Updated plan for modeling effects of climate change on fish and fisheries in the western North Pacific Ocean

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AORI FRA Fisheries Research Agency NEMURO MAFIA EHIME JAFIC

MAFF

Today's contents

1. overview of MAFF project
2. recent progress
3. updated plan

MAFF Project

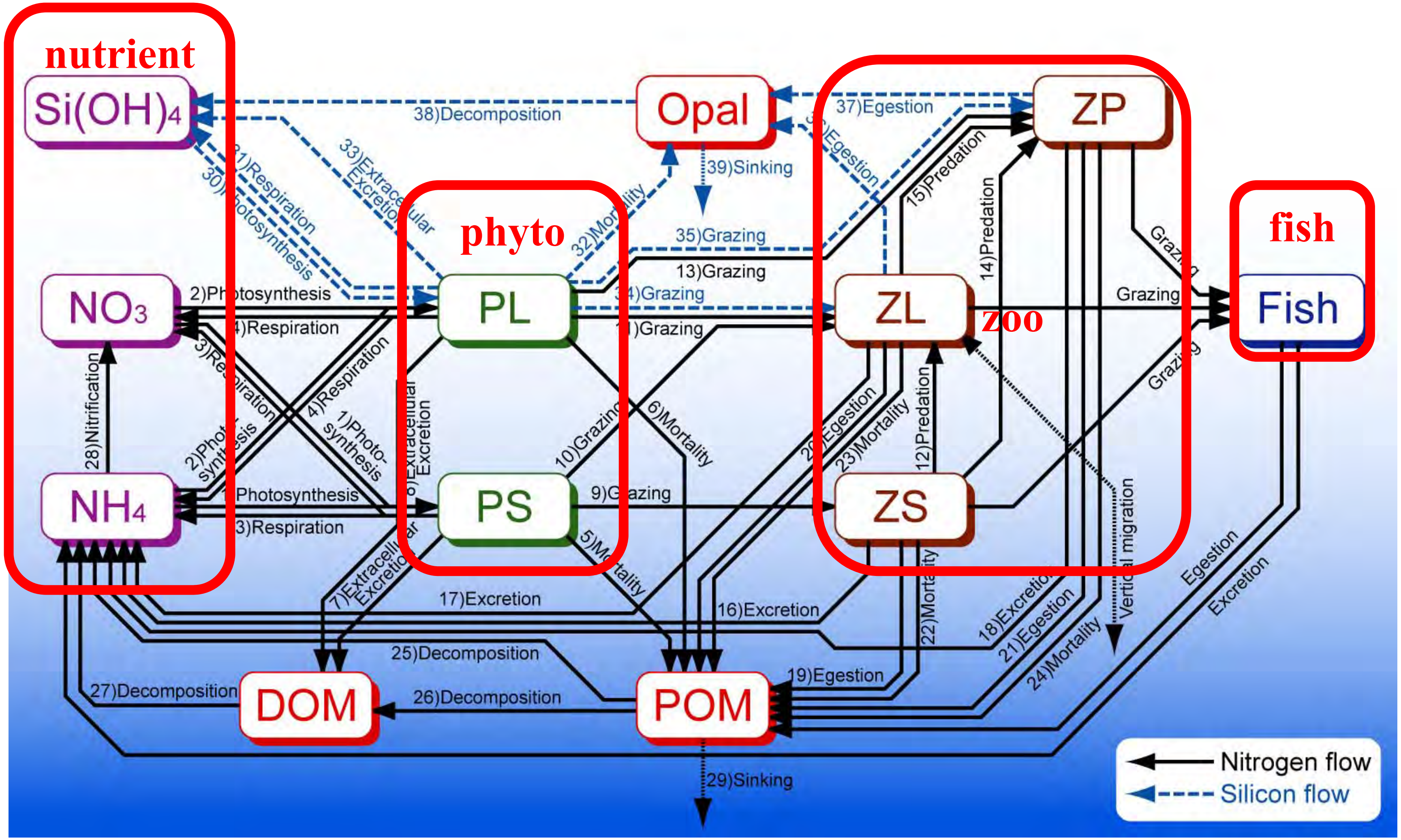
MAFF: Ministry of Agriculture, Forestry and Fisheries, Japan

2002-2005	Assessment and mitigation techniques of global warming effects on the sector of agriculture, forestry and fisheries
2006-2009	Development of technology for impacts, mitigation and adaptation of climate change
2010-2012	Development of mitigation and adaptation technologies to climate change in the sectors of agriculture, forestry and fisheries @Development of mitigation technologies to climate change in fisheries sector
2013-2017	Development of mitigation and adaptation technologies to climate change in the sectors of agriculture, forestry and fisheries II @Evaluation of climate change impacts on fisheries and aquaculture

Including monitoring program (A-line, O-line, CK-line) and long run project.
However, the budget have been decreased.
The evaluation program will finish in 2017.........

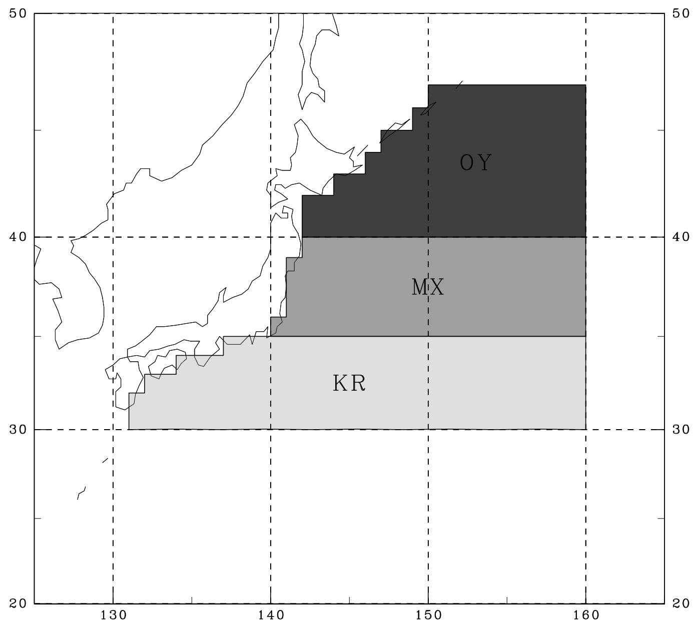
Fish growth model coupled to NPZD ecosystem model

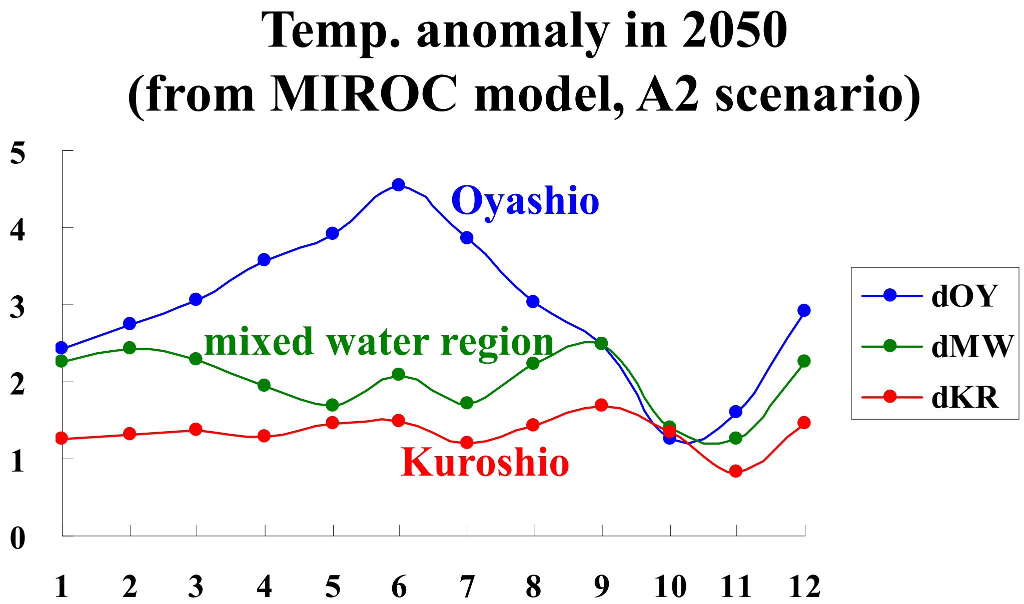
NEMURO.FISH



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

Pacific saury: Global warming experiment



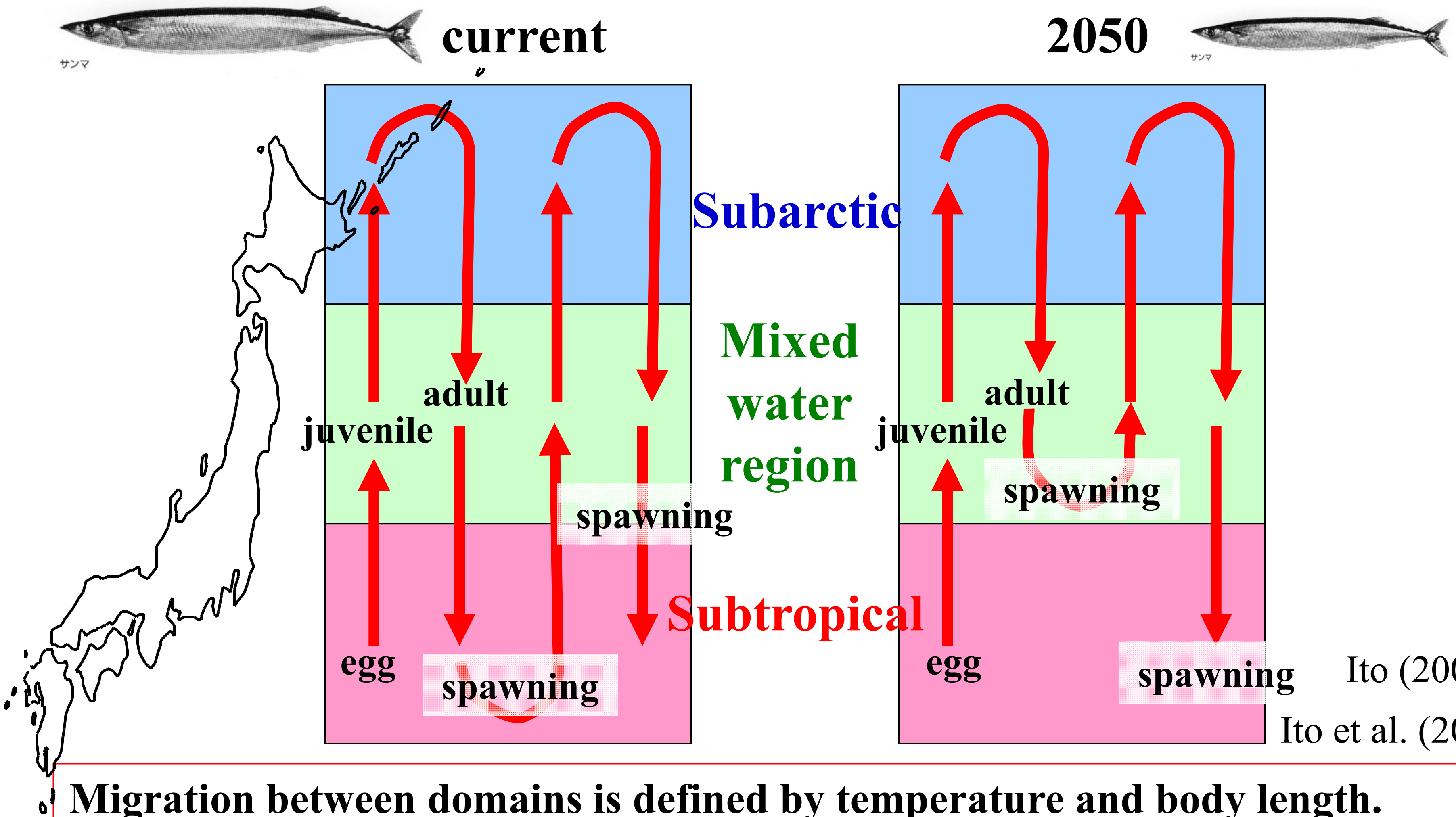


Ito et al. (2010, Oxford Press)

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): simple model application

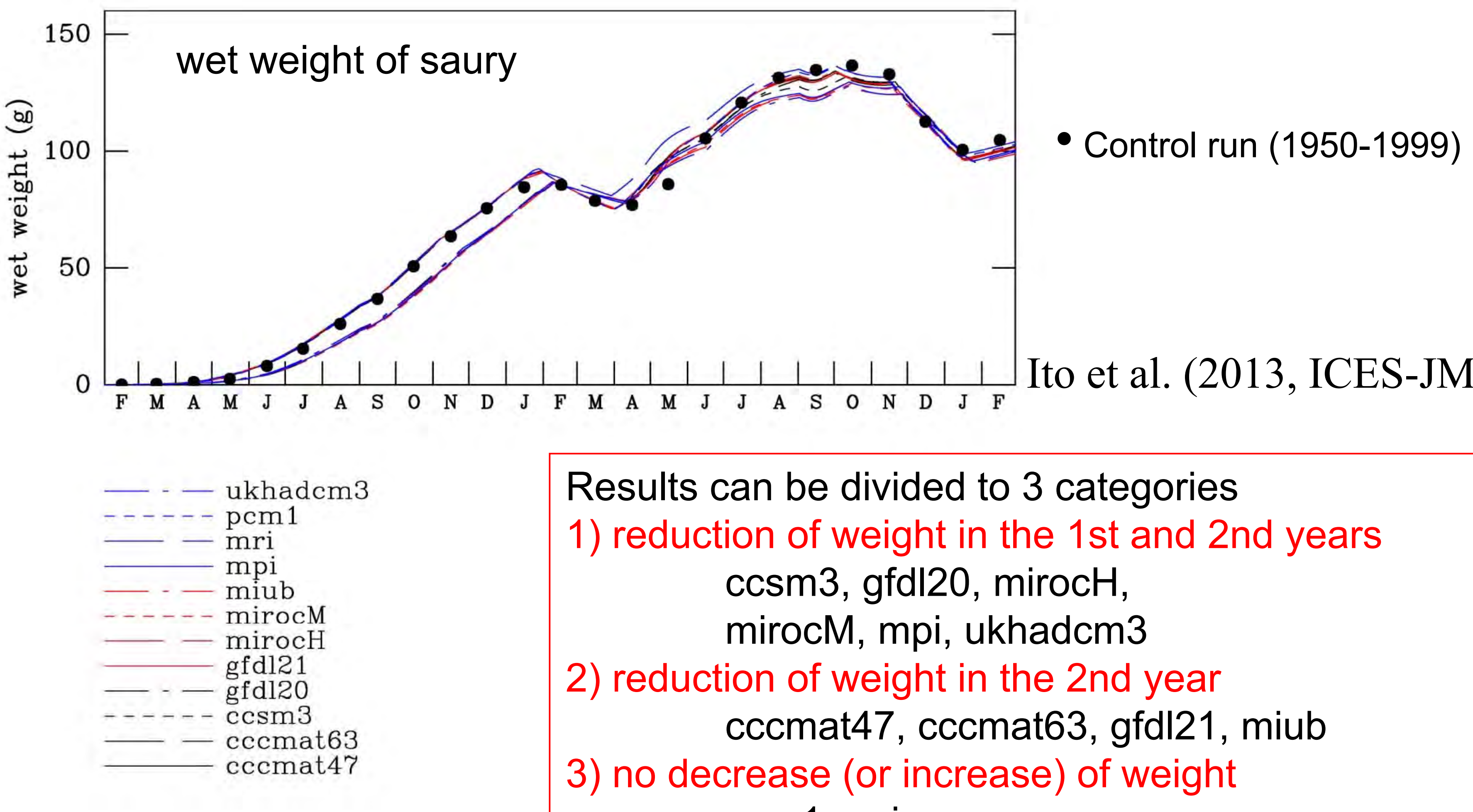


Ito (2007b)

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.

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

Dependency on emission scenarios

24 (73%) of 33 runs showed decrease of saury weight.
The result seems robust.
However only 11 (33%) showed increase in egg production.

	A2	A1B	B1
ukhadcm3	1st&2nd year decrease	1st&2nd year decrease	1st&2nd year decrease
mirocH		1st&2nd year decrease	1st&2nd year decrease
mirocM	1st&2nd year decrease	1st&2nd year decrease	2nd year decrease
cccm3	2nd year decrease	1st&2nd year decrease	2nd year decrease
mpi	2nd year decrease	1st&2nd year decrease	no decrease
gfdl20	no decrease	1st&2nd year decrease	
miub	1st&2nd year decrease	2nd year decrease	2nd year decrease
cccmat63		2nd year decrease	no decrease
ccmat47	2nd year decrease	2nd year decrease	no decrease
gfdl21	no decrease	2nd year decrease	2nd year decrease
mri	2nd year decrease	no decrease	2nd year decrease
pcm1	no decrease	no decrease	no decrease

Ito et al. (2013, ICES-JMS)

future response of Japanese sardine

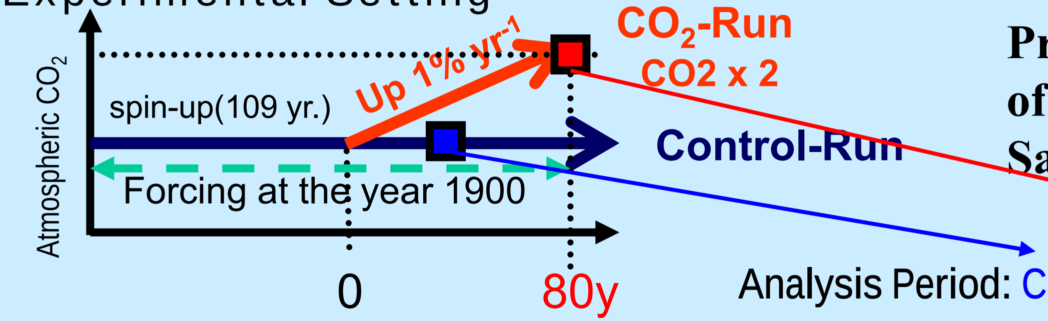
Climate model

Okunishi et al. (2012), Climatic Change

MIROC 3.2 (The CCSR/NIES/FRCGC Coupled Ocean-Atmosphere GCM)

Horizontal Resolution (Ocean Part): 1/4 x 1/6 degree

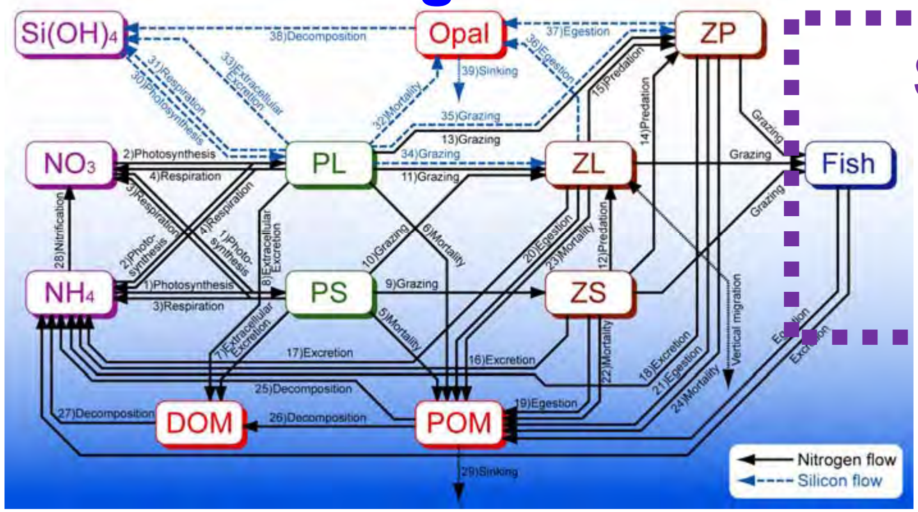
Experimental Setting



Predicted Physical Fields for off-line Eco. Model from Sakamoto et al., (2005) GRL.

Analysis Period: Control-Run (46-55y), CO_2-Run (76-85y)

NPZD + fish growth model



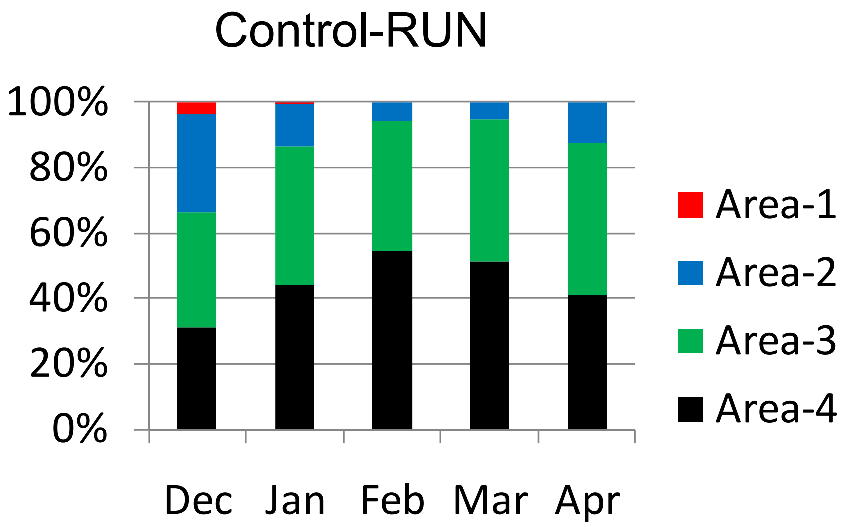
Sardine Migration Model

Okunishi et al. (2009)

We will focus on spawning ground and pre-mature adult distribution.

Spawning grounds

Okunishi et al. (2012), Climatic Change



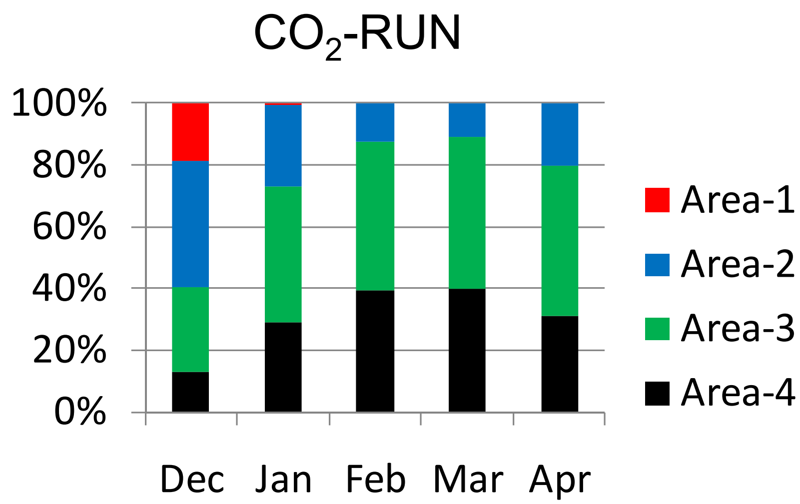
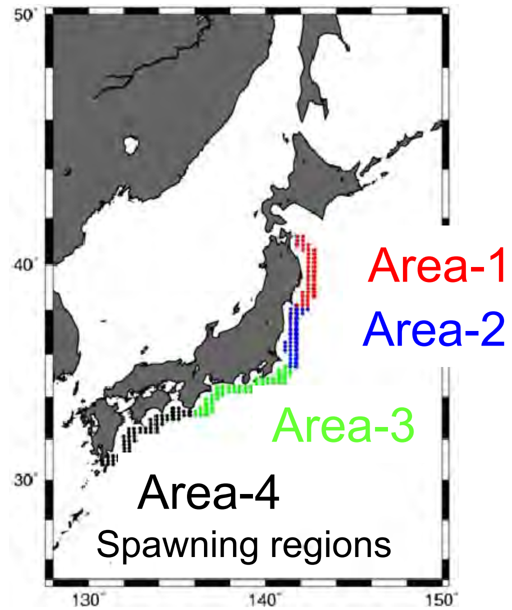


Fig. Proportion of hatched numbers in the four spawning regions



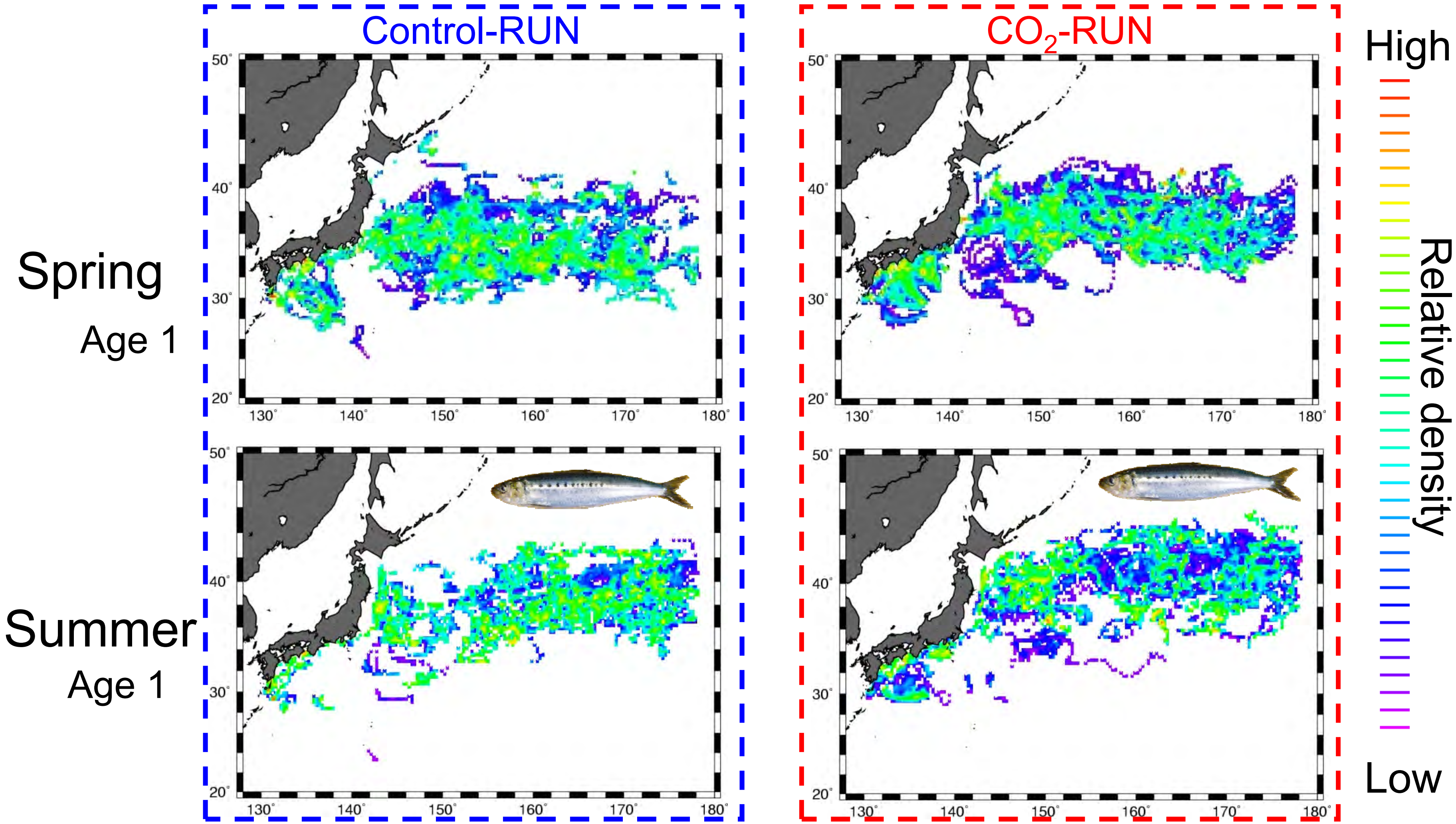
Spawning condition: SST 15- 21°C
Dec – Apr

Projection

Spawning grounds shifted to north-eastward.

Change in geographical distribution

Okunishi et al. (2012), Climatic Change

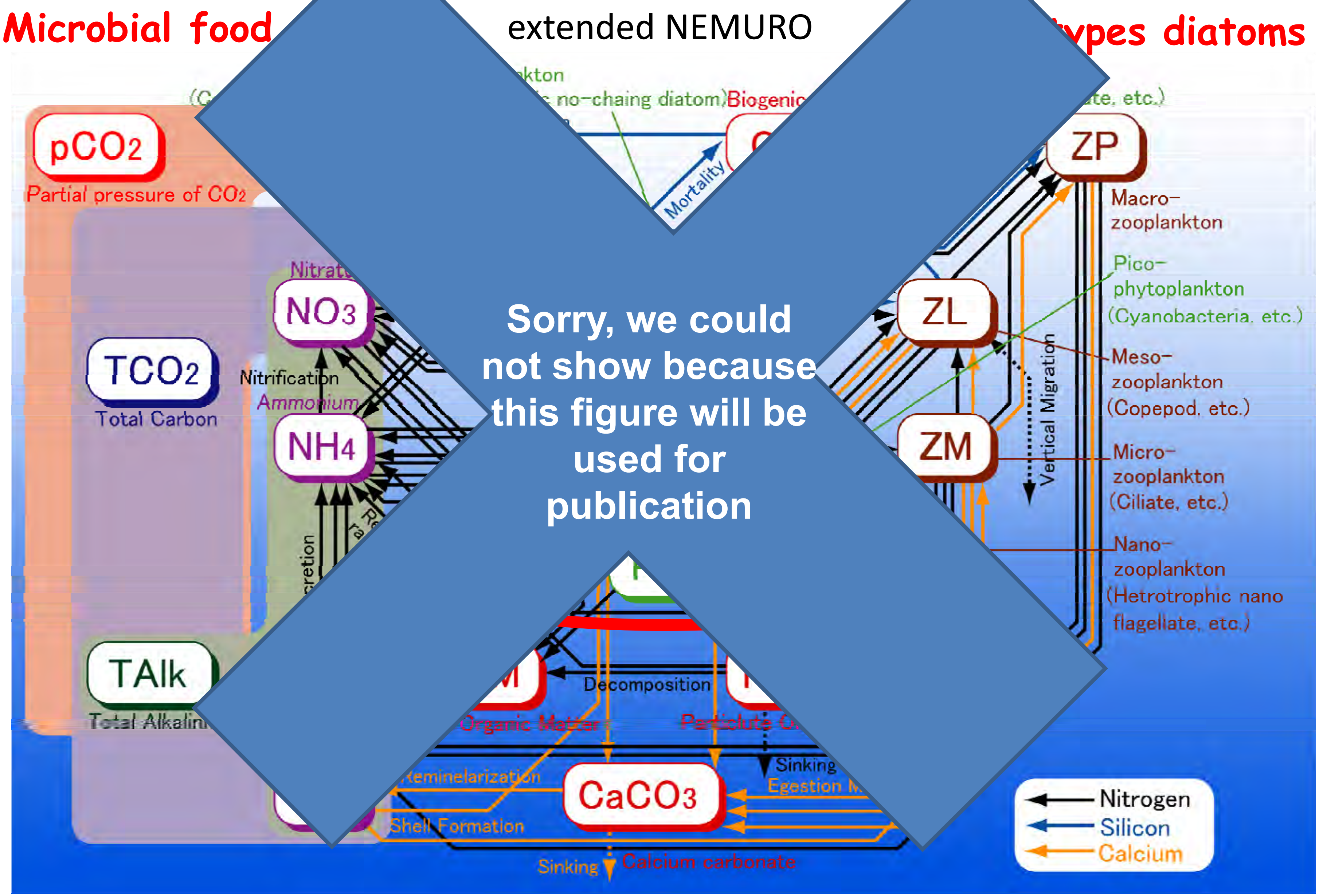


Projection: The distribution shifted northward. The size of sardine did not change since they compensate food by northern migration.

Recent progress

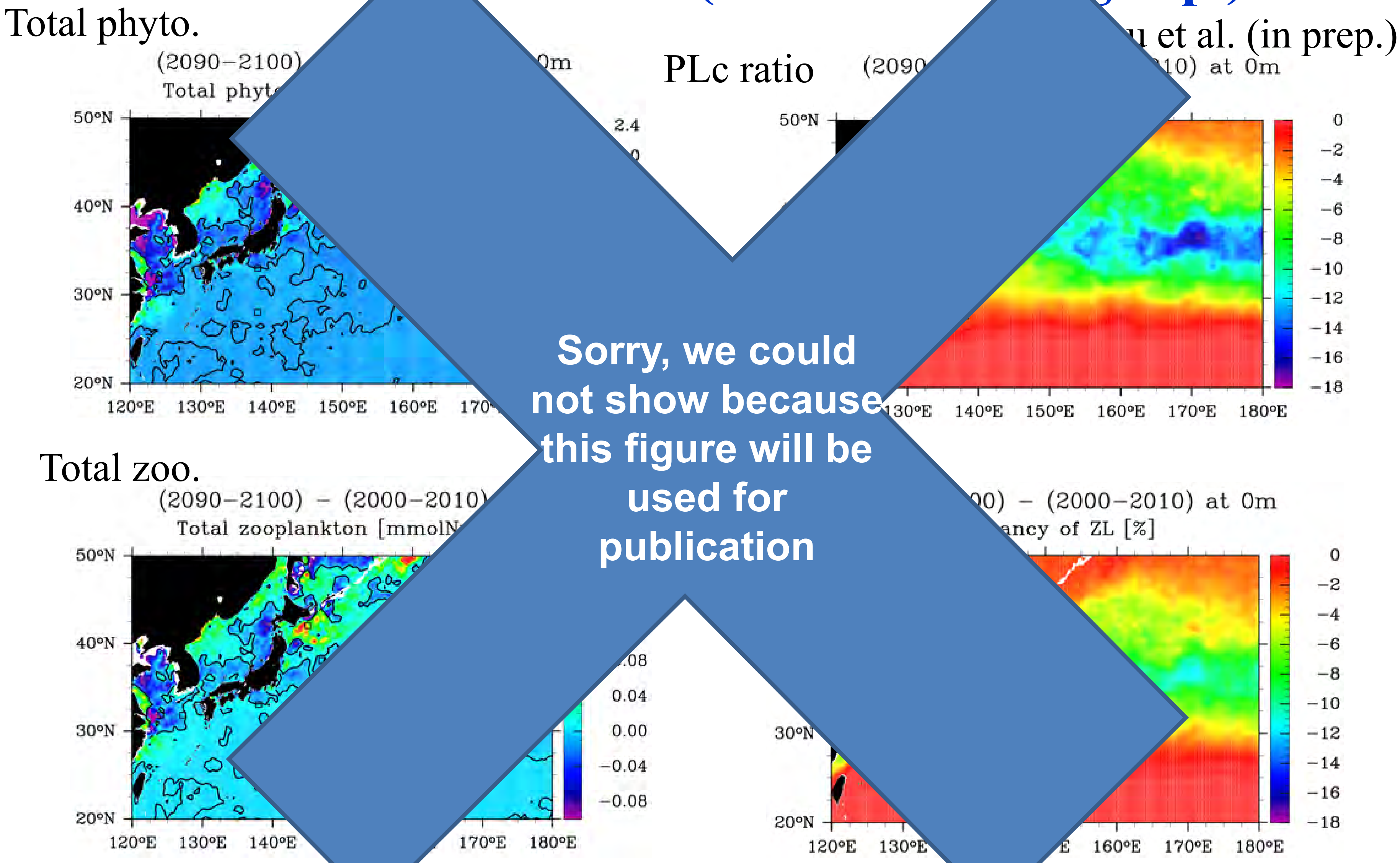
eNEMURO

extended NEMURO



Courtesy of Naoki Yoshie

CHOPE-NEMURO (Global warming exp.)

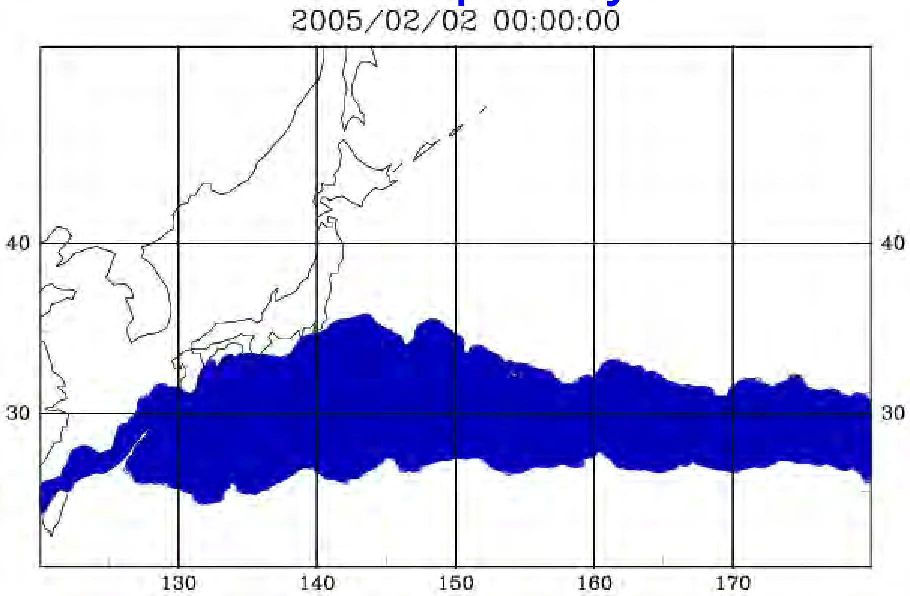


Planktons decreased in almost all area except for a part of Oyashio region.
Large diatom and zooplankton decrease especially in the mixed water region.

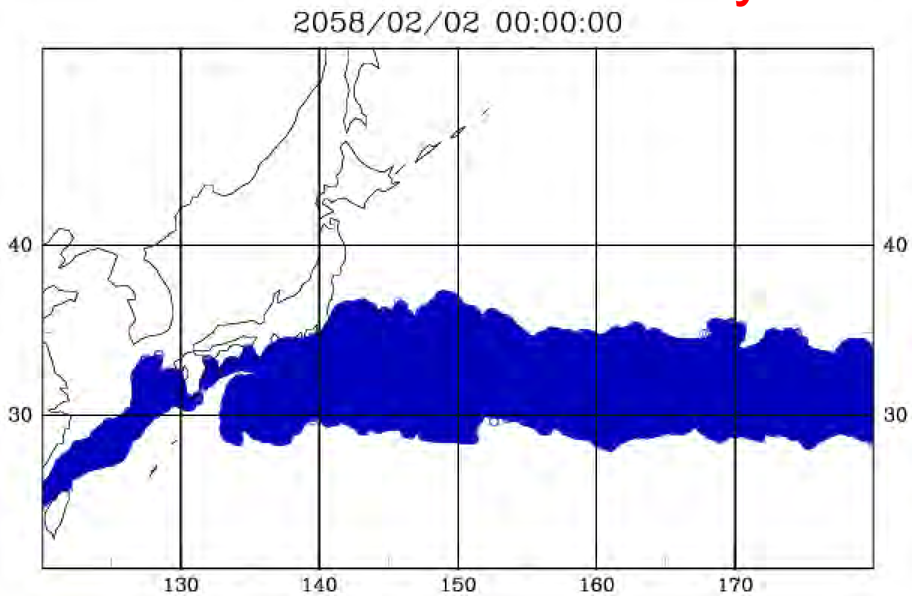
Projection of spawning ground of saury

Based on Takasuka et al. (2014) and Iwahashi et al (2006), spawning ground was set to the region which sea surface temp. is between 17.8 and 21.6 degC.

contemporary



middle of 21st century



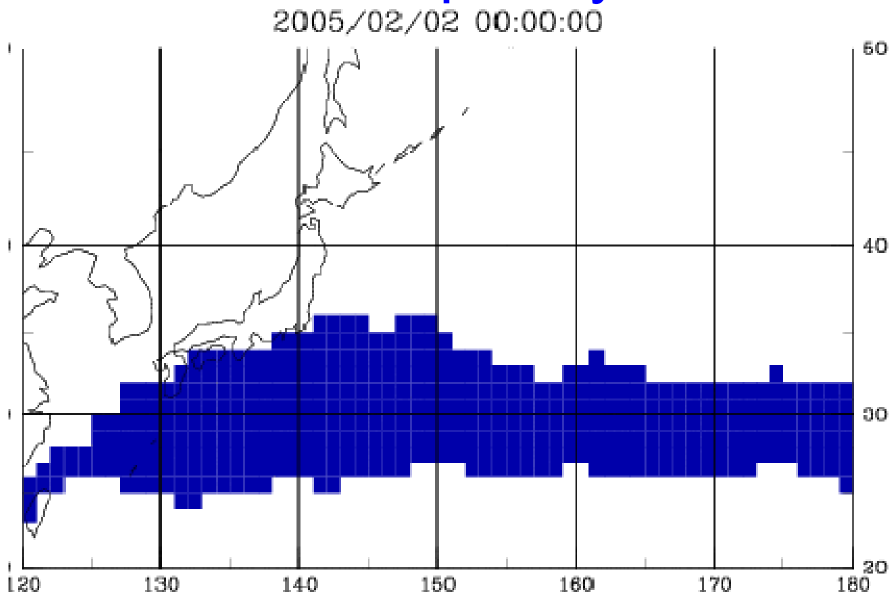
Projection

The spawning ground was shifted northward about 2 degree in latitude.

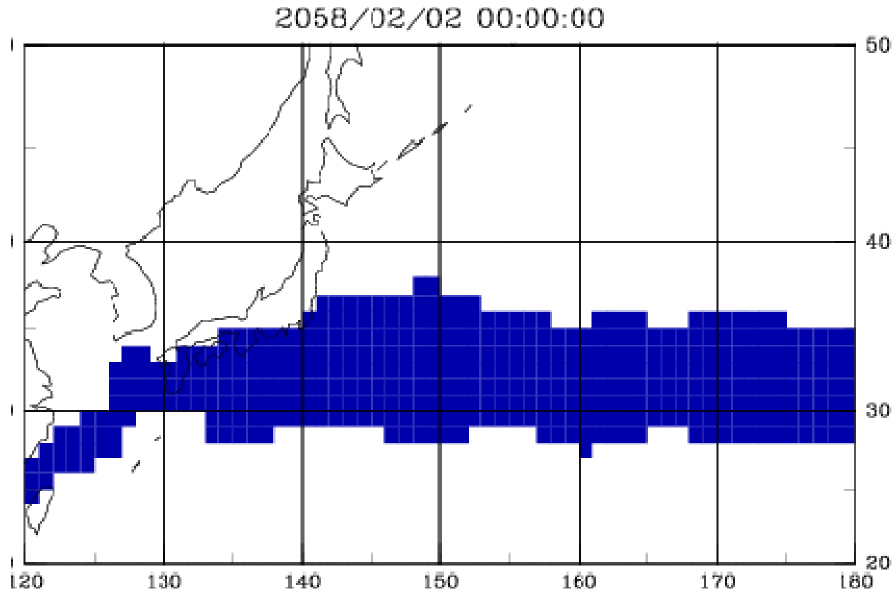
Projection of migration of Pacific saury

example for saury spawned on Feb. 2nd

contemporary



middle of 21st century



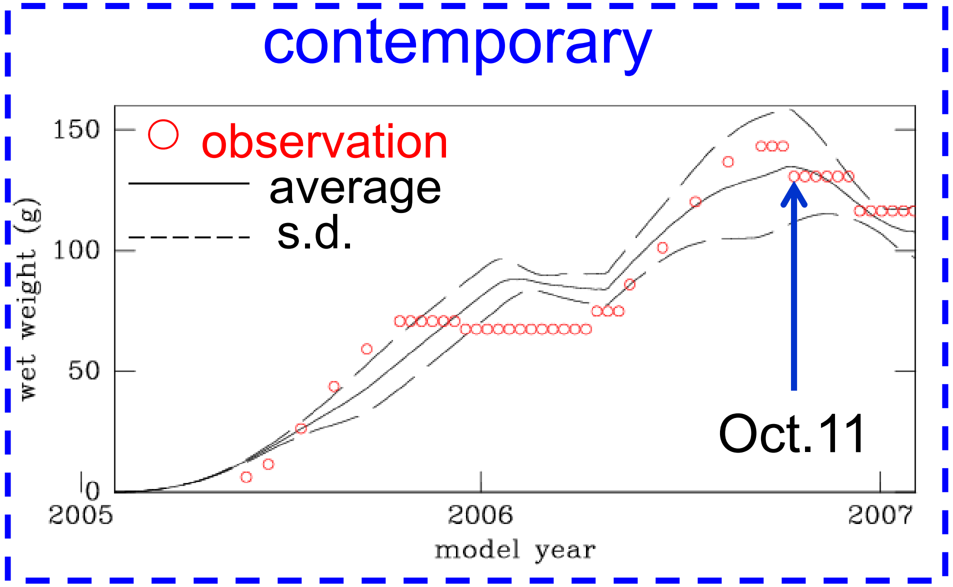
Projection

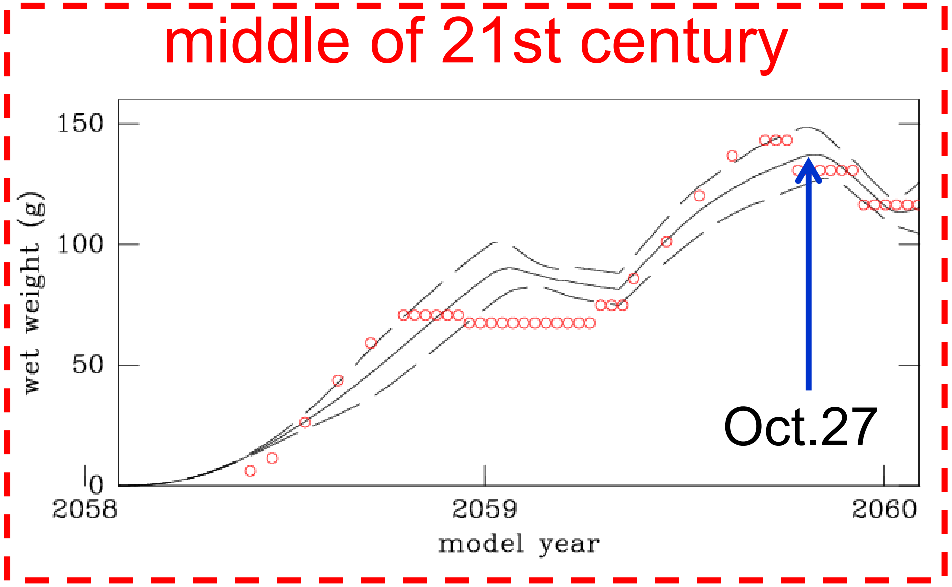
The migration route was shifted northward.

Migration to the fishing ground (Japan coast) was delayed.

Projection of growth of Pacific saury

example for saury spawned on Feb. 2nd



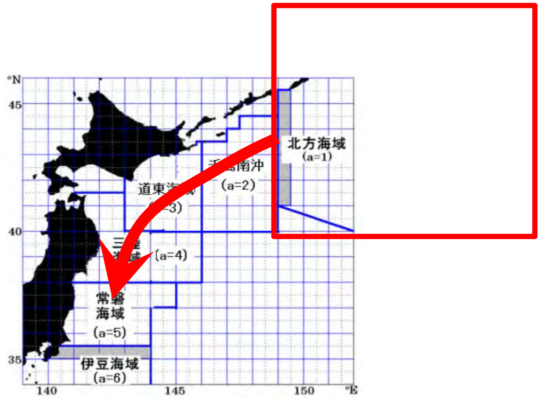


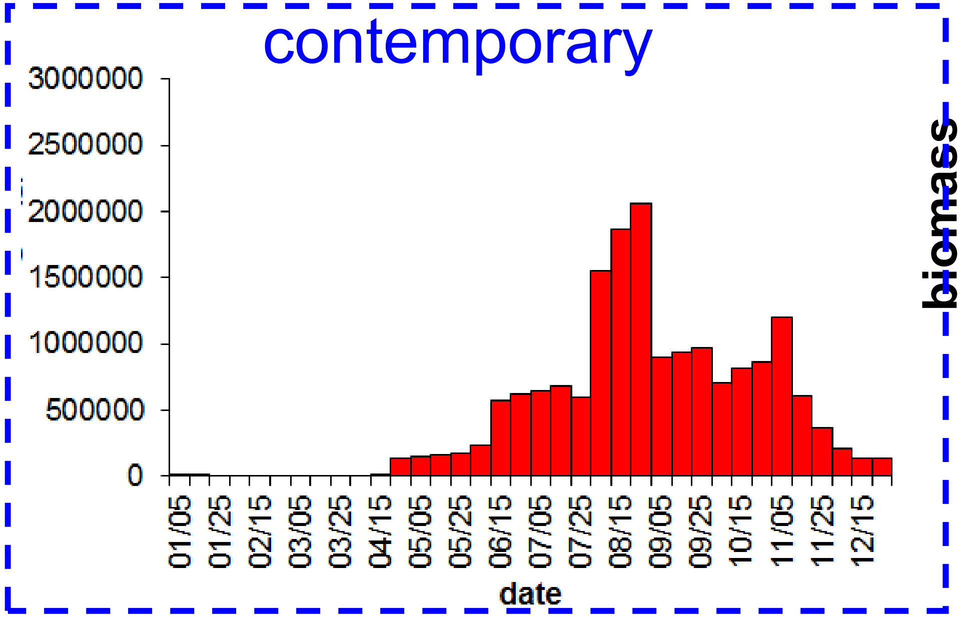
Projection

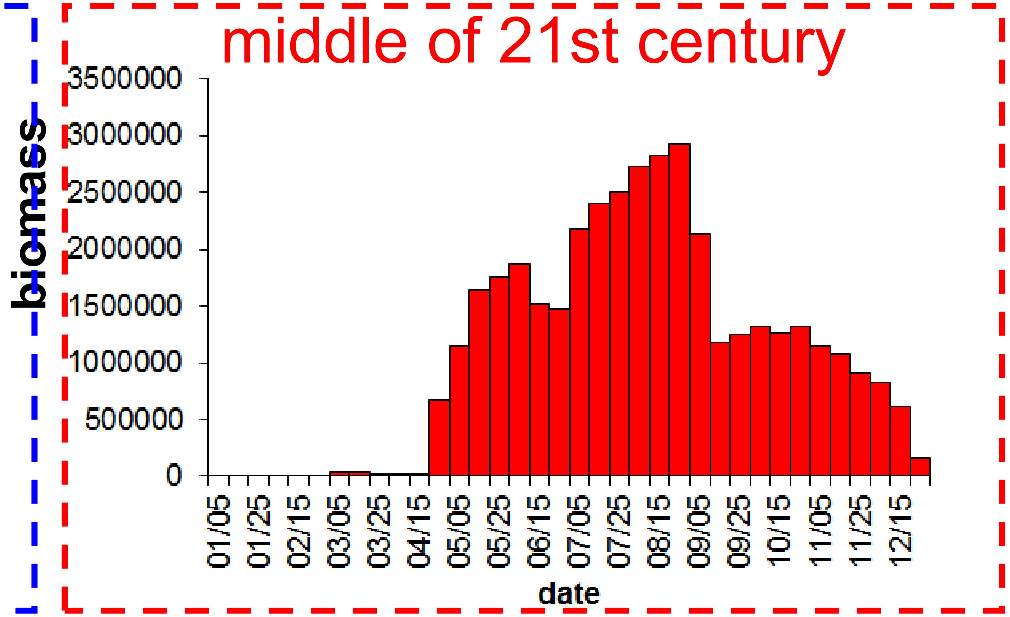
The timing of maximum weight was delayed.
Standard deviation of adult saury weight became small.
This result shows reduction of high price large fish.

Projection of migration biomass of Pacific saury

example for saury migration biomass
to 40-50N, 149-160E area
which spawned on Feb. 2nd







Projection
The biomass increased since the number increased.
The timing of maximum biomass was not changed.

Updated plan

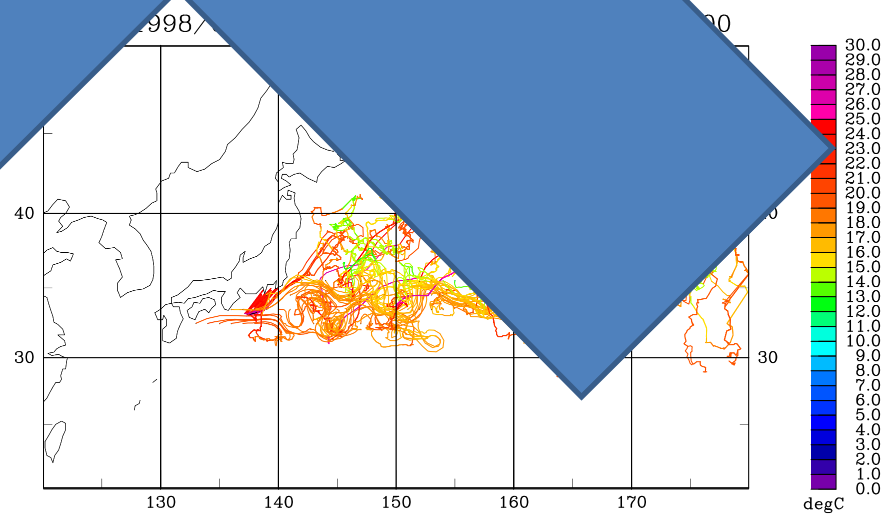
Proj… tion with RCP scena… os

FRA-RO… …RO: Climate Chang… …3.5)

Sorry, we could not show because this figure will be used for publication

Courtesy of Takashi Setou

FRA-ROMS
1way nesting
N.P.-mode…
NW.P.-m… …g.)



NEMURO with iron limitation (MEM)

- Introducing iron … with inputs from dust deposition, … and sediments
- Categorizing … rticles into fast and slow ones
- Introducing … ptake) kinetics as nutrie…
- Paramet… netic algorism

Shigemitsu et al. (2012)

Original NEMURO.FISH

IBM model targeting a specific species
Target: plankton feeder

saruy | herring | sardine | anchovy | squid | salmon

Currently developing model

Multi-species IBM
Target: plankton feeder & fish predator

saruy | sardine | anchovy

squid | mackerel | Spanish mackerel | Jack mackerel

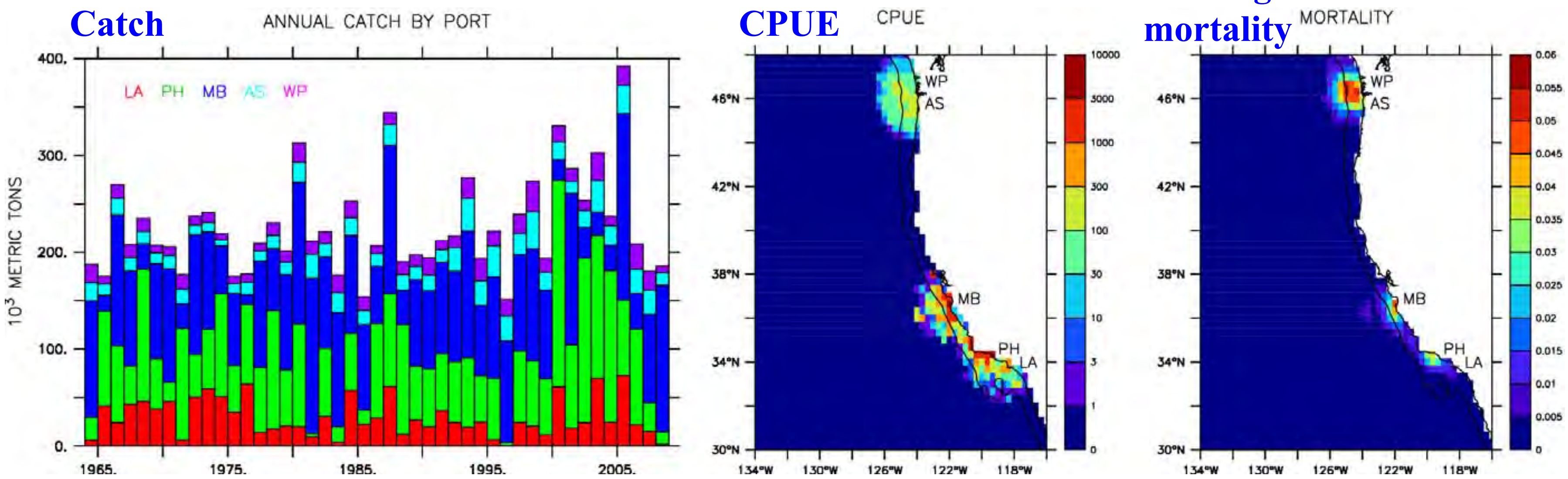
Top predator | fishing boats

Multi-species full life cycle NEMURO.FISH

NEMURO.SAN

full life cycles, multi-species
predators, fishing boats, high resolution

Catch **CPUE** **fishing mortality**



1985 2005

Rose et al. (2015, Prog. Oceanogr.)

comparative study using NEMURO.SAN between California Current and Kuroshio-Oyashio systems.

Updated plan for modeling effects of climate change on fish and fisheries in the western North Pacific Ocean

1. eNEMURO-ROMS.FISH
   RCP 8.5
   1/2 deg. North Pacific
   1/10 deg. western North Pacific

2. MEM (NEMURO with iron limitation)
   RCP6.0
   1/2-1 deg. Global

3. NEMURO.SAN (end-to-end model)
   scenario not fixed
   1/10 deg. western North Pacific