Potential impact of climate change on Pacific saury

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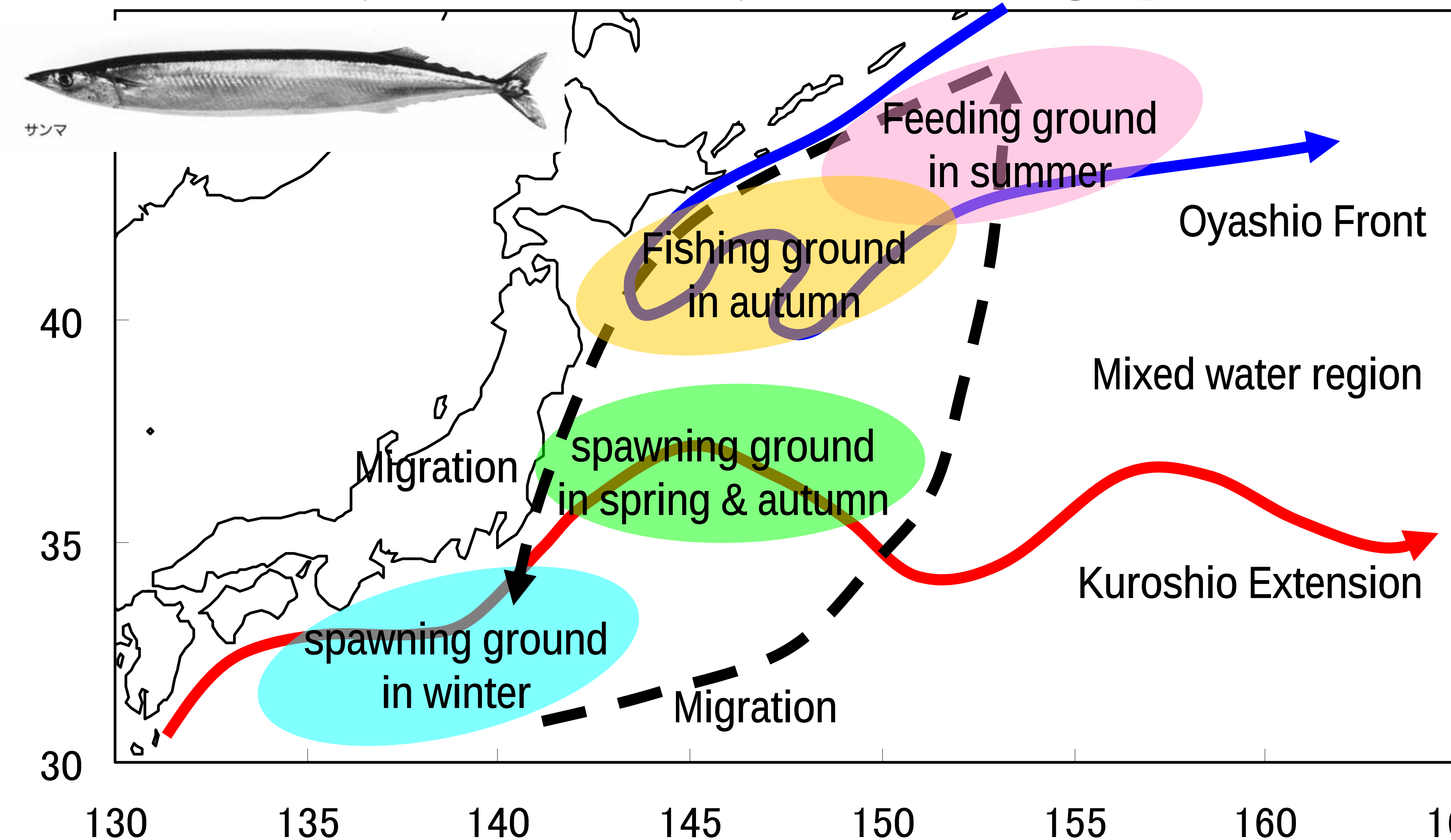
Today's contents

1. Life history of saury and NEMURO.FISH
2. Single projection of Pacific saury
3. Ensemble projection of Pacific saury
4. Future perspectives

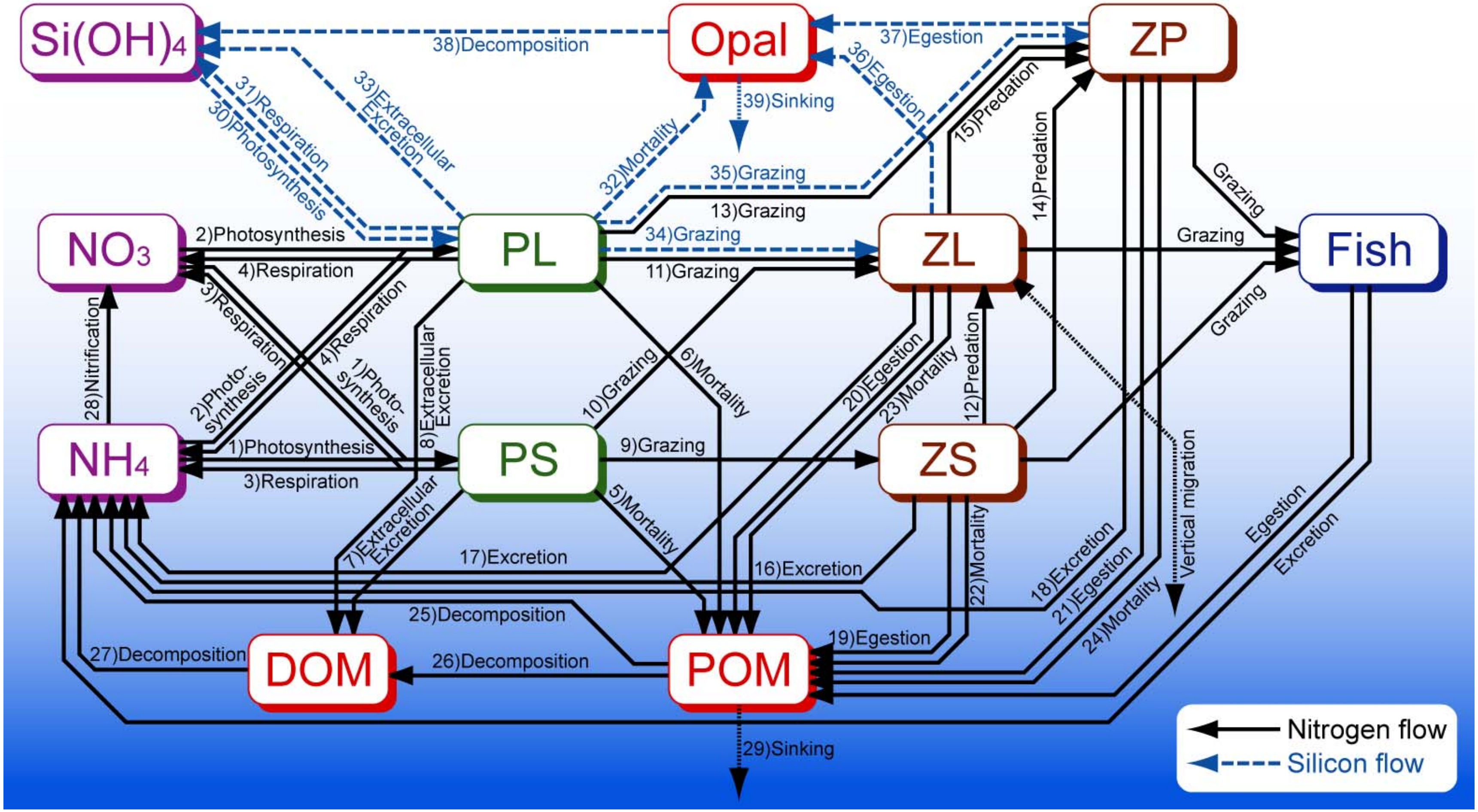
Life History of Pacific Saury with Oceanographic Features



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.

3-box version

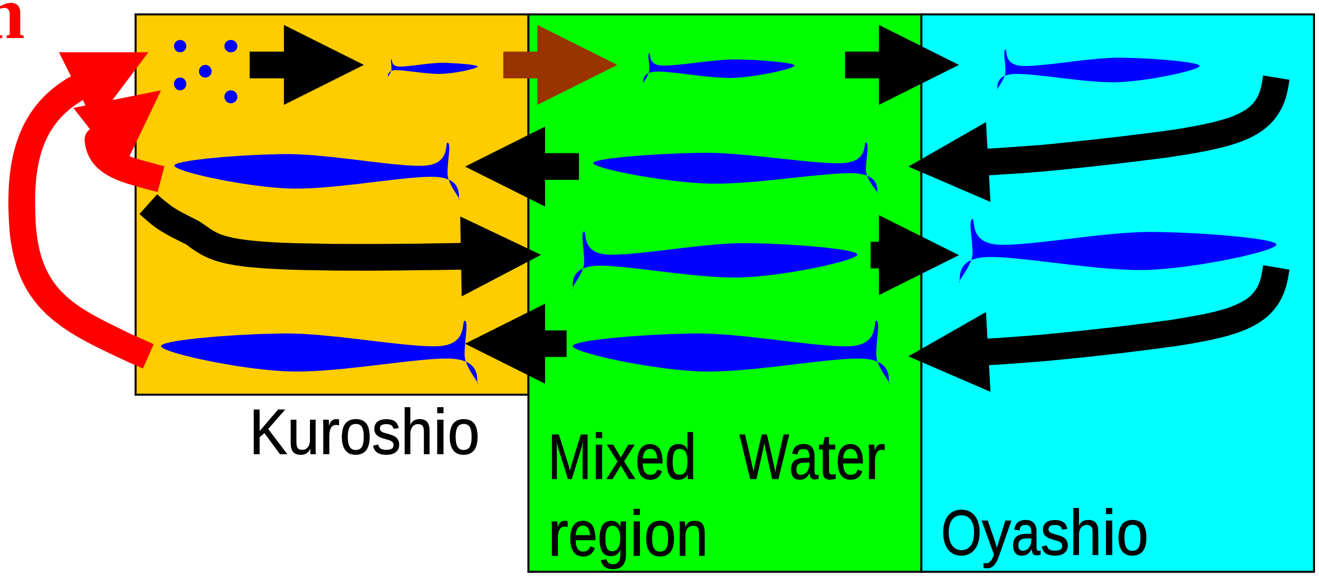


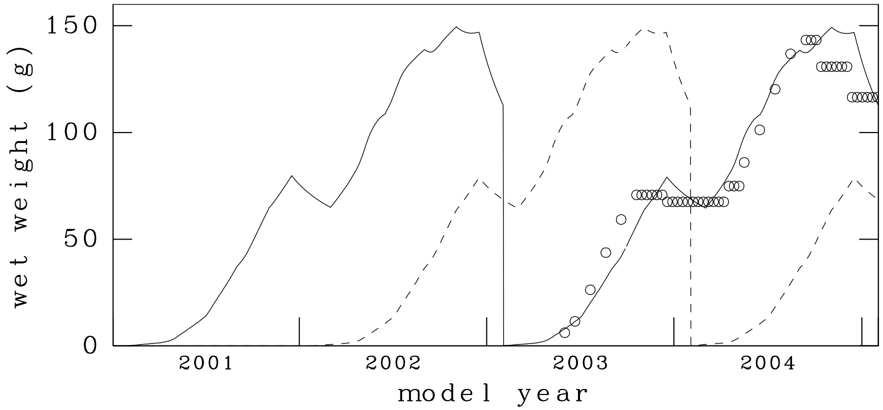
Table 2. Life stages of Pacific saury in the saruy bioenergetics model

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. (2004b, Fish. Oceanogr.)
Ito et al . (2007, Ecol. Model.)
Mukai et al. (2007, Ecol. Model.)

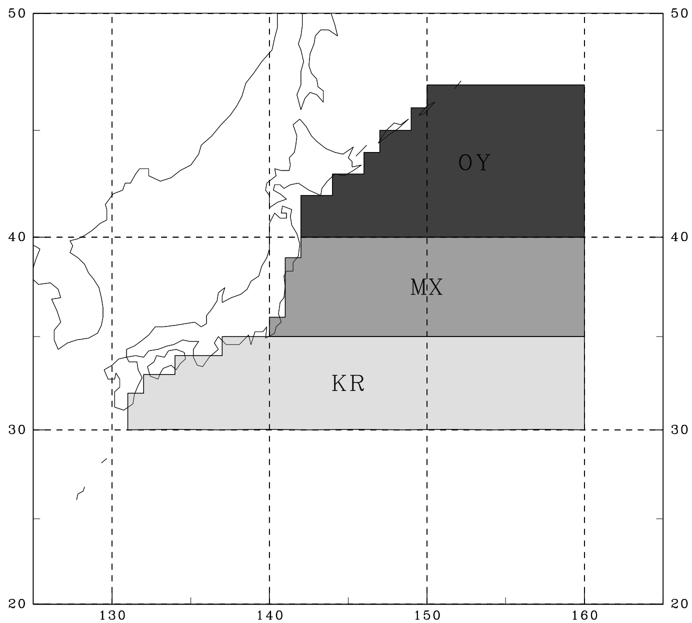
Performance of NEMURO.FISH

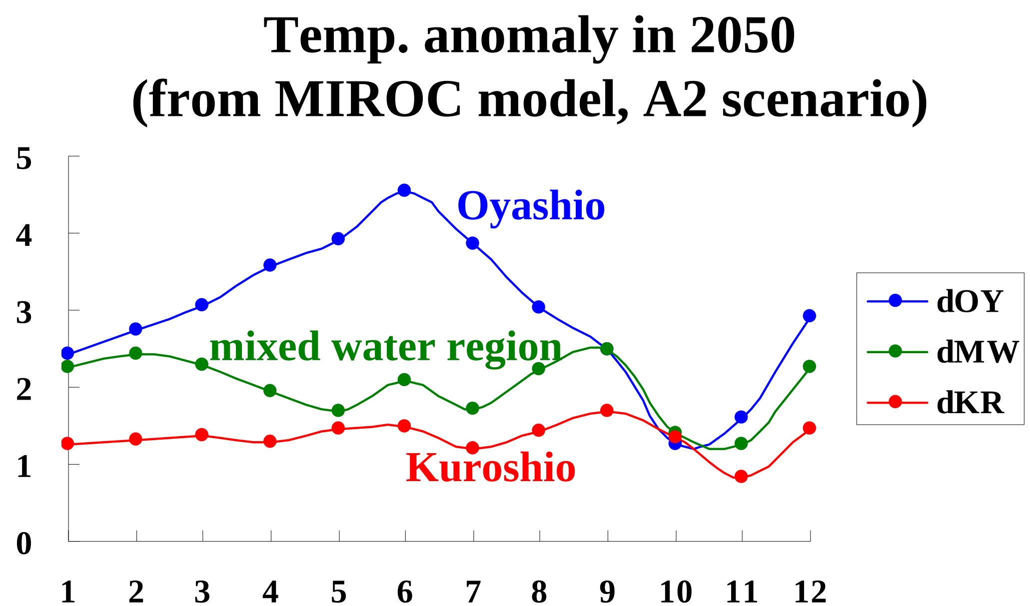


Simulated wet weight (Ito et al. 2004b) & observed growth (Kurita et al.)

1. **NEMURO.FISH successfully, reproduced realistic growth of Pacific saury (Ito et al. 2004, Fish. Oceanogr.).**
2. **NEMURO.FISH reasonably reproduced growth difference between cohorts spawned in different seasons (Mukai et al. 2007, Ecol. Model.).**
3. **NEMURO.FISH reasonably reproduced inter-annual variation of Pacific saury growth except for influences by Japanese sardine (Ito et al. 2007, Ecol. Model).**

Pacific saury: Global warming experiment



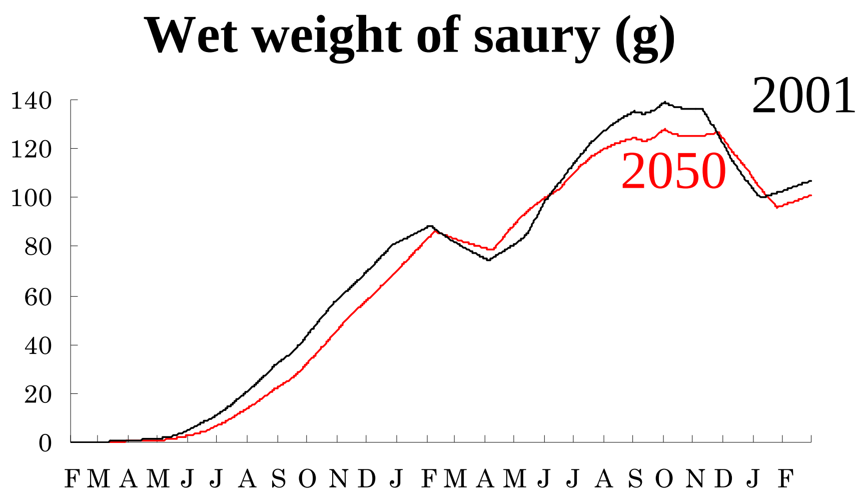


Ito (2007b), Ito et al. 2010)

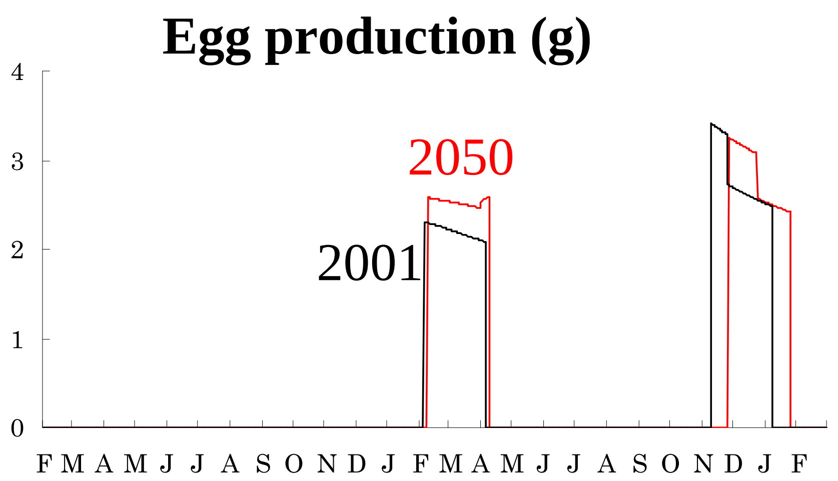
numerical experiment

1. **Averaged SST anomaly in three ocean domains.**
2. **Estimate future SST field by adding SST anomaly with current SST.**
3. **Integrate NEMURO.FISH with future SST.**

Pacific saury: Global warming experiment



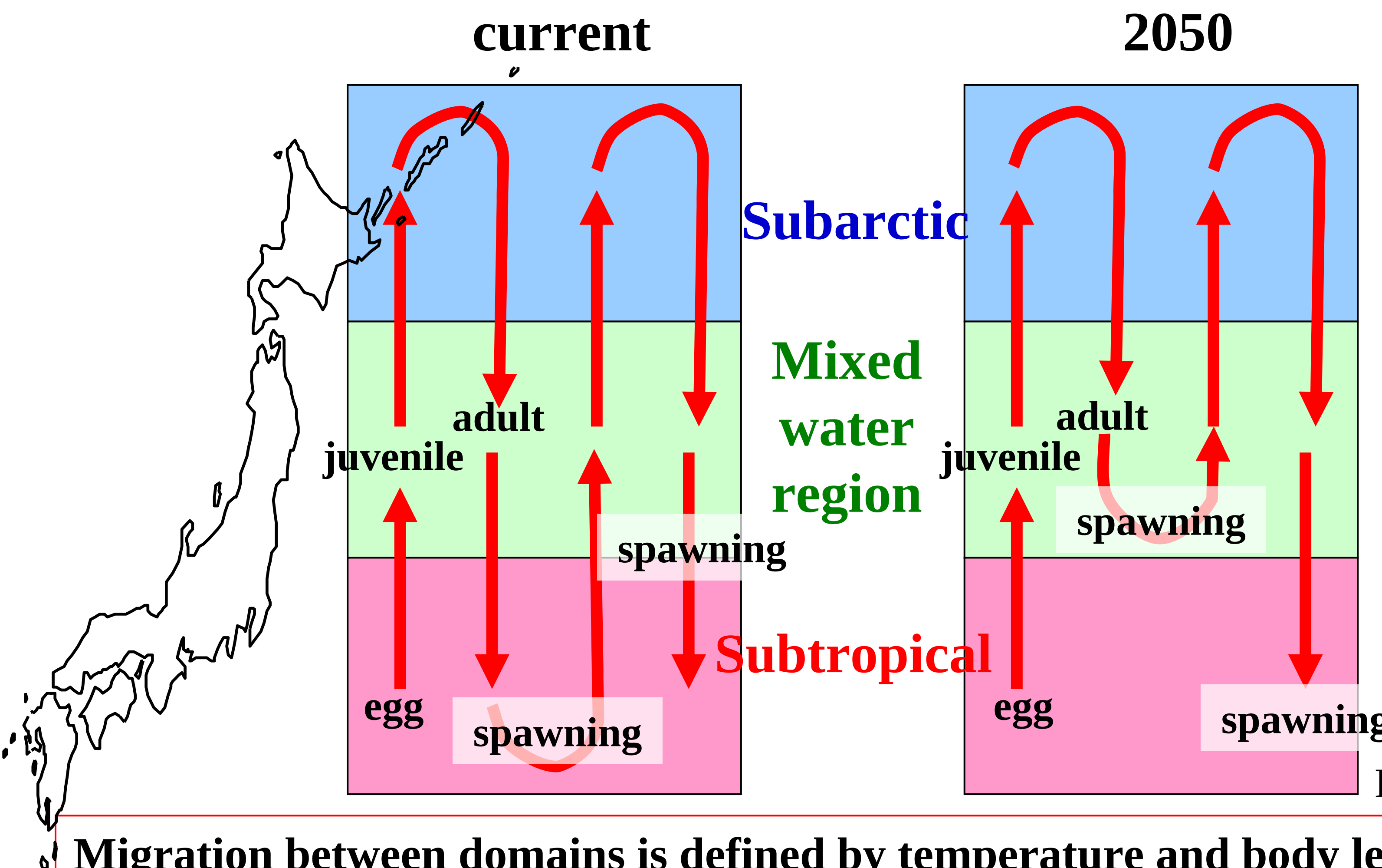
Under global warming, the wet weight of adult saury was reduced about 10 g because of the decrease of prey zooplankton.



However, the egg production was enhanced by global warming.

Ito (2007b), Ito et al. (2010)

Pacific saury (Global warming): simple model application

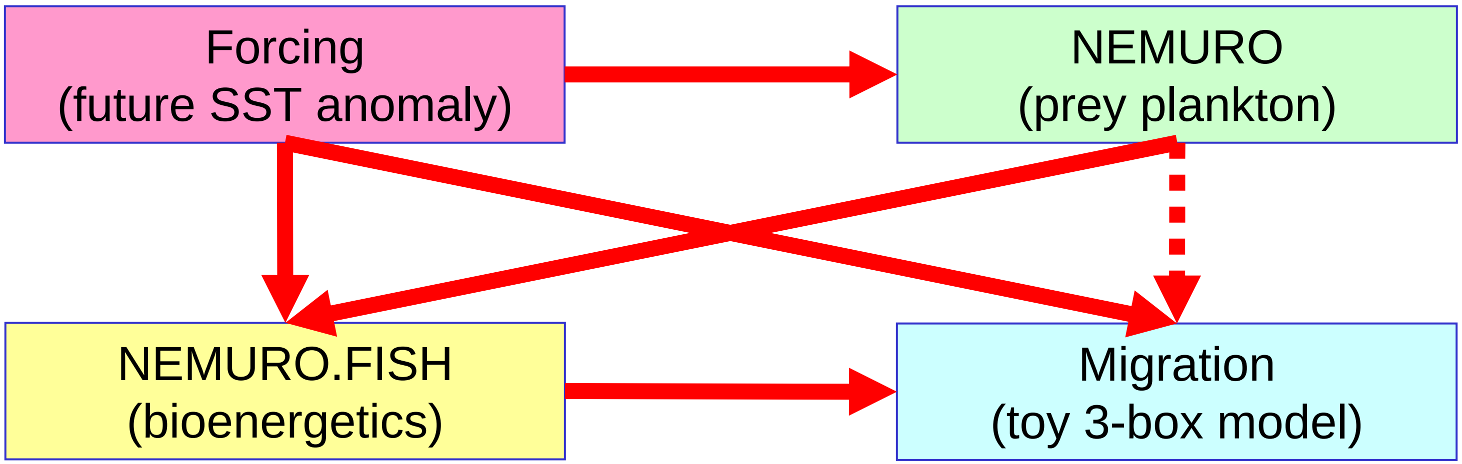


Ito (2007b)

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.

Is the projection reliable?

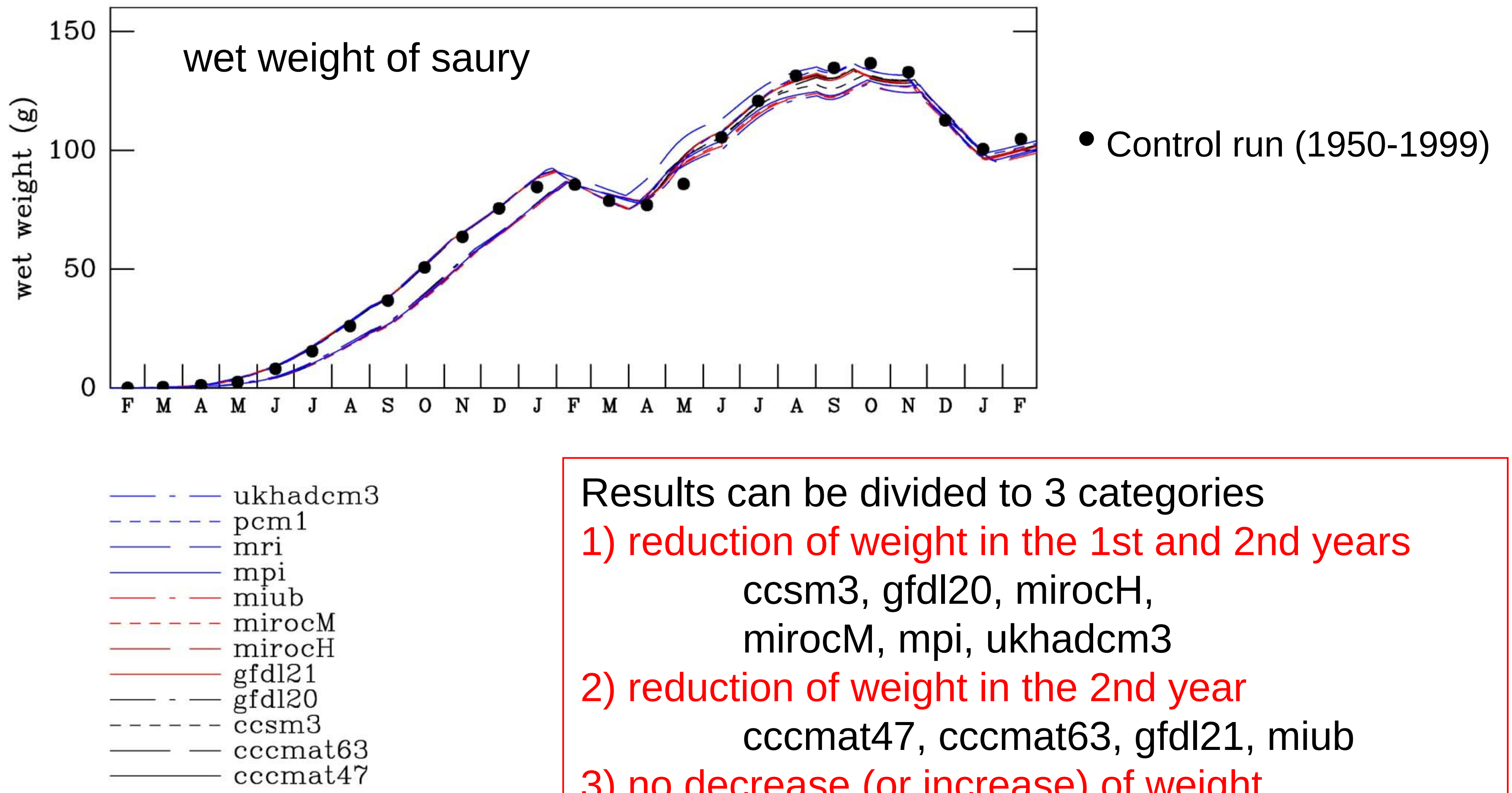


- All components of model have uncertainty.
- IPCC-AR4 showed ensemble prediction of future climate.
- However, Ito et al. (2010) used only one SST prediction.

Overland and Wang (2007) concluded only 12 models of IPCC-AR4 models successfully reproduced PDO (Pacific Decadal Oscillation).

As a first step, we conducted ensemble projection of saury growth using these multi-SST predictions.

Ensemble experiment with 12 IPCC-SSTs (A1B senario)



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

SST increase in 3 regions and response of saury

There is a tendency that higher anomaly of SST cause more decrease of weight. But it is not in order. The response is not simple.
Timing, threshold, and combination with prey availability are important.

		KR	MW	OY	average
decrease in 1st and 2nd years	ccm3	1.36	1.73	2.80	1.97
	gfdl20	1.41	1.86	1.41	1.56
	mirocH	2.28	2.73	2.70	2.57
	mirocM	1.71	2.24	3.16	2.37
	mpi	1.78	2.07	3.22	2.35
	ukhadcm3	1.93	3.30	2.78	2.67
decrease in 2nd year	cccmat47	1.46	1.48	1.77	1.57
	cccmat63	1.63	1.55	1.75	1.65
	gfdl21	1.46	1.53	1.85	1.61
	miub	1.14	1.41	1.58	1.38
no decrease	pcm1	1.10	1.17	1.03	1.10
	mri	1.32	1.59	2.04	1.65

Ensemble experiment with 12 IPCC-SSTs (A1B senario)

The ensemble experiments showed uncertainty of the model result which is caused by forcing.

But the biological model also has uncertainty.
Especially, accuracy of zooplankton responses has large uncertainty.

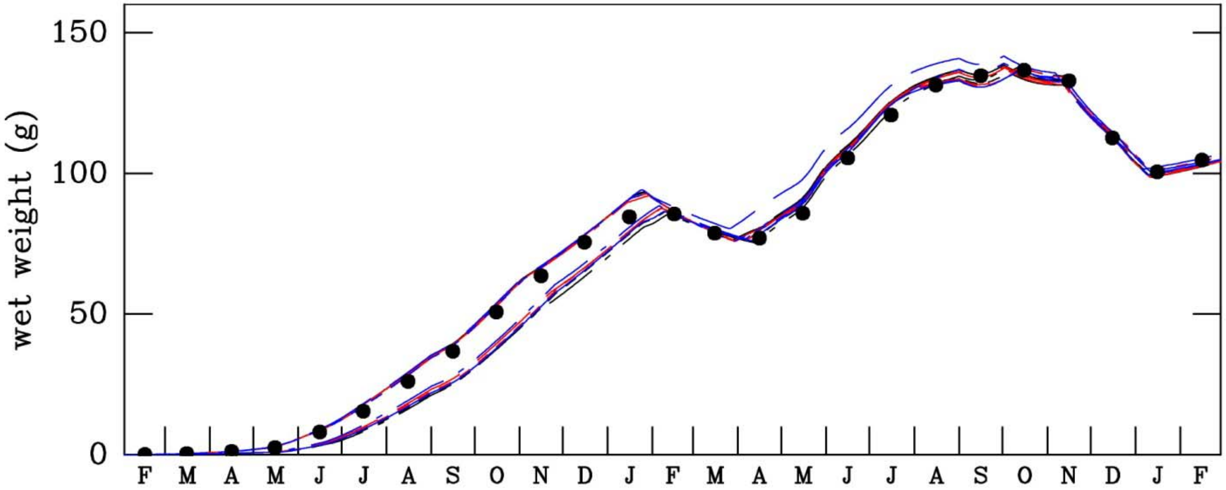
This is because bottom-up focusing scientists start from phytoplankton and top-down focusing scientists start from fish. Therefore, zooplankton resolution or accuracy often becomes an weakness.

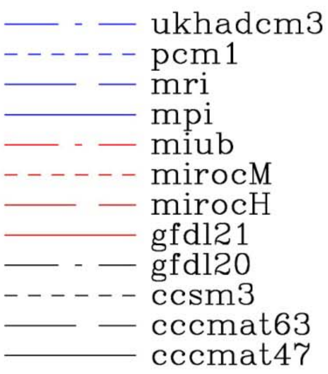
However, the most benefit of this simple model is that it is possible to separate the direct effects of SST and its effect through prey production.

We conducted an ensemble experiment in which only SST is changed but the prey density is kept as the same as the control run (1950-1999).

Ensemble experiment (direct effect of SST)

only change the SST but keep the prey density as same as the control run.





● Control run (1950-1999)

There is no projection showed decrease in 2nd year.

Results can be divided to 2 categories

reduction of weight in the 1st year

ccsm3, gfdl20, mirocH,
mirocM, mpi, ukhadcm3

no decrease or increase of weight

cccmat47, cccmat63, gfdl21,
miub, pcm1, mri

Conclusion and Future Perspectives

Model results suggested the possibilities of

- **size reduction, and**
- **number increase**

of Pacific saury under global warming conditions.
However, model and forcing contain uncertainty.

A merit of model investigation is that it enables to separate causes. Model 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, now we are trying to

- **fill the parameter gap in biological model**
- **projection with sequential future climate forcing (not steady forcing)**