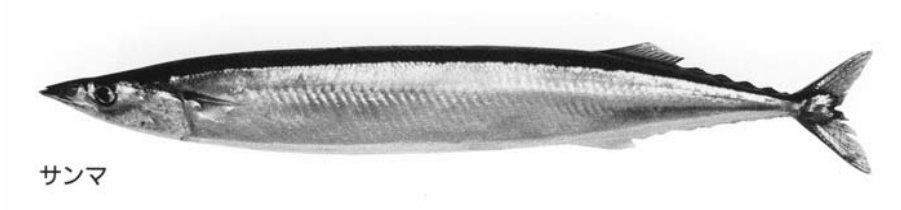
A study for interannual variability of Pacific saury using a simple 3-box model of NEMURO.FISH

Shin-ichi Ito	**FRA, Tohoku Natl. Fish. Res. Inst.**
Michio J. Kishi	**Hokkaido Univ. / Frontier Res. Sys.**
Daiki Mukai	**Hokkaido Univ.**
Yutaka Kurita	**FRA, Tohoku Natl. Fish. Res. Inst.**
Yasuhiro Ueno	**FRA, Tohoku Natl. Fish. Res. Inst.**
Yasuhiro Yamanaka	**Hokkaido Univ. / Frontier Res. Sys.**
Bernard. A. Megrey	**NMFS, Alaska Fish. Sci. Cent.**
Francisco E. Werner	**Univ. of North Calorina**



30 cm

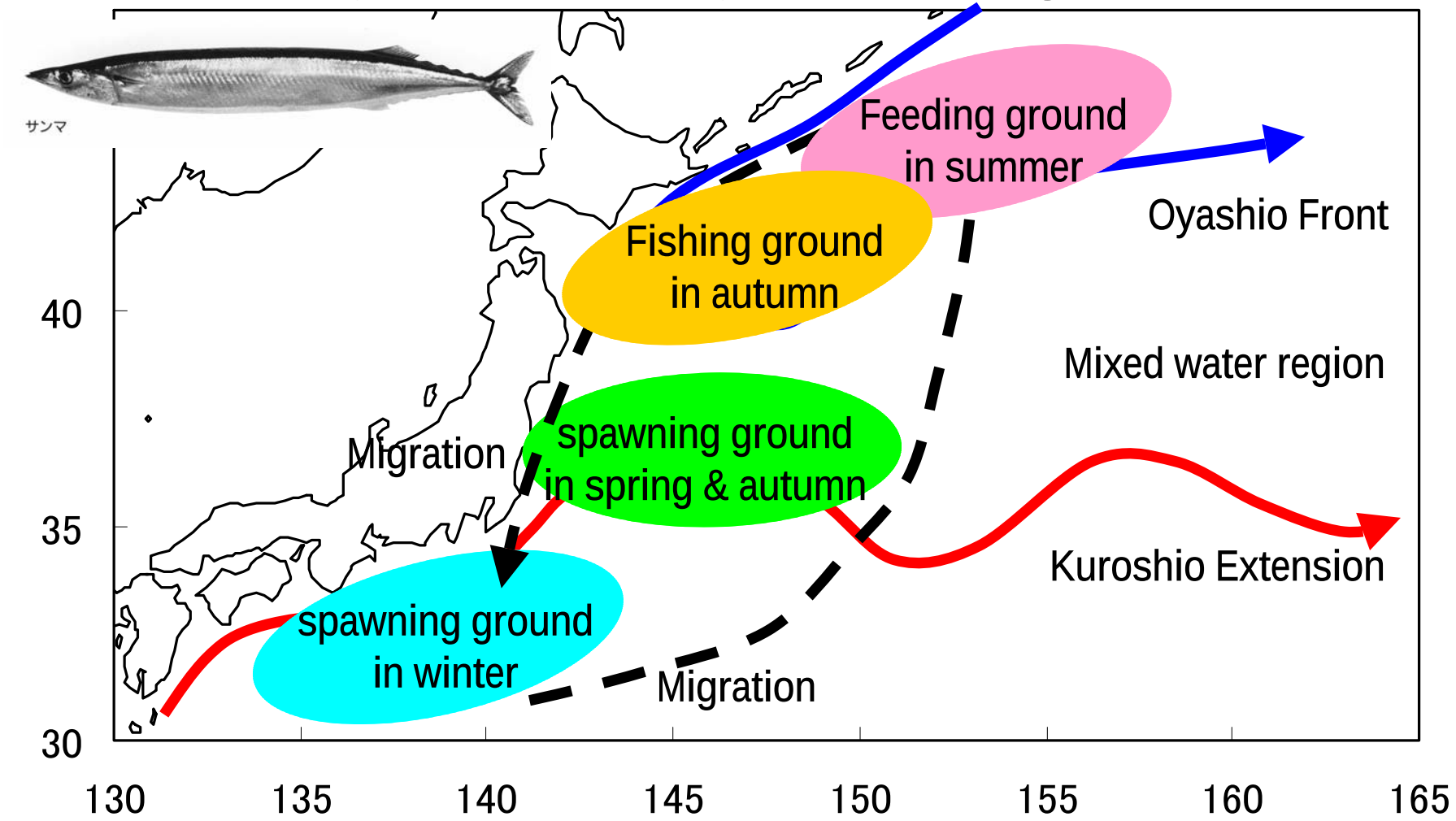
Biomass: 2.8 million tones
west of 162E: 0.9-1.3 million tones

Number: 56.1 billion

Total catch: 0.25 million tones
0.58-0.05 million tones

By TNFRI survey

Life History of Pacific Saury with Oceanographic Features



Modified from Watanabe et al. (1989)

3-box version

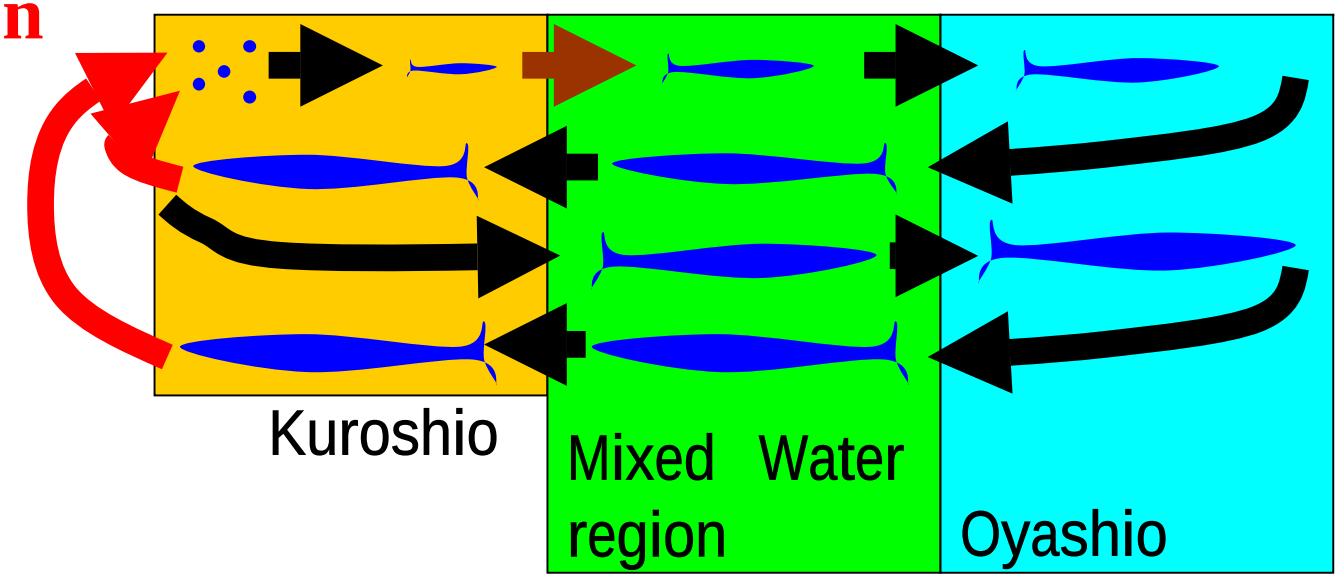


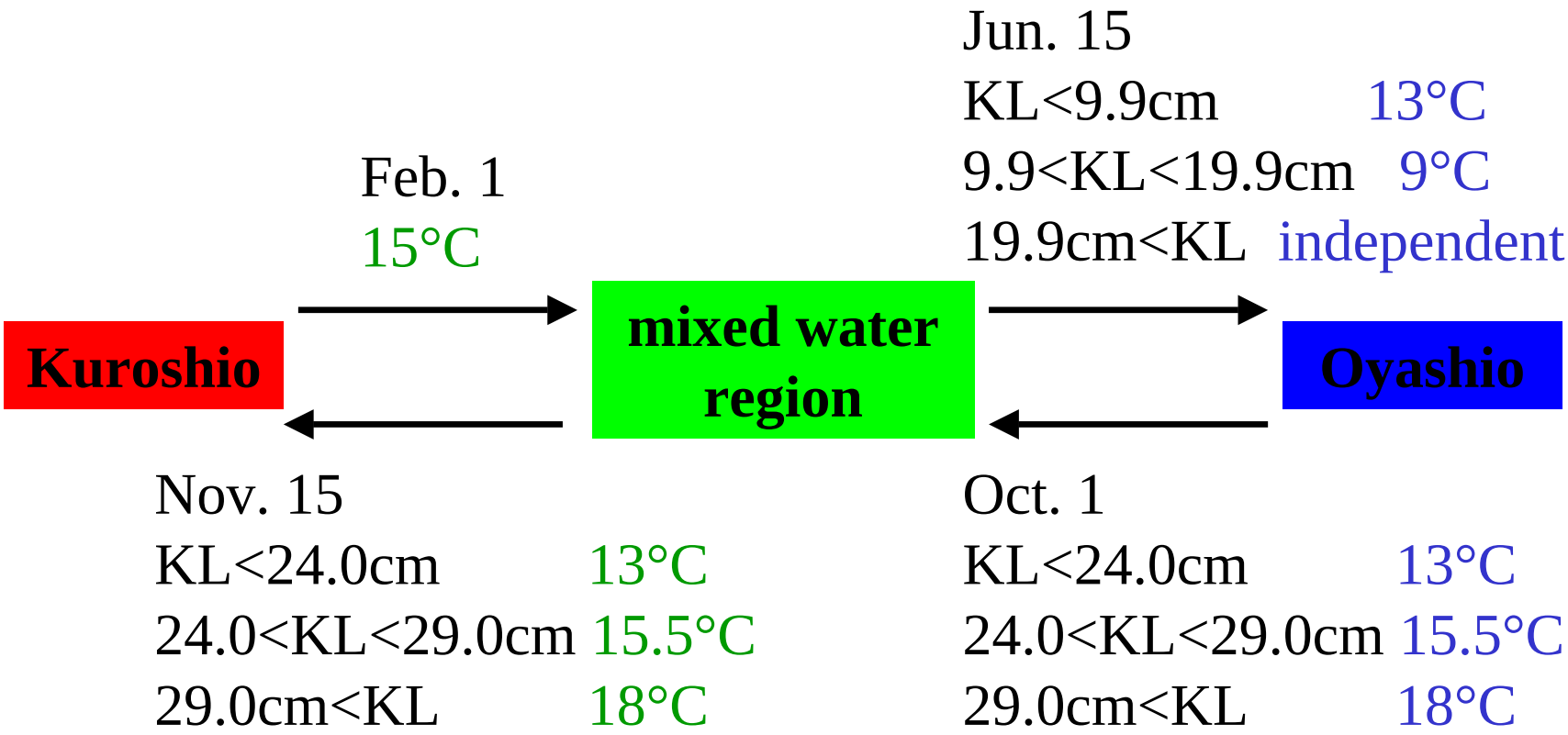
Table 2. Life stages of Pacific saury in the saruy bioenergetics model

Stage	region
larvae	Kuroshio
juvenile & young	mixed region
small	Oyashio
adult	mixed region
adult matured	Kuroshio
adult	mixed region
adult	Oyashio
adult	mixed region
adult matured	Kuroshio

9 life stages

Ito et al. (2004)

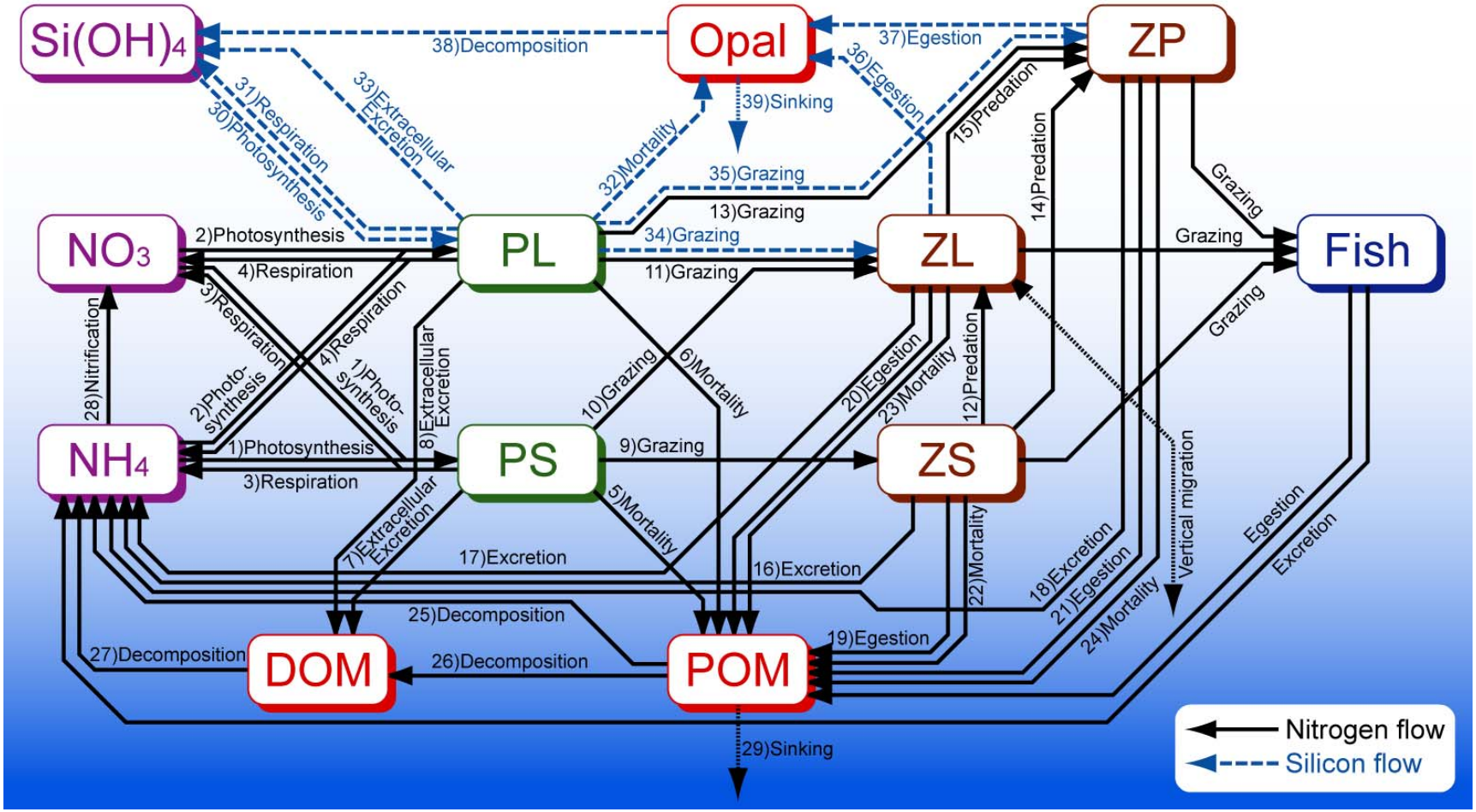
timing of migration

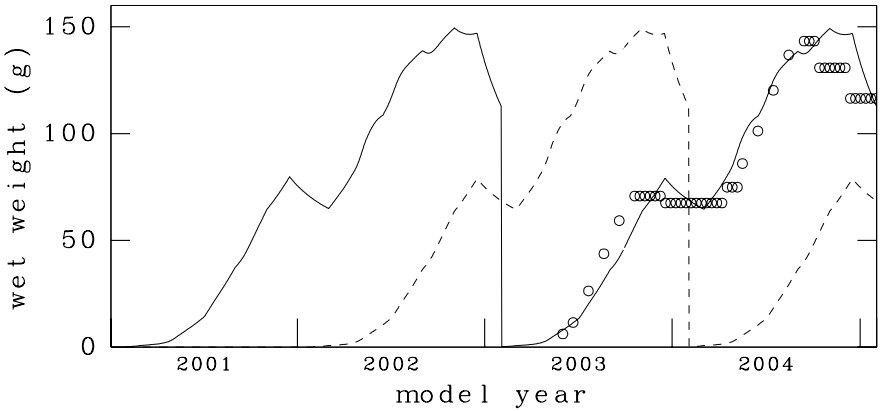


defined by KL and temperature
based on Fukushima (1987)
Kosaka (2000)

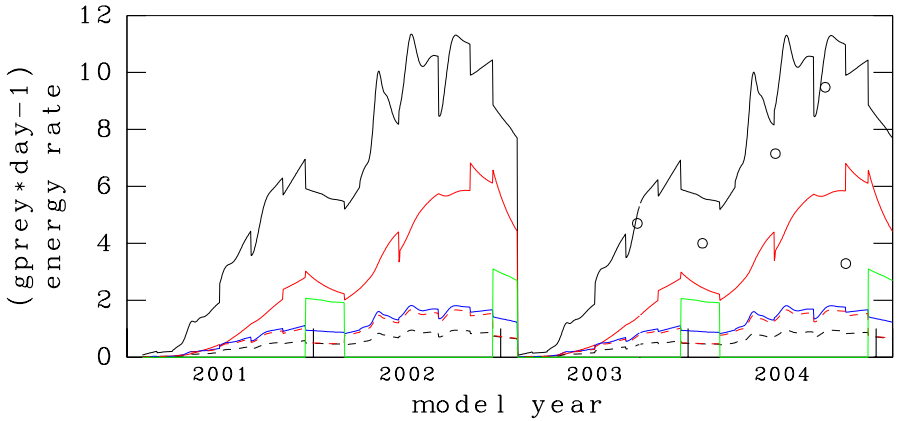
Mukai et al. (submitted)

NEMURO.FISH


Si(OH)4
Opal
ZP
NO3
PL
ZL
Fish
NH4
PS
ZS
DOM
POM
38)Decomposition
37)Egestion
36)Egestion
39)Sinking
31)Respiration
30)Photosynthesis
33)Extracellular Excretion
32)Mortality
35)Grazing
13)Grazing
15)Predation
14)Predation
Grazing
2)Photosynthesis
34)Grazing
4)Respiration
11)Grazing
3)Respiration
4)Respiration
28)Nitrification
2)Photo-synthesis
1)Photo-synthesis
8)Extracellular Excretion
10)Grazing
6)Mortality
20)Egestion
23)Mortality
12)Predation
Grazing
1)Photosynthesis
3)Respiration
9)Grazing
5)Mortality
7)Extracellular Excretion
17)Excretion
16)Excretion
22)Mortality
18)Excretion
21)Egestion
24)Mortality
Vertical migration
Egestion
Excretion
25)Decomposition
27)Decomposition
26)Decomposition
19)Egestion
29)Sinking
Nitrogen flow
Silicon flow

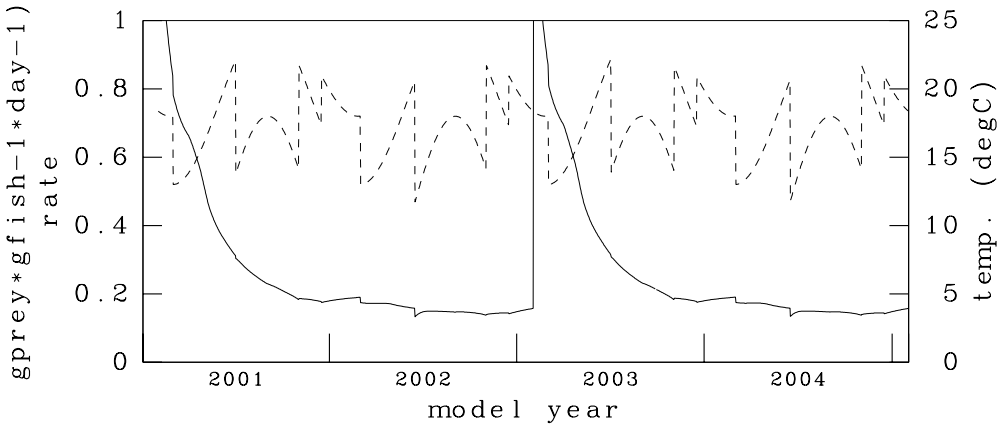


Simulated wet weight & observed growth (Kurita et al.)



Terms of the bioenergetics equation

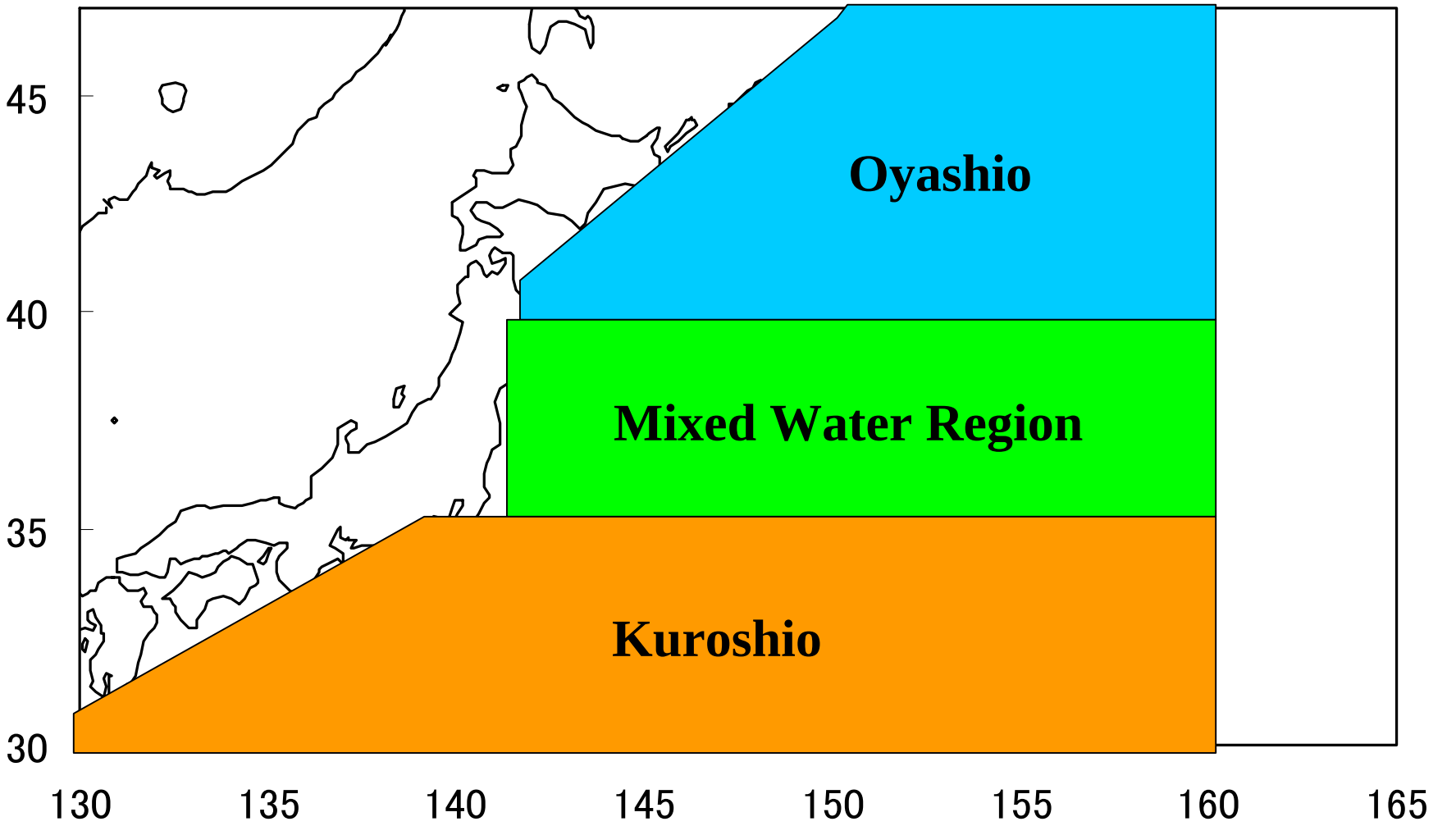
- **black solid: consumption**
- **red solid: respiration**
- **blue solid: egestion**
- **black dotted: excretion**
- **red dotted: specific dynamic action**
- **green: egg production**
- **open circle: observed consumption by Kurita (2002)**



maximum consumption rate multiplied by temperature function (solid line) & water temperature (dotted line).

Ito et al. (2004)

Interannual Forcing (SST)

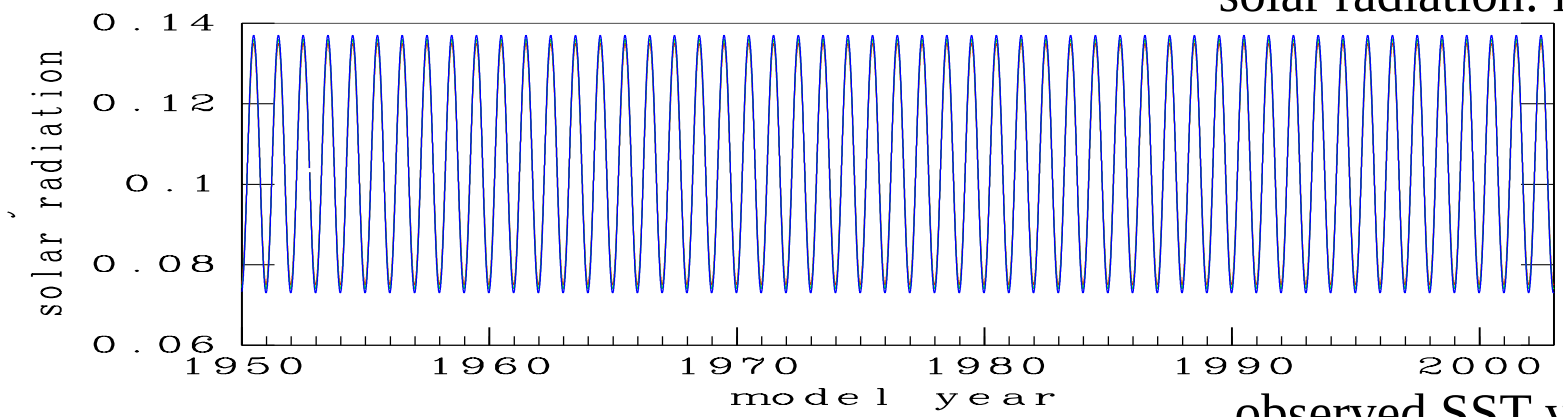


JMA SST product (1deg x 1deg, 10days)

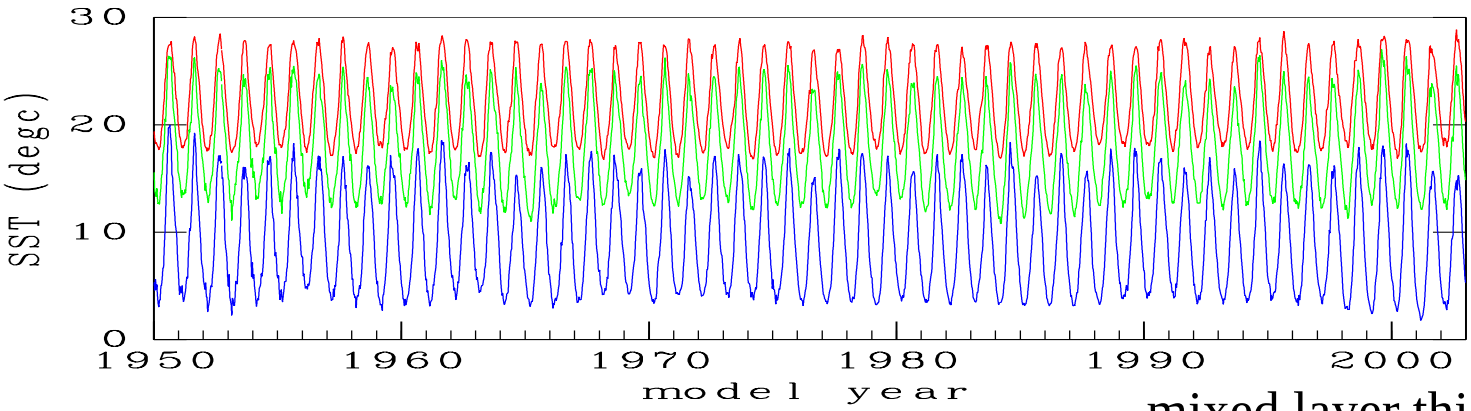
1950 - 2002

forcing

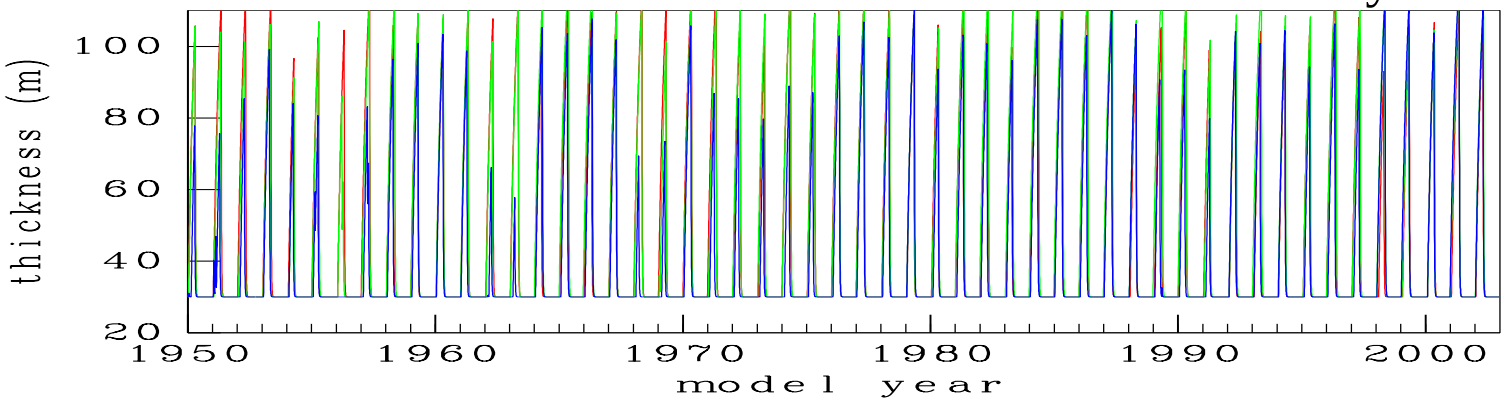
solar radiation: idealized



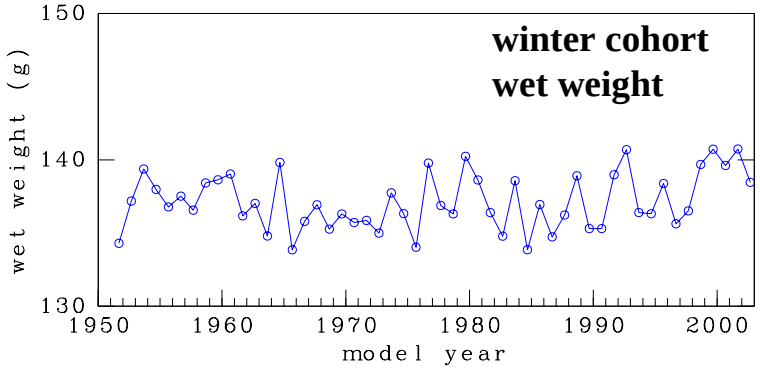
observed SST variability

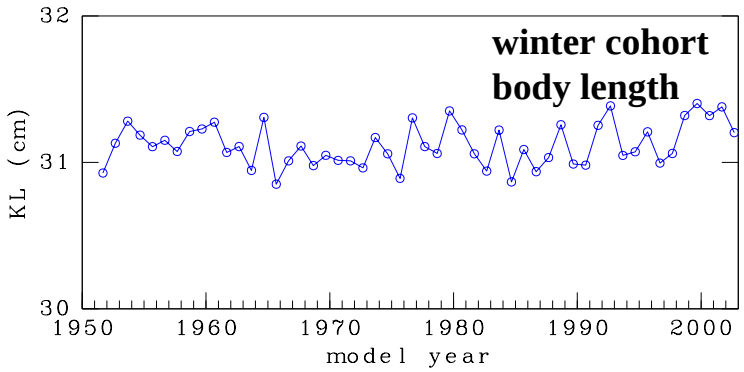


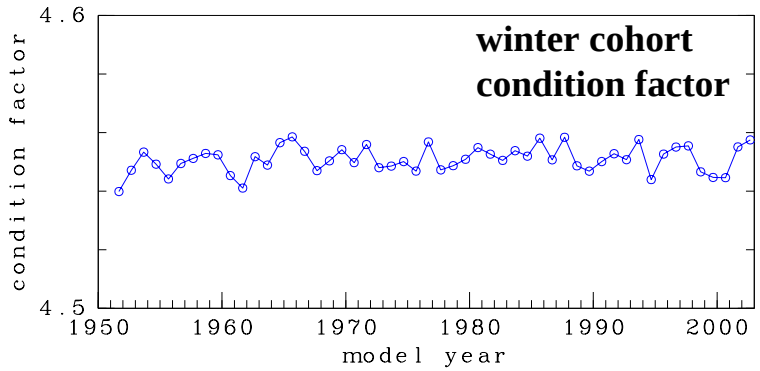
mixed layer thickness

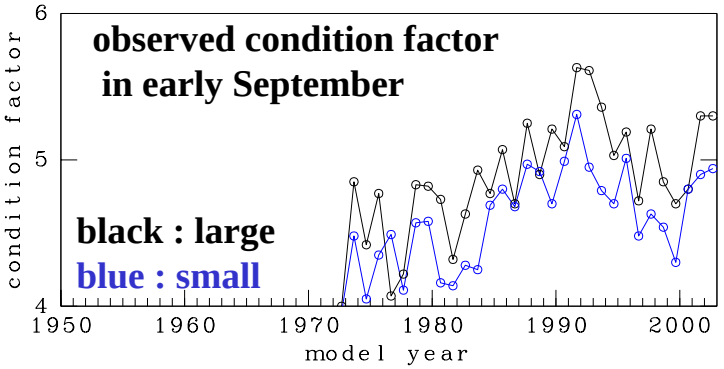


model result vs observation







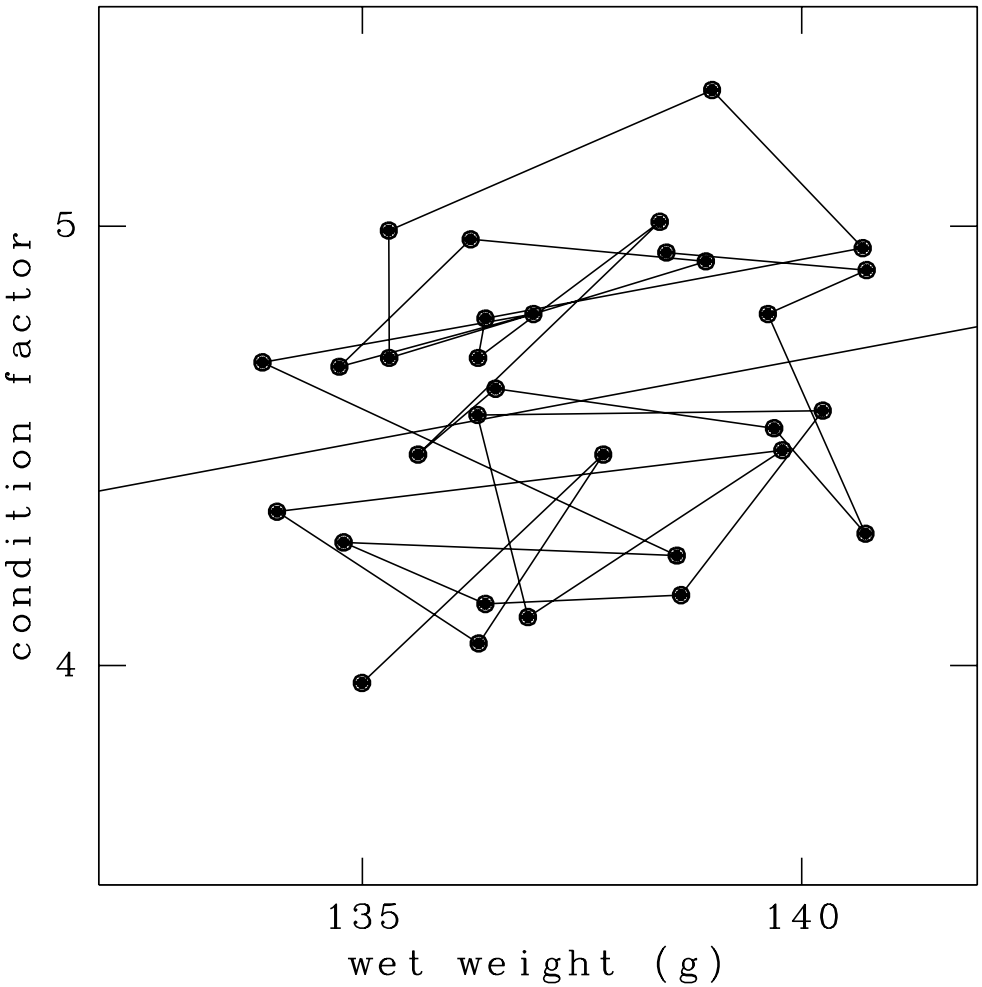


$CF = W/KL^3 * 1000$

In the model the body length is calculated using fixed W-KL relation.
Therefore, the CF is almost fixed in the model.
W is better indicator for growth of saury in the model.

The model result does not well reconstruct the observed variation.

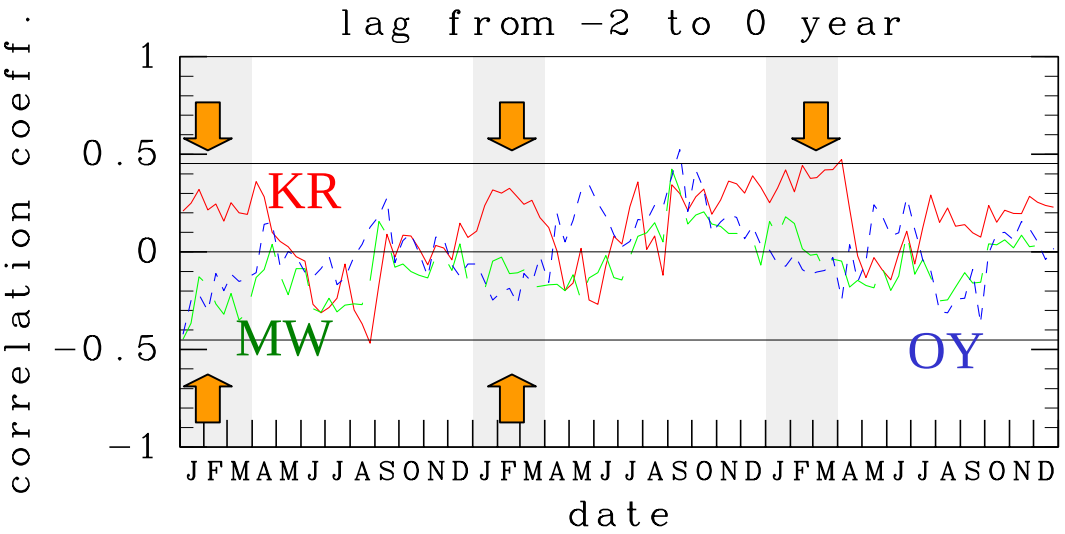
model result vs observation



avg of obs CF: 4.60 avg of model W: 137.36
std of obs CF: 0.33 std of model W: 2.08
cor. coff. : 0.234
99% sig. lev.: 0.452
95% sig. lev.: 0.354
CFobs = 0.3740E-01 *Wmodel + -.5402E+00
rms error : 0.3291E+00

Thought the model result does not well reconstruct the observed variation, there is positive correlation between obs. condition factor and modeled W.

SST - CF relation (observation)

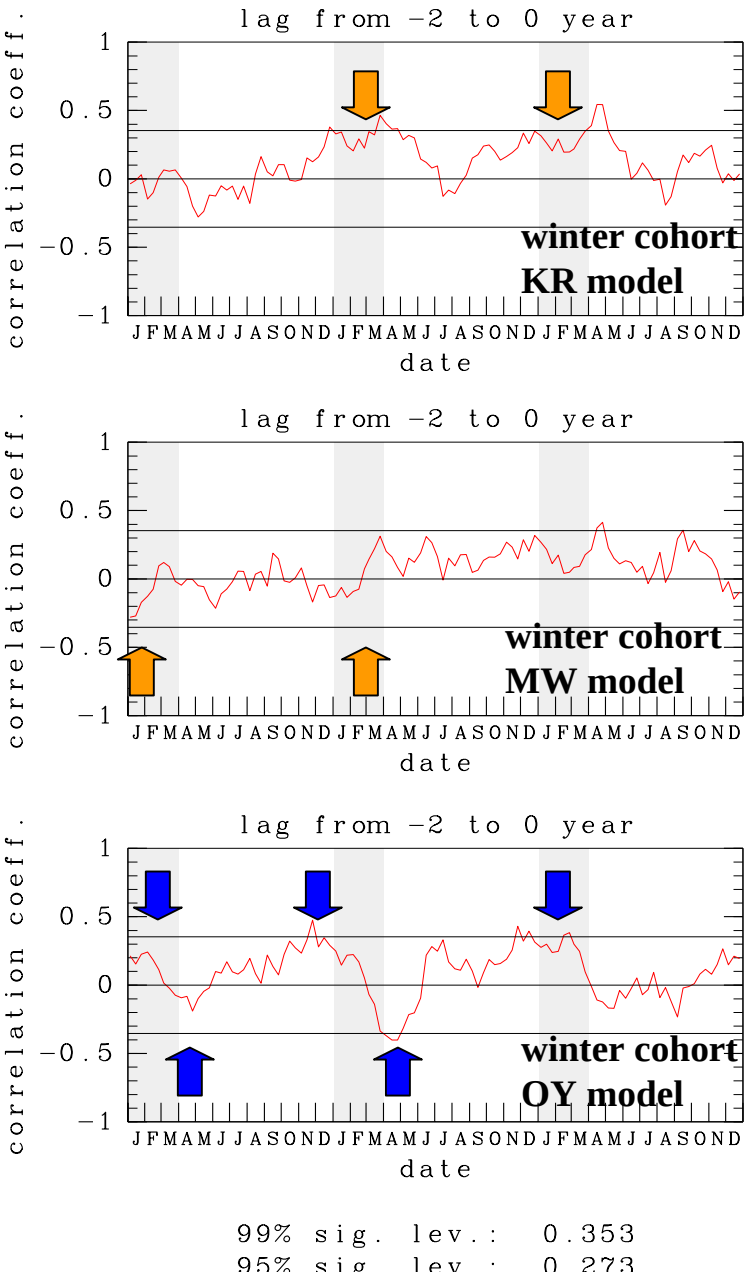


Observed condition factor shows positive correlation with winter KR SST, negative correlation with winter SST in MW and OY.

Warm SST in KR
=> avoid severe condition
SST does not distinctly affect the secondary production because lack of ZL

Cold SST in MW & OY
=> deep convection
=> high nutrient
=> high PL, ZL

SST - W relation (model)



Three additional experiments are performed.

SST has interannual variability

only in Kuroshio region: KR exp

only in mixed water region: MW exp

only in Oyashio region: OY exp

KR exp :

positive correlation in winter (OK)

MW exp :

negative correlation in winter (OK)

OY exp :

positive correlation in winter

negative correlation in spring

=> delay of spring bloom is good for saury growth

=> inconsistent with the observation

Discussion

1. The NEMURO.FISH is able to reproduce appropriate relationship between KR SST and saury growth.

2. The NEMURO.FISH is able to reproduce appropriate relationship between MW SST and saury growth.

3. The NEMURO.FISH cannot reproduce appropriate relationship between OY SST and saury growth.

possibility 1 : salinity effect

In Oyashio region, the effect of salinity to the stratification is important. SST may be not able to reproduce realistic variation of the mixed layer thickness without the effect of fresh water flux.

possibility 2 : sardine effect

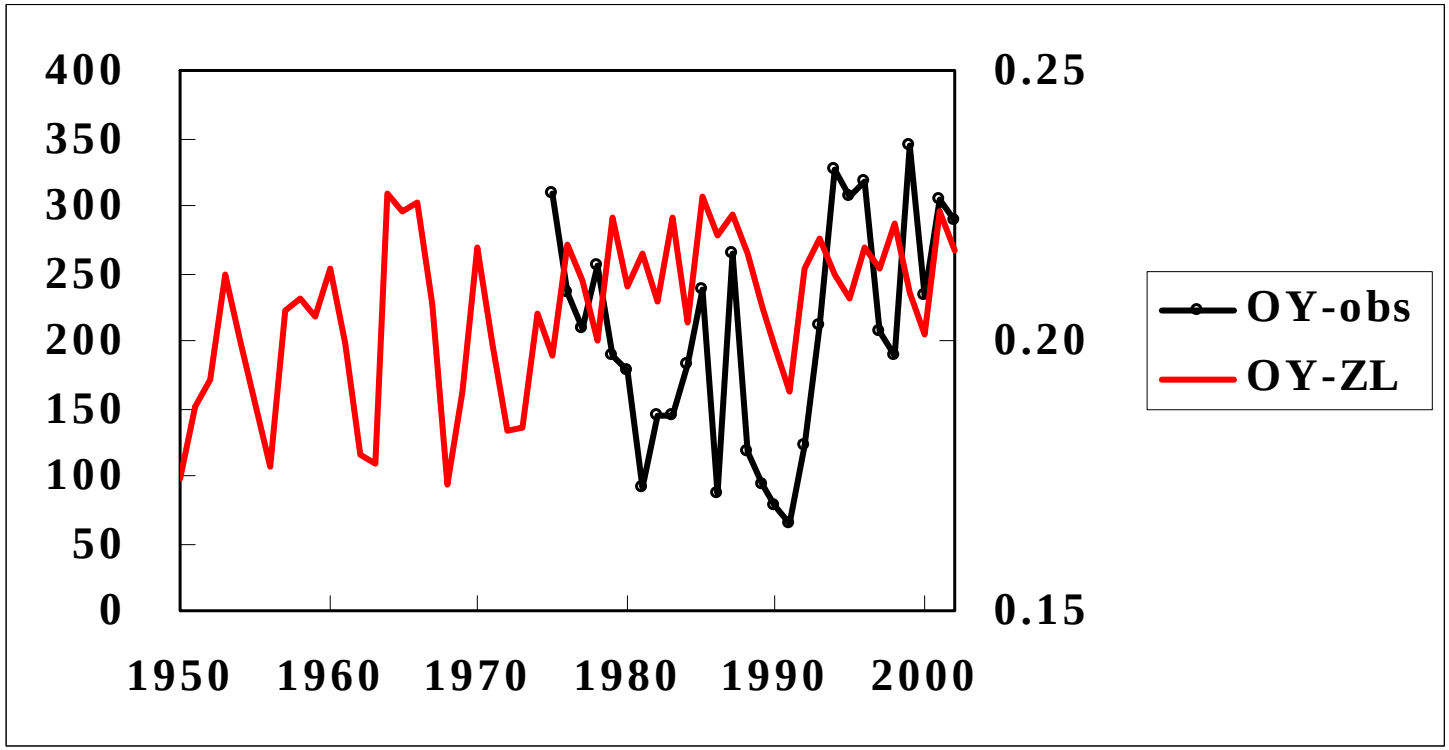
The biomass of Japanese sardine fluctuated so much and it may affect to the abundance of zooplankton, especially in Oyashio in summer season (saury migration season). Therefore, it may destroy the relationship between SST and zooplankton density in Oyashio region.

Discussion

possibility 2 : sardine effect

summer zooplankton density (Odate data: courtesy of Dr. Sugisaki)
NEMRUO output

Model does not follow the variability during 1980's.
Japanese sardine increased extraordinary in this period.



Future Perspectives

1. Apply NEMURO.FISH to sardine, anchovy, mackerel, & others.

2. Perform dynamic linkage between fish and plankton models.

3. Construct multi-species model of NEMURO.FISH.