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

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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
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

- Spawning ground in winter
- Spawning ground in spring & autumn
- Feeding ground in summer
- Fishing ground in autumn
- Mixed water region
- Kuroshio Extension
- Oyashio Front

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 scenario)

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 was enhanced in several cases but not in other cases.

Ito et al. (2013, ICES-JMS)
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.

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<th>To reduce the uncertainty, it is important to</th>
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<td>• fill the parameter gaps in biological model</td>
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<td>• conduct projections with more realistic conditions</td>
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<td>(better zooplankton models, including 2D-migration, sequential future climate forcing, etc.)</td>
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eNEMURO
extended North Pacific Ecosystem Model for Understanding Regional Oceanography

Couple to C-HOPE (1/16 degree horizontal resolution model).
Forced by MIROC-high output with A1B scenario.
SST increased more than 2.5°C in the mixed water region.
Decrease in salinity, spin up of Kuroshio, 
Decrease in MLD and nutrient concentration in the mixed water region and subarctic area.
Planktons decreased in almost all area except for a part of Oyashio region.
Large diatom and zooplankton decrease especially in the mixed water region.
Higher temp.
→ limitation of southward migration
→ strong eastward transport of Kuroshio Extention
→ offshore migration
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 31 cm
- 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!

