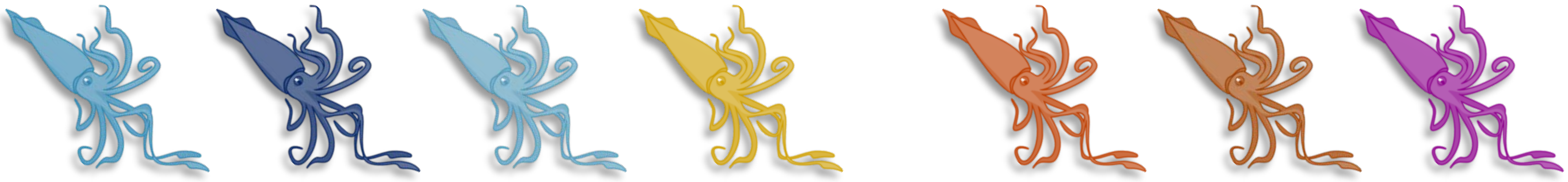
POSSIBLE EFFECTS OF GLOBAL WARMING ON THE NEON FLYING SQUID WINTER-SPRING COHORT



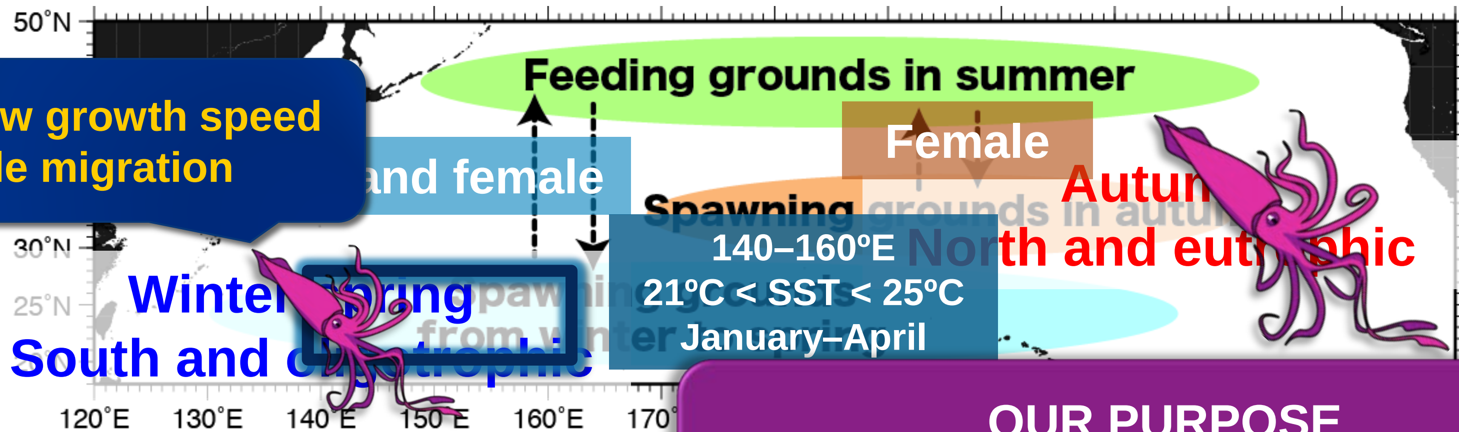
Haruka Nishikawa, Yoichi Ishikawa, Shiro Nishikawa, Toshiyuki Awaji
(Japan Agency for Marine-Earth Science and Technology)

RECCA
Research Program on Climate Change Adaptation
Ministry of Education, Culture, Sports, Science and Technology, Japan

Winter-spring cohort and autumn cohort of the neon flying squid

Spawning grounds, feeding grounds and migration routes of the neon flying squid.
Because spawning grounds is confined by SST (21ºC–25ºC), spawning grounds are separated seasonally.

- **Slow growth speed**
- **Male migration**



Due to the difference of spawning gr

- **Winter-spring cohort grows slo** 2003)**.**
- **Male and female winter-spring** **migrate** to the north because the **autumn cohorts does not migrate** because forage around the spawning grounds is enough to mature for autumn male (Ichii et al., 2011).

OUR PURPOSE

Discuss the possible change of ecology of the winter-spring cohort when global warming increases on the basis of **the Chl-a concentration in the winter-spring main spawning grounds.**

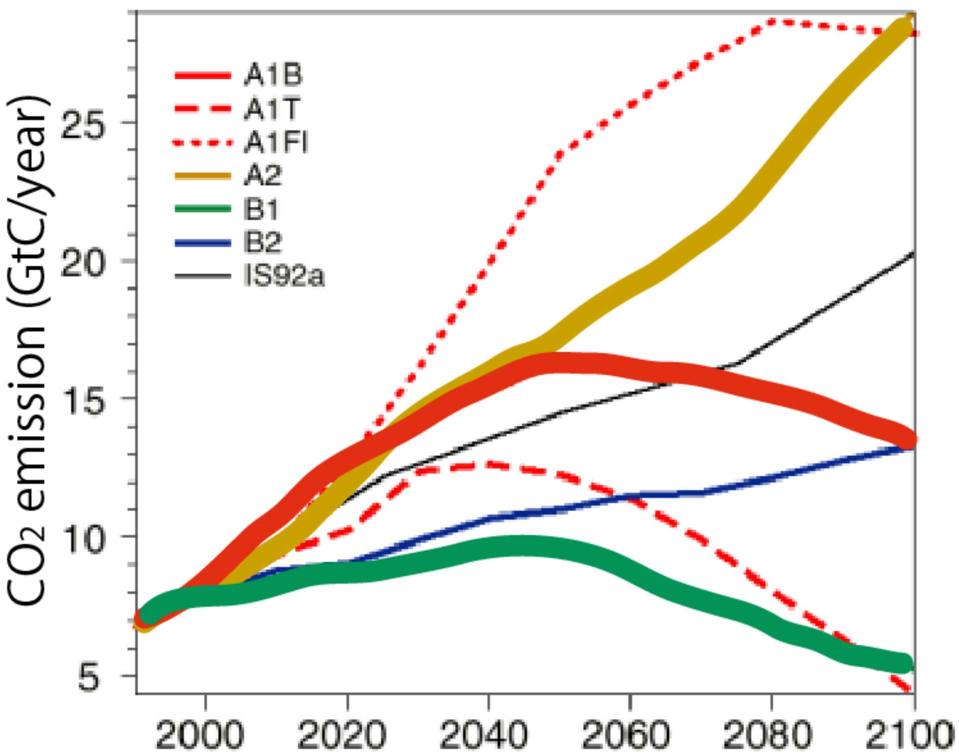
METHODS

To estimate future Chl-a concentration in the winter-spring spawning grounds

- **Select the global warming scenarios**
- **Select the climate models that simulate future climate change on the basis of the selected scenarios**
- **Estimate Chl-a concentration by using model SST and mixed layer depth (MLD).**

  Because climate models did not calculate phytoplankton biomass. We need to estimate Chl-a concentration by using available parameters.

Climate change scenarios



CO_2 emission of Special Report on Emissions Scenarios (SRES) (CMIP3, 2000)

A2

Rapid economic growth that is attained by self-reliant effort of each country

A1B

Rapid economic growth by using balanced energy sources

B1

More ecologically friendly world

Climate models

We compared 23 climate models and choose 2 models that have sufficient reproducibility around the squid spawning grounds.

Model	Organization	Country	A1B	A2	B1	Horisontal resolution
MIROC3.2(hires)	CCSR and JAMSTEC	Japan	○	✖	○	$1.125^{o} \times 0.28^{o}$
CGCM3.1(T47)	CCCMA	Canada	○	○	○	$1.9^{o} \times 1.9^{o}$

Each model forecasts physical parameters (temperature, salinity, etc.) from 2001 to 2100.

At first, we planned to use 4 models. MIROC, CGCM, CSIRO model and MRI model, however, reproducibility of CSIRO and MRI is not good.

How to estimate Chl-a concentration in the spawning grounds?

Two possible causes that changes Chl-a concentration in the spawning grounds

Conflicting possibility!

Northward shift of the spawning grounds

Because the spawning grounds are confined by SST (21ºC–25ºC).

Chl-a increse

We estimated the Chl-a concentration in the new spawning grounds by using the **spatial relation between Chl-a distribution and MLD distribution**.

Decrease of the ocean production

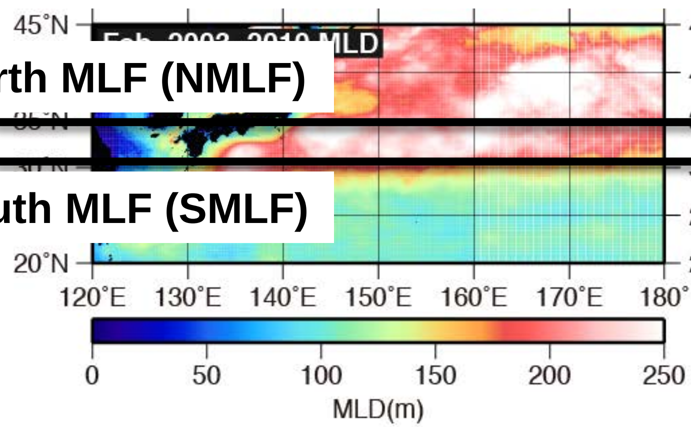
due to intensified stratification.

Chl-a decrease

We corrected the Chl-a concentration in the new spawning grounds based on **how MLD decreases by intensified stratification**.

Mixed layer depth and Chl-a distribution 1

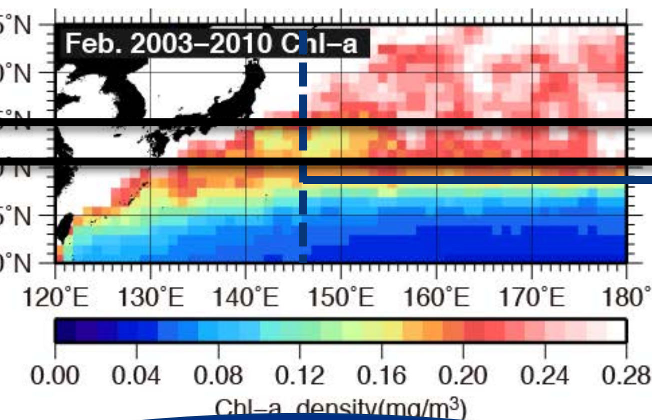
OBS Feb-MLD (2003–2010)



North MLF (NMLF)

South MLF (SMLF)

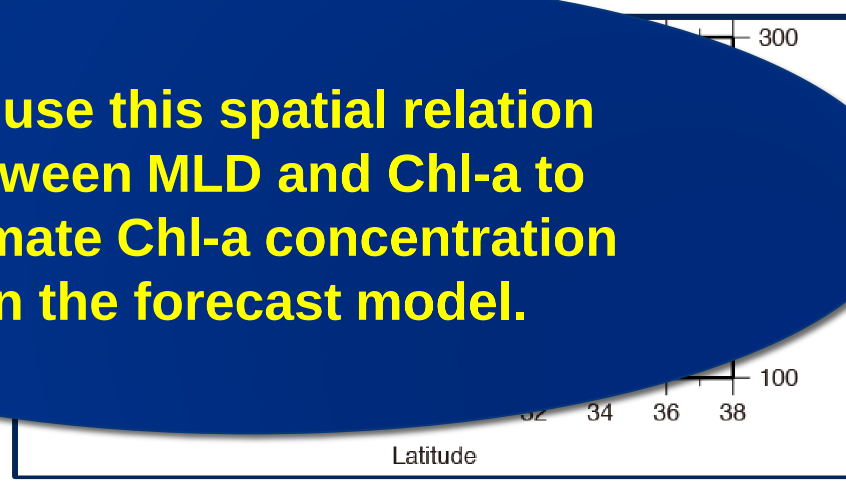
OBS Feb-Chl-a (2003–2010)



Chl-a concentration does not increase monotonically fro to north but has a

The Chl-a troug formed between mixed layer fronts (MLFs).

We use this spatial relation between MLD and Chl-a to estimate Chl-a concentration in the forecast model.

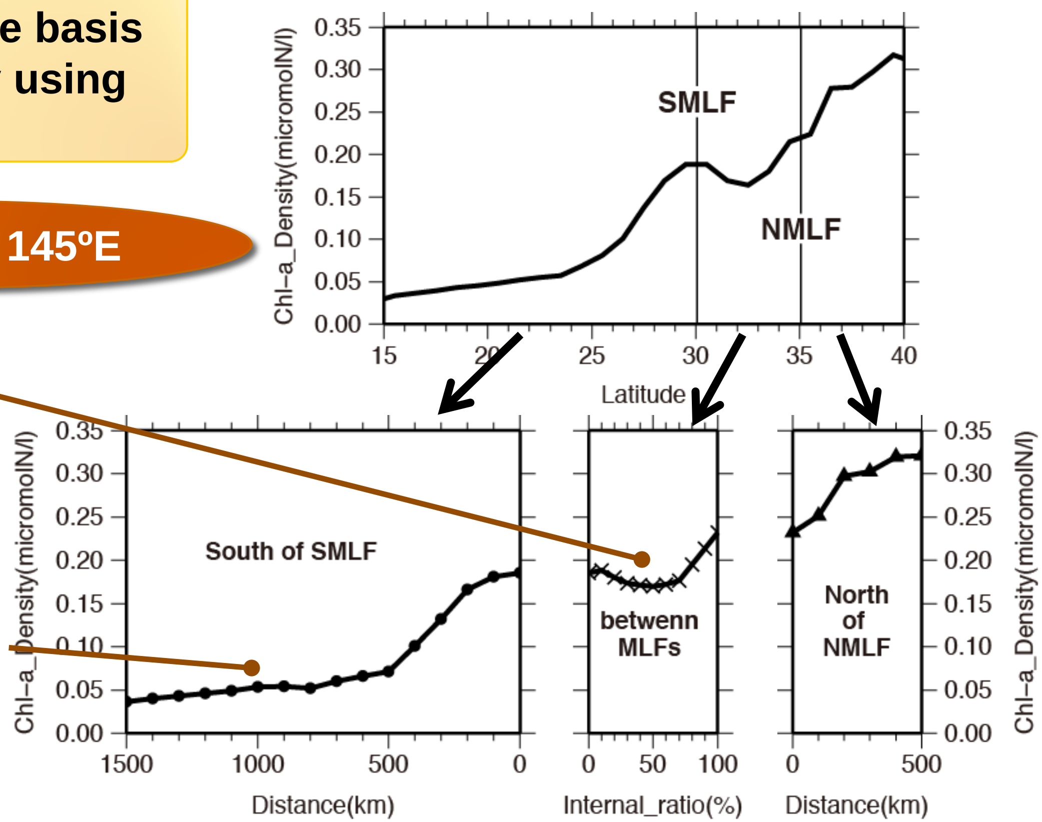


145ºE cross section

Mixed layer depth and Chl-a distribution 2

1. Create the Chl-a concentration map in each longitude on the basis of the distance from MLF by using current observation data.

Example of 145ºE



Chl-a concentration at the point where MLF gap is divided internally by 1:1 is 0.15 mg/m^3

Chl-a concentration **at the 1000 km away from SMLF** is 0.05 mg/m^3

2. Detect the MLF in the forecast models. (MLF is defined by latitudal gradient of MLD.)

3. Estimate the Chl-a concentration in the forecast models.

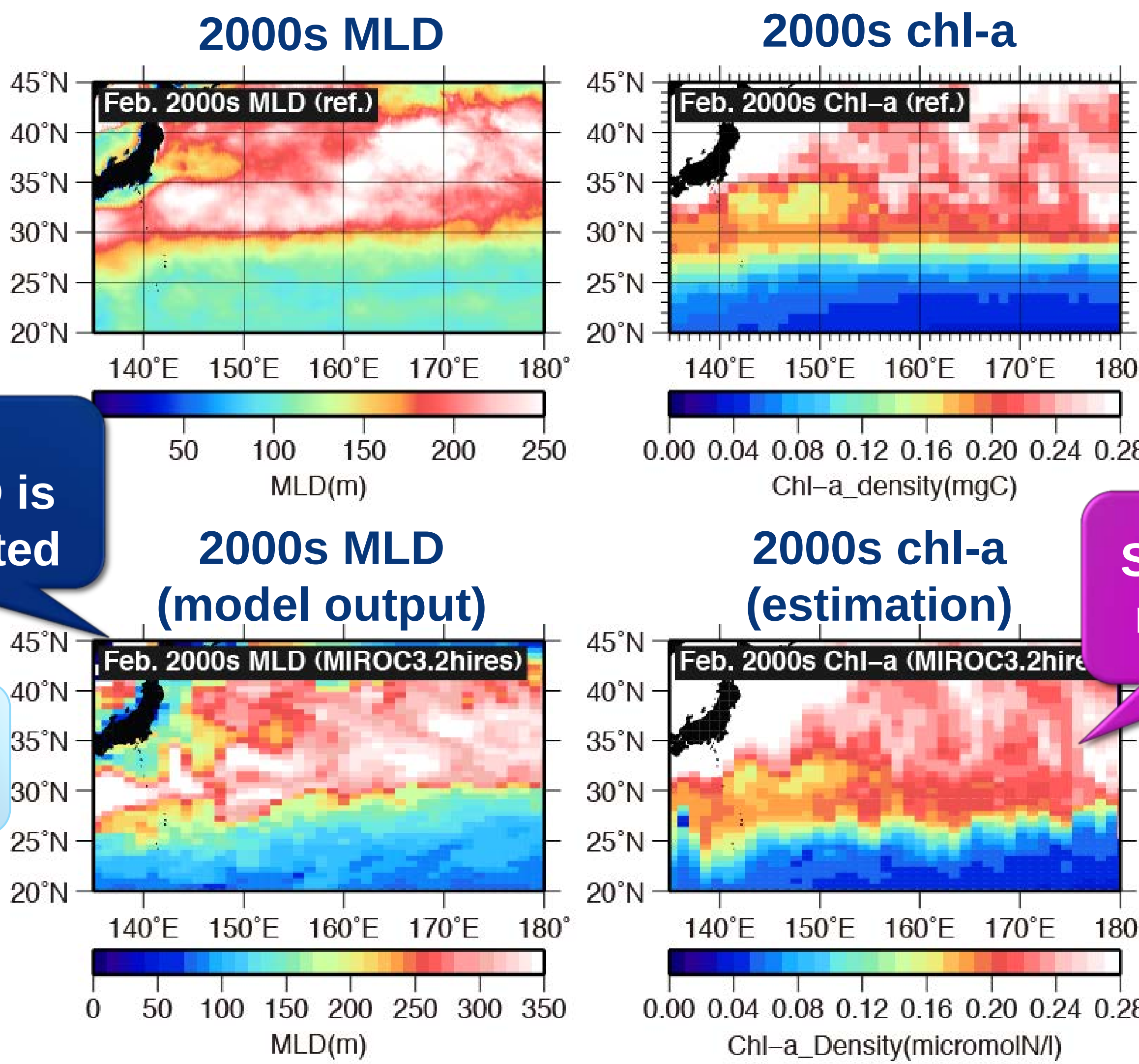
Example of the Chl-a estimation

Reference
(observation)

Forecast model MLD is overestimated

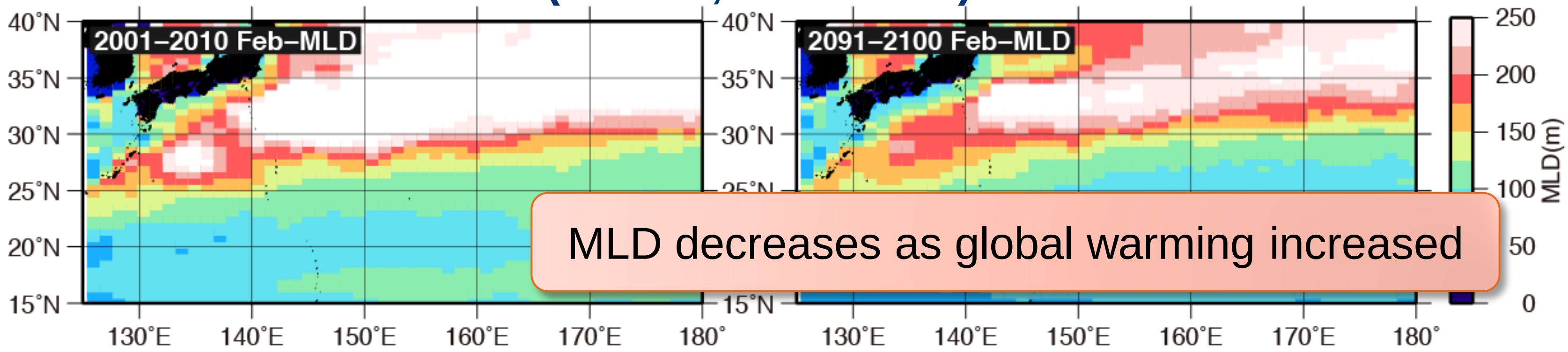
Forecast model
(MIROC3.2 hires)

Successfully reproduced



Effect of the mixed layer shoaling on the Chl-a 1

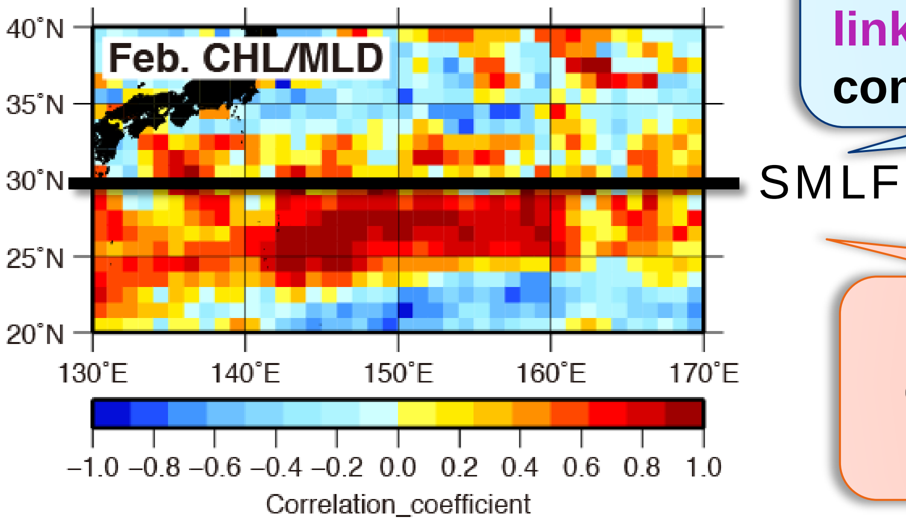
Comparison of Feb-MLD distribution between 2000s and 2090s (MIROC, SRES A1B)



However, the effect of the mixed layer shoaling on the Chl-a concentration is not so simple.

Effect of the mixed layer shoaling on the Chl-a 2

Correlation coefficient distribution between Feb Chl-a and Autumn-winter MLD



North of SMLF

Global warming may not directly link to decrease of the Chl-a concentration

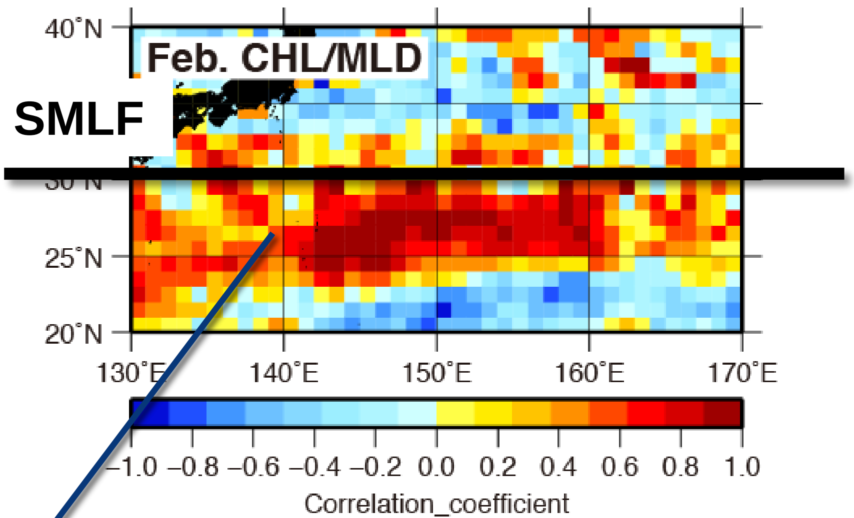
South of SMLF

Global warming may decrease the Chl-a concentration

Chl-a increases as autumn-winter MLD increased in the south of SMLF but this relation is not clearly seen in the north of SMLF

Chl-a data: Terra/Aqua MODIS
MLD: Data assimilation system (MOVE/MRI.COM) from 2003 to 2010

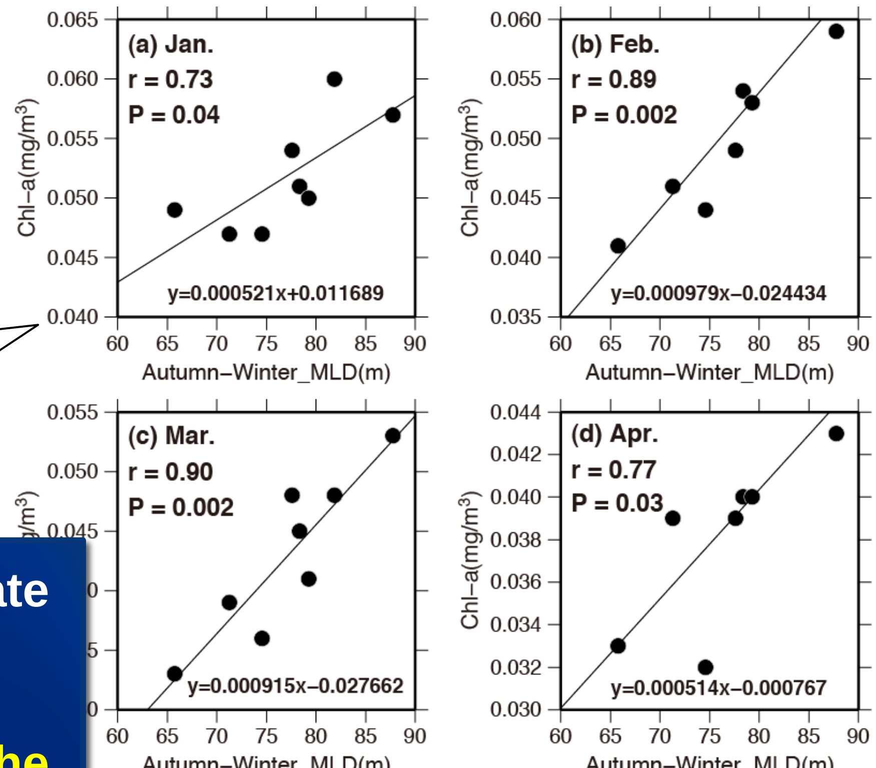
South of SMLF



South of SMLF
Significant positive correlation between Chl-a concentration and autumn-winter MLD in the area 140–160ºE and 24ºN–SMLF

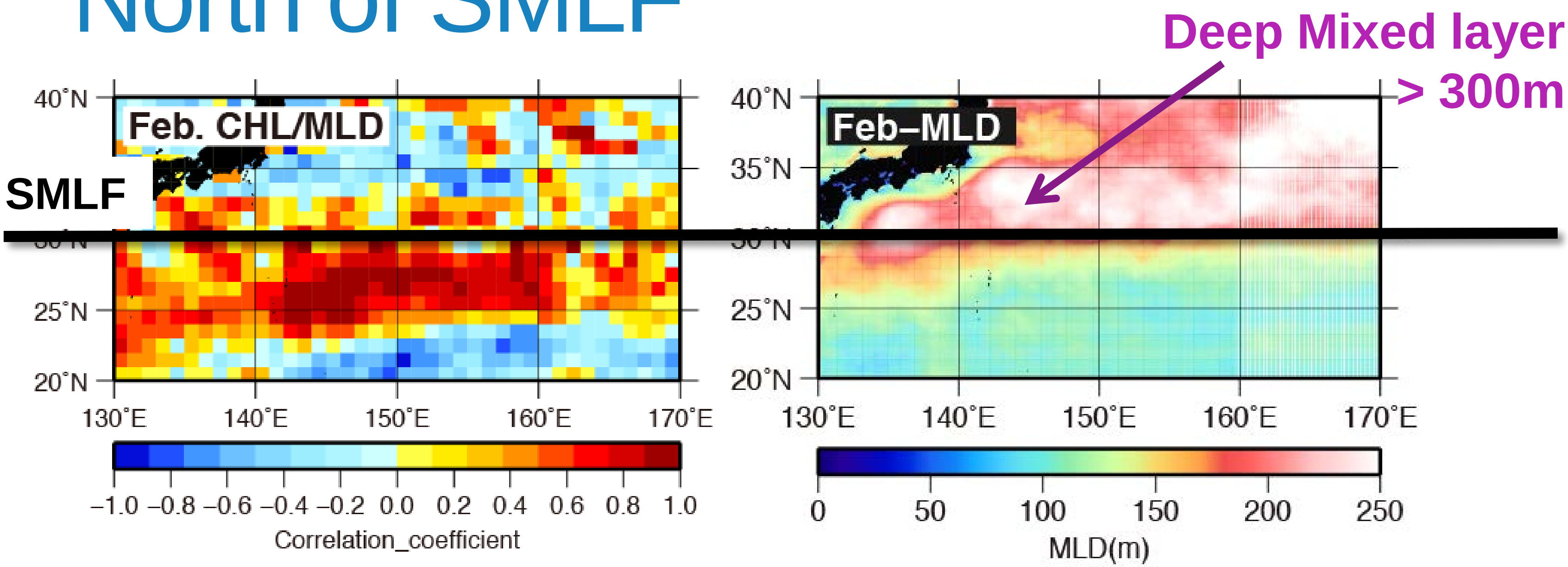
If MLD decreases by 1 m, Chl-a concentration decreases by 0.000521mg/m³ in January.

In case spawning grounds locate in the south of SMLF, we decreased the Chl-a concentration on the basis of the MLD decrease from 2000s.



Chl-a concentration and autumn-winter MLD from 2003 to 2010

North of SMLF



Why clear correlation between Chl-a and MLD is not seen?

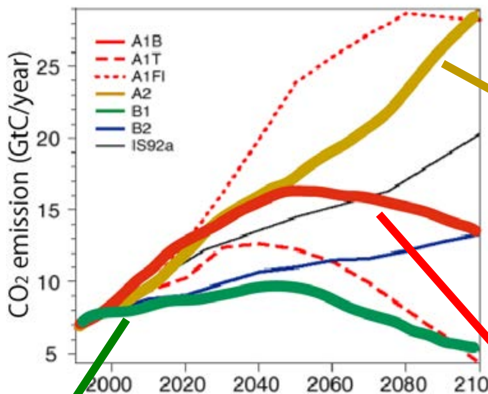
In a part of the north of SMLF, too deep winter mixed layer sometimes inhibits photosynthesis. In the region, **Winter mixed layer shoaling cause high winter Chl-a concentration** (Yasuda and Watanabe, 2007).

For that reason, global warming may not link to the **decrease of Chl-a concentration** in winter when squid spawns.

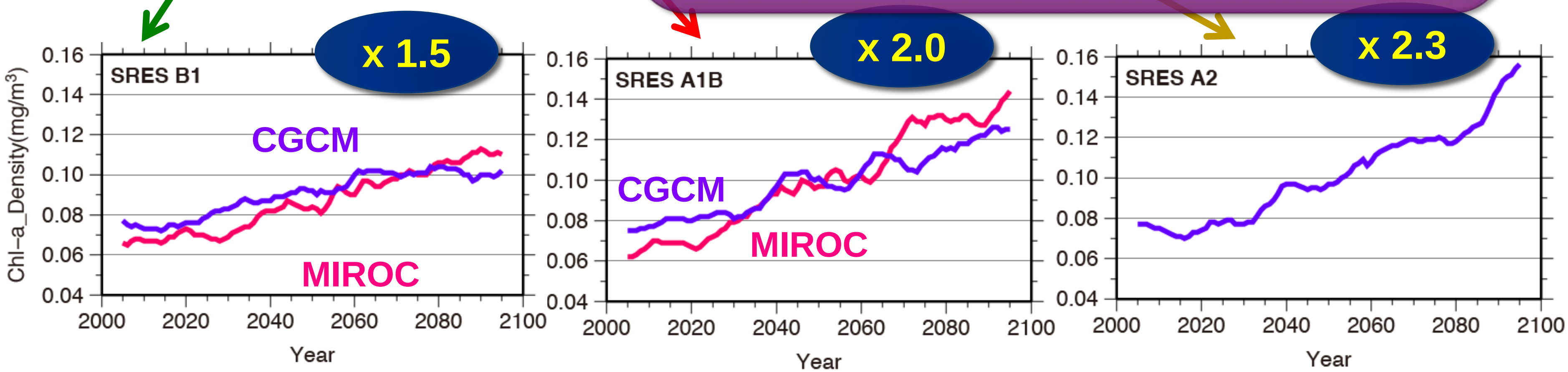
However, since we cannot detect significant correlations between Chl-a concentration and MLD, **we did not take into account the effect of the mixed layer shoaling in the north of SMLF**.

Chl-a variation during the 21st Century

- **Chl-a concentration increases in all models and in all scenarios in the spawning grounds of the winter-spring cohort.**
- Spawning grounds shift to north, eutrophic waters. The effect of mixed layer shoaling may be relatively low.
- There isn't so much of a difference between MIROC and CGCM.



CO_2 emission



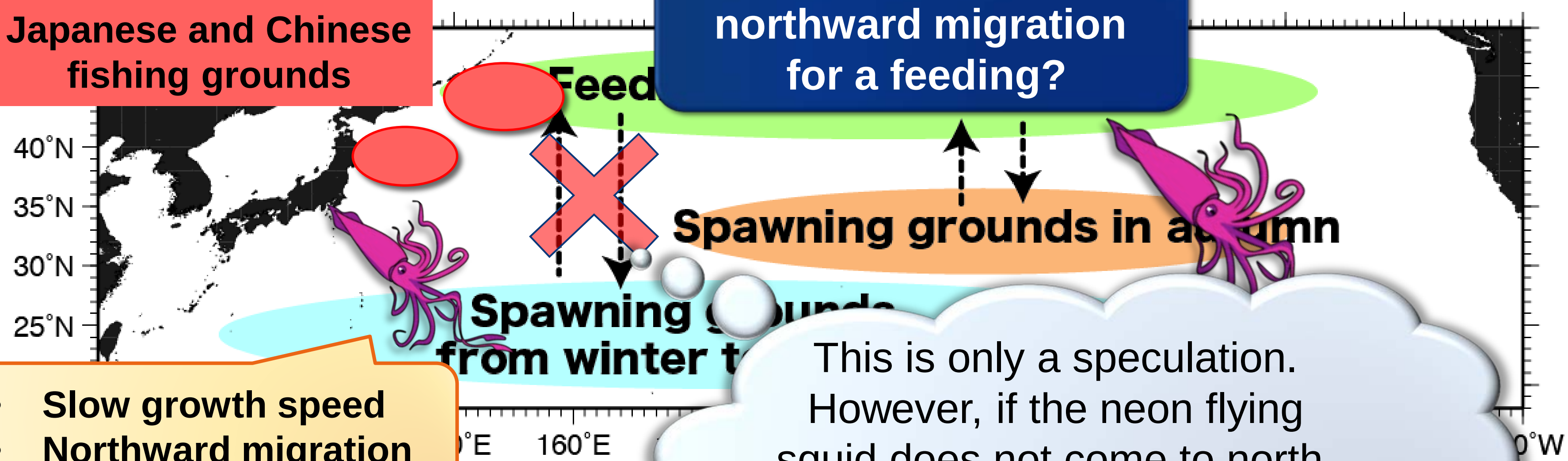
Chl-a concentration in the spawning grounds (140–160ºE, 21ºC < SST < 25ºC)
(averaged from January to April)

Growth and life history of WS cohort

In future, because of the better feeding condition in the spawning grounds,

Japanese and Chinese fishing grounds

Require no northward migration for a feeding?



- **Slow growth speed**
- **Northward migration**

Growth speed will be increased in the early life stage

This is only a speculation. However, if the neon flying squid does not come to north, the **East Asian fisheries suffer a serious blow.**

Future works

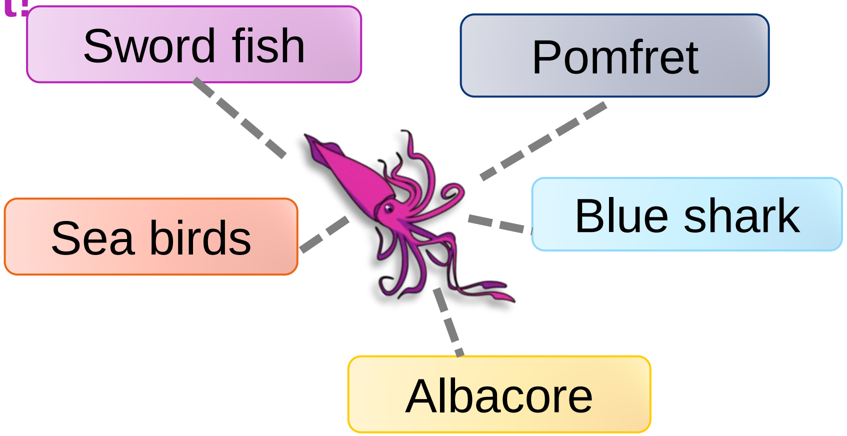
The growth speed increase links to the stock increase?

Previous studies suggested that "**Bigger is better hypothesis**" is applicable to the neon flying squid (Ichii et al., 2011, Nishikawa et al, 2014). Growth speed is related to the survival rate and stock level **only if predation pressure is constant** from year to year.

But predator's behavior will also change by global warming.

Predator information is insufficient!

It is difficult to research the food web in the oceanic subtropical region, however, understanding of the interspecies relationship is necessary to estimate the neon flying squid (and other related species) stock in future.



Possible predators

Thank you for listening!