Global Change effects on Pacific saury distribution and its effects on fisheries

Shin-ichi Ito, Kosei Komatsu (AORI, Univ. Tokyo), Takeshi Okunishi, Akinori Takasuka (FRA), Naoki Yoshie (Ehime Univ.), Takahiko Kameda, Sohsuke Ohno (FRA), Kazuyoshi Watanabe (JAFIC), Takashi Setou, Hiroshi Kuroda (FRA)

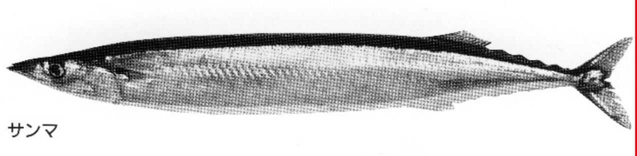
Today's contents

1. Life history of saury and NEMURO.FISH
2. Ensemble projection of Pacific saury
3. Projection with eNEMURO & 2D-migration
4. Conclusion

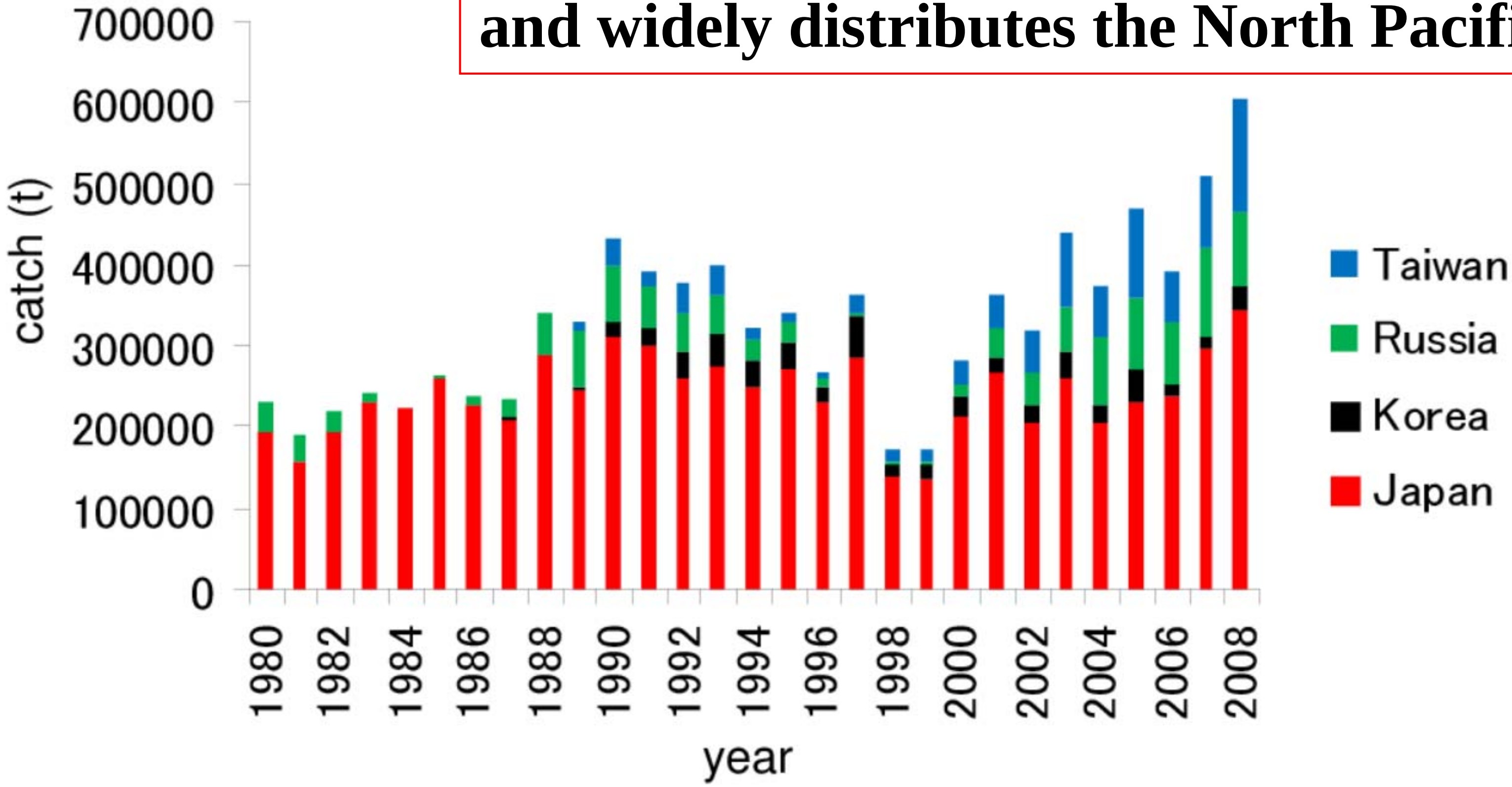
MAFF

PICES
WG-29

Catch of Pacific Saury

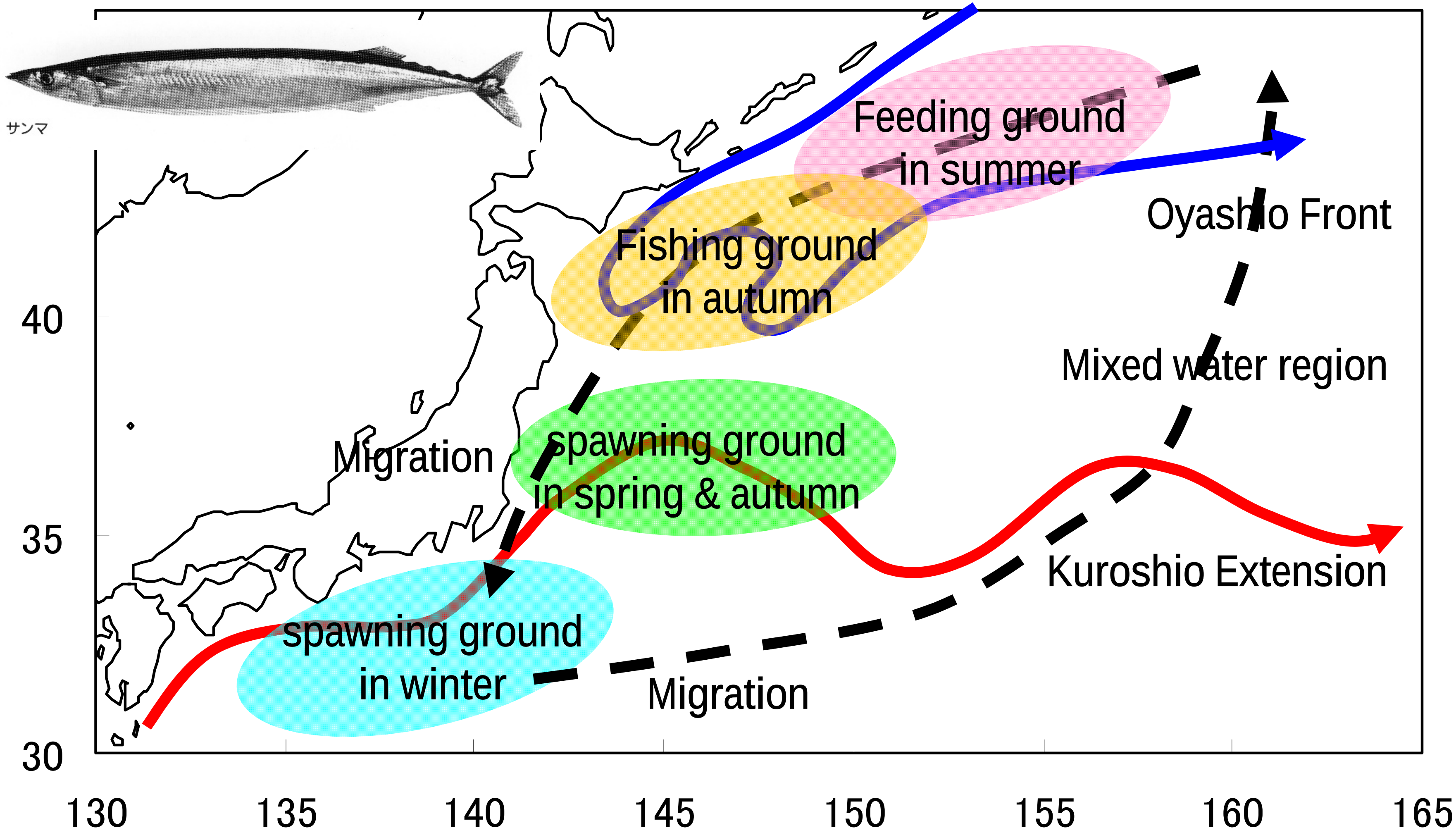


Pacific saury is one of the dominant small pelagic fish in the northwestern Pacific and widely distributes the North Pacific.



Ito et al. (2013, ICES-JMS)

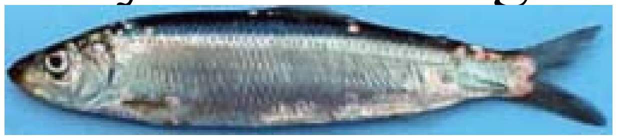
Life History of Pacific Saury with Oceanographic Features

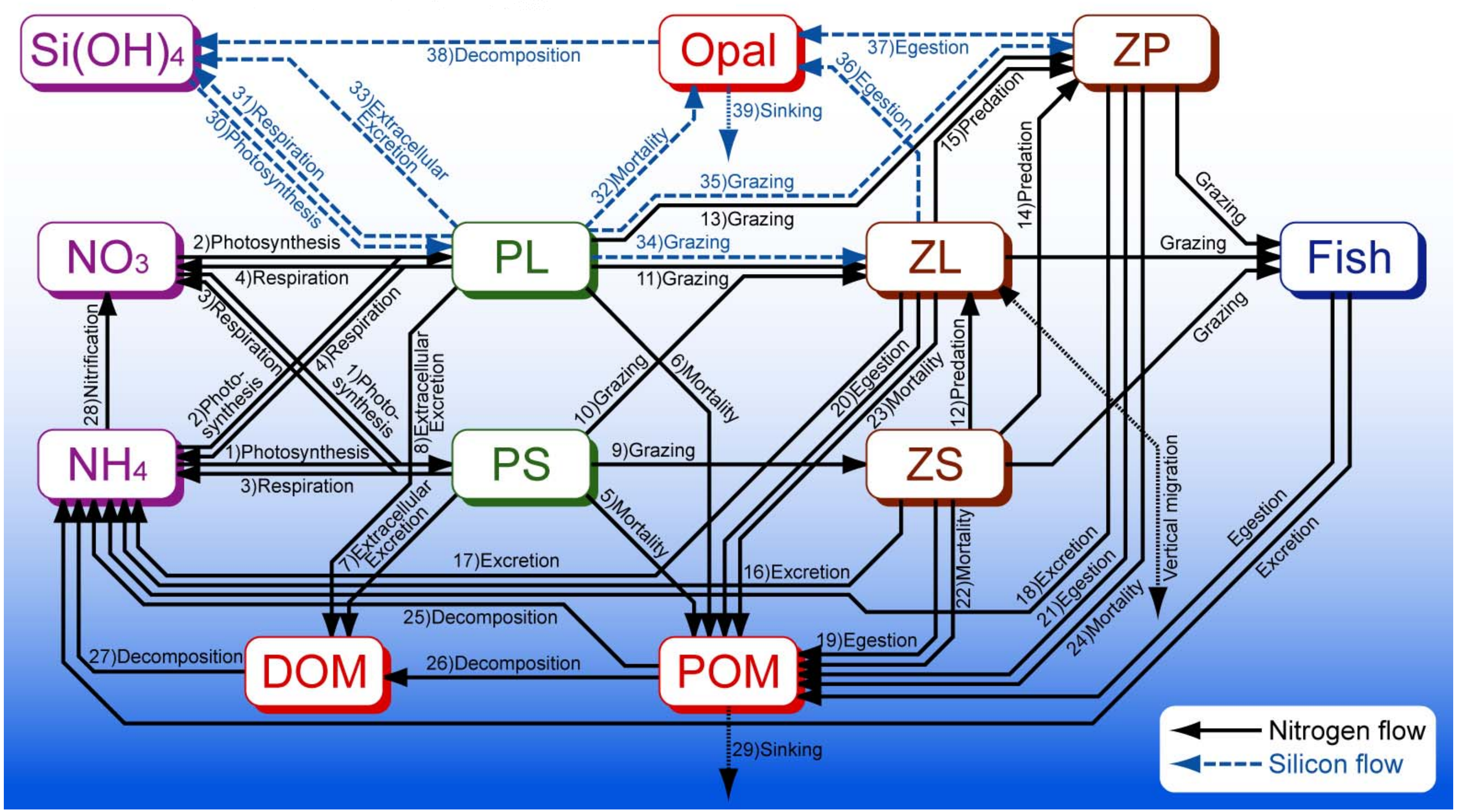


Ito et al. (2004a, Fish. Oceanogr.)

NEMURO.FISH

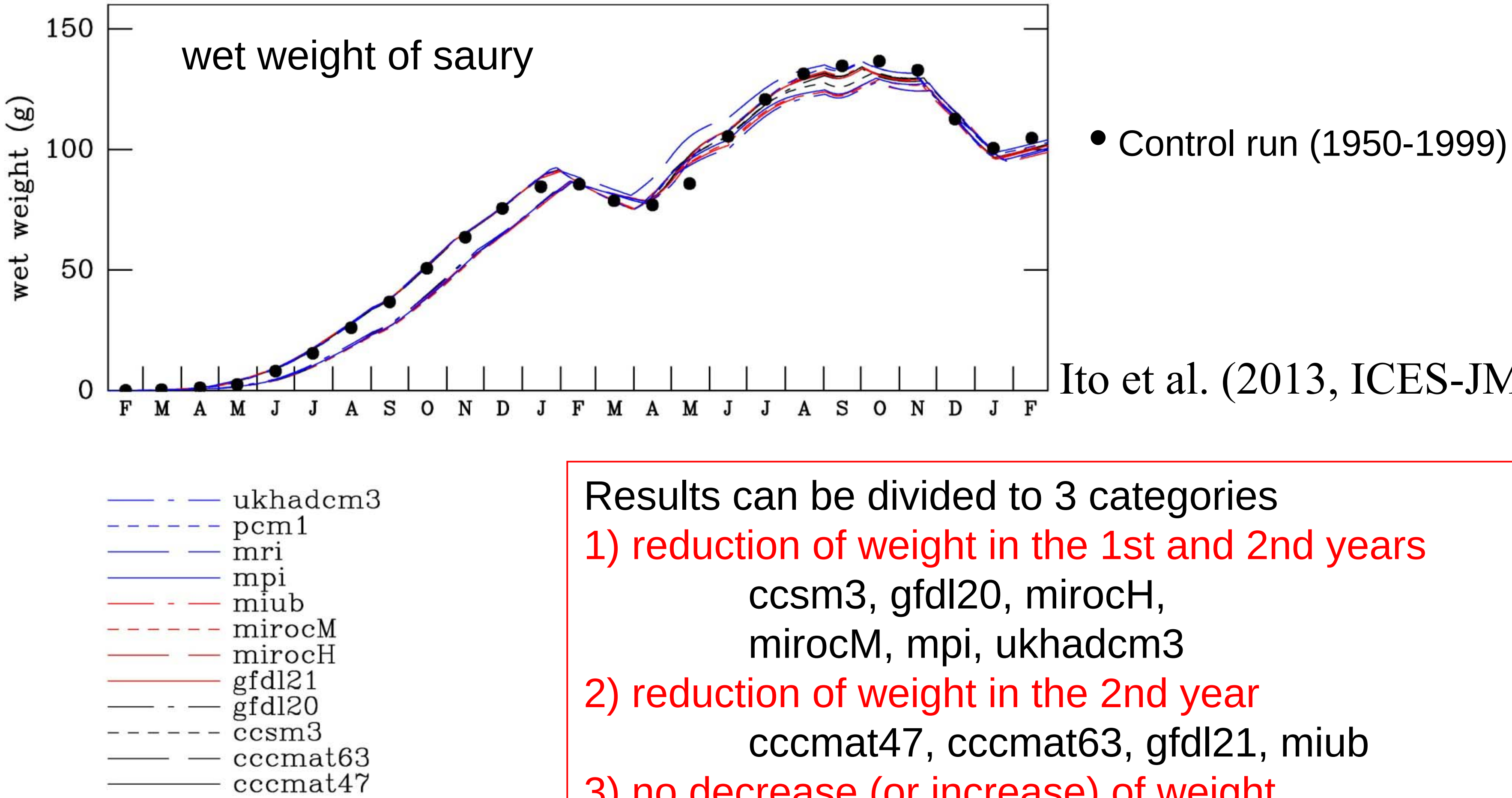
NEMURO for Including Saury and Herring





Megrey et al. (2007a, Ecol. Model.), Ito et al. (2004b Fish. Oceanogr.) etc.

Ensemble experiment with 12 IPCC-SSTs (A1B senario)



Ito et al. (2013, ICES-JMS)

Results can be divided to 3 categories

1) reduction of weight in the 1st and 2nd years

ccsm3, gfdl20, mirocH, mirocM, mpi, ukhadcm3

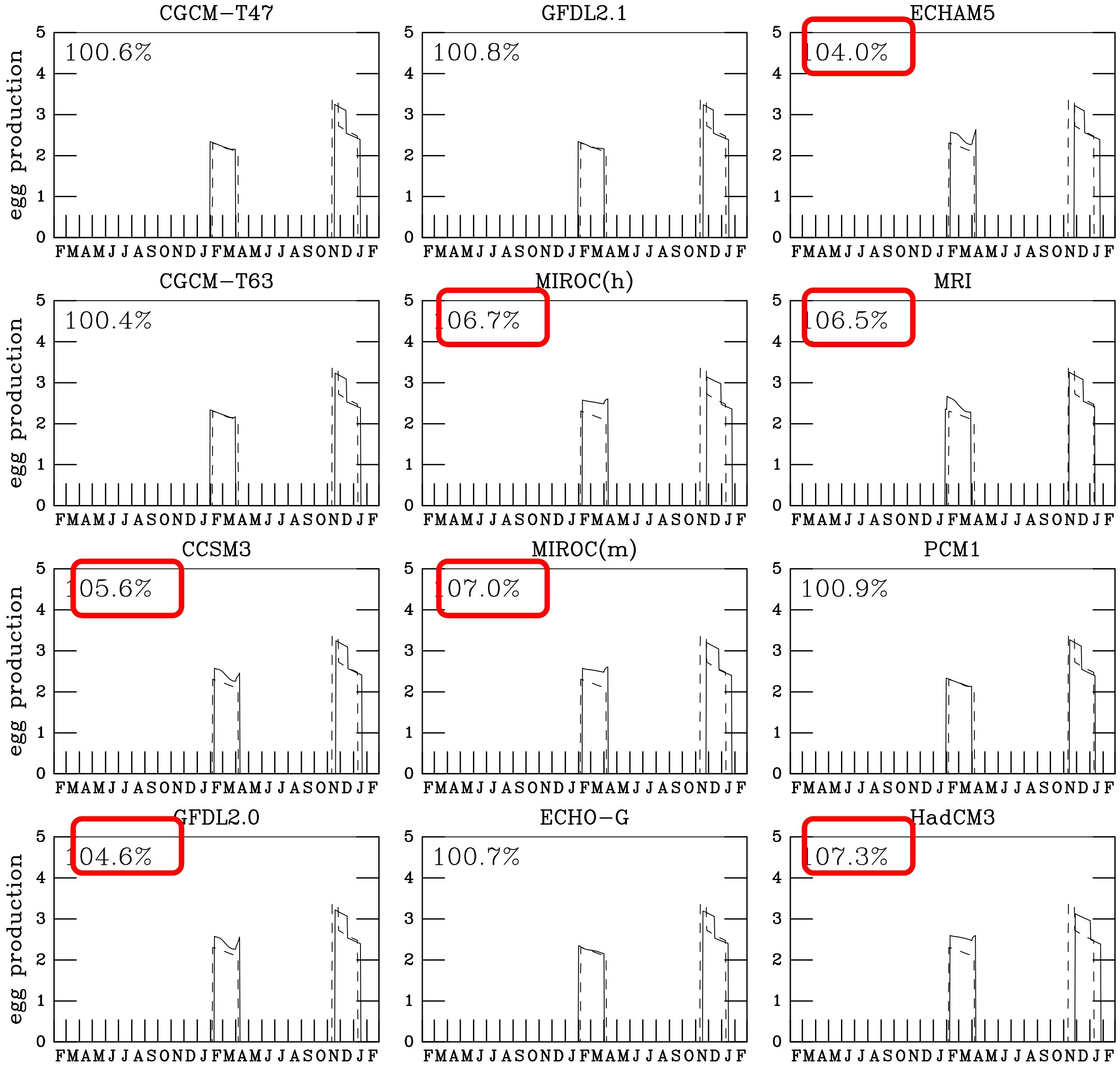
2) reduction of weight in the 2nd year

cccmat47, cccmat63, gfdl21, miub

3) no decrease (or increase) of weight

pcm1, mri

Ensemble experiment with 12 IPCC-SSTs (A1B scenario)



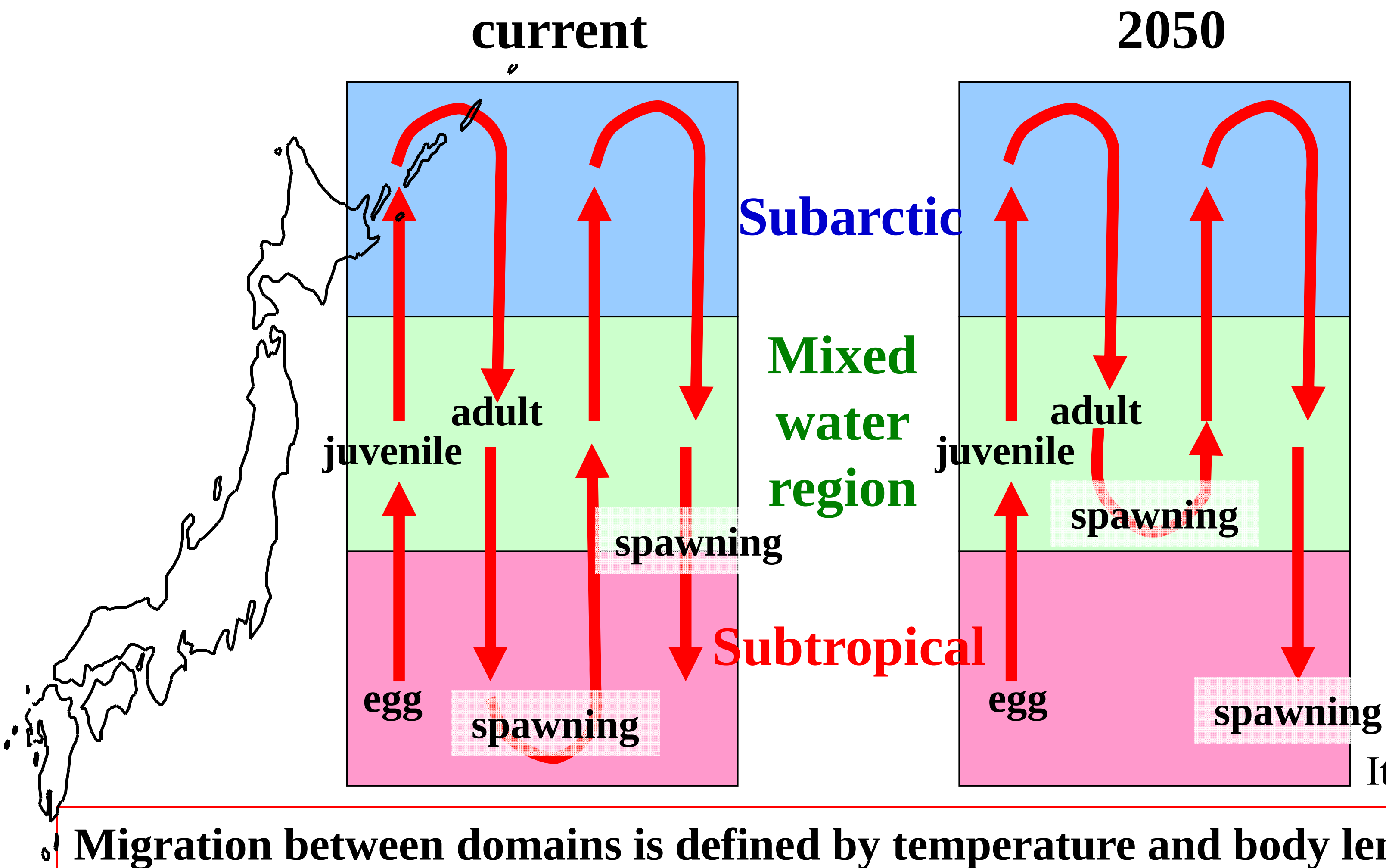
egg production

Broken: Control run (1950-1999)
Solid: 2050-60

Egg production was enhanced in several cases but not in other cases.

Ito et al. (2013, ICES-JMS)

Mechanism of enhancement of egg production



Ito (2007b)

Ito et al. (2010)

Migration between domains is defined by temperature and body length.
Under global warming situation, fish size is reduced and temperature is enough high in the mixed water region.
These factors prevent southward migration of saury in 1st winter and delay 2nd year migration. As a result, saury egg production is enhanced.

Ito et al. (2013, ICES-JMS)

Model results suggested the possibilities of

- **size reduction (73%), and**
- **number increase (33%)**

of Pacific saury under global warming conditions.
Model and other forcing also contain uncertainty.

A merit of model investigation is that it enables to separate the causes. Model sensitivity results suggested

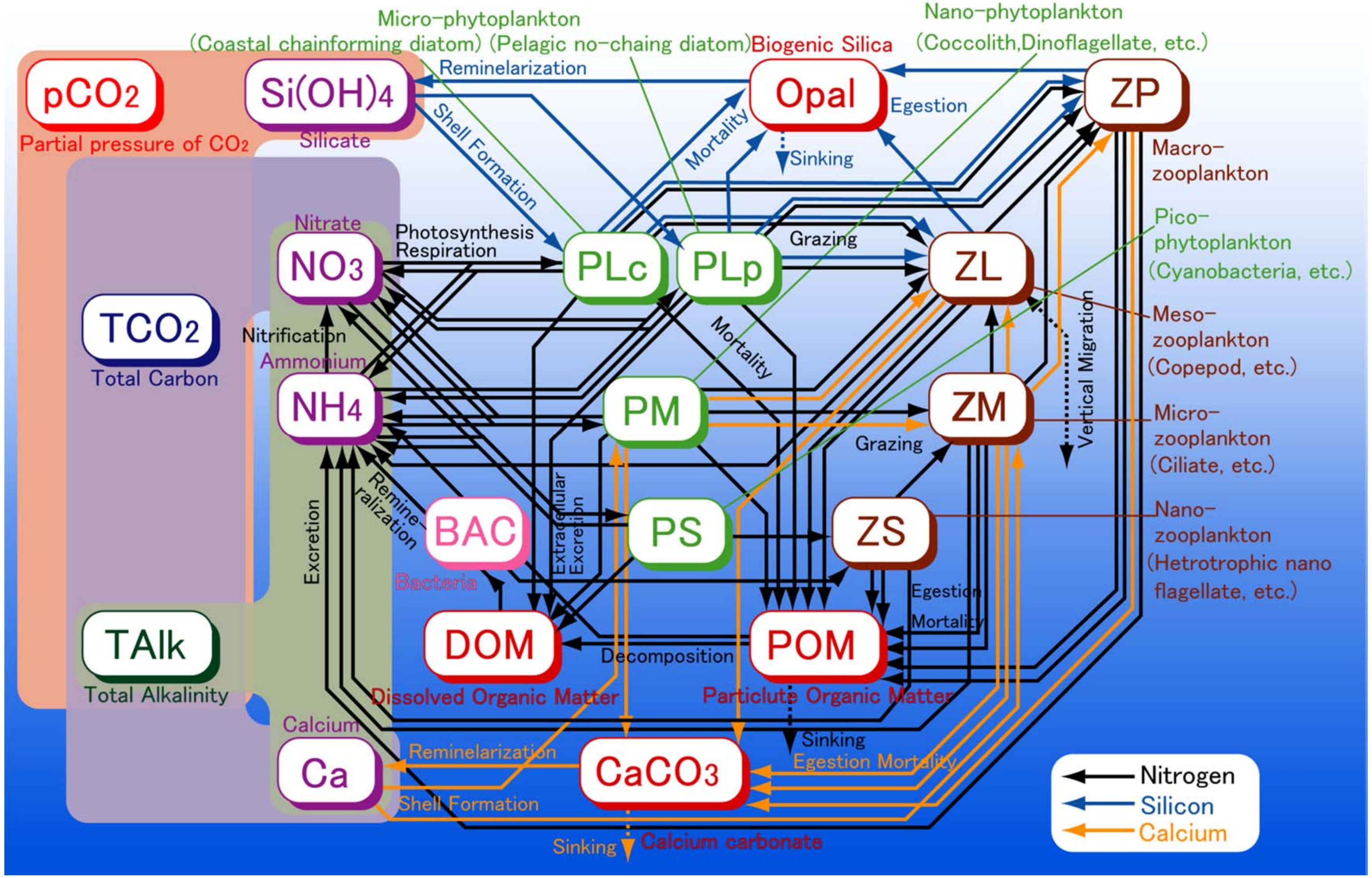
- **SST increase (especially in MW) directly reduces juvenile growth, and**
- **prey decrease influences on the growth of adult and migration pattern, hence egg production.**

To reduce the uncertainty, it is important to

- **fill the parameter gaps in biological model**
- **conduct projections with more realistic conditions (better zooplankton models, including 2D-migration, sequential future climate forcing, etc.)**

eNEMURO

extended North Pacific Ecosystem Model for Understanding Regional Oceanography



Courtesy of Prof. Naoki Yoshie

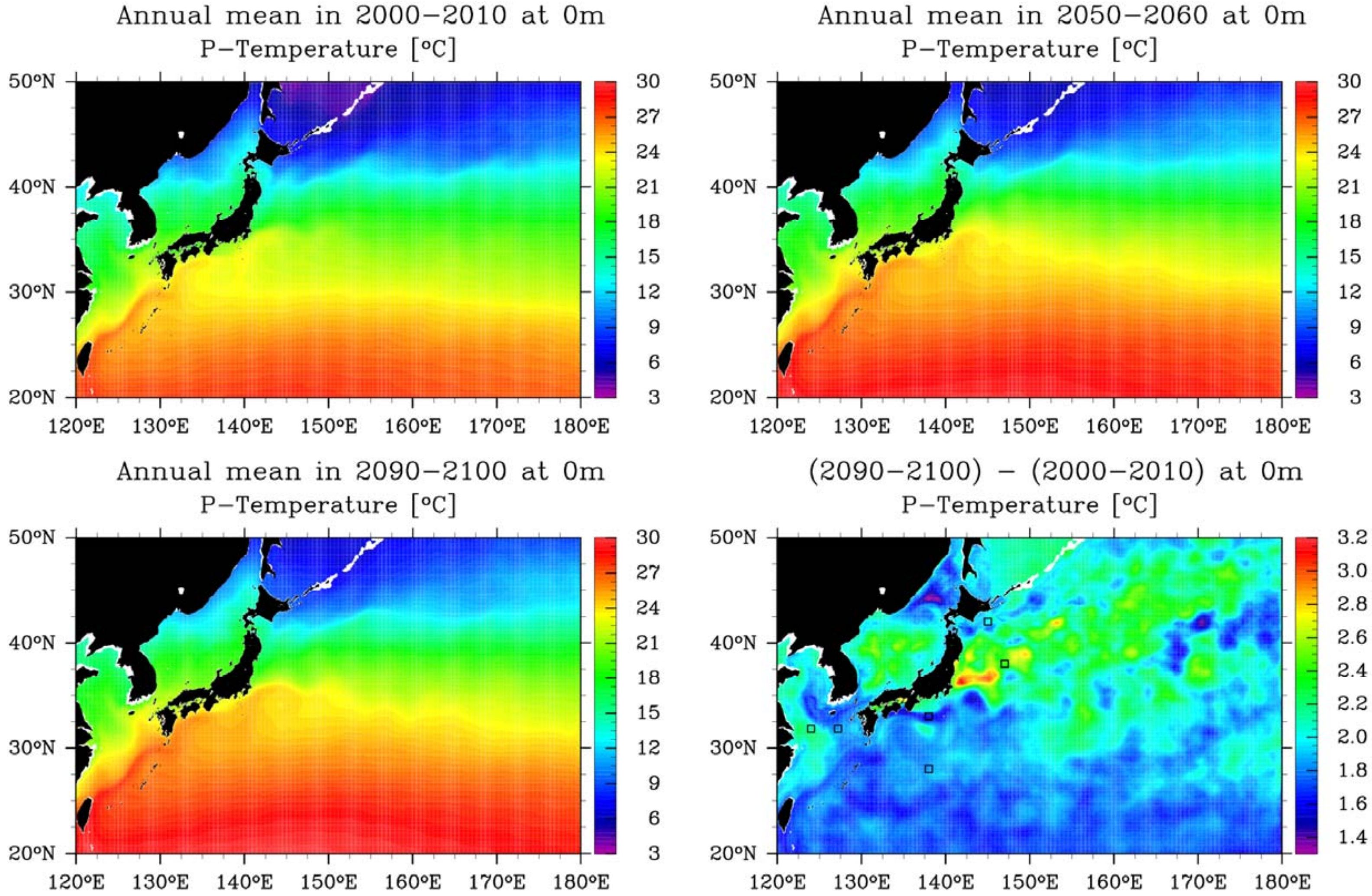
Couple to C-HOPE (1/16 degree horizontal resolution model).

Forced by MIROC-high output with A1B scenario.

CHOPE-eNEMURO (Global warming exp.)

Komatsu et al. (in prep.)

SST

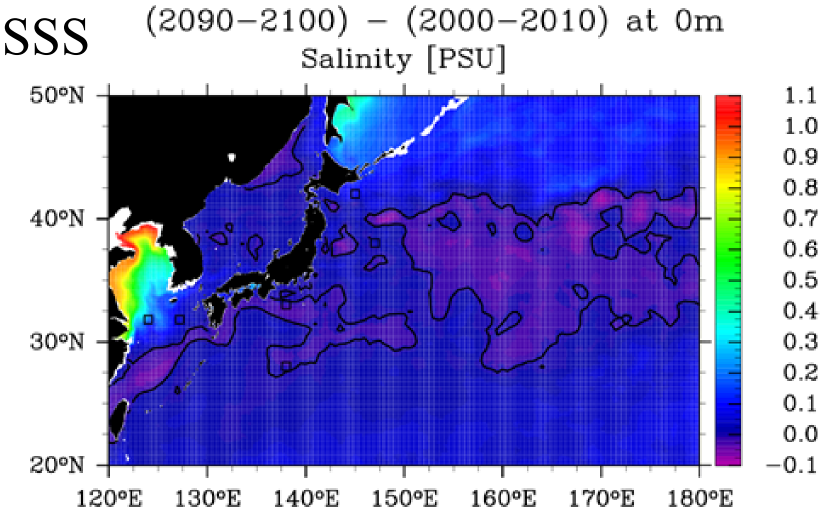


SST increased more than 2.5℃ in the mixed water region.

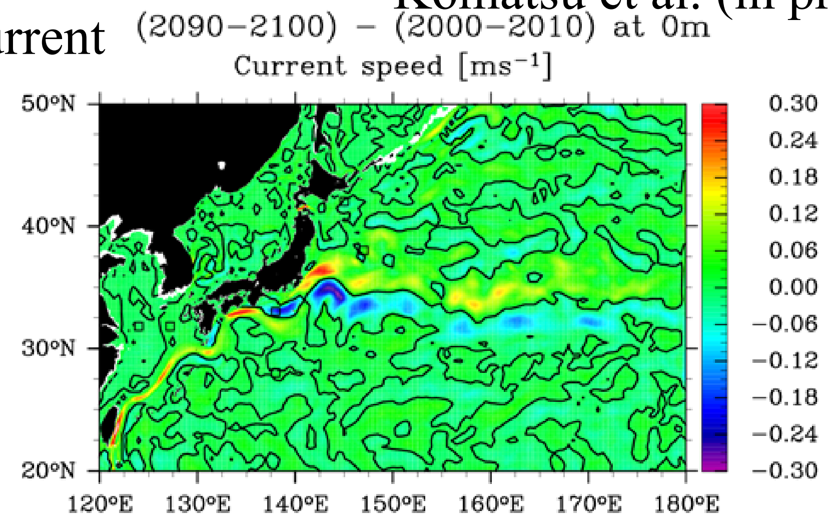
CHOPE-eNEMURO (Global warming exp.)

Komatsu et al. (in prep.)

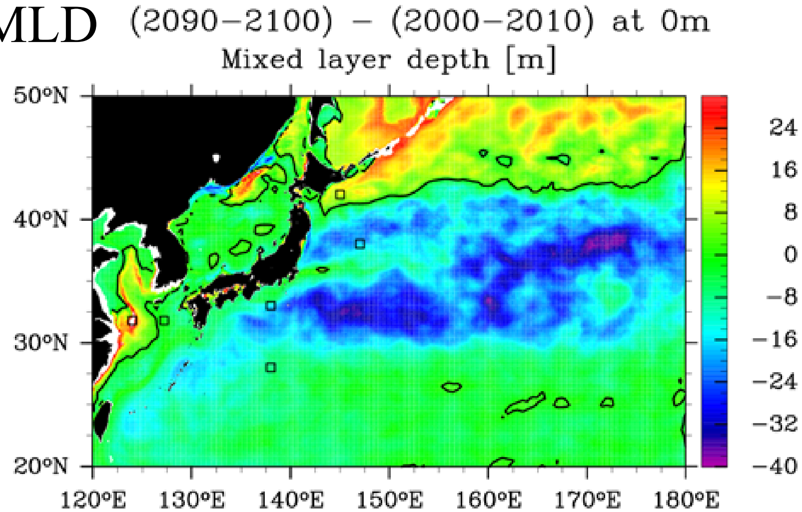
SSS



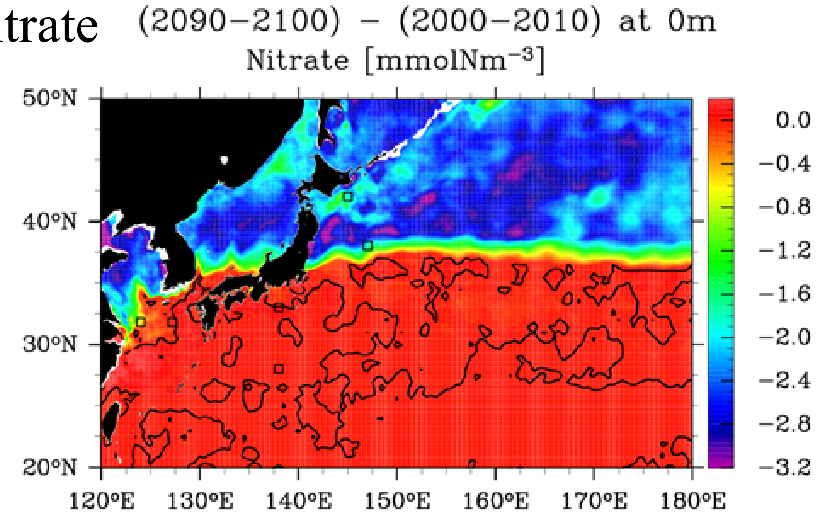
current



MLD



Nitrate

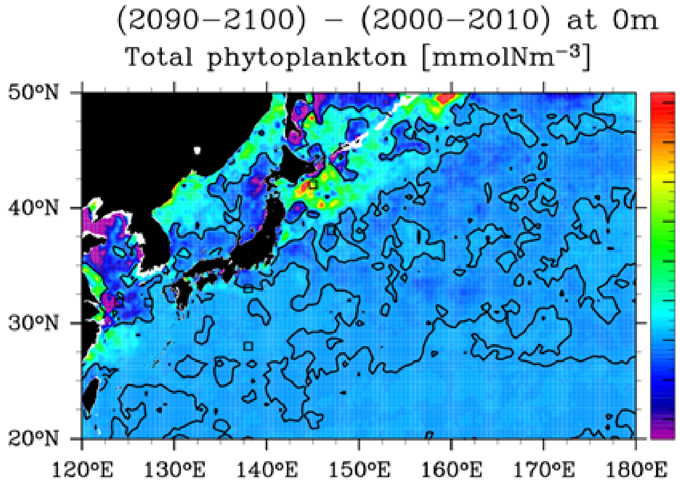


Decrease in salinity, spin up of Kuroshio,
Decrease in MLD and nutrient concentration in the mixed water region and subarctic area.

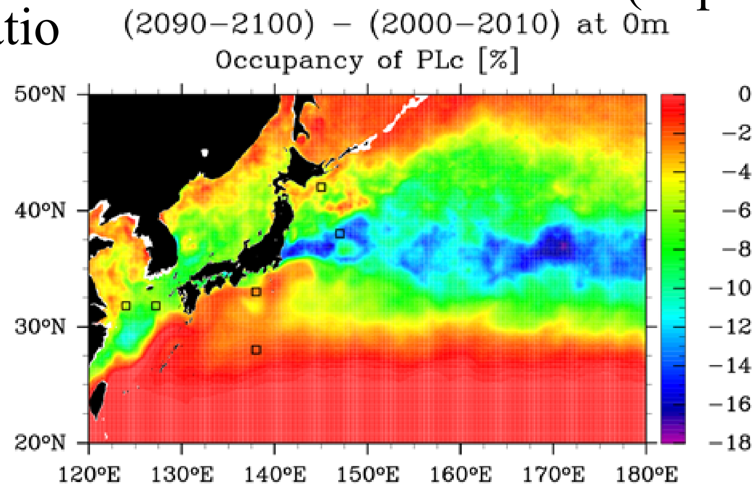
CHOPE-eNEMURO (Global warming exp.)

Komatsu et al. (in prep.)

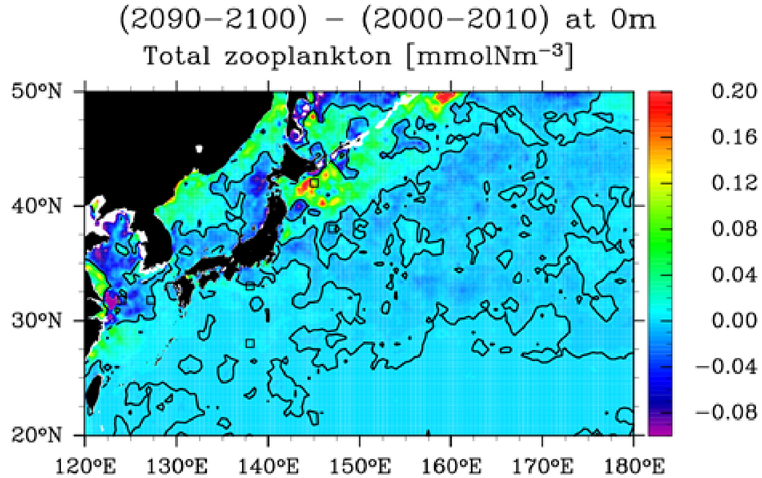
Total phyto.



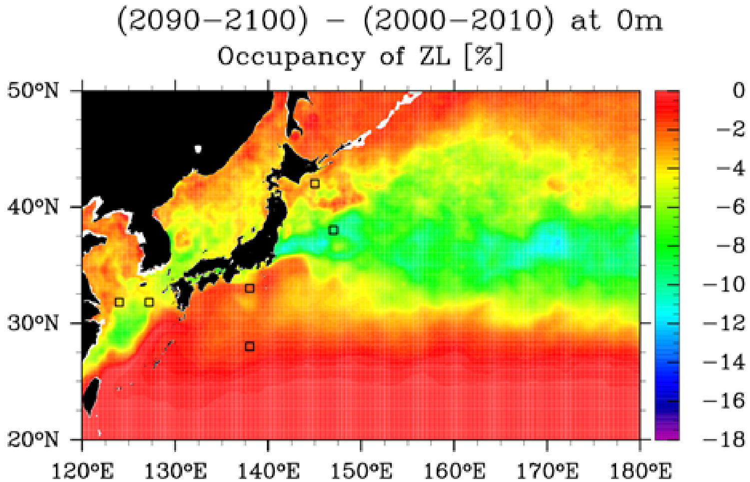
PLc ratio



Total zoo.



ZL ratio



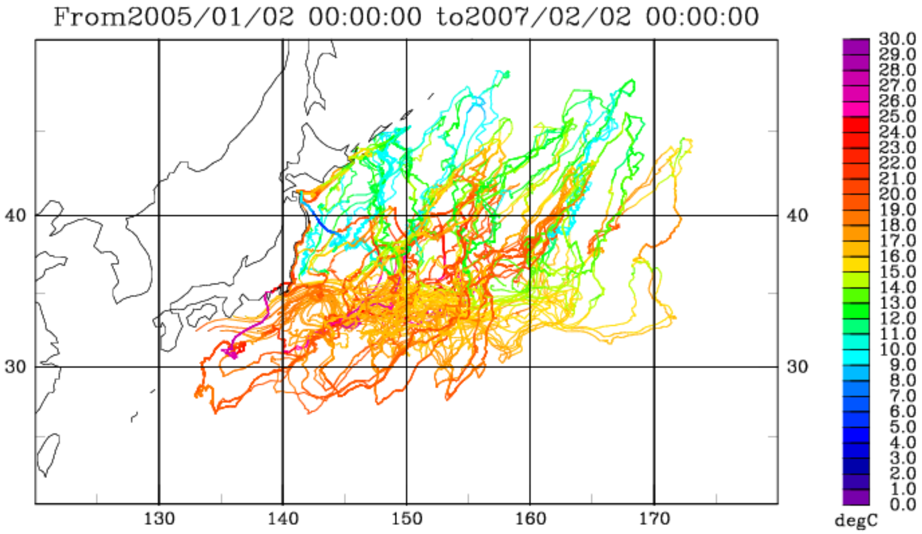
Planktons decreased in almost all area except for a part of Oyashio region.
Large diatom and zooplankton decrease especially in the mixed water region.

CHOPE-eNEMURO.FISH (Global warming exp.)

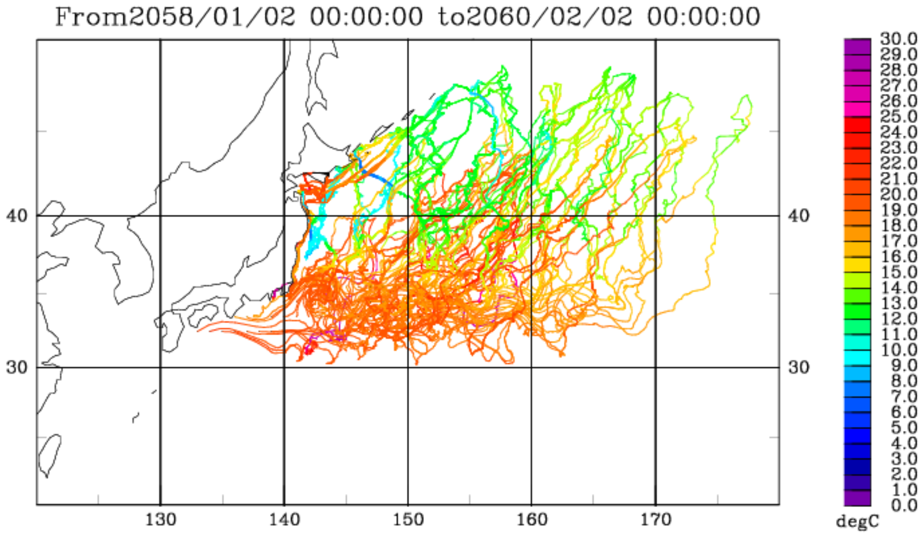
Pacific saury

Ito et al. (in prep.)

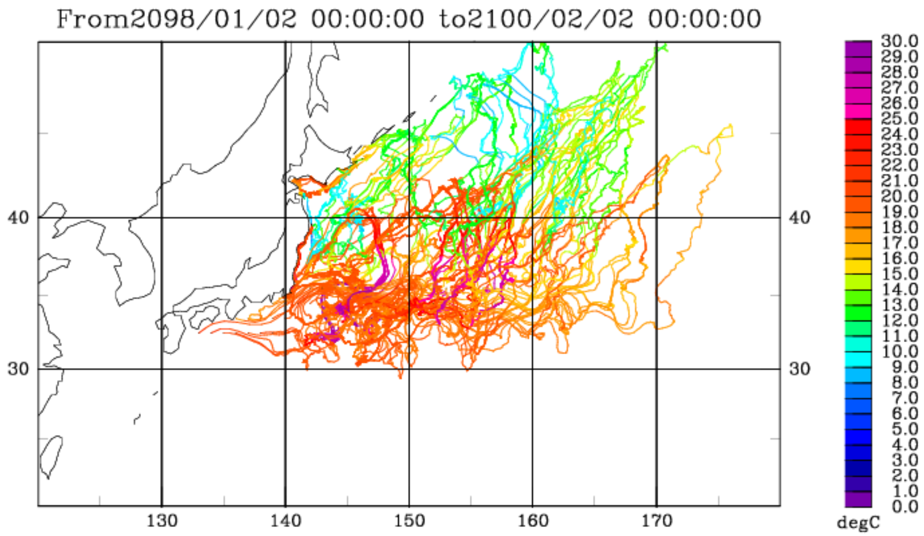
2000-2010



2050-2060



2090-2100



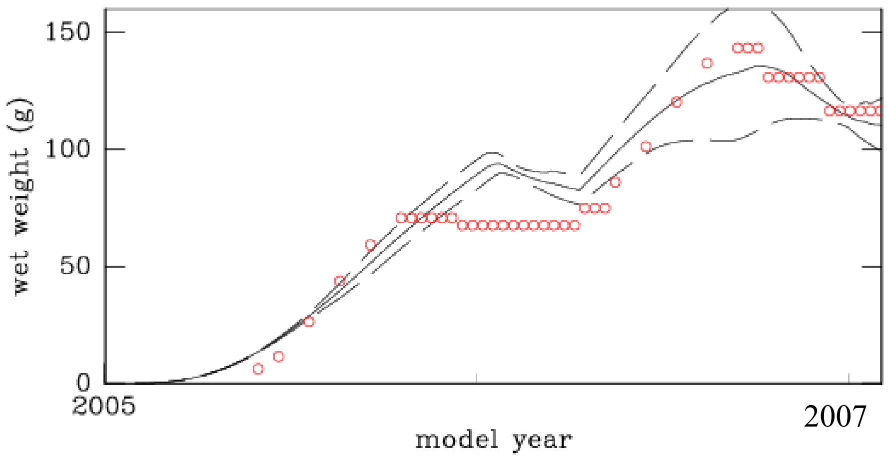
Higher temp.
→limitation of southward migration
→strong eastward transport of
Kuroshio Extention
→offshore migration

CHOPE-eNEMURO.FISH (Global warming exp.)

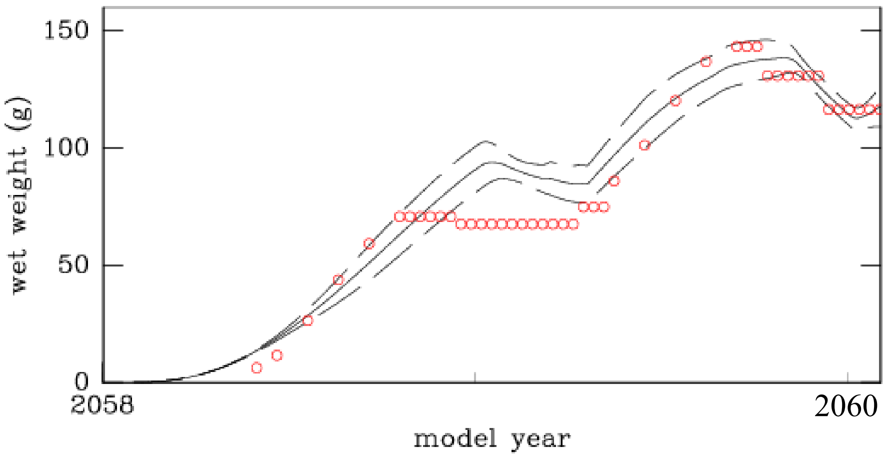
Pacific saury

Ito et al. (in prep.)

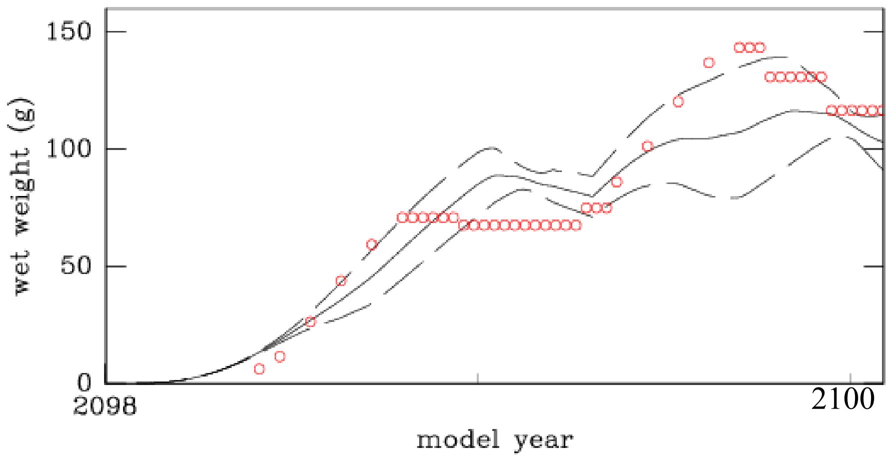
2000-2010



2050-2060



2090-2100

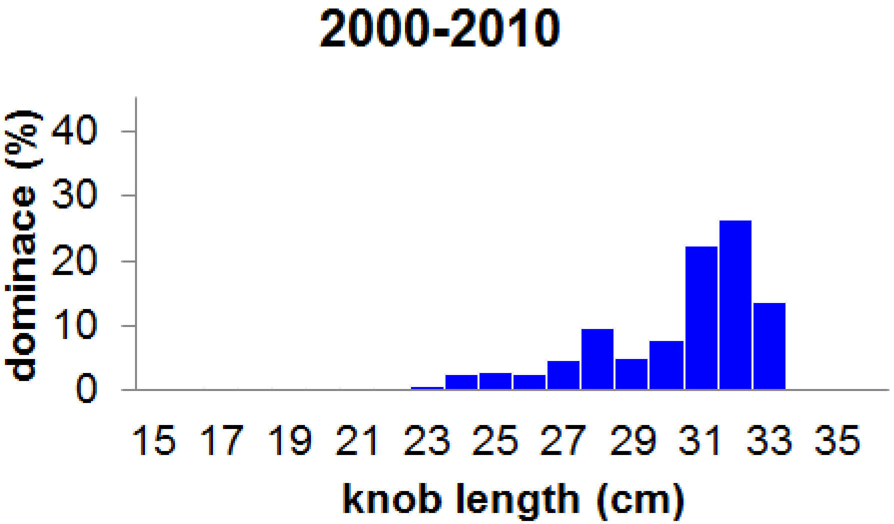


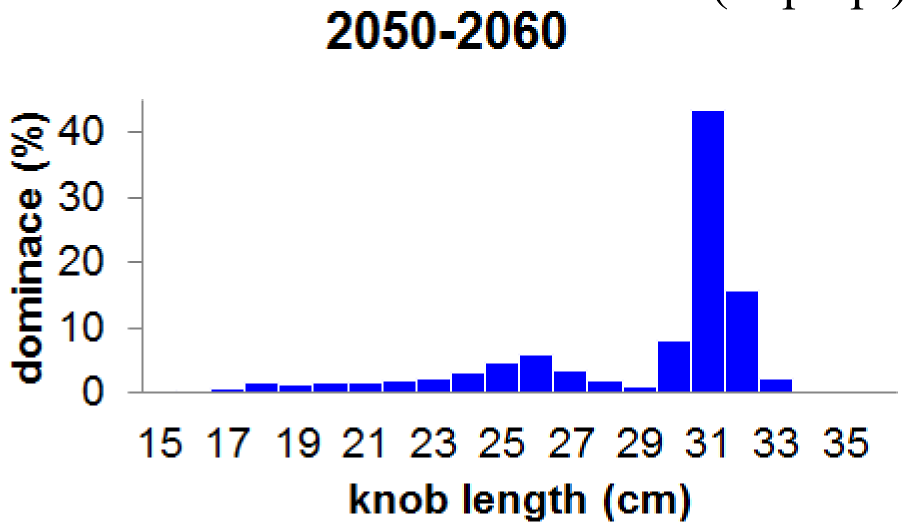
Higher temp.
→limitation of southward migration
→strong eastward transport of
Kuroshio Extention
→offshore migration
→reduction of variation (middle size)

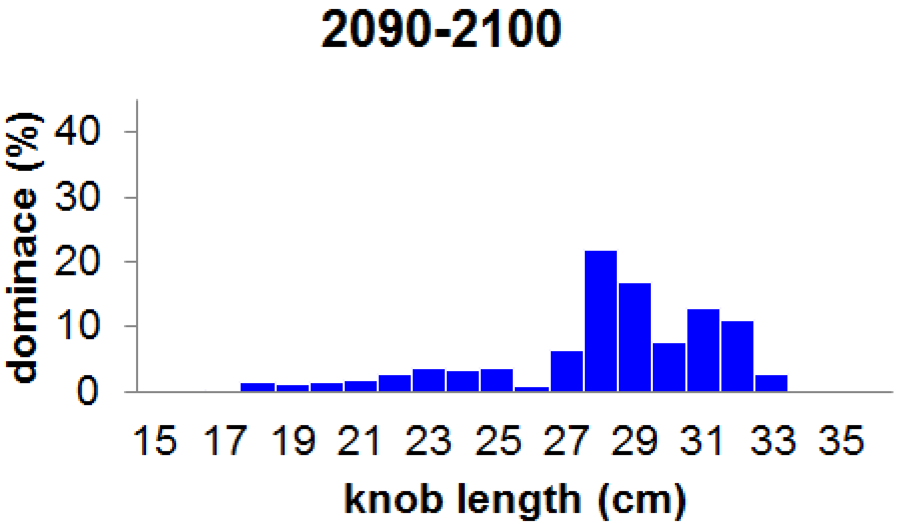
Decrease in prey plankton
→reduction of size (smaller size)

CHOPE-eNEMURO.FISH (Global warming exp.)
Size composition in west of 150E during Jul.-Dec.

Ito et al. (in prep.)







Contemporary:
- mode in 32 & 28 cm

2050-2060:
- mode in 31cm
- high price saury decreased

2090-2100:
- Mode in 31 & 28 cm
- Decrease of larger fish

Concluding remarks

All models and forcing contain errors. No models could provide precise projections.
Continuous efforts are essential to conduct reasonable and feasible projections.

As a step to reduce the unreality, better resolution of zooplankton and 2D-migration was considered.

- **offshore shift of distribution**
- **centralization to the middle size, and then reduction in size**
- **High price fish may be gone.**
- **Delayed fishing season may influence Japanese culinary culture.**

Even if we cannot make precise projections, challenges to make projections tell us decisions we must take at current stage (reduction in uncertainty gives better understanding).

Under FUTURE project we must tackle to it!

references

Ito S., T. Okunishi, M. J. Kishi and M. Wang, 2013, Modelling ecological responses of Pacific saury (*Cololabis saira*) to future climate change and its uncertainty, ICES J. Mar. Sci., 70, 980-990, doi: 10.1093/icesjms/fst089.

Ito S., K. A. Rose, A. J. Miller, K. Drinkwater, K. M. Brander, J. E. Overland, S. Sundby, E. Curchitser, J. W. Hurrell and Y. Yamanaka, 2010, Ocean ecosystem responses to future global change scenarios: A way forward, In: M. Barange, J.G. Field, R.H. Harris, E. Hofmann, R. I. Perry, F. Werner (Eds) Global Change and Marine Ecosystems. Oxford University Press., 287-322, pp440.

Ito S., B. A. Megrey, M. J. Kishi, D. Mukai, Y. Kurita, Y. Ueno and Y. Yamanaka, 2007, On the interannual variability of the growth of Pacific saury (*Cololabis saira*): a simple 3-box model using NEMURO.FISH. *Ecol. Modelling*, 202, 174-183, doi:10.1016/j.ecolmodel. 2006.07.046.

Ito S., M. J. Kishi, Y. Kurita, Y. Oozeki, Y. Yamanaka, B. A. Megrey and F. E. Werner, 2004, Initial design for a fish bioenergetics model of Pacific saury coupled to a lower trophic ecosystem model, Fish. Oceanogr., 13, Suppl. 1, 111-124