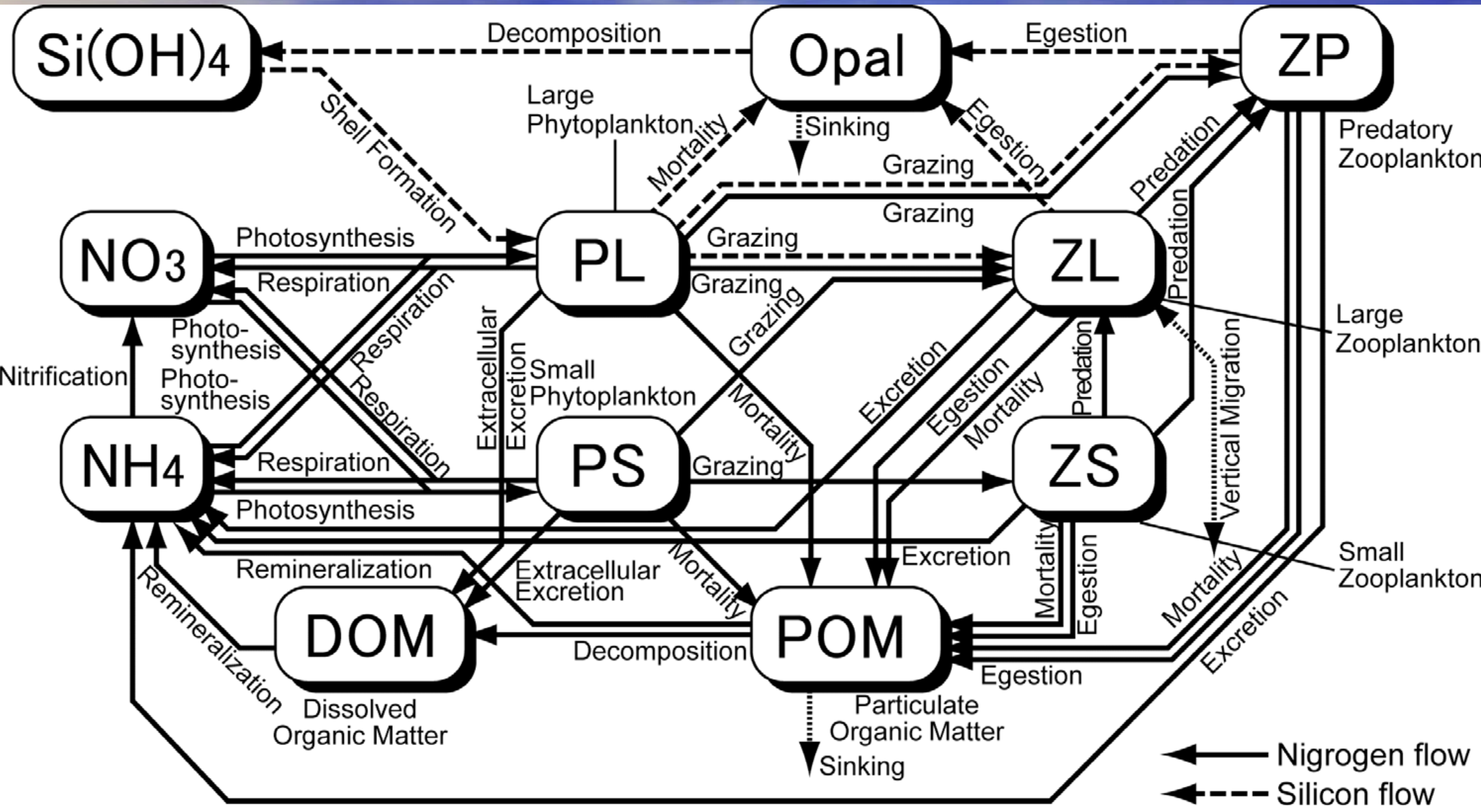
Fish growth comparisons around Japan using NEMURO.FISH

(S8-2262)

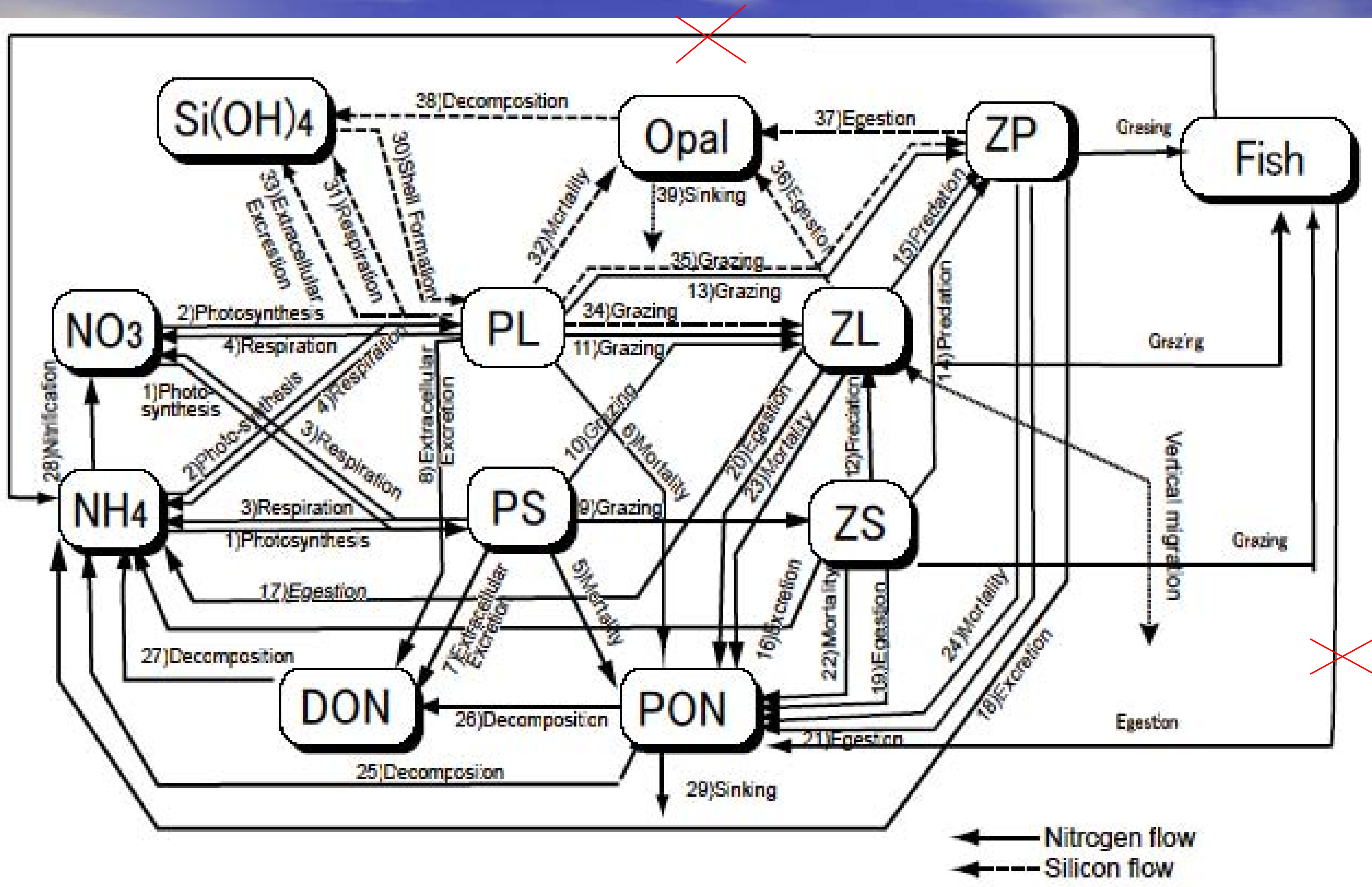
- Michio J. Kishi, Ippo Nakajima and Yasuko Kamezawa
  - Hokkaido University, Faculty of Fisheries Sciences

Supported by

NEMURO


Si(OH)4
Decomposition
Opal
Egestion
ZP
Shell Formation
Large Phytoplankton
Mortality
Sinking
Egestion
Grazing
Grazing
Predation
Predatory Zooplankton
NO3
Photosynthesis
Respiration
PL
Grazing
Grazing
ZL
Predation
Photo-synthesis
Respiration
Grazing
Large Zooplankton
Nitrification
Photo-synthesis
Respiration
Extracellular Excretion
Small Phytoplankton
Mortality
Excretion
Egestion
Mortality
Predation
Vertical Migration
NH4
Respiration
PS
Grazing
ZS
Photosynthesis
Remineralization
Extracellular Excretion
Mortality
Excretion
Mortality
Egestion
Mortality
Small Zooplankton
Remineralization
DOM
Decomposition
POM
Egestion
Excretion
Dissolved Organic Matter
Particulate Organic Matter
Sinking
Nigrogen flow
Silicon flow

NEMURO. FISH



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

NEMURO.FISH

- NEMURO>S8-2377 by Z.Wang *et al.*
- NEMURO/saury>POC_Paper-2255 by Y. Yamanaka *et al.*
- Saury>>S4-2412 by S. Ito *et al.*
- Herring>S4-2504 by F.E. Werner *et al.*

NEMURO.For Incorporating other Sea Habitats

Bioenegetics Model

$$\frac{dW}{W \cdot dt} = [C - (R + SDA + F + E + P)]$$

W:wet weight(g),　t:time(day),
C:consumption (gprey/gfish/day),
R:respiration or losses through metabolism (gprey/gfish/day),
SDA: specific dynamic action or losses due to energy costs of digesting food (gprey/gfish/day),
F:egestion or losses due to feces (gprey/gfish/dday),
E:excretion or losses of nitrogenous excretory wastes (gprey/gfish/dday),
P:egg production or losses due to reproduction (gprey/gfish/d)

★**Foods of saury are**ZS, ZL, ZP **with selective function**

(VENFISH, 2002 PICES MODEL/REX TASK TEAM, 伊藤ら2002)

consumption

NEMURO

$$C = C_r \cdot f_c(T)$$

$$C_r = \sum_{j=1}^{n} C_j$$

$$C_j = \frac{C_{MAX} \cdot \frac{PD_{ij} \cdot v_{ij}}{K_{ij}}}{1 + \sum_{k=1}^{n} \frac{PD_{ik} \cdot v_{ik}}{K_{ik}}}$$

$$C_{MAX} = a_c \cdot W^{b_c}$$

$$f_c(T) = gcta \cdot gctb$$

where

$$tt5 = \frac{1}{(te2 - te1)}$$

$$t5 = tt5 \cdot a\log\left[0.98 \cdot \frac{(1.0 - xk1)}{(0.02 \cdot xk1)}\right]$$

$$t4 = e^{[t5 \cdot (T - te1)]}$$

$$tt7 = \frac{1}{(te4 - te3)}$$

$$t7 = tt7 \cdot a\log\left[0.98 \cdot \frac{(1.0 - xk4)}{(0.02 \cdot xk4)}\right]$$

$$t6 = e^{[t7 \cdot (te4 - T)]}$$

PD_{ij} :density of prey type j (g wet weight/m^3),

v_{ij} :vulnerability of prey type *j* to predator *i*

K_{ij} :half saturation constant (g wet weight/m^3),

C consumption rate (g/g/d),

C_{MAX} :maximum consumption rate (g/g/d),

$f_c(T)$:temperature dependence function for consumption

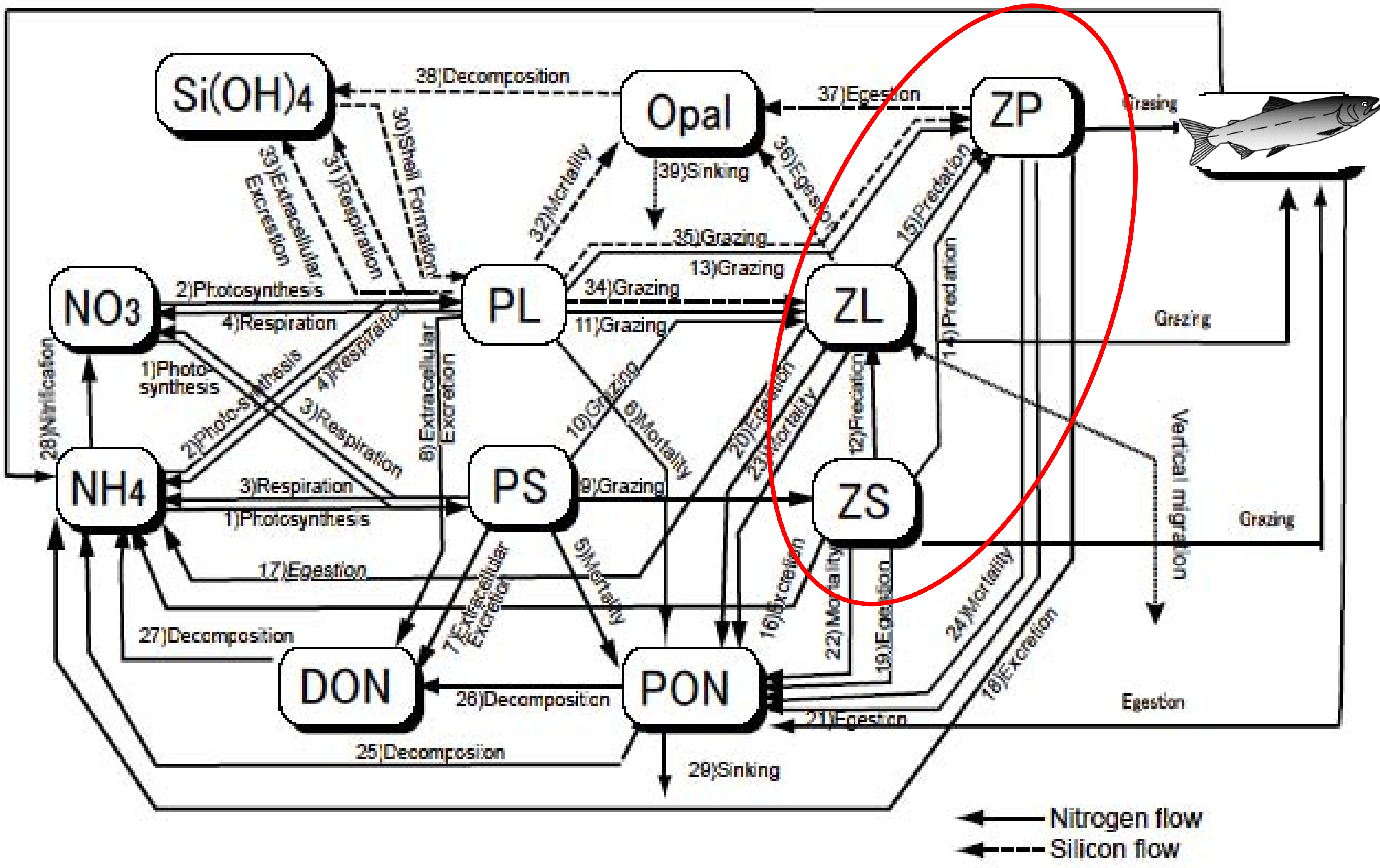
i predator type

$$gcta = \frac{(xk1 \cdot t4)}{(1.0 + xk1 \cdot (t4 - 1.0))}$$

$$gctb = \frac{(xk4 \cdot t6)}{(1.0 + xk4 \cdot (t6 - 1.0))}$$

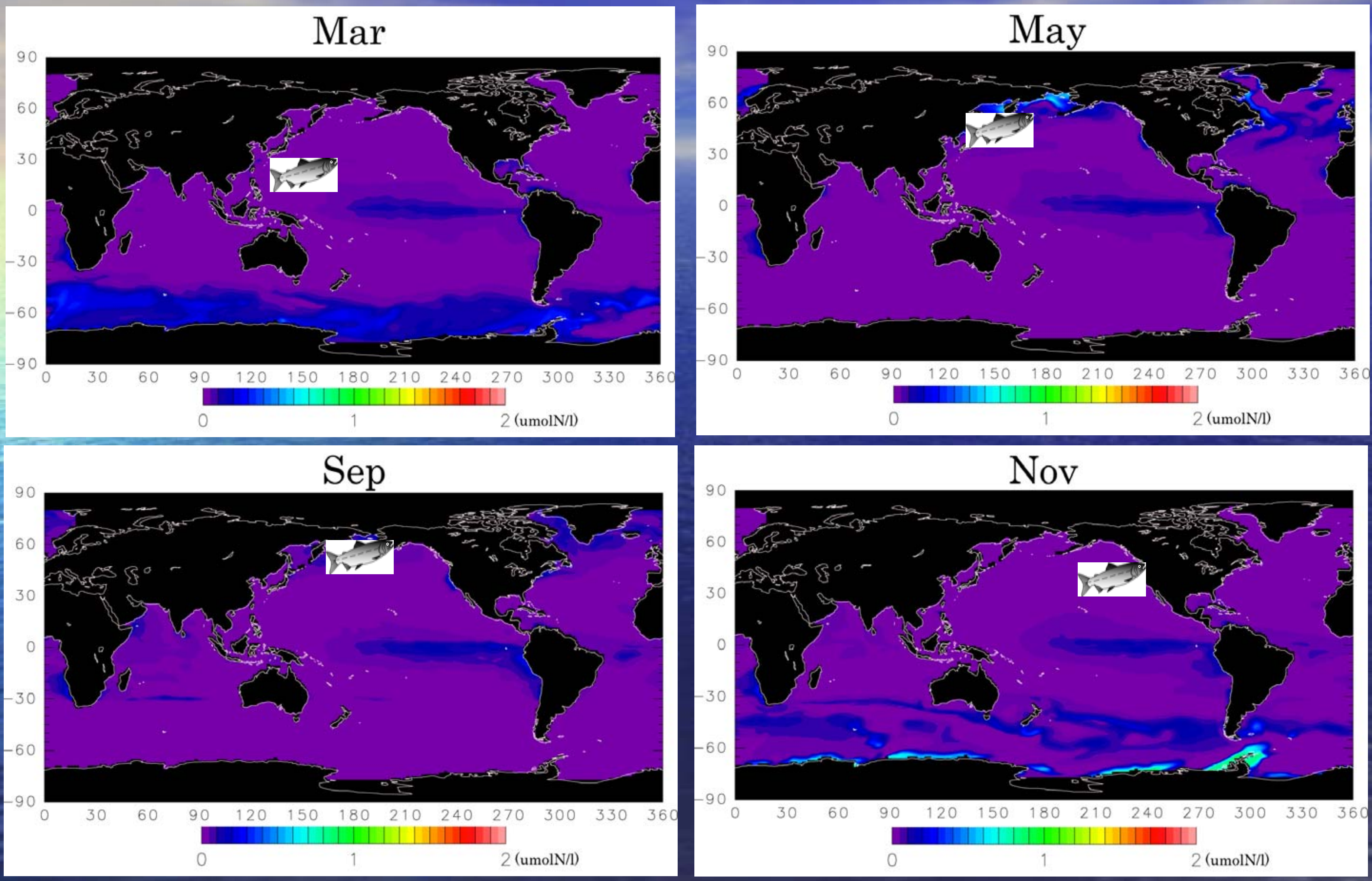
Physical model

NEMURO. FISH



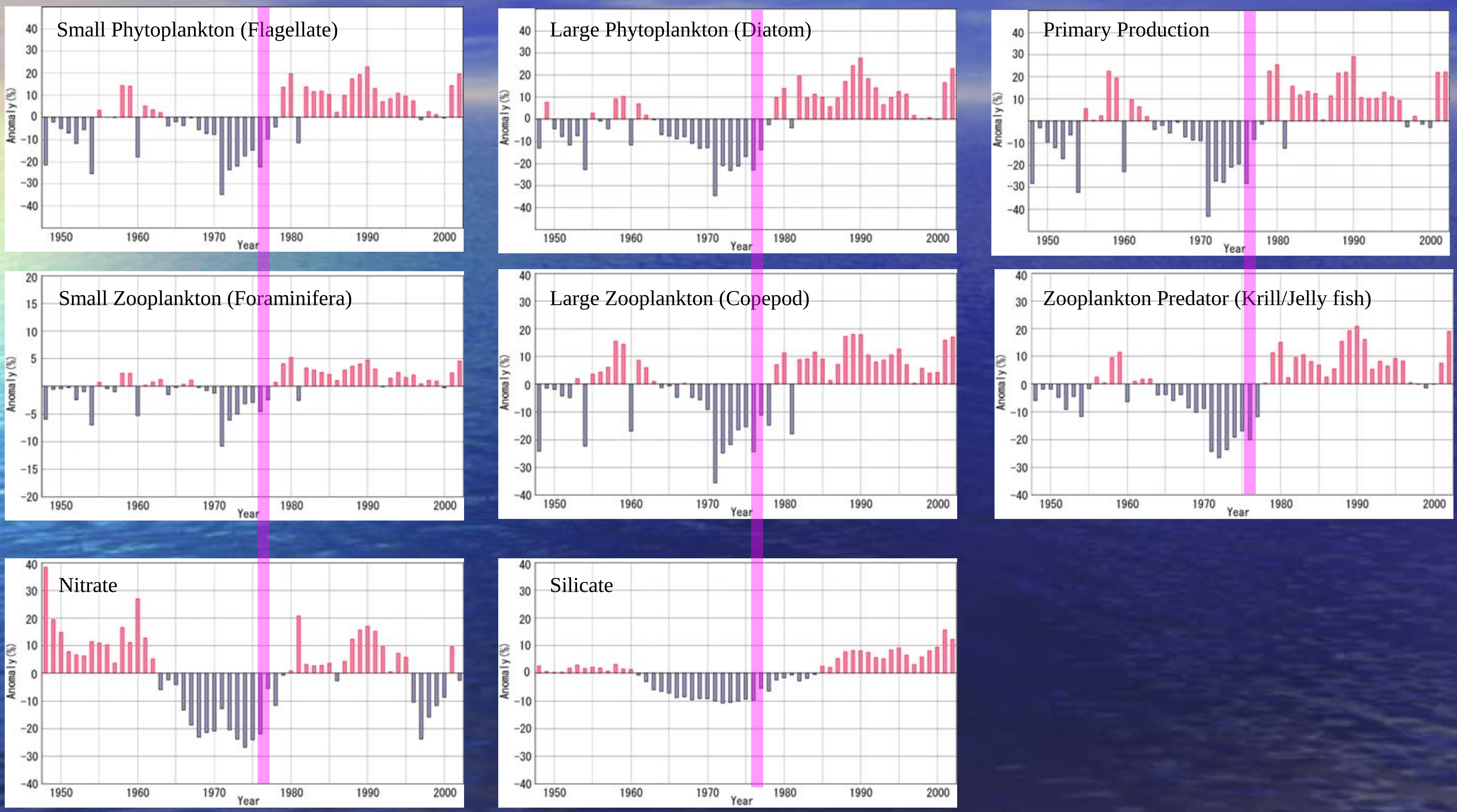
Si(OH)4
Opal
ZP
NO3
PL
ZL
NH4
PS
ZS
DON
PON
38)Decomposition
37)Egestion
36)Egestion
39)Sinking
35)Grazing
13)Grazing
34)Grazing
11)Grazing
32)Mortality
30)Shell Formation
31)Respiration
33)Extracellular Excretion
2)Photosynthesis
4)Respiration
1)Photo-synthesis
2)Photo-synthesis
3)Respiration
8)Extracellular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

The distribution of ZL (Copepod) at sea surface



Example of time series by 3-D NEMURO (Physical-Biological coupled model)

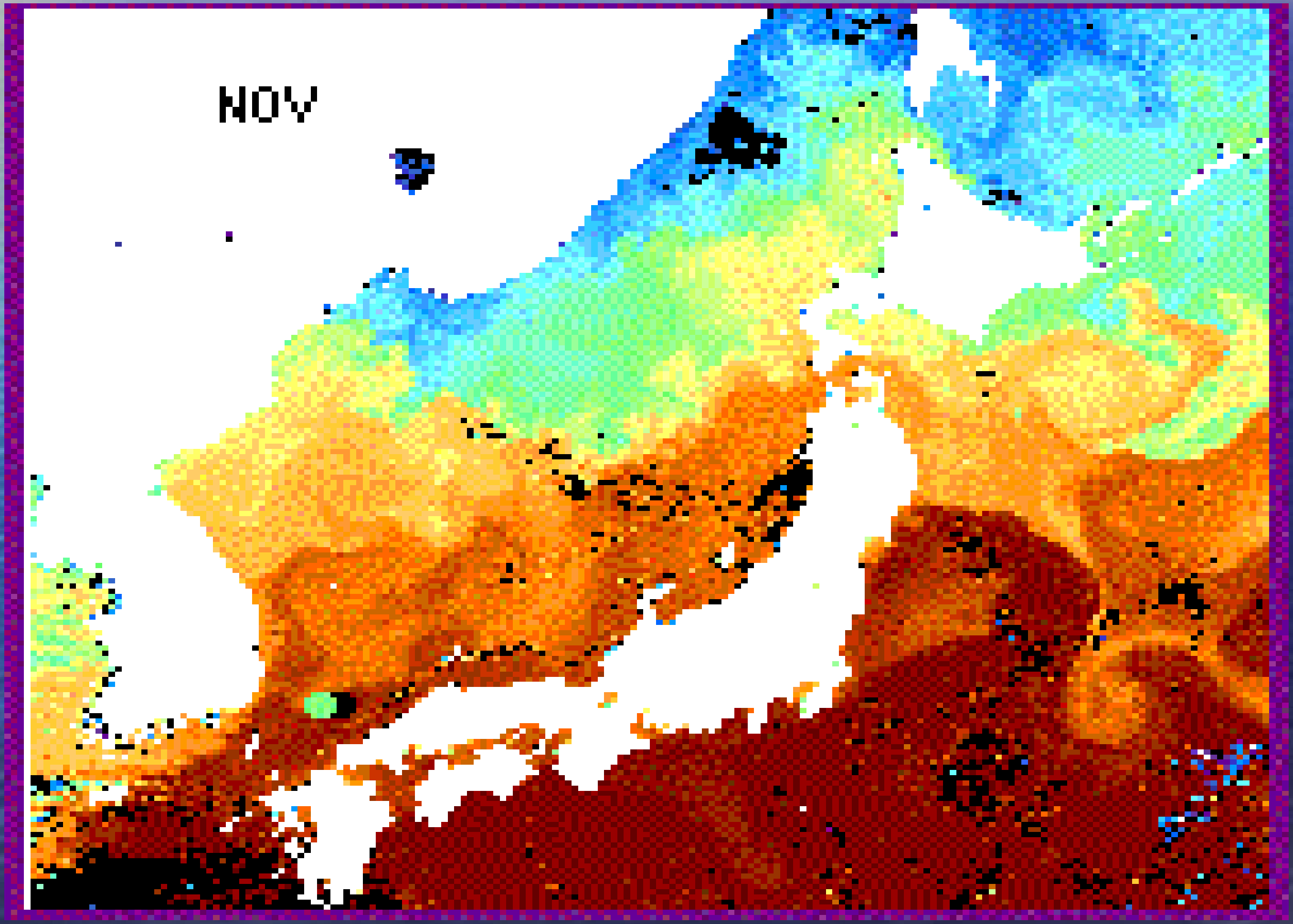
Eastern Bering Shelf



MODEL (FRCGC) has time series computed by Earth Simulator

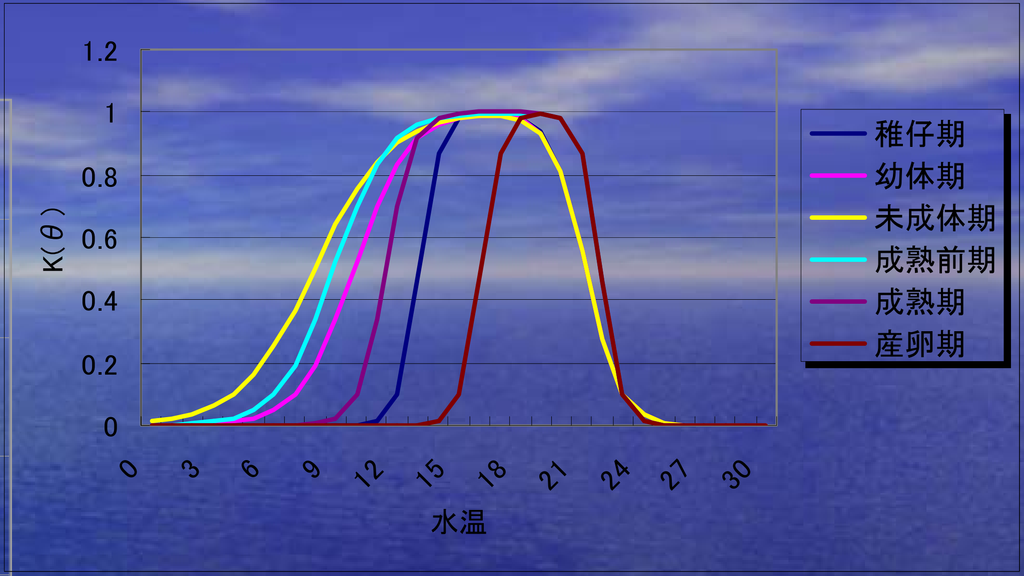
Common squid

Migration root and SST



Temperature function

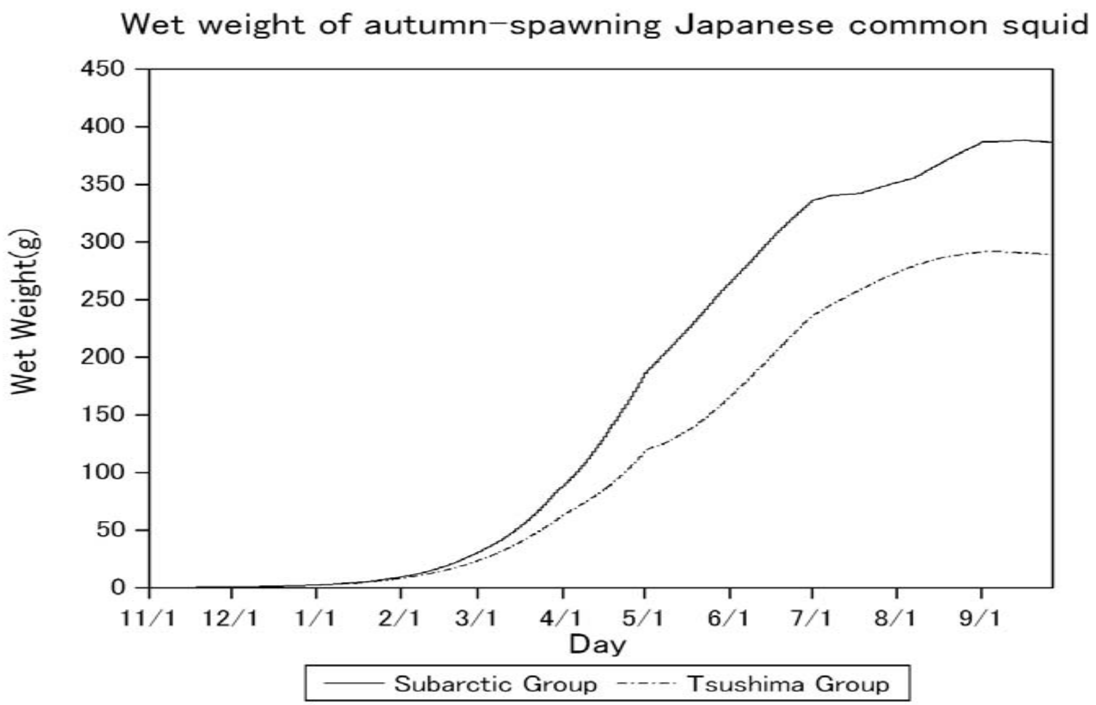
stage	*period*
1.larvae	1101−1215
2.juvenile	1216−0401
3.young	0402−0502
4.Pre mature	0502−0702
5.mature	0703−0903
6.spawning	0904−1031



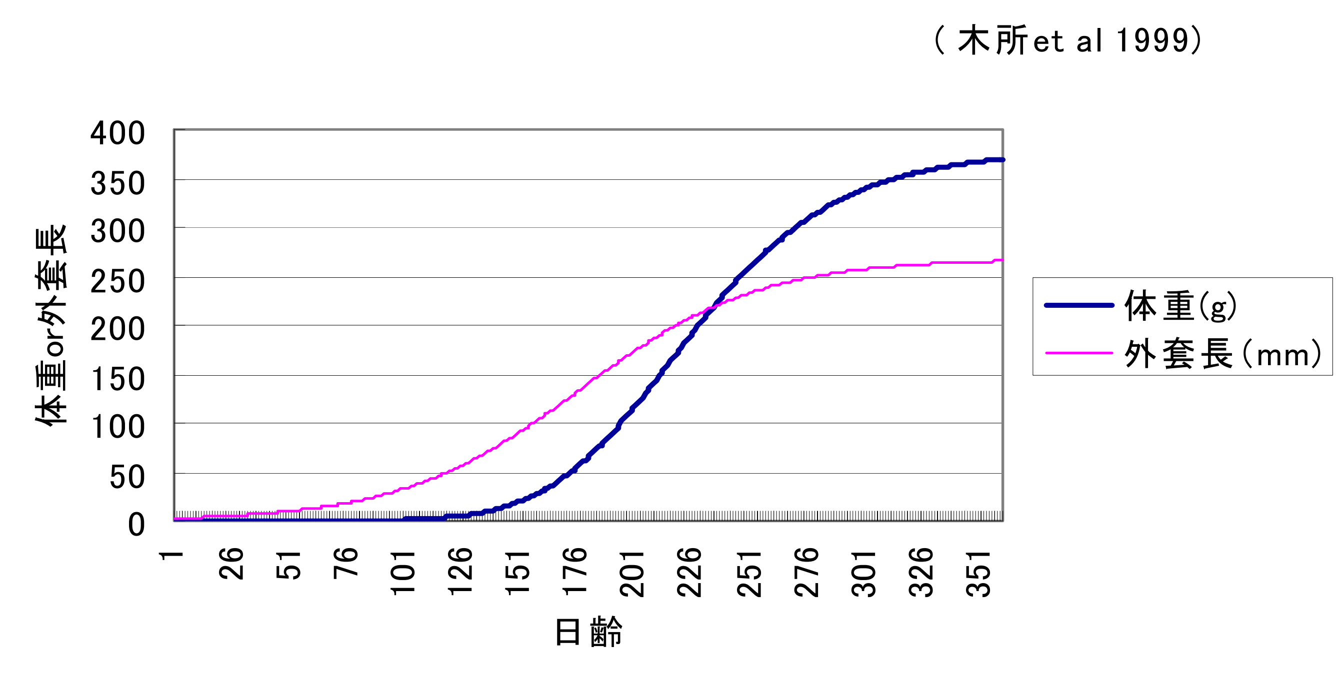
温度とステージ

	te1	te2	te3	te4
STAGE1	12	15	18	23
STAGE2	7	15	18	23
STAGE3	4	15	18	23
STAGE4	6	14	20	23
STAGE5	10	14	20	23
STAGE6	15	18	20	23

適水温

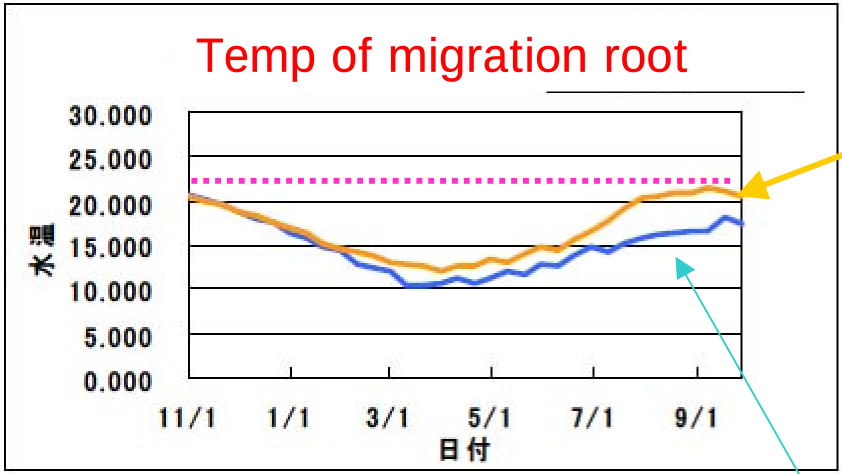


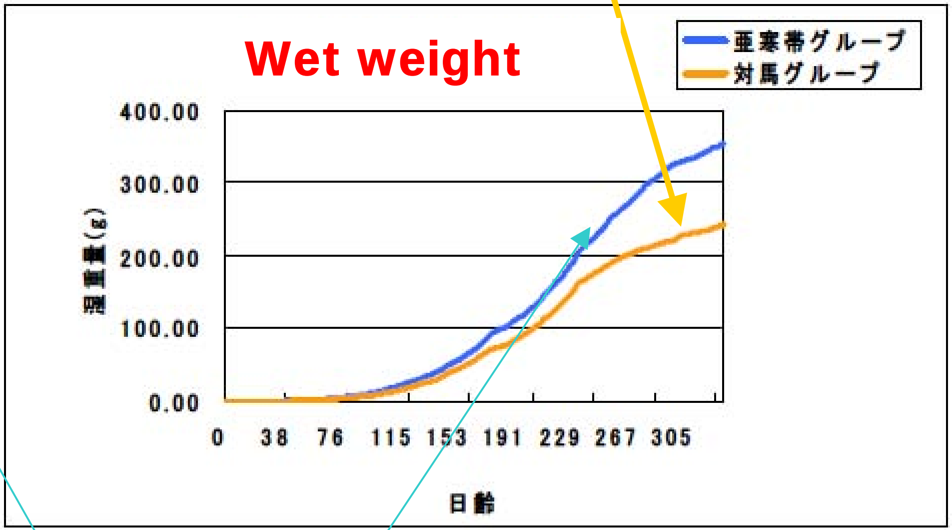
Wet weight of autumn-spawning Japanese common squid
Wet Weight(g)
0
50
100
150
200
250
300
350
400
450
11/1
12/1
1/1
2/1
3/1
4/1
5/1
6/1
7/1
8/1
9/1
Day
Subarctic Group
Tsushima Group

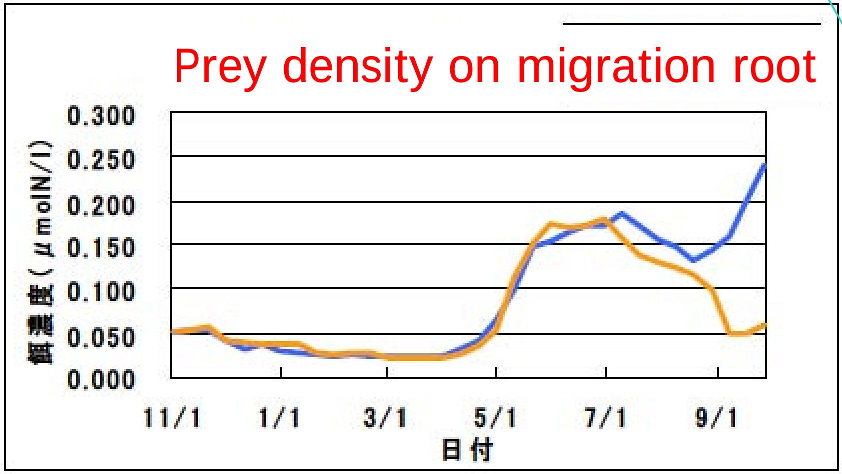


(木所et al 1999)
体重or外套長
0
50
100
150
200
250
300
350
400
1
26
51
76
101
126
151
176
201
226
251
276
301
326
351
日齢
体重(g)
外套長(mm)

Tsushima group

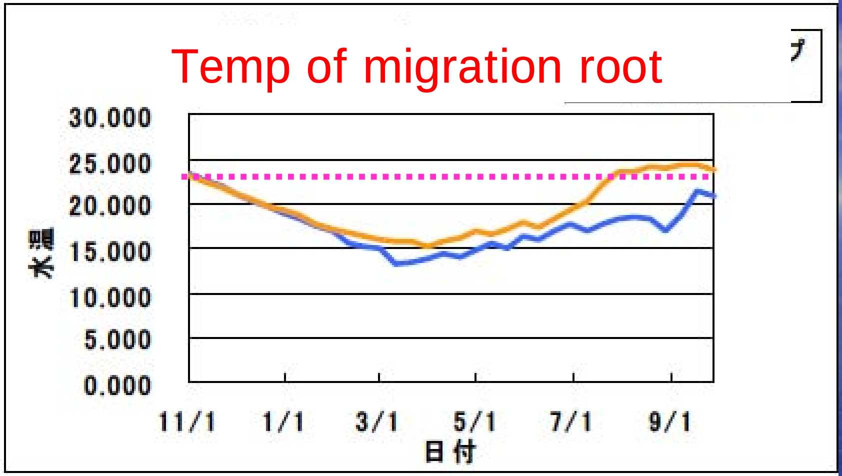


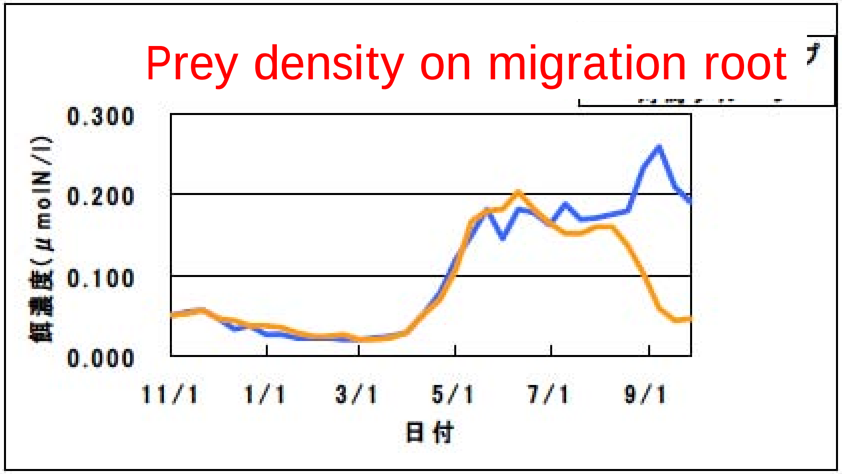




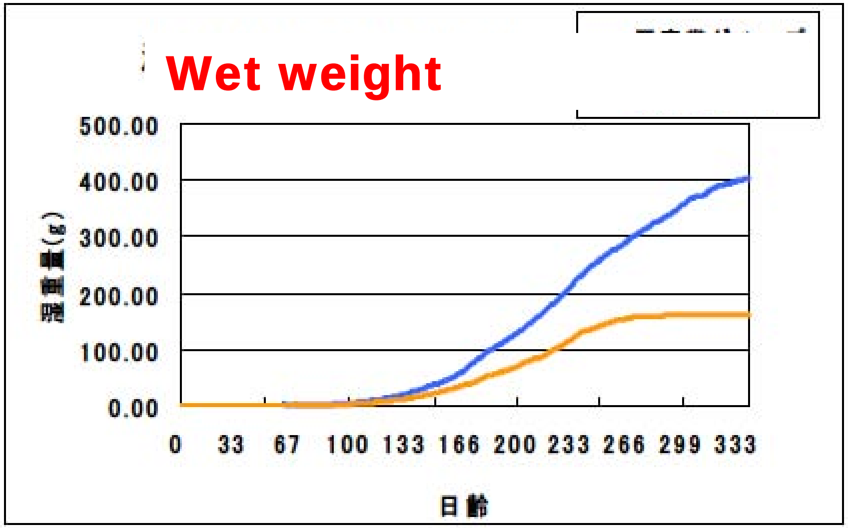
Subarctic group

Global Warming Scenario



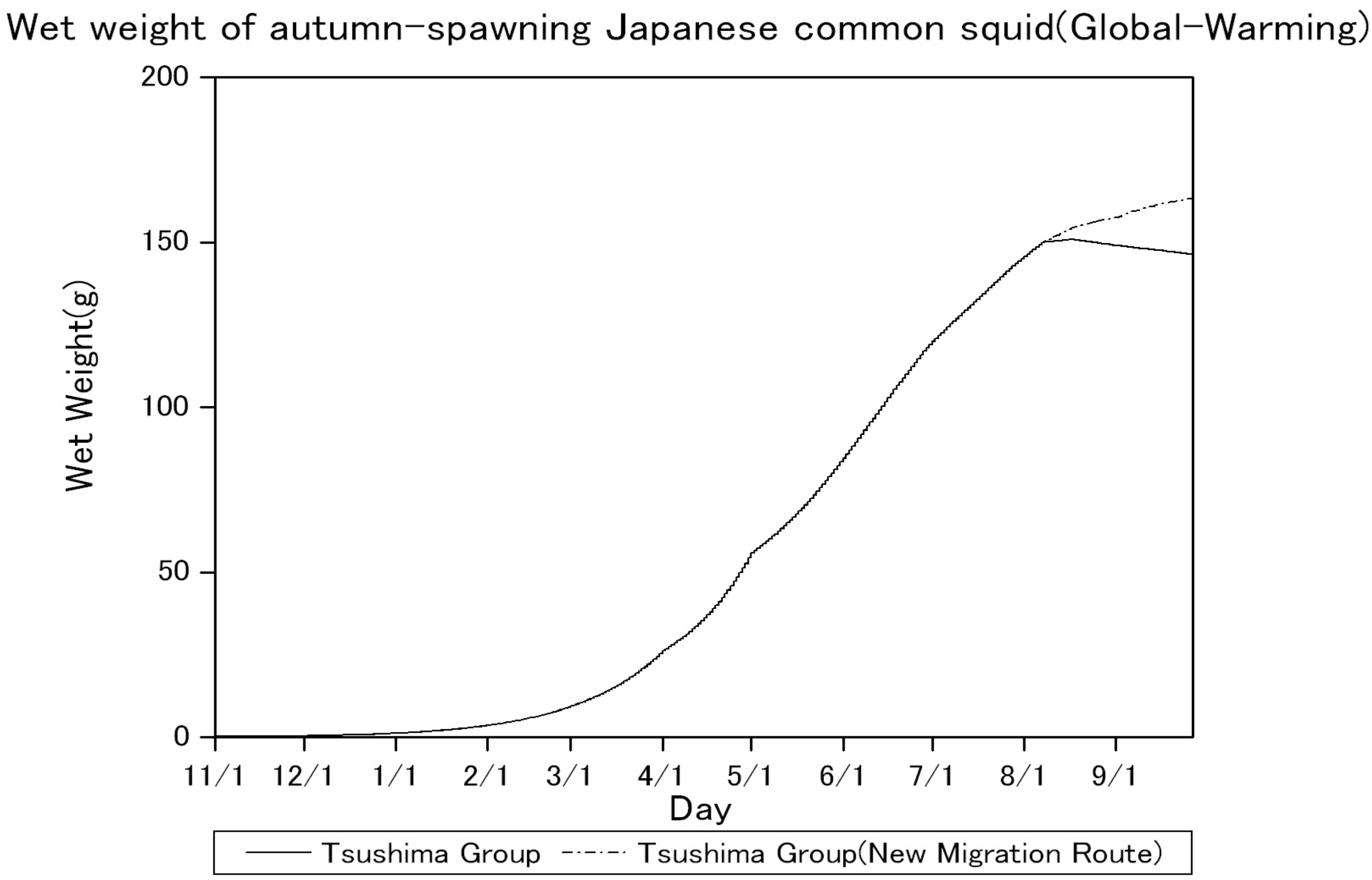


Migration route fixed

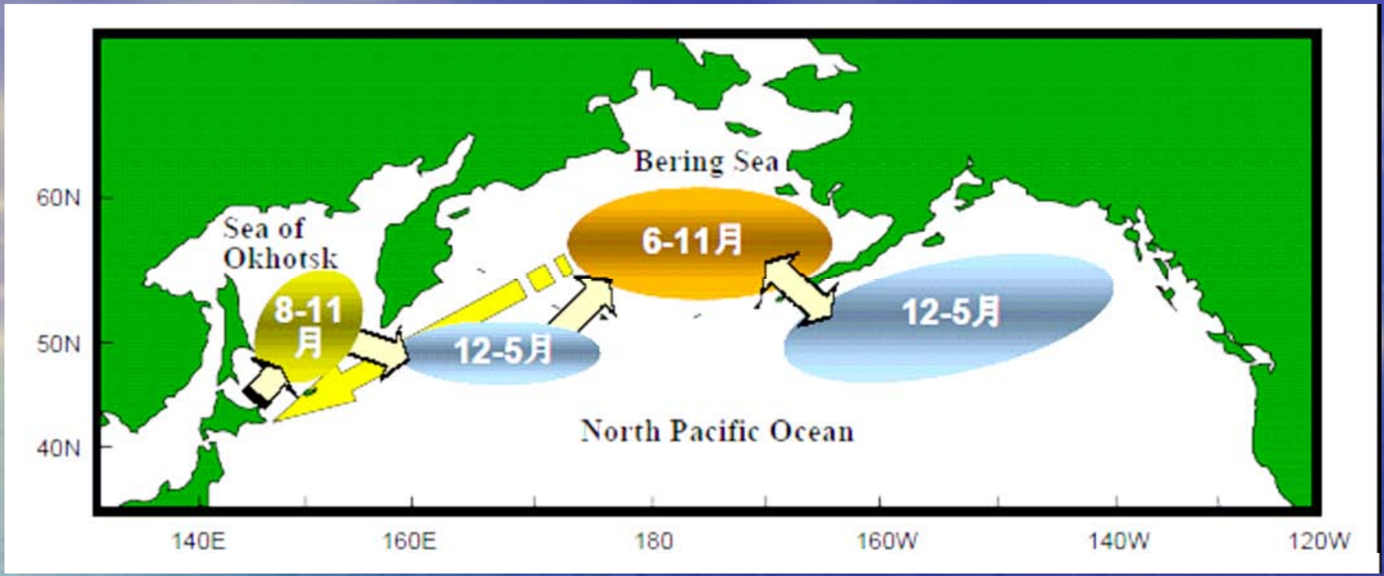


Global Warming Scenario

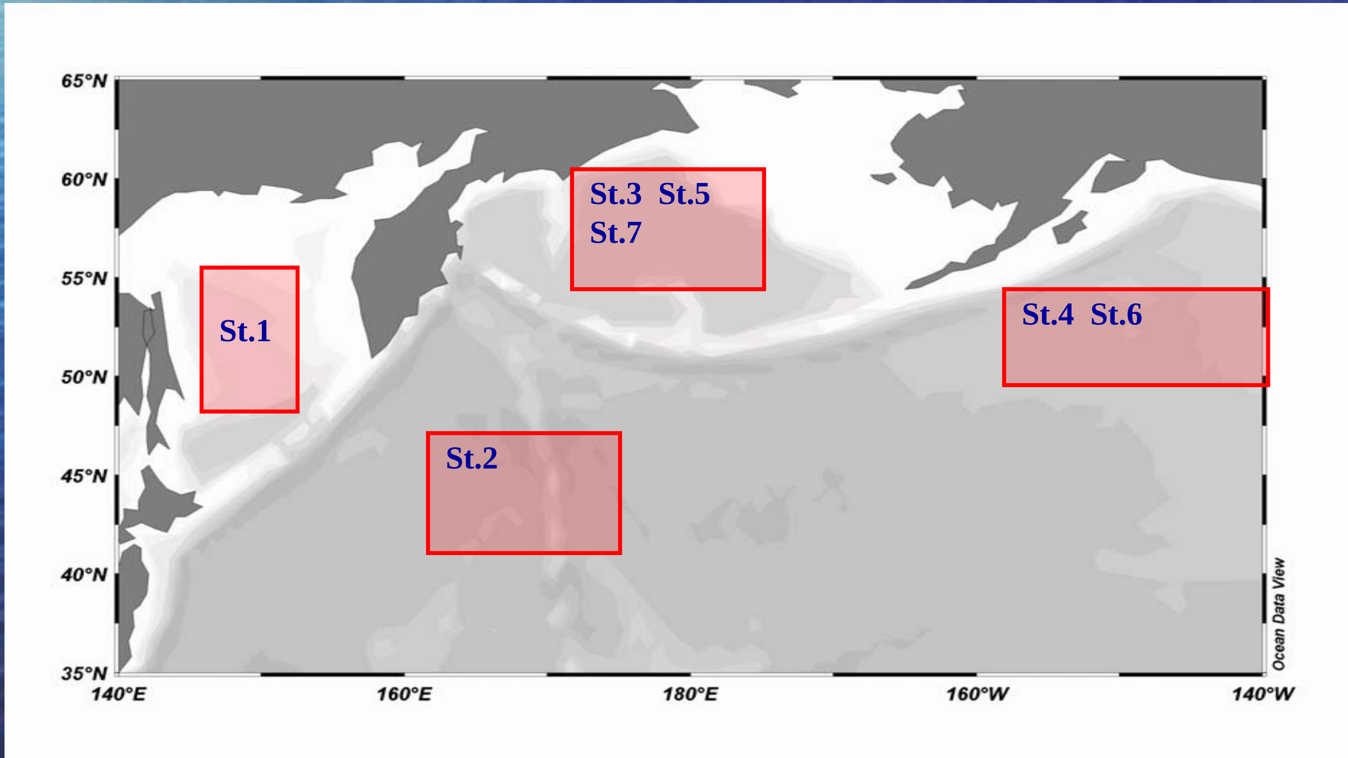
Migration route change



Chum salmon *Oncorhynchus keta*

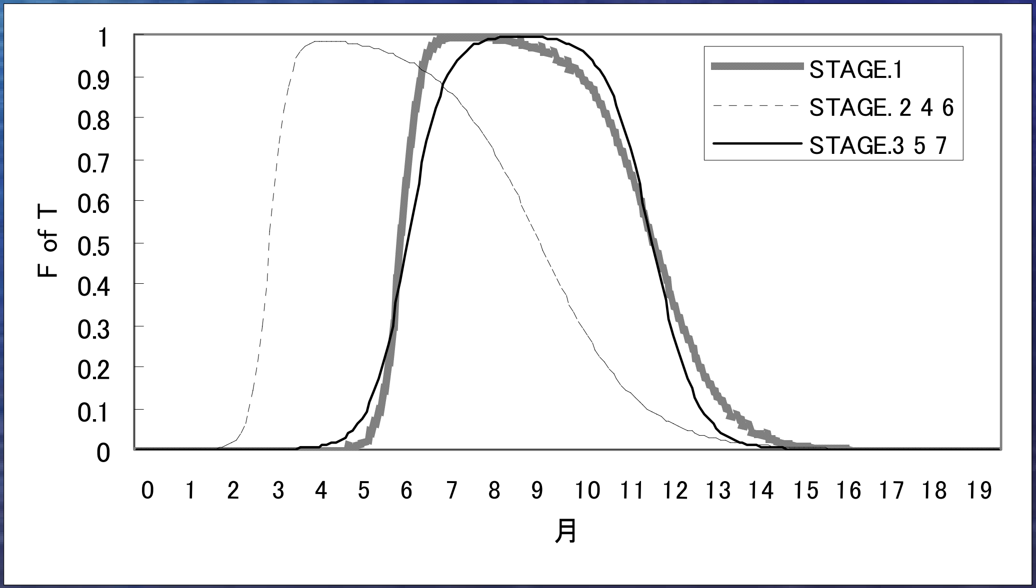


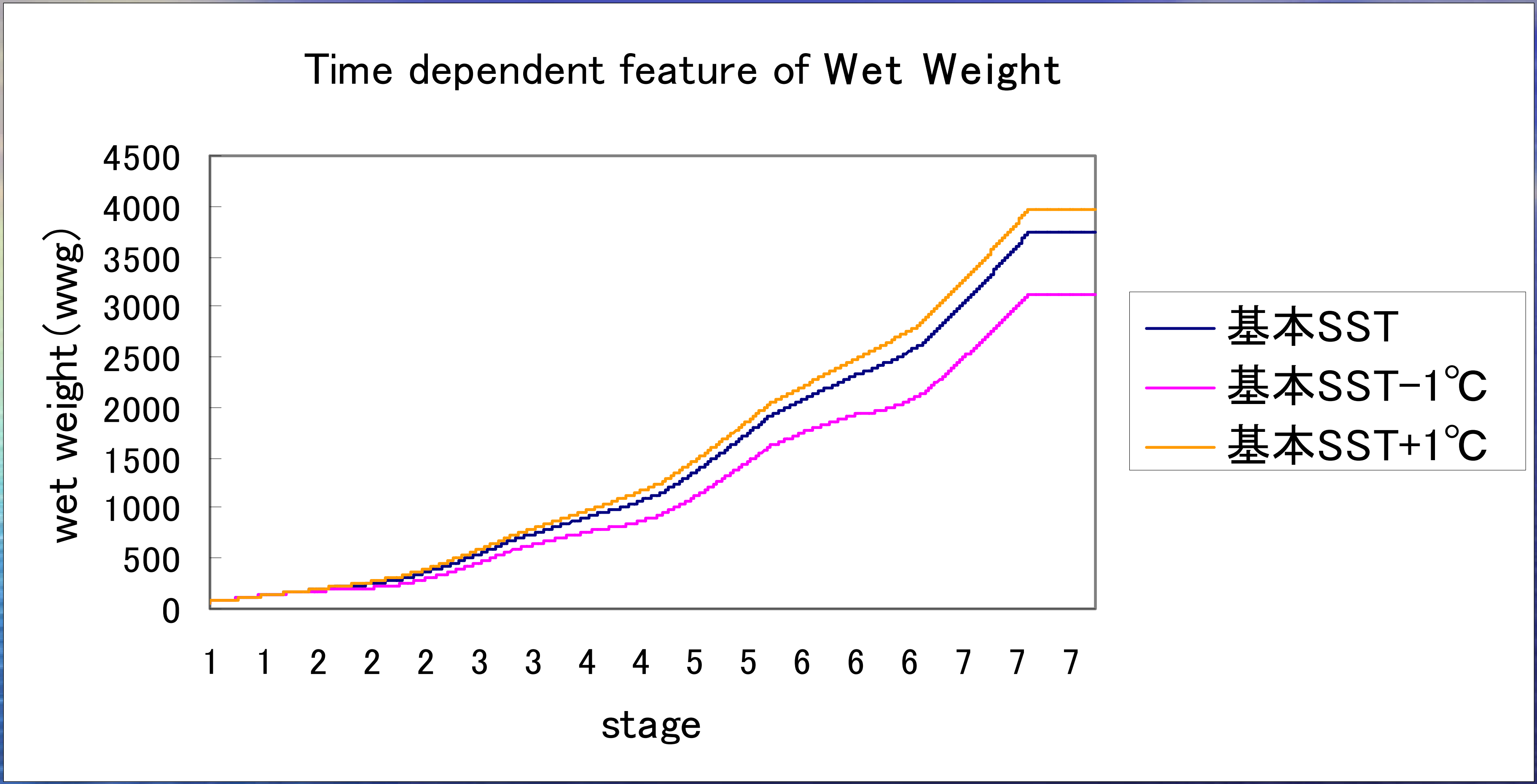
Bering Sea
Sea of Okhotsk
8-11月
12-5月
6-11月
12-5月
North Pacific Ocean
60N
50N
40N
140E
160E
180
160W
140W
120W



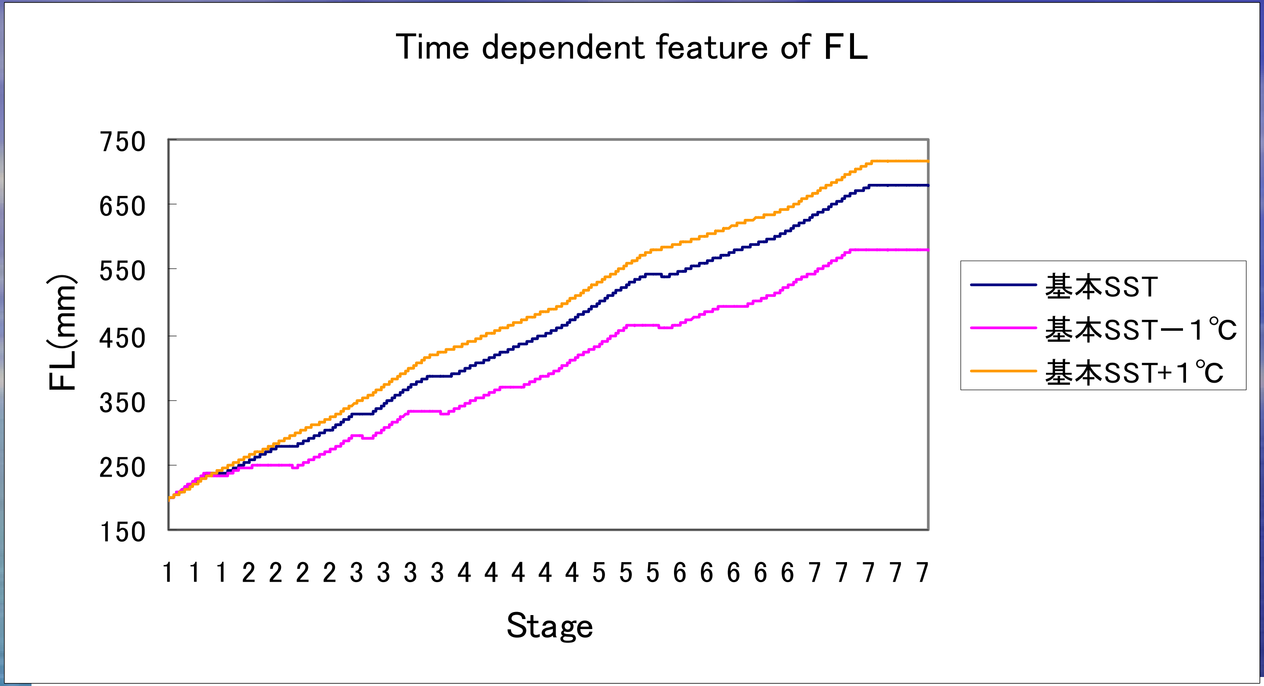
St.3 St.5
St.7
St.1
St.4 St.6
St.2
65°N
60°N
55°N
50°N
45°N
40°N
35°N
140°E
160°E
180°E
160°W
140°W
Ocean Data View

	te1	te2	te3	te4
STAGE 1	6	7	9	12
STAGE 2	3	4	5	9.4
STAGE 3	6	8	10	12
STAGE 4	3	4	5	9.4
STAGE 5	6	8	10	12
STAGE 6	3	4	5	9.4
STAGE 7	6	8	10	12

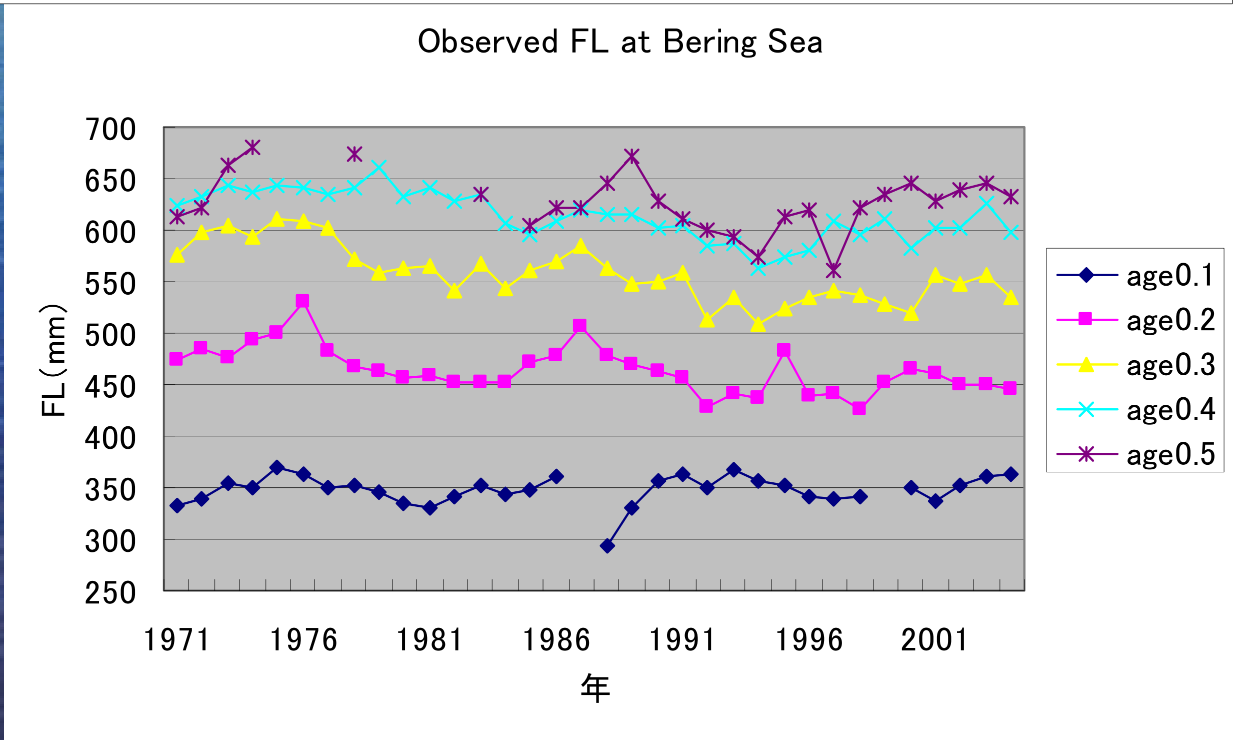




Time dependent feature of Wet Weight
wet weight（wwg)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1 1 2 2 2 3 3 4 4 5 5 6 6 6 7 7 7
stage
基本SST
基本SST−1℃
基本SST+1℃



Time dependent feature of FL
750
650
550
450
350
250
150
FL(mm)
1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 4 5 5 5 6 6 6 6 6 7 7 7 7 7
Stage
基本SST
基本SST－1℃
基本SST+1℃



Observed FL at Bering Sea
700
650
600
550
500
450
400
350
300
250
FL(mm)
1971
1976
1981
1986
1991
1996
2001
年
age0.1
age0.2
age0.3
age0.4
age0.5

Conclusion (not concluded)

- NEMURO.FISH can well simulate time dependent features of pelagic fish growth in Northern Pacific.
- NEMURO.FISH shows good results for saury, herring and squid, chum salmon.

1) Grazing pressure by fish on NEMURO is not included
2) Population dynamics must be included by various ways

- **This a small step for a biologist, but a giant leap for a modeler.**

Thank you for your cooperation