Progresses and achievements of GLOBEC research projects in JAPAN

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&
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Primary goal for GLOBEC

To advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.

Four serial research programs related to GLOBEC leaded by Fisheries Research Agency (FRA)

- Objectives
- Main achievements
- Relationship with the international programs

Bio-Cosmos Project (1989 - 92, 93 - 95, 96 - 98)

(Pelagic Fish Management)

To elucidate the mechanism causing the variability of the **Japanese sardine** (*Sardinops melanostictus)* population

1984 - 1989 SARP (Sardine/Anchovy Recruitment Program)

1989 - 2nd SARP → 1994, 1996 - GLOBEC-SPACC

1992 - International GLOBEC

VENFISH Project (1997- 2001)

(Comprehensive study of the Variation of the oceanic ENvironment and FISH populations in the North-western Pacific)

To develop ecosystem model based on the **bottom-up control processes** from the phytoplankton production to the recruitment of **Pacific saury** (*Cololabis saira*) and **walleye pollock** (*Theragra chalcogramma*)

FRECS Project (2000 - 2006)

(Fluctuation of Recruitment of fish eggs and larvae by changes of spawning grounds and transport patterns in the East China Sea)

To understand the mechanisms of environmental impacts on the spawning grounds of **jack mackerel** (*Trachurus japonicus*) and **Japanese common squid** (*Todarodes pacificus*), and their linkages to recruitment

2000 - "Ocean Futures" activity

Draft Framework for Future Research on Biological and Chemical Aspects of Global Change

DEEP Project (2002- 2006)

(Deep-sea Ecosystem and Exploitation Program)

To understand the meso- or bathypelagic ecosystem structure and dynamics, relationship between the pelagic fish community and the meso- or bathypelagic ecosystem

History and progress of the Bio-Cosmos Project

1st period (1989 - 1992)

- Verification of three hypotheses
- Accumulation of basic information

Decrease of Sardine population

2nd period (1993 - 1995)

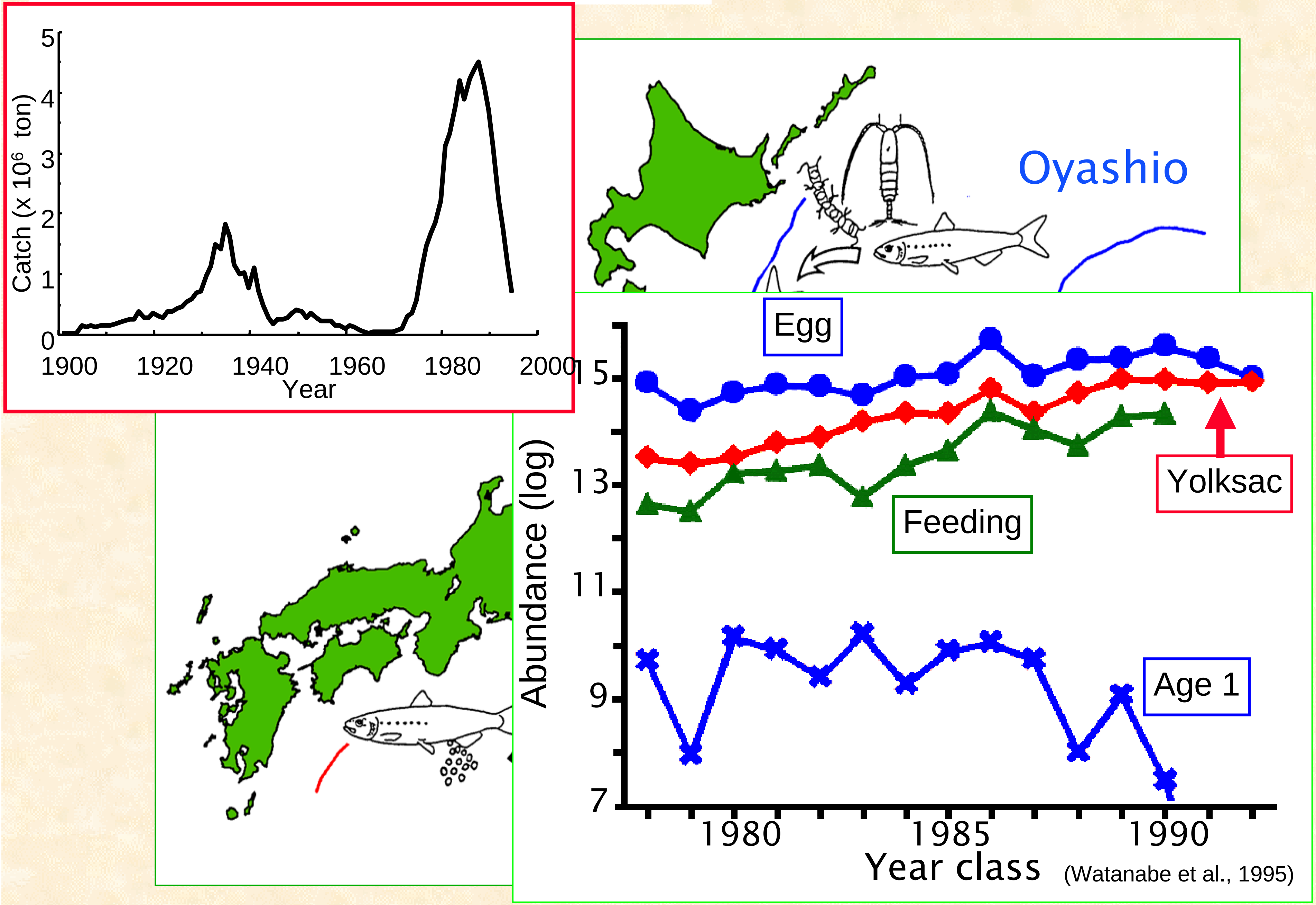
- Comparative study among three locations
- Focusing on the stage from post larvae to YOY stage

Shift to the GLOBEC-like project

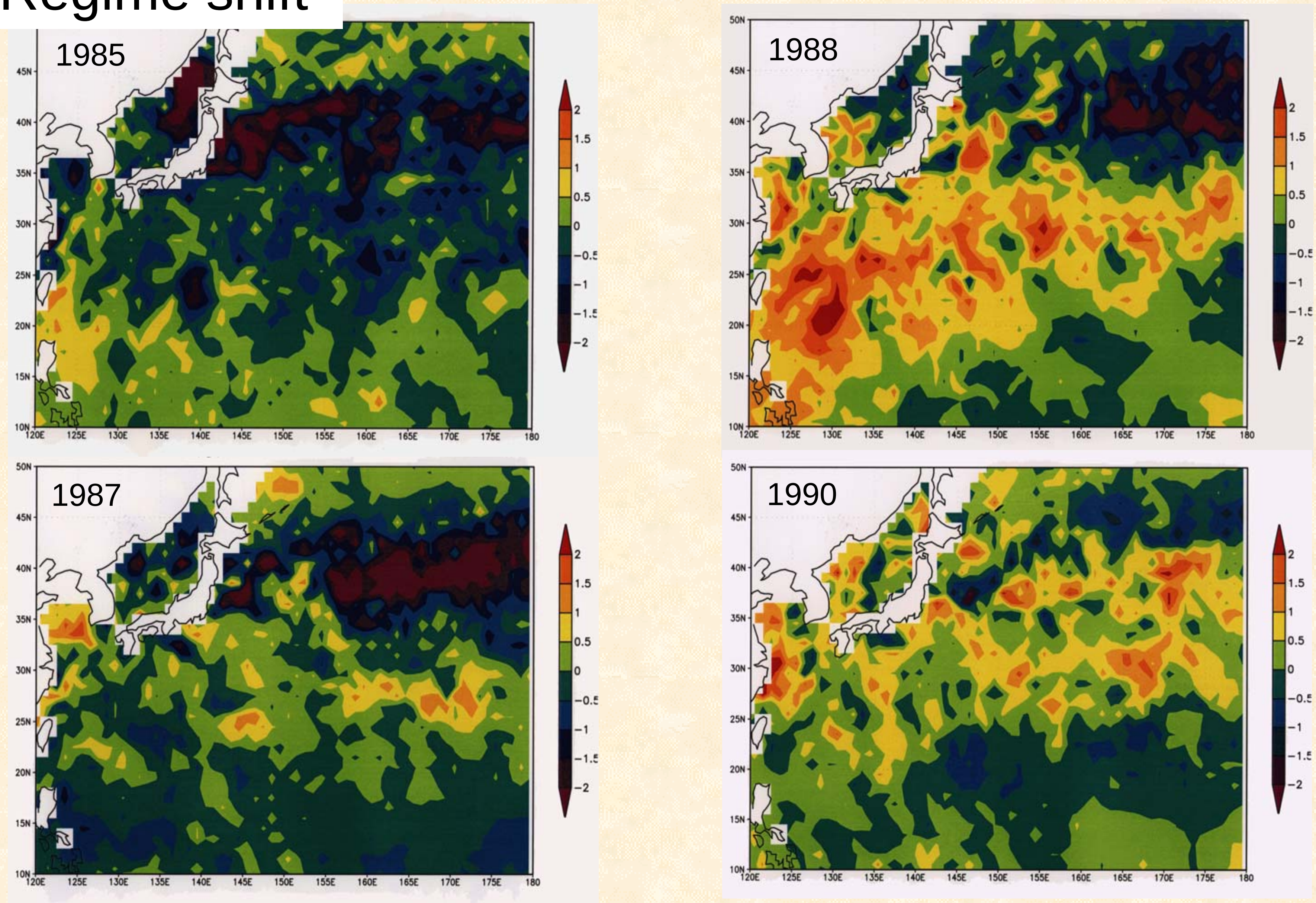
3rd period (1996 - 1998)

- Focusing on the sardine population along the Pacific Coast
- Modeling of the population dynamics based on the information of physical conditions

Japanese sardine population



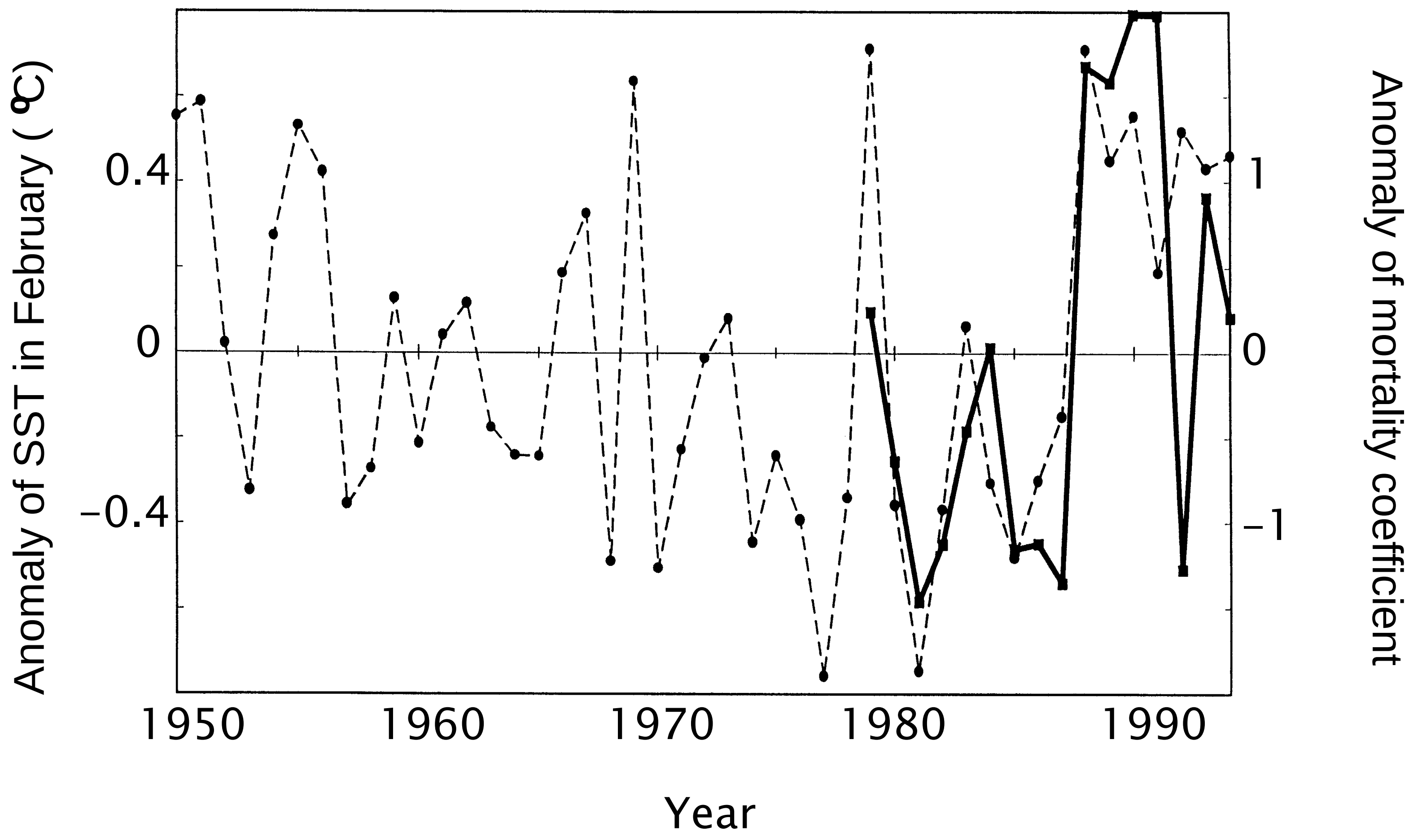
Regime shift



Sea surface temperature anomaly in February

(Noto & Yasuda, 1999)

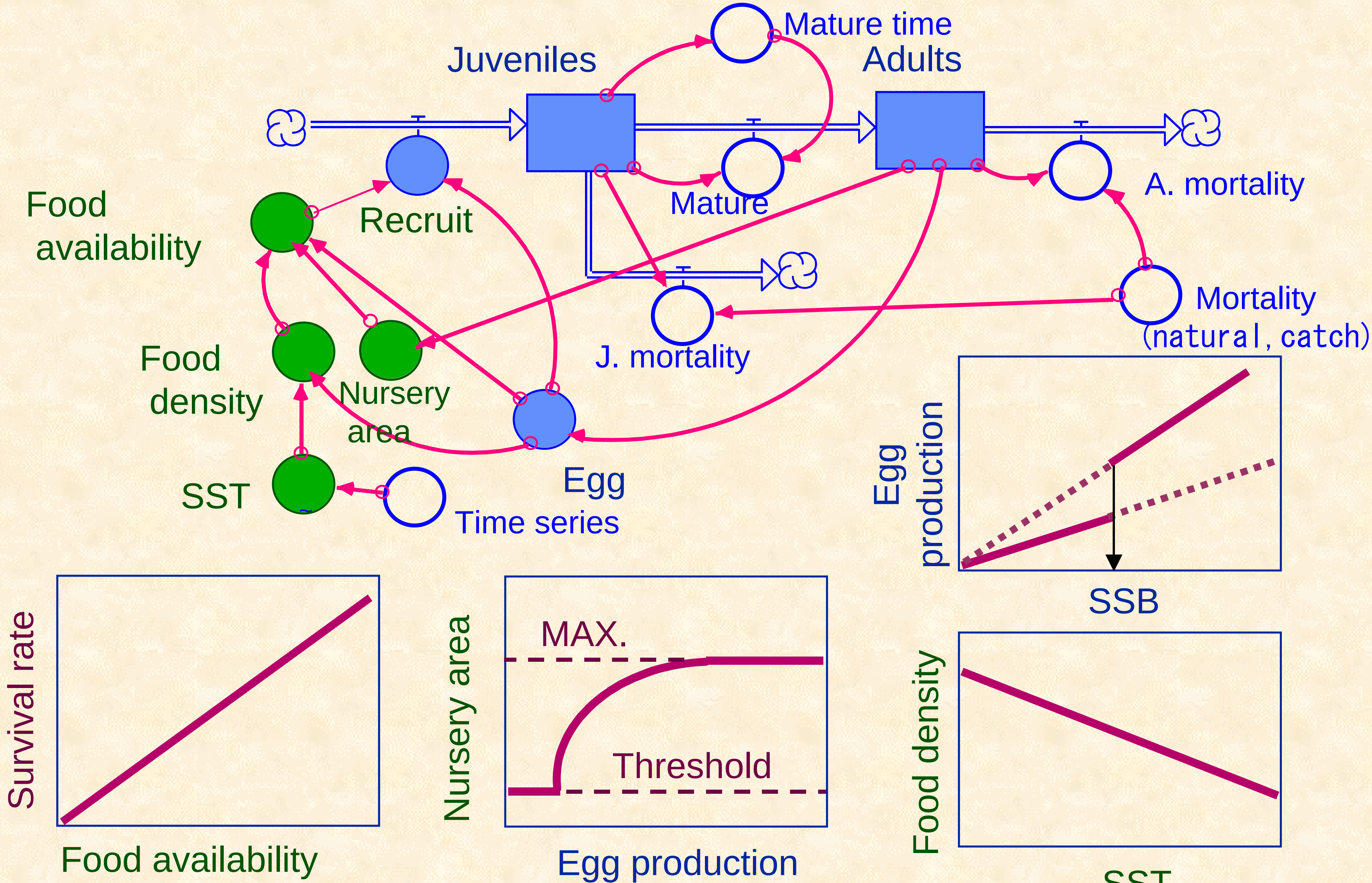
Survival of Japanese sardine



Mortality coefficient (M) was calculated from the regression formula; $N_1 = N_0 \cdot e^{-M}$, where N_0 is the number of larvae and N_1 is the number of one year old fish.

(Noto & Yasuda, 1999)

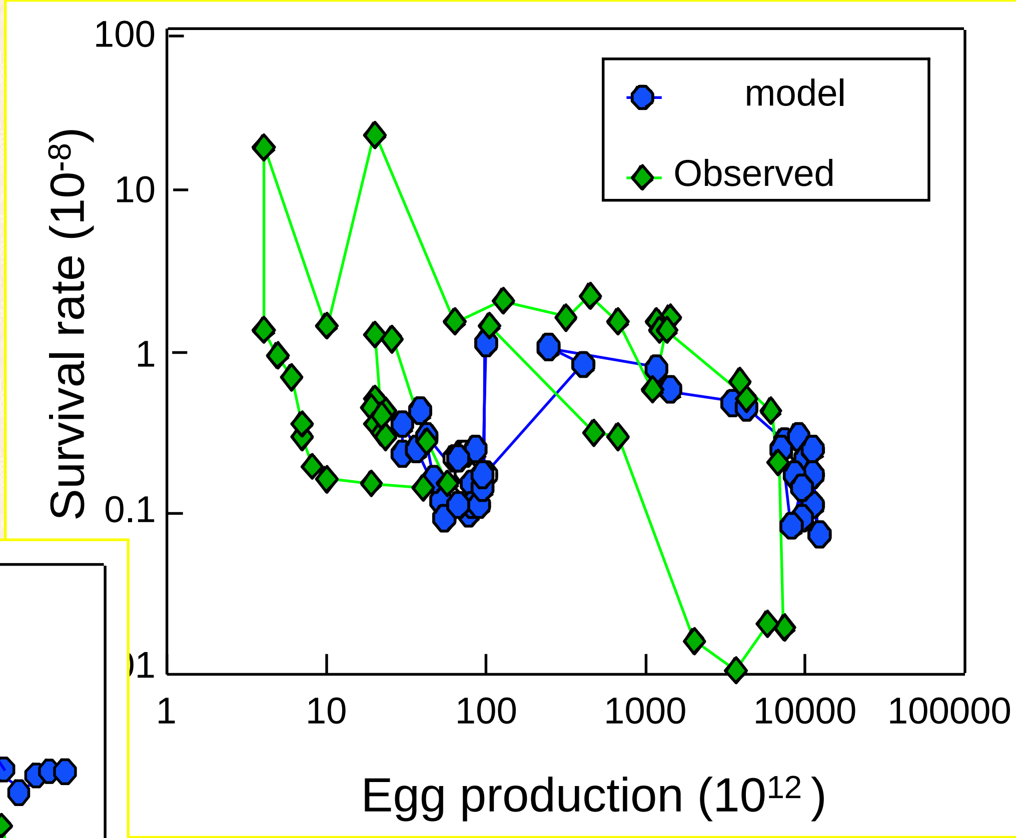
Arrow diagram of simulation model

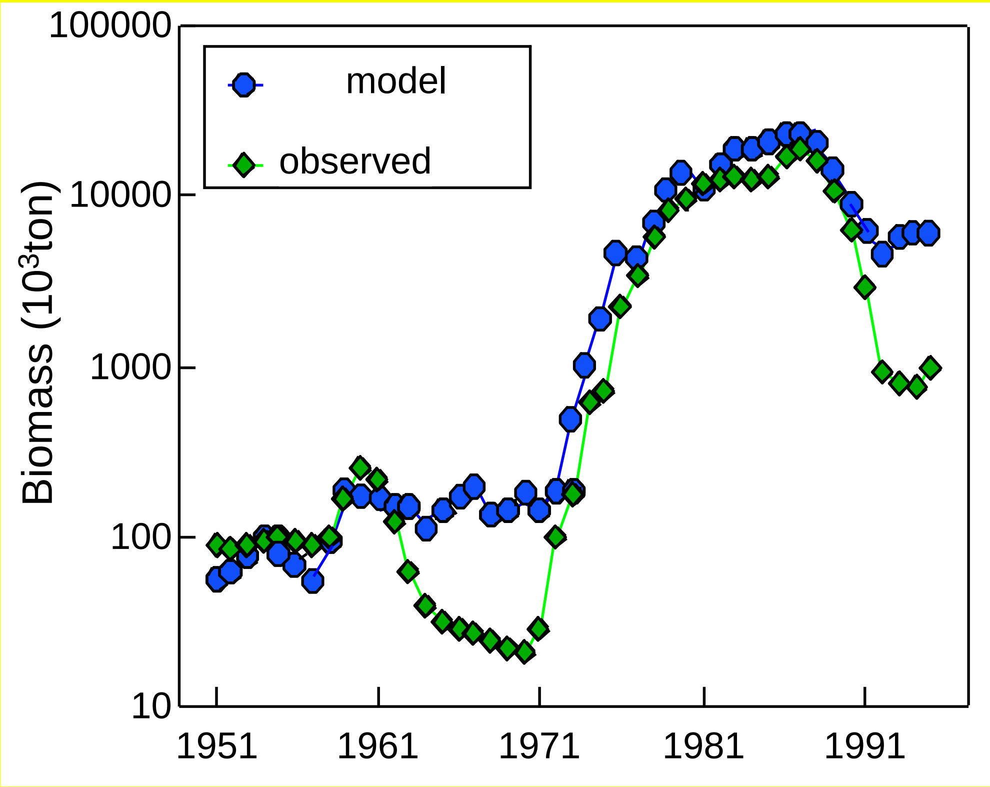


$$= \frac{a \times (\text{Food dens}^2 \times \text{Nursery area})}{\text{Egg production}}$$

(Wada et al.)

Results of positive feedback simulation model





(Wada et al.)

Food for juvenile sardine in the Kuroshio-Oyashio transition region

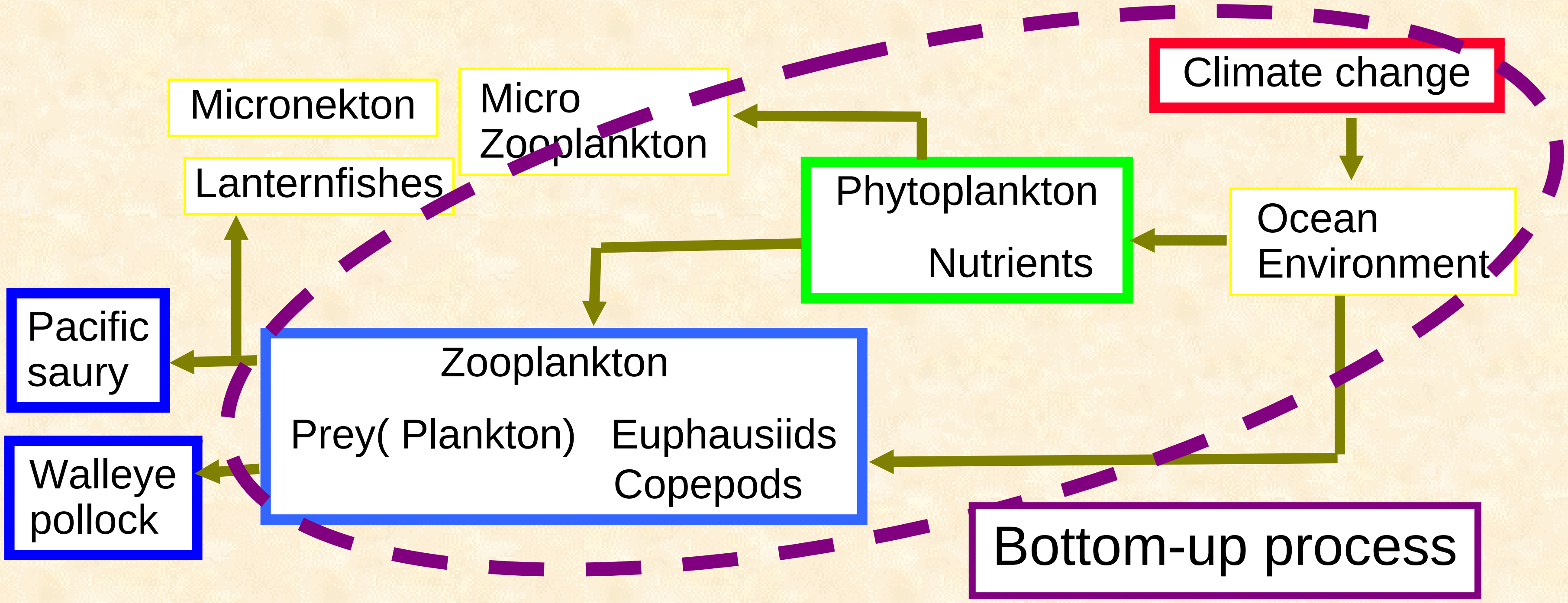
100000

- Juvenile sardine eats large zooplankton (size range from 0.6 to 1.6 mm) selectively after their metamorphosis, however the optimum prey concentration is low in the KEX region.
- Size fraction change of food organisms might be the key factor relating to the alternation of fish species from sardine to anchovy.
- Bottom-up process should be studied from the view point of the food organisms for fish from juvenile to YOY.

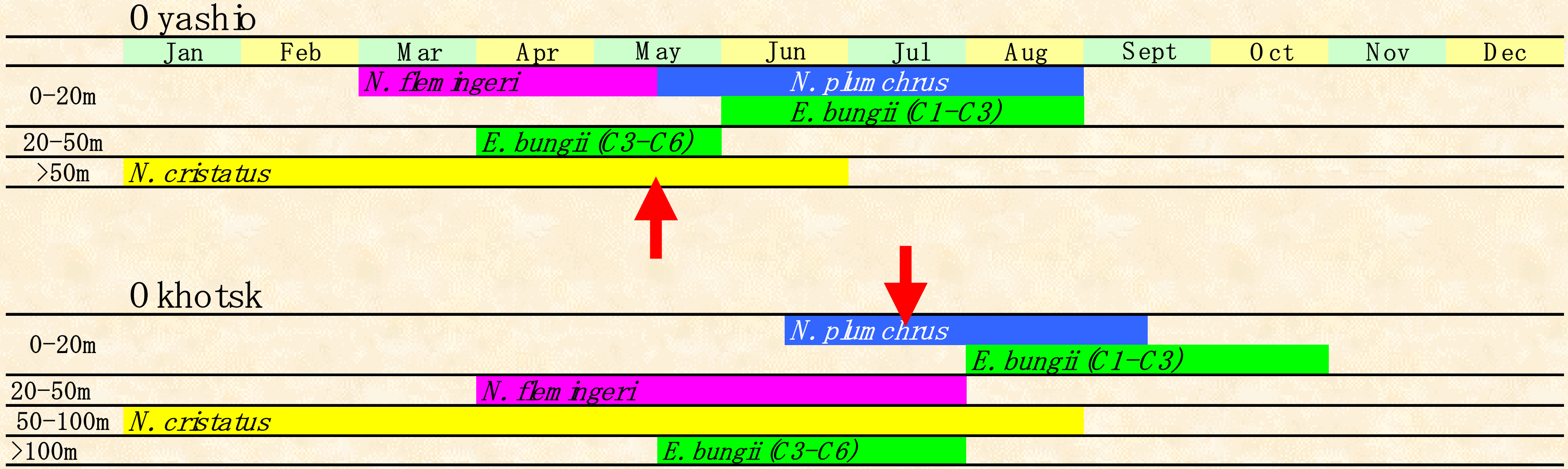
Sardine length (mm)

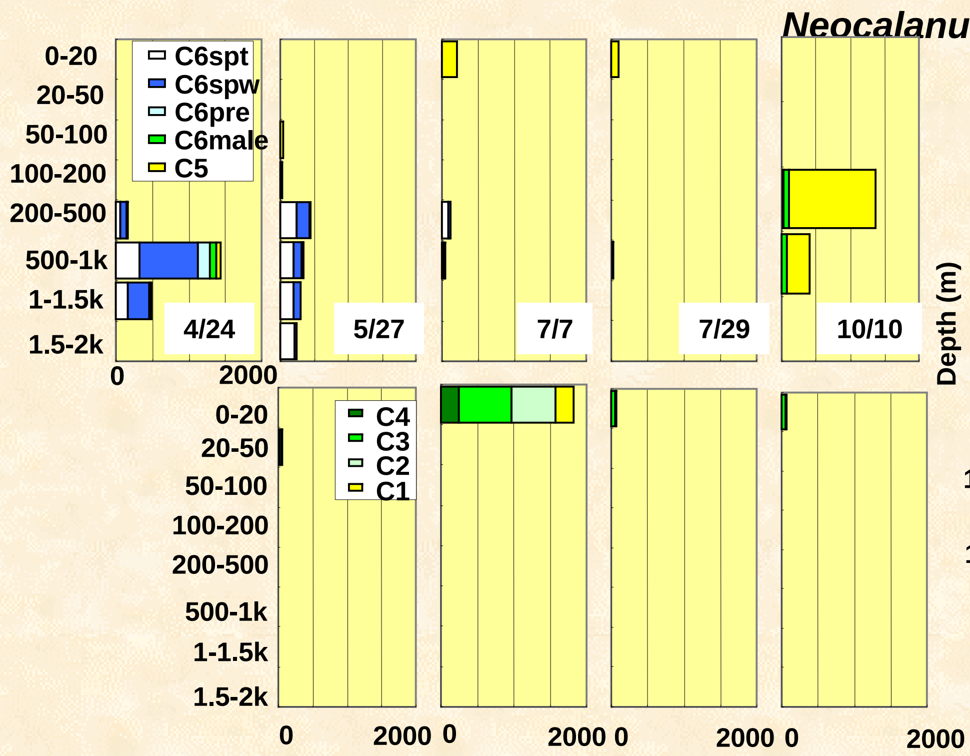
VENFISH Project

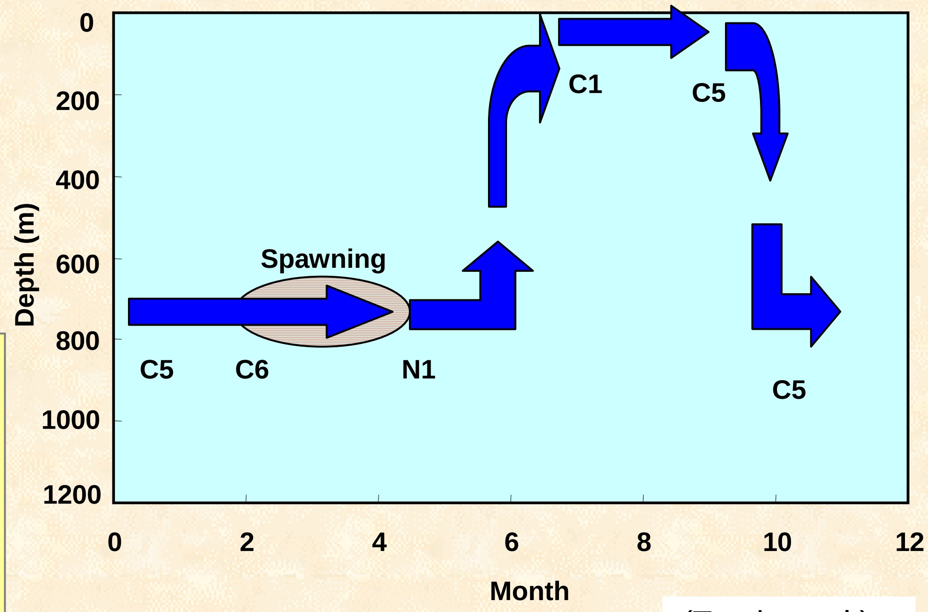
To make clear the influence of the oceanic environment, phytoplankton and zooplankton to the resources variation of **Pacific saury** (*Cololabis saira*) and **walleye pollock** (*Theragra chalcogramma*) and develop the forecasting ecosystem models through food chain.



Vertical migration of four copepods in the Oyashio and Okhotsk area

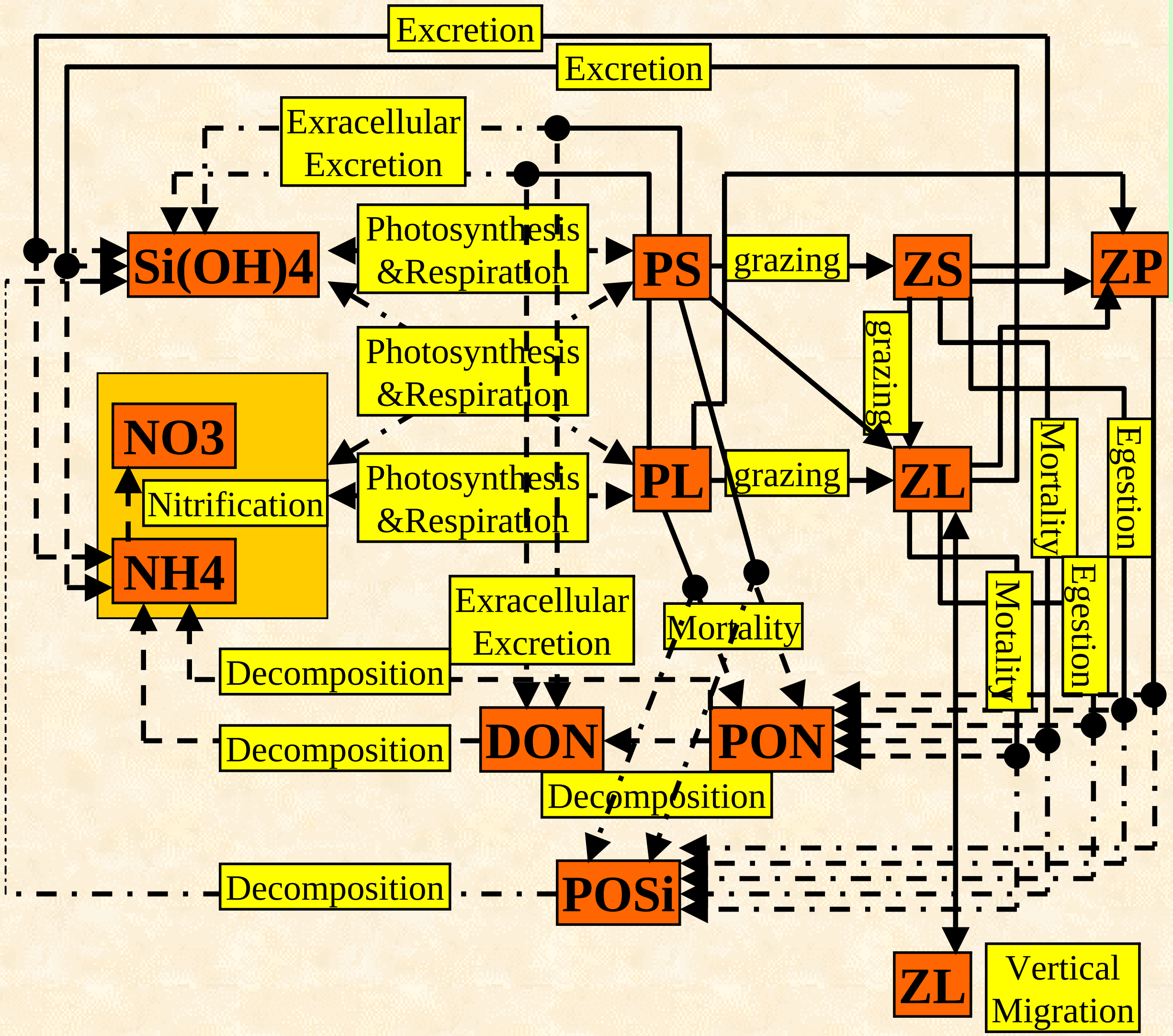






(Tsuda et al.)

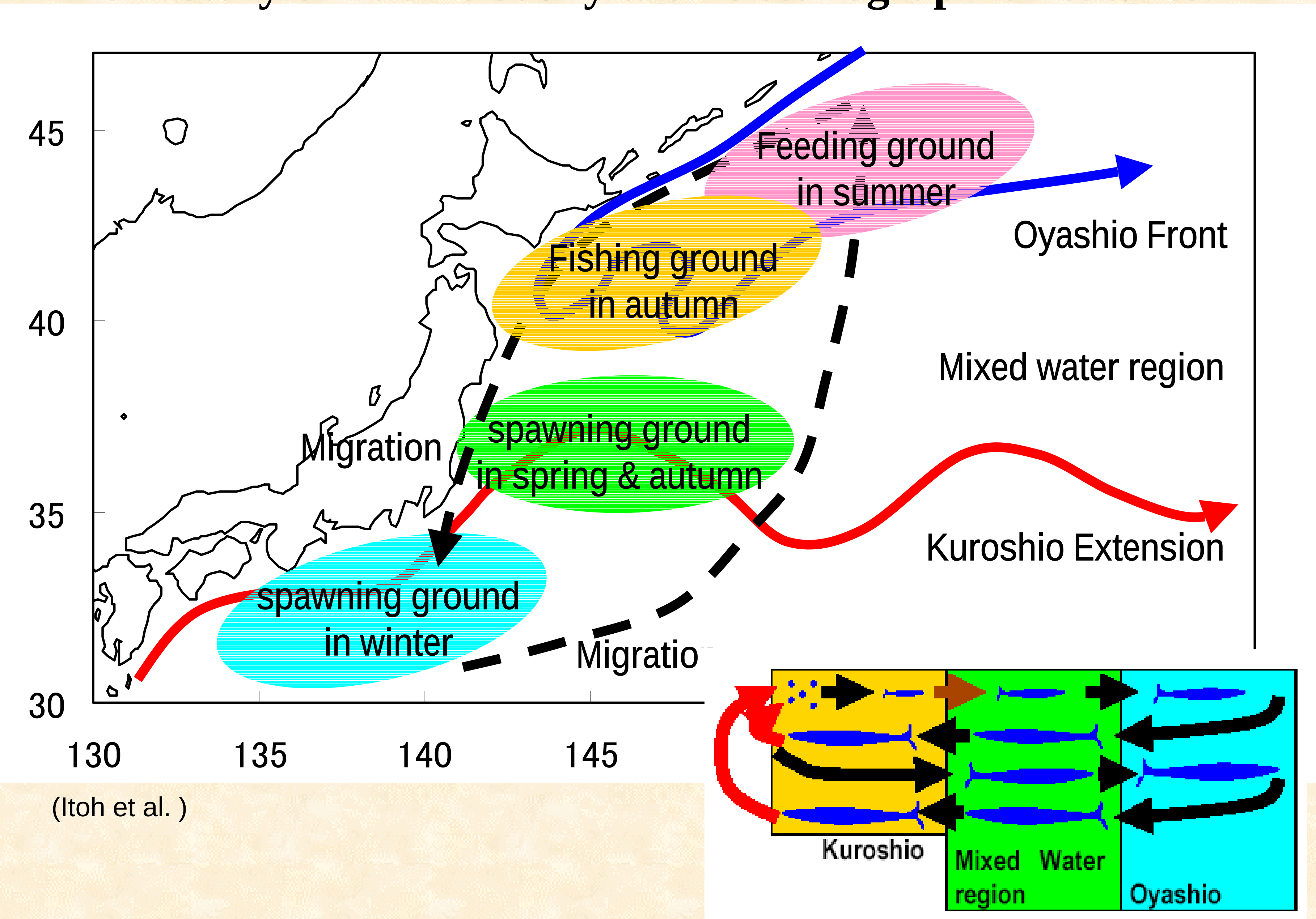
NEMURO



three zooplankton
- **small**
- **large**
- **predatory**

(Itoh et al.)

Life History of Pacific Saury with Oceanographic Features



(Itoh et al.)

Result from NEMRO.FISH

Pacific Saury Bioenergetics Model

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

change of weight

C: consumption

R: respiration
(loses through metabolism)

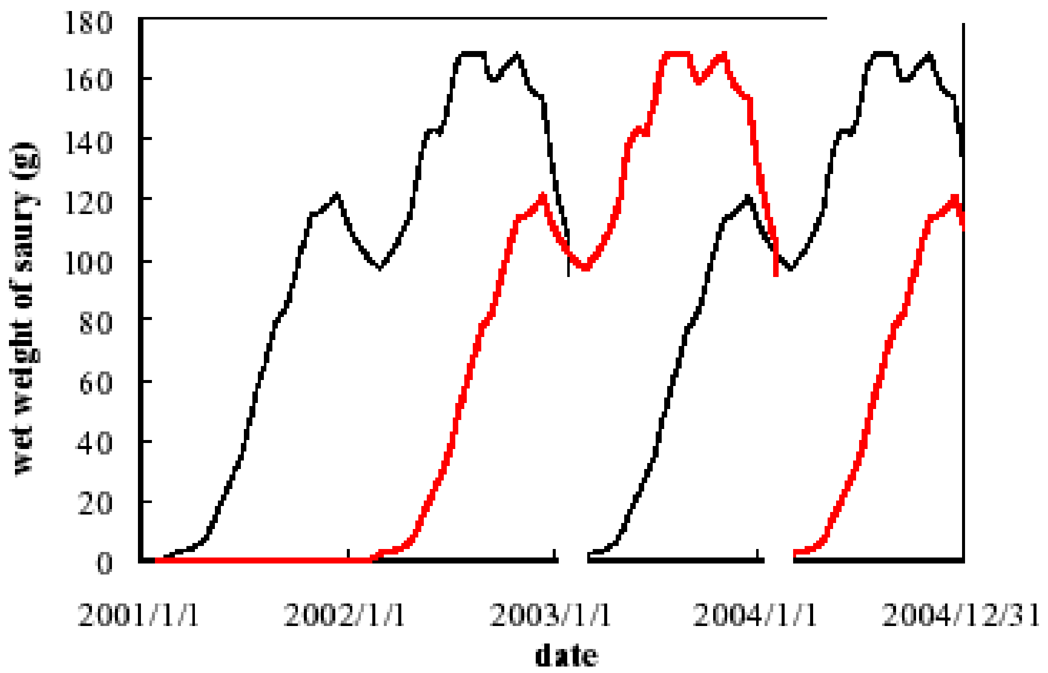
S: specific dynamic action
(digesting food)

F: egestion

E: excretion

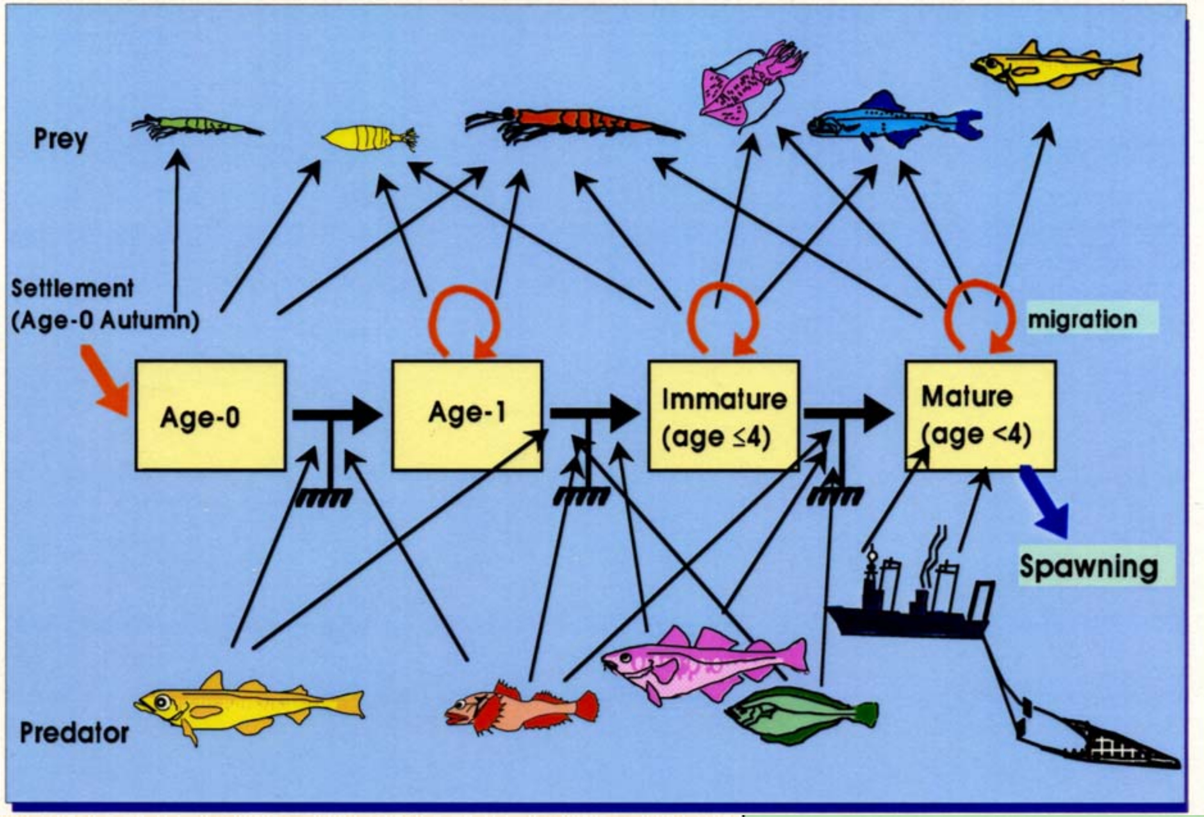
P: egg production

wet weight of saury

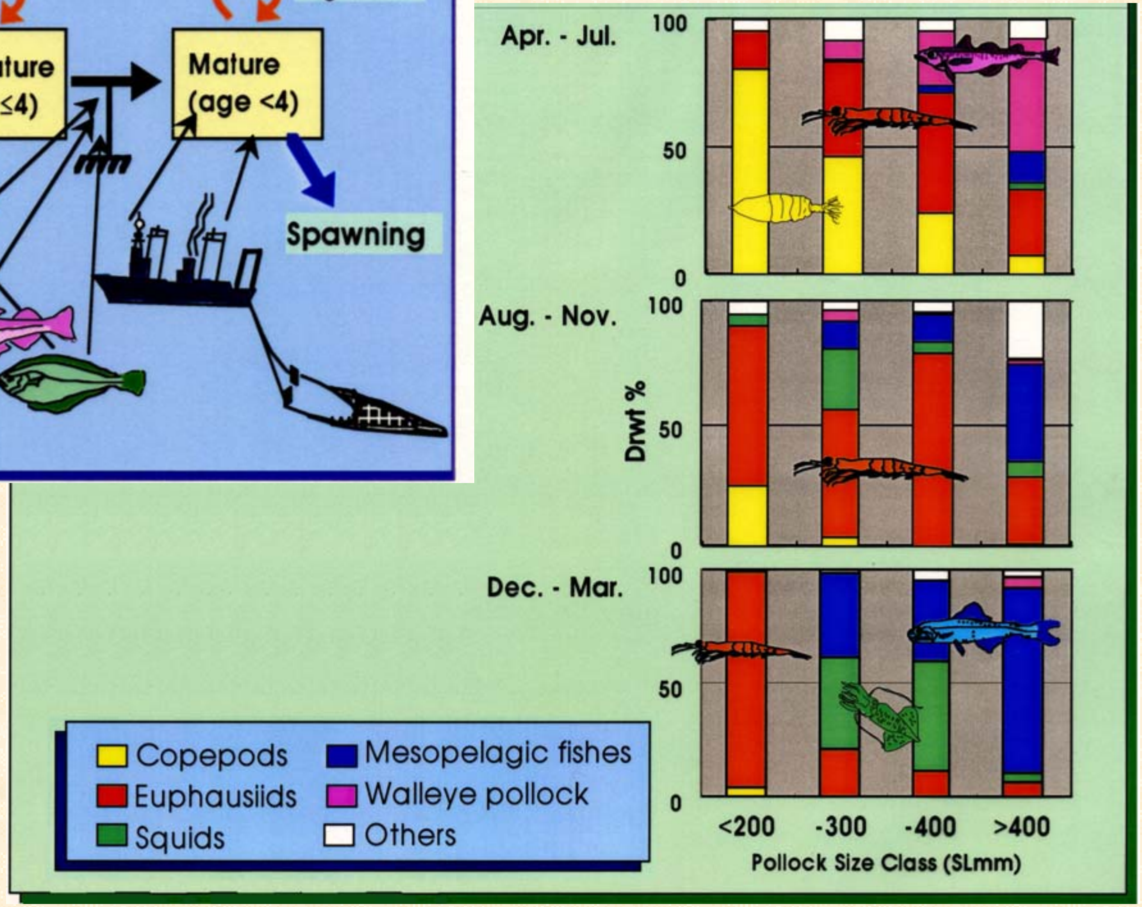


(Itoh et al.)

Trophodynamic model of walleye pollock



(Yamamura et al.)

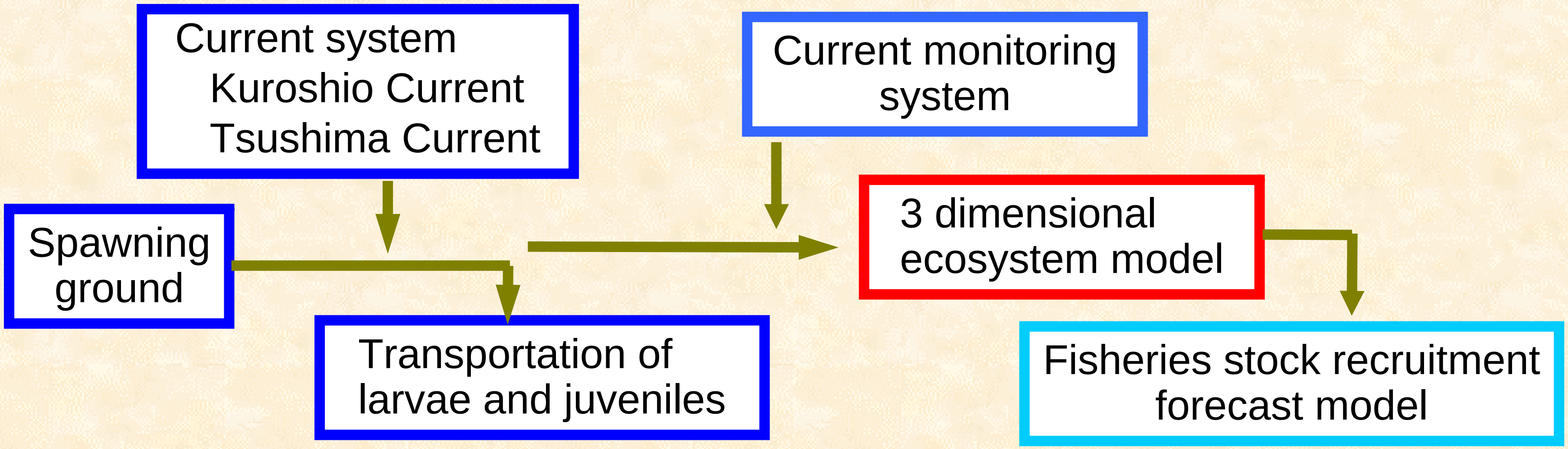


Synthesis of the VENFISH project

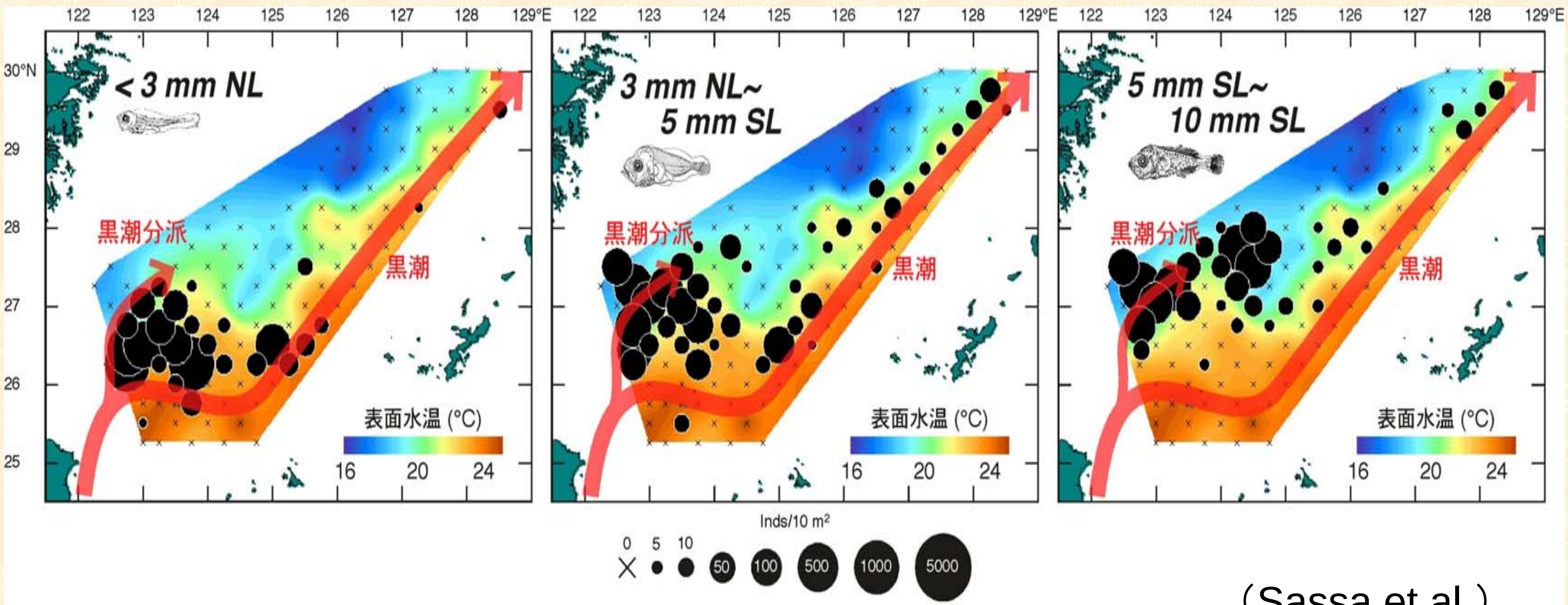
- Accumulation of biological and ecological information of the Oyashio region
- Establishment of bottom-up model from nutrients to zooplankton (**NEMRO model**).
- Increasing biological information on Pacific saury.
- Recognizing **importance of meso- and bathypelagic ecosystem** closed up as the carnivores and competitor to pelagic fish.

FRECS Project

To understand the mechanisms of environmental impacts on the spawning grounds and their linkages to recruitment; the mechanisms by which eggs and larvae are injected into the Tsushima and Kuroshio Currents and are carried to coastal areas; and factors affecting survival during growth processes. Target species are **jack mackerel** (*Trachurus japonicus*) and the Japanese common squid (*Todarodes pacificus*).



Transportation of jack mackerel larvae and juveniles from southern area of East China Sea



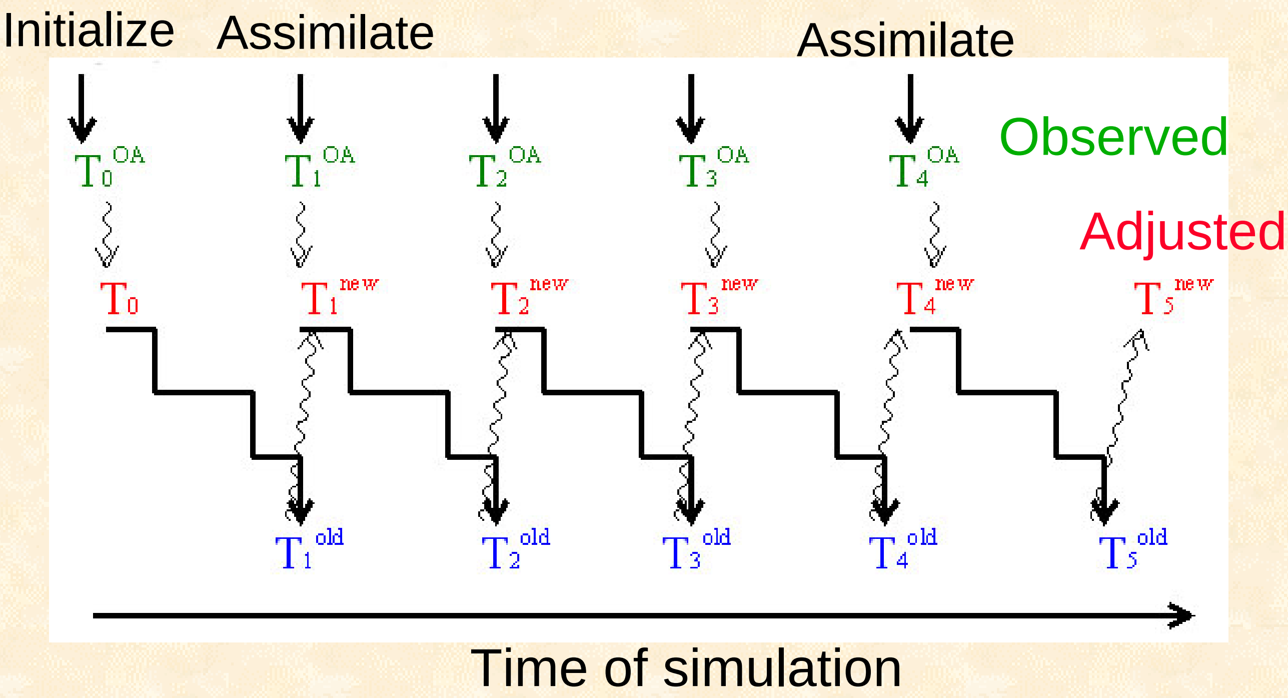
（Sassa et al.）

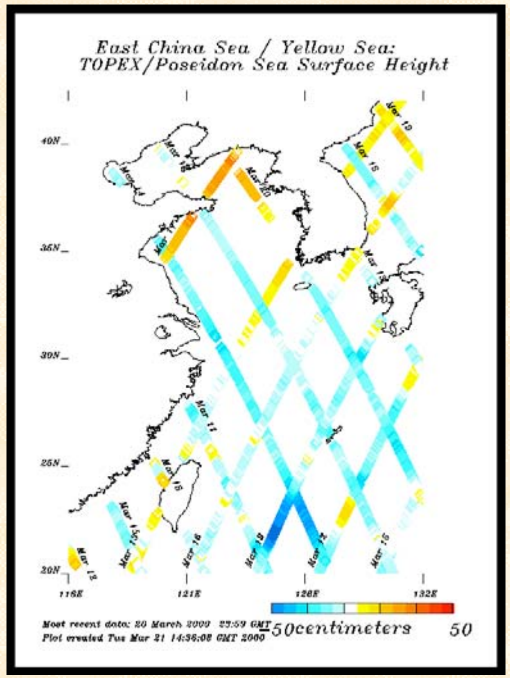
High resolution 3 dimensional advection process simulation model

Ocean general circulation model:

Three dimensional primitive model (C-HOPE)

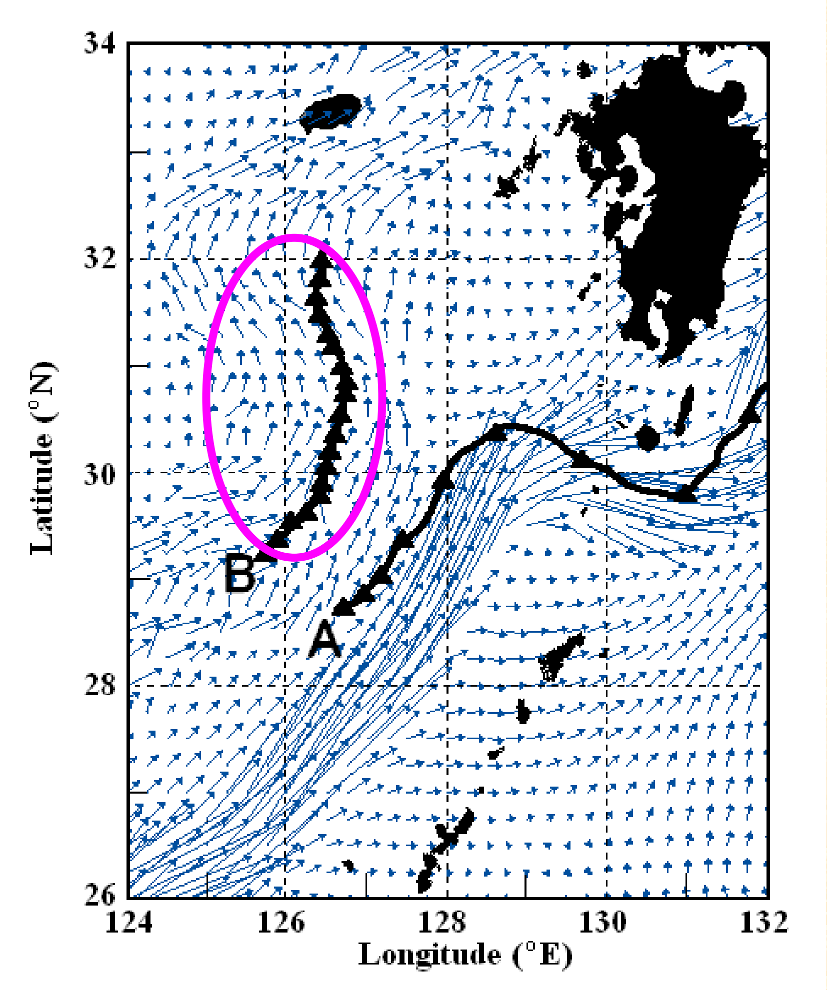
Observed date assimilated to the satellite altimetry data (Jason-1) by the Adjoint method (TAMC)

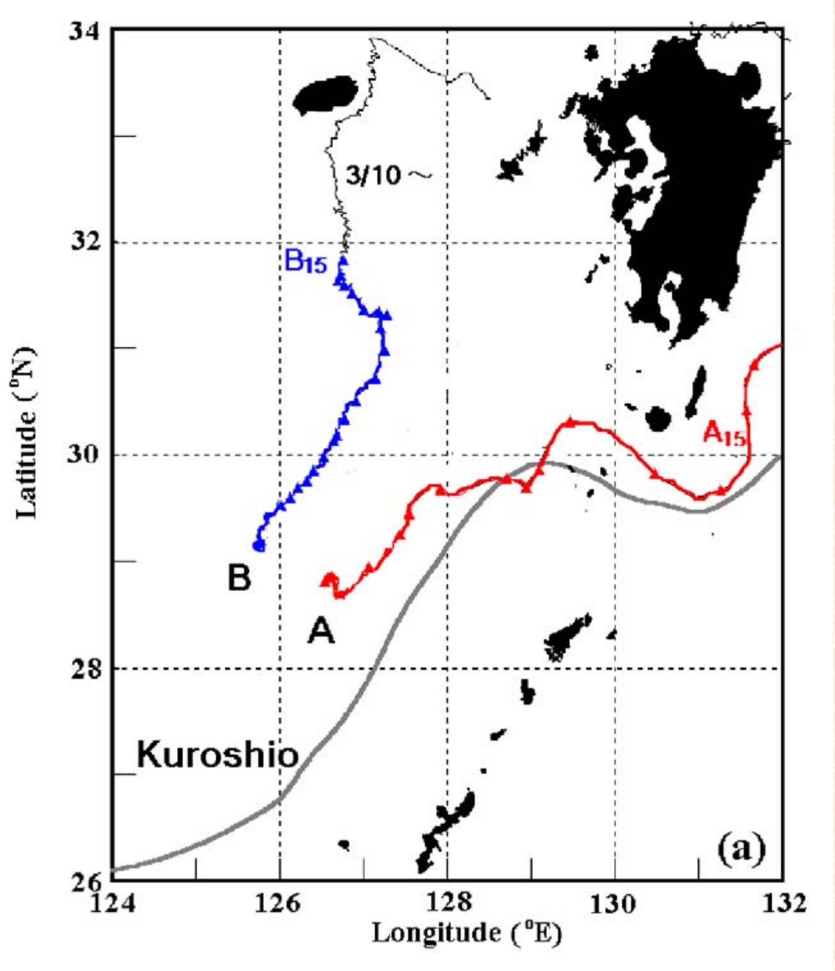




(K. Komatsu)

Result





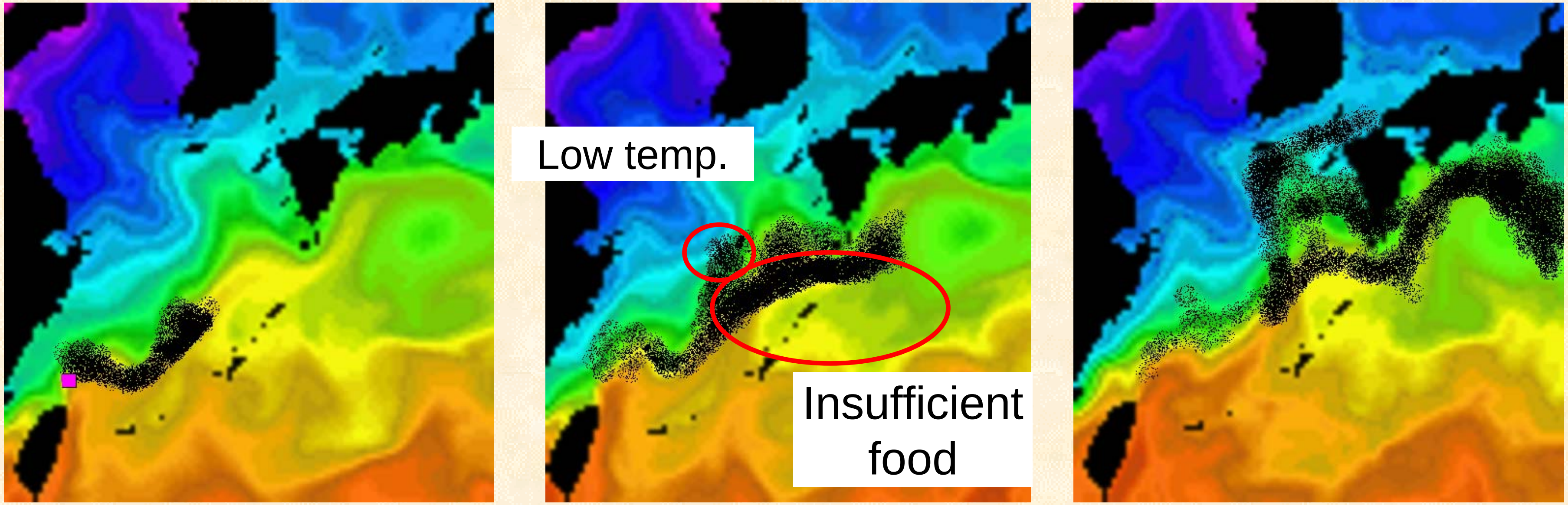
Simulation (20m)

Observation

Current: 2001/02/21/0:00

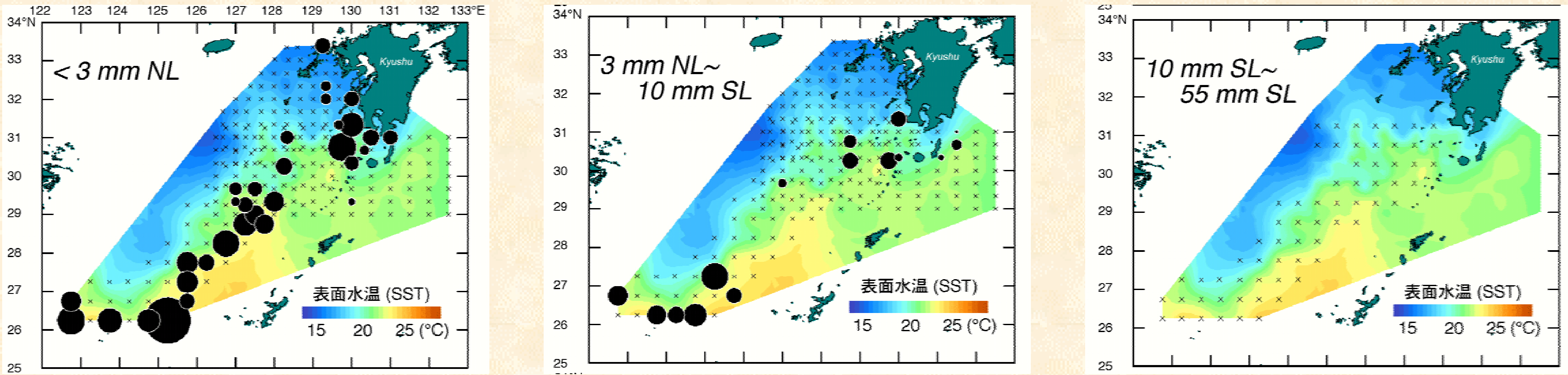
(K. Komatsu)

Advection experiment of pseudo- jack mackerel eggs (from 15th Feb 2001)



0-6days **7-16days** **17-30days**

(K. Komatsu)

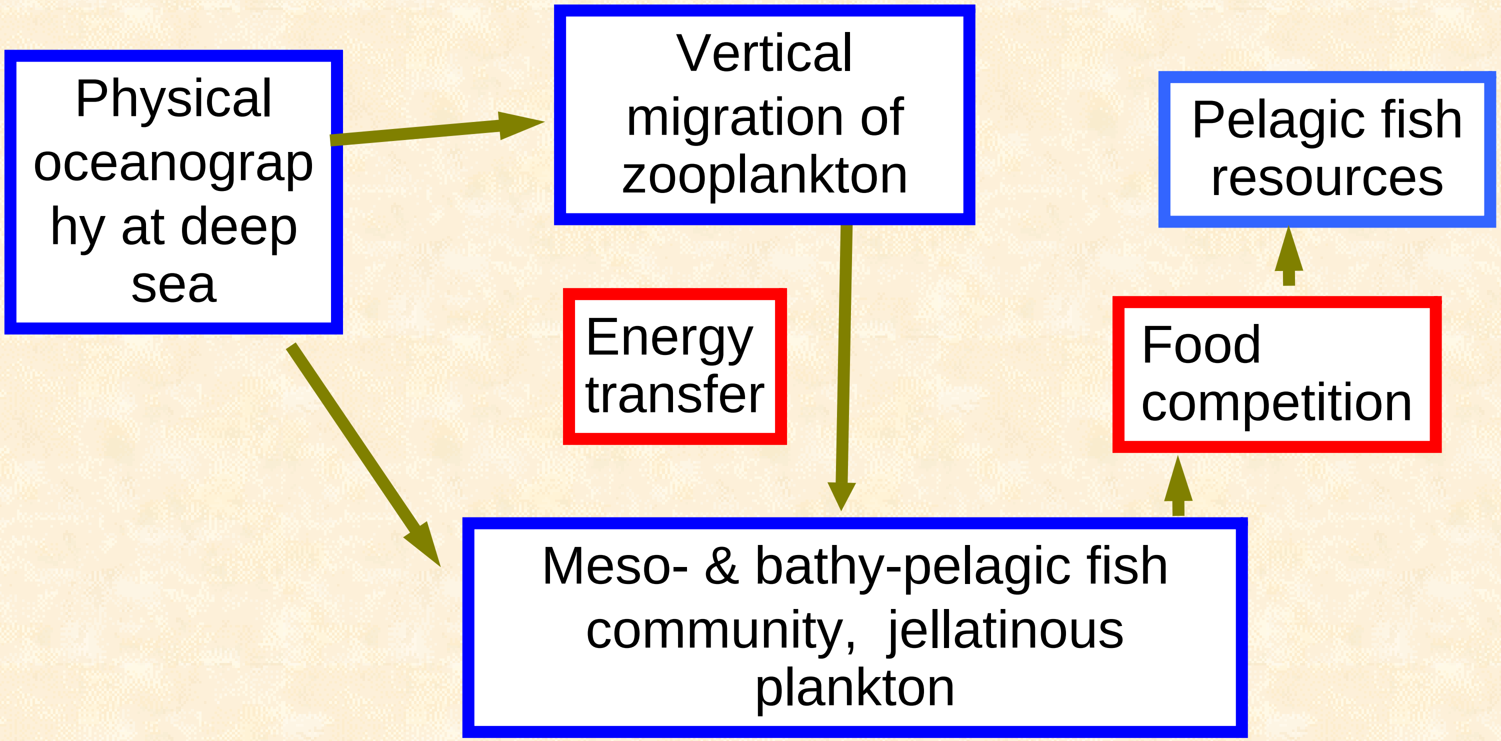


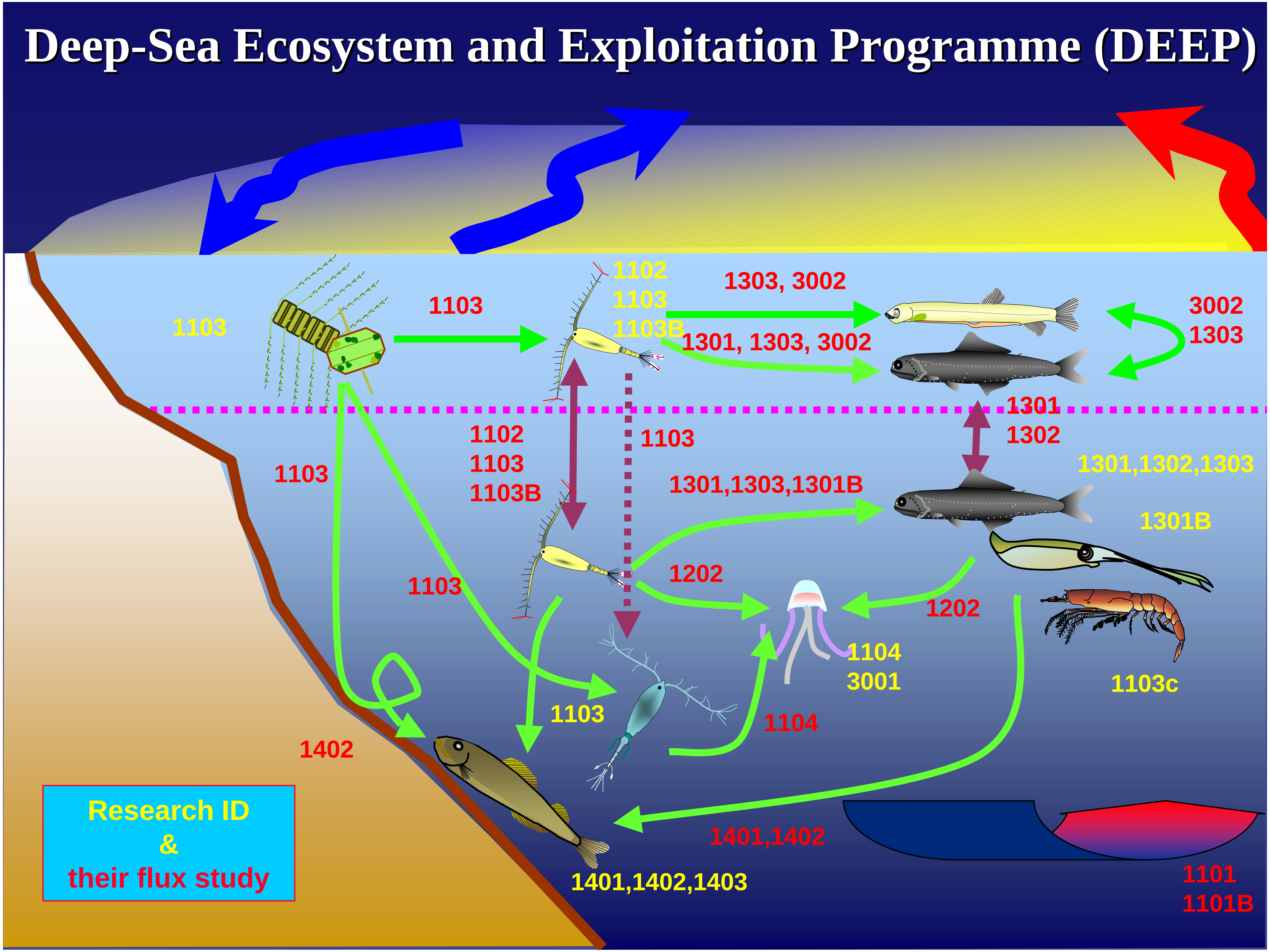
(Sassa et al. 2002)


DEEP
Deep-Sea Ecosystem and Exploitation Programme

DEEP project

To understand the meso- or bathypelagic ecosystem structure and dynamics, relationship between the pelagic fish community and the meso- or bathypelagic ecosystem.




Deep-Sea Ecosystem and Exploitation Programme (DEEP)
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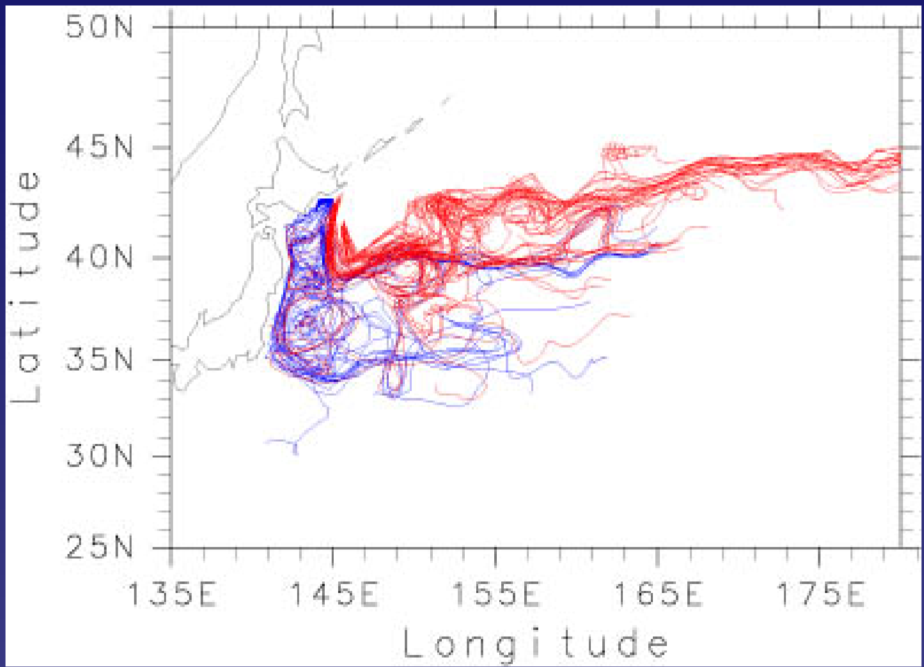
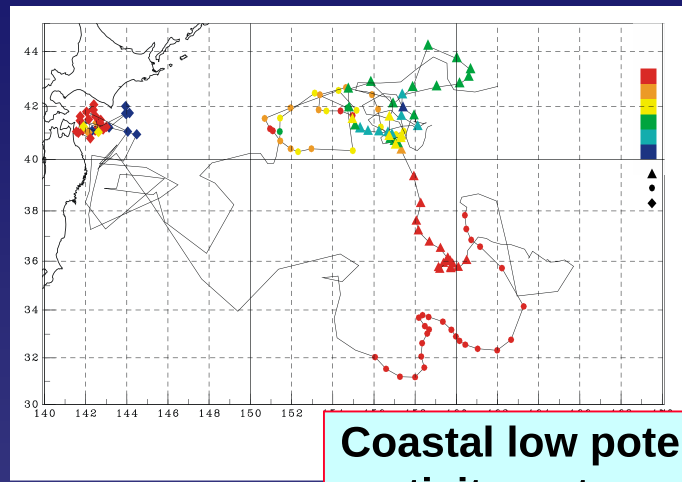
Research ID
&
their flux study

Structure and movement of intermediate water

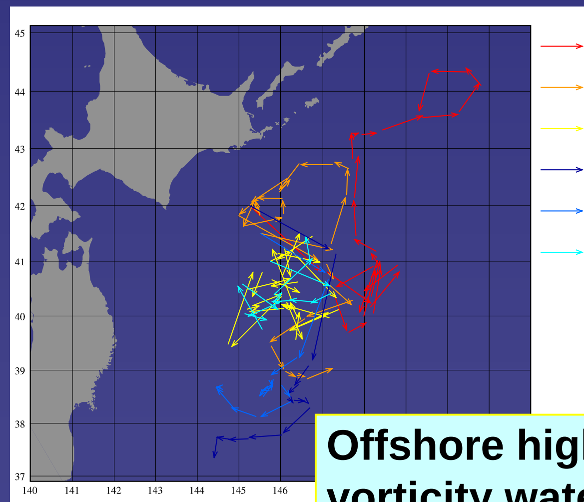
Particle flow model experiment



Isopycnal-Lagrangian float



Coastal low potential vorticity water



Offshore high potential vorticity water

Low potential vorticity water moves southward to transition region or the Kuroshio Extension.

High potential vorticity water moves

1) southward to transition region
2) back to the subarctic circulation.

Transportation by physical process and biological pump

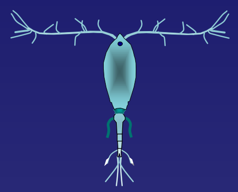
Annual carbon flux by Copepods in various depth layers toward to southwestward crossing OICE-line（$\times 10^{10}$ gC）

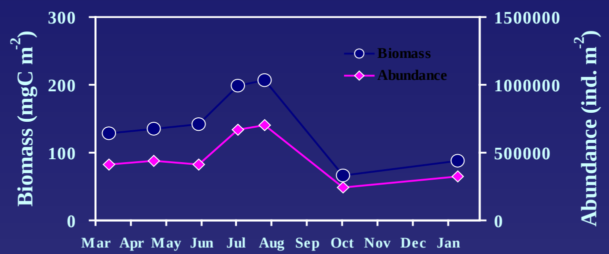
Layer	*N. cristatus*	*N. flemingeri*	*N. plumchrus*	*E. bungii*
0–50m	8.2	4.5	8.0	7.9
50–150m	5.8	0.1	0.3	2.3
150–300m	1.9	1.6	0.6	3.0
300–500m	3.6	2.0	0.7	7.5
Total	19.5	8.3	9.6	20.7

Total 580,000 ton carbon was transported by the four Copepod species in the Low potential vorticity Oyashio water southwestward crossing OICE-line for one year from 2001 spring to 2002 winter.

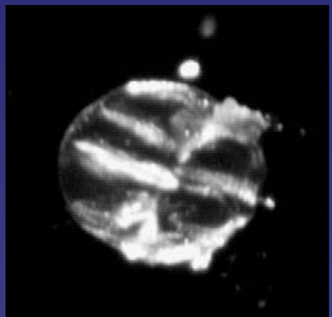
Organic materials transported to meso- or bathypelagic layer

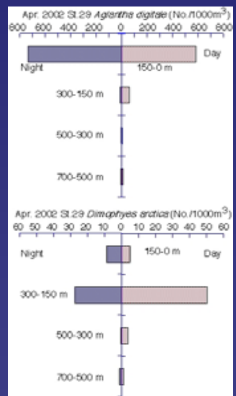
Plankton feeders in the meso- or bathypelagic layer



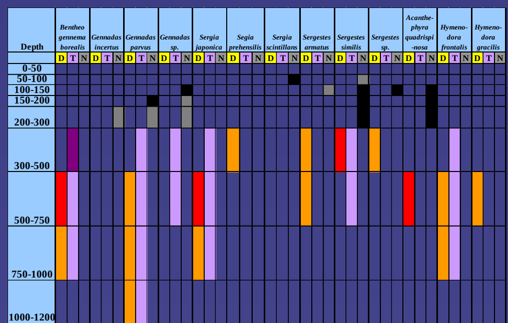


Fecal pellet feeder
Biomass and vertical distribution of *Oithona similis*



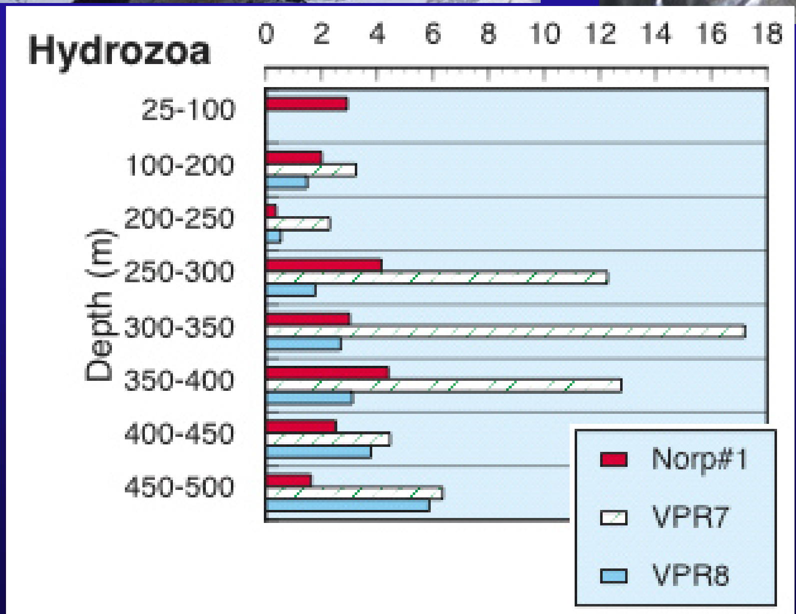


Biomass, vertical distribution, and feeding ecology of jellatinous plankton

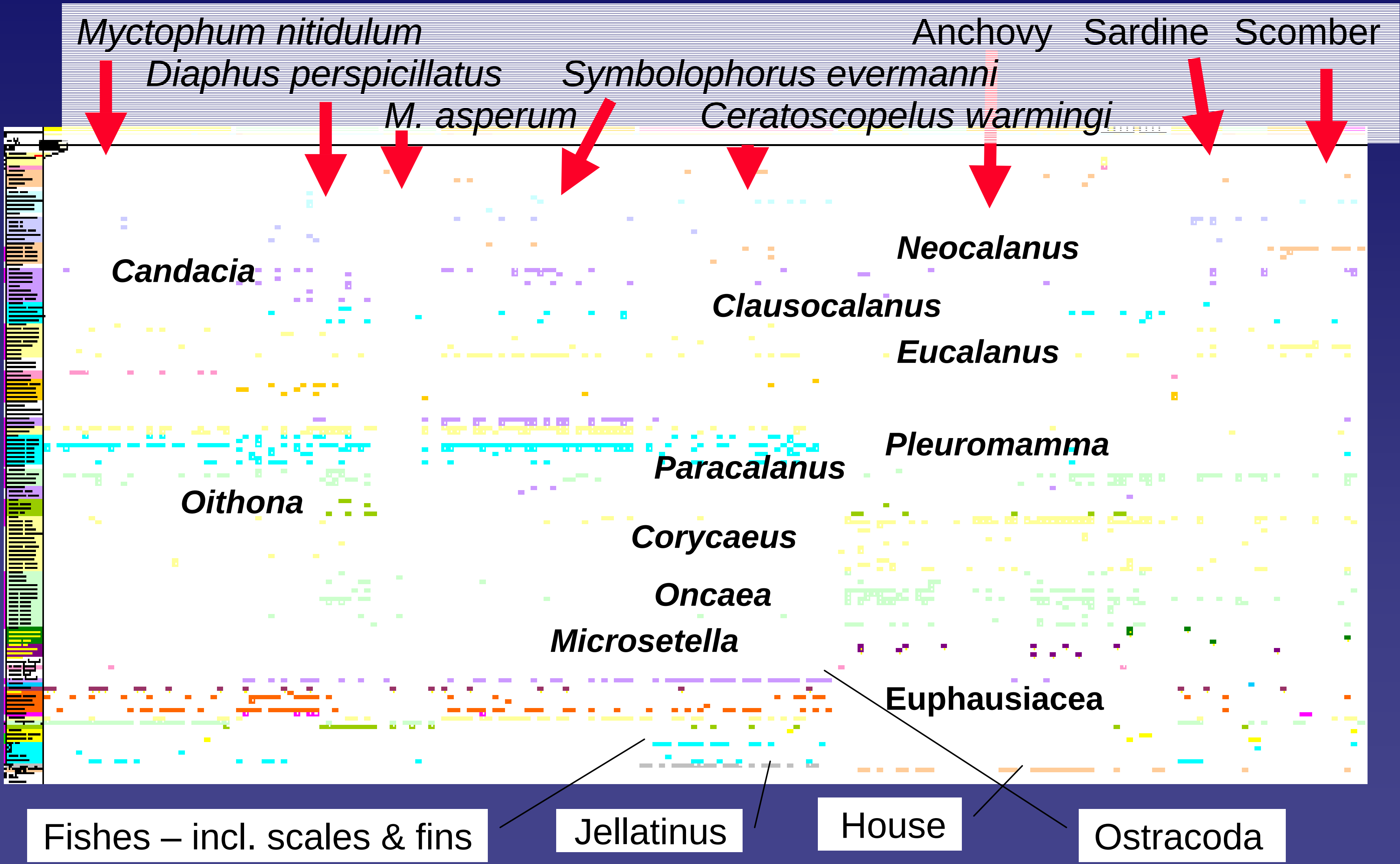


Biomass, daily vertical migration, feeding ecology of meso- or bathypelagic decapoda

VPR was modified for measuring meso- and bathypelagic jellatinus plankton biomass



Feeding ecology of small pelagic fishes and mesopelagic fishes



Food consumed by mesopelagic fishes

Daily ratio of lantern fishes (%WW m^{-2} d^{-1})

Oyashio area

Metridia → *D. theta*
0.017

Metridia →*S. leucopsarus*
0.015

Euphausiids → *L. jordani*
（night, surface） 0.058

Mysid → *L. jordani*
（day, deep ） 0.039

Oyashio-Kuroshio transition area

Metridia → *D. theta*
0.008

Metridia → *S. leucopsarus*
0.034

N.cristatus → *S. nannochir*
0.001

Euphausiids → *L. jordani*
（night, surface） 0.046

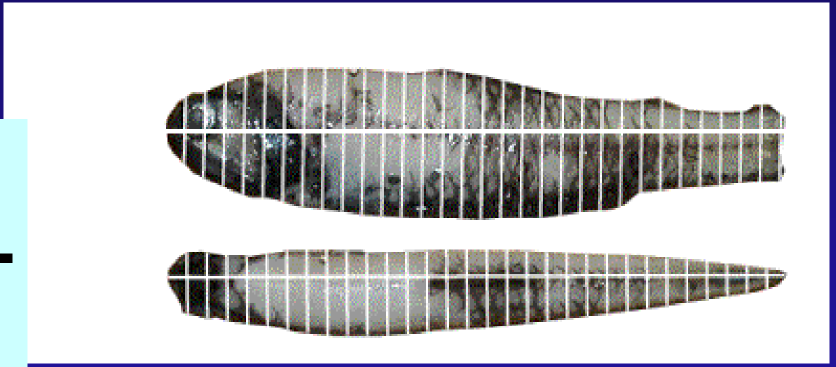
Acoustic survey for mesopelagic fishes

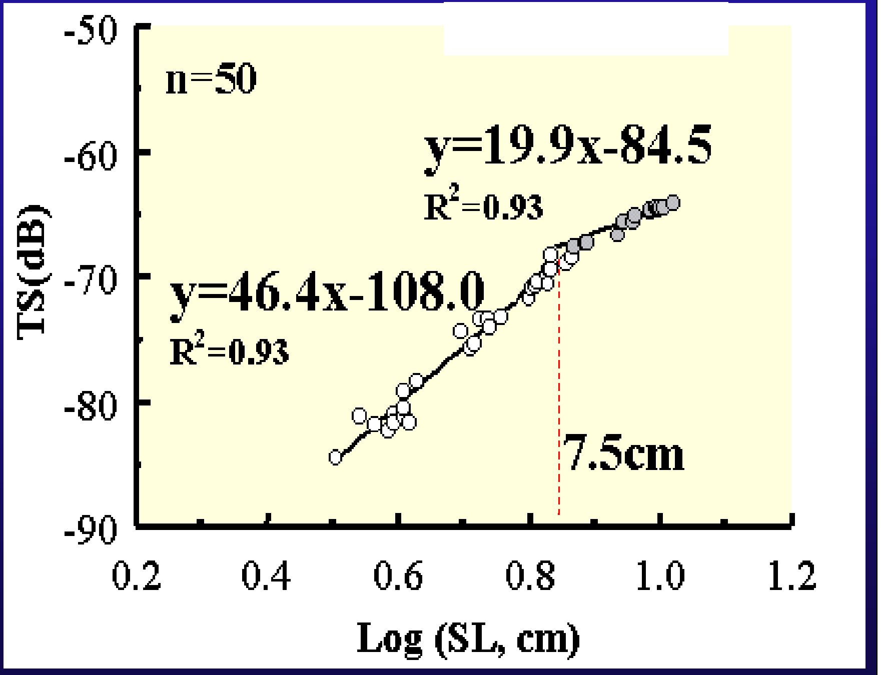
Acoustic parameters of lantern fishes

Estimated biomass of *Stenobrachius leucopsarus* in Bering sea

Area	(km²)	Biomass (g/m²)	Total weight (10^4ton ±SE)
1	27,902	55.5	156.3 ±7.8
2	10,433	70.0	73.7 ±2.2
3	4,045	78.5	32.1 ±2.5
4	1,413	132.6	18.9 ±2.5
Total	**43,793**	**64.1**	**281.0**

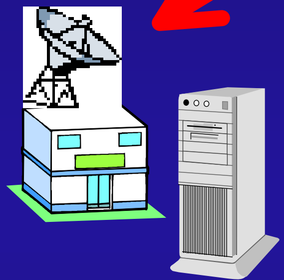
Weight in average 10.1(g/ind.)

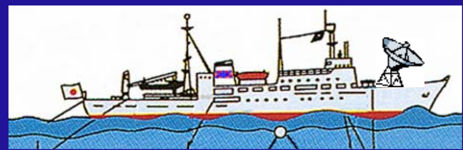


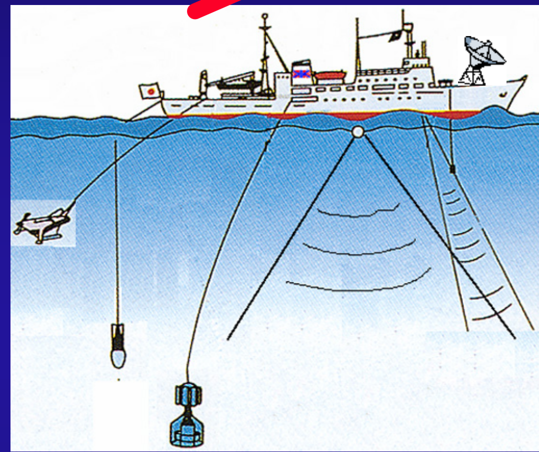


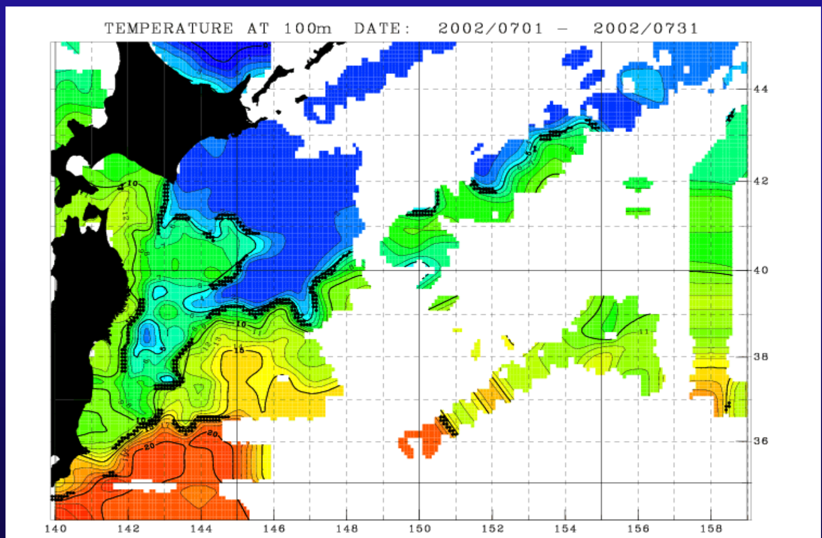
Real-time data exchange network via internet

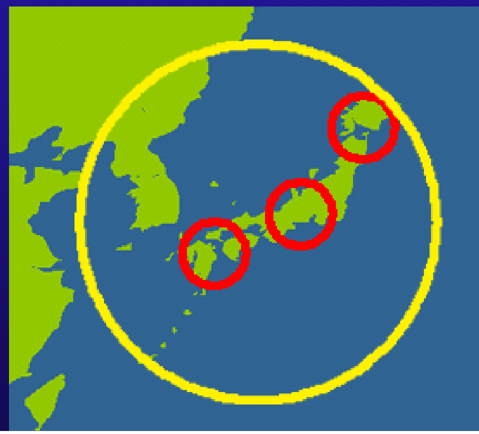
Internet satellite “ETS-VIII” system





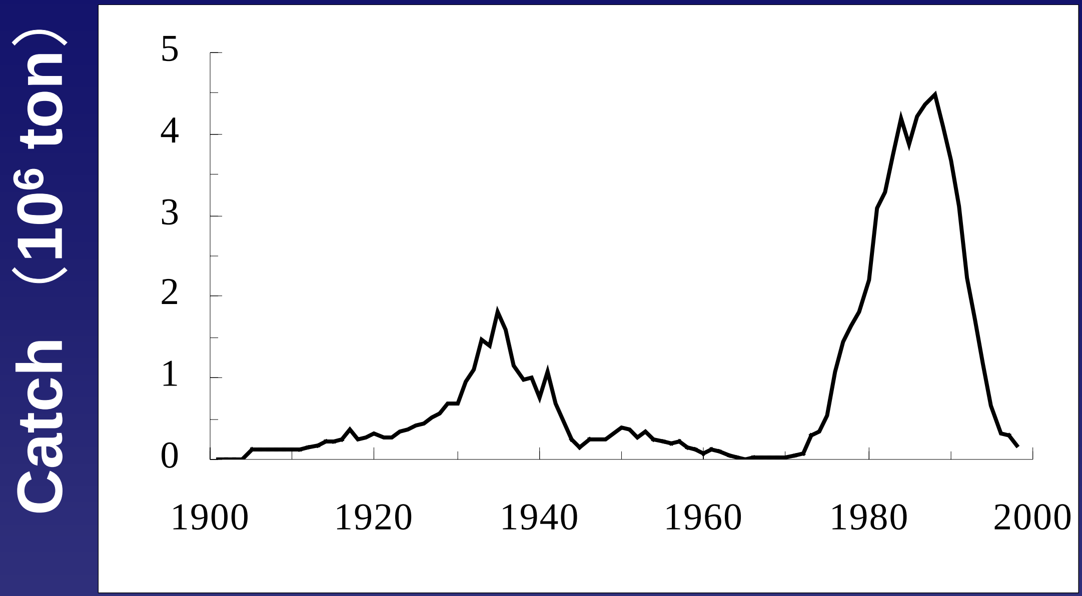






1.5 Mbps coverage area

Population fluctuation of Japanese sardine



Oyashio area &
Oyashio-Kuroshio
Transition area

Stock ~ 10^{12} gC
Feeding 2.4 $\times 10^{12}$ gC/ 4 months

Meso-pelagic fish
Estimated feeding
5.1 $\times 10^{12}$ gC

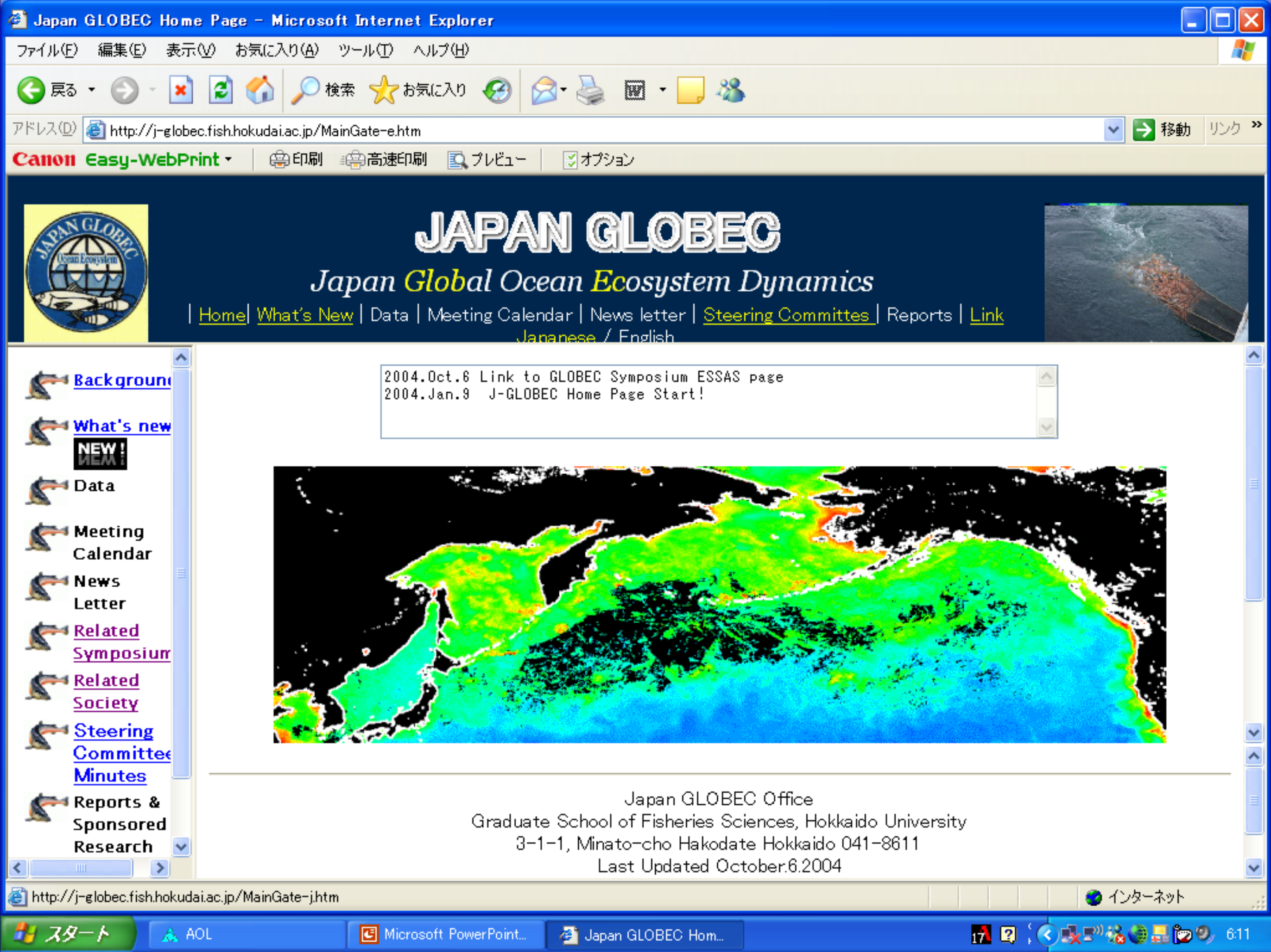
Population fluctuation of Japanese sardine affects meso- or bathypelagic ecosystem

Fluctuation of meso- or bathypelagic fish population affects the pelagic fish population

National committee of Japan-GLOBEC

Chaired by Yasunori Sakurai (Hokkaido Univ.)

http://j-globec.fish.hokudai.ac.jp/MainGate-e.htm



On-going projects

Diagnostics of Marine Ecosystem and Forecasting

Michio Kishi (Hokkaido Univ.) **(2004-2009)**

Japanese Fisheries Oceanography Data Base

(http://jfodb.dc.affrc.go.jp/kaiyodb.pub)

Data published in gray documents by Japanese Fisheries Agency

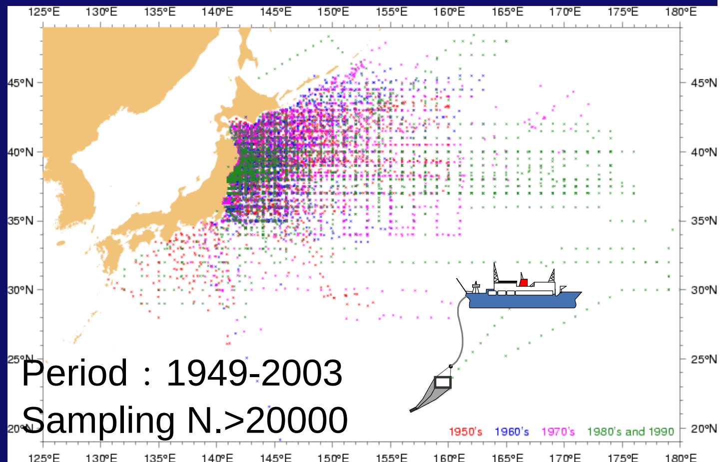
(from 1920' to present)

The Odate Project

Long-term variations of zooplankton community in the Western North Pacific

Using "Odate collection" collected >20000 samples from 1949

Result will be presented by Chiba et al. and Tadokoro et al.
10:30- and 10:50- on 21 Oct, S9

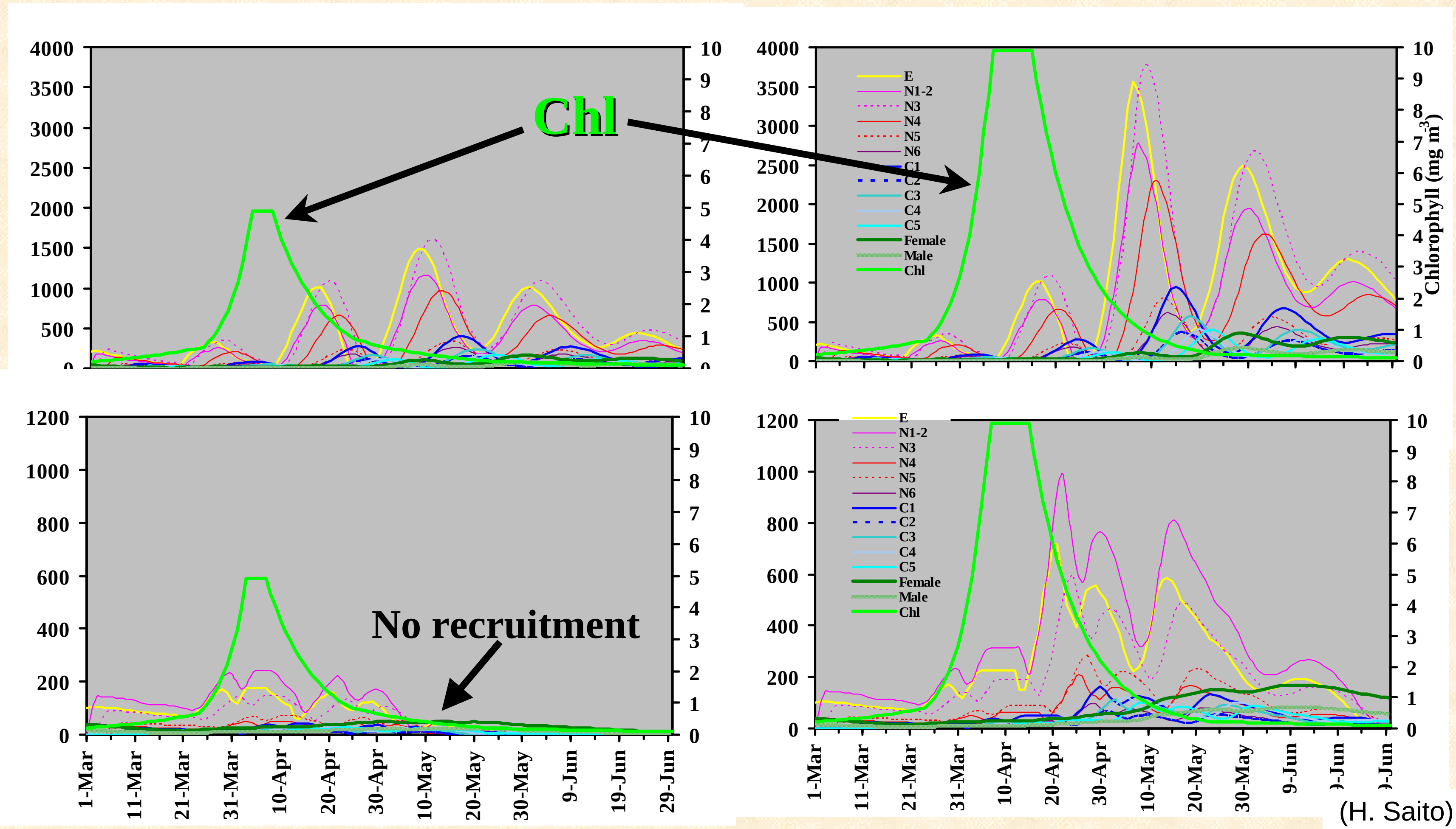


Small spring bloom

Large spring bloom

Paracalanus

Calanus



(H. Saito)

Population dynamics model of two copepod species, *Paracalanus* sp. (upper) and *Calanus pacificus* (lower), in the Kuroshio-Oyashio transition region.

Left case (small spring bloom): *Paracalanus* increases but *Calanus* does not respond.

Right case (large spring bloom): Both *Calanus* and *Paracalanus* increase

Synthesis of the Bio-Cosmos project

- Biological and ecological information of the Japanese sardine have been accumulated.
- Importance of biological monitoring was recognized in order to verify the models constructed in this project.
- Construction of ocean fluctuation model is needed to predict the future of pelagic fish populations.
- Biological research on the other pelagic fishes should be accelerated based on the knowledge of Japanese sardine.
- Research activities on bottom-up process should be succeeded to the coming project.