Forecasting ocean circulation and fishery-resource variabilities for operational use

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Ocean Forecasting System

- Ocean forecasting systems (numerical modeling & data assimilation) are developed remarkably.
- Ocean Forecasting systems can provide realistic circulation fields which can be used for operational application.
  - Short-term prediction with high spatial resolution (eddy resolving)
  - Long-term prediction for climate variability

Ongoing projects

- Application of forecasting systems for fisheries
  - Including further development of forecasting system
- *An innovative method of forecasting ocean circulation and fishery-resource variability linked to climate change for operational use*

  (Research program on Climate Change Adaptation)

RECCA
Research Program on Climate Change Adaptation

http://www.mext-isacc.jp/eng/staticpages/index.php/report_awaji_e

An innovative method of forecasting ocean circulation and fishery-resource variabilities linked to climate change for operational use

Toshiyuki Awaji (Japan Agency for Marine-Earth Science and Technology)

Fishing in the northern Pacific off Aomori Prefecture

Overview The goal of this project is to develop both the new integrated atmosphere-ocean-marine ecosystem data assimilation system and the downscaling approach toward the better understanding and prediction of the linkage between ocean/climate variations and biogeochemical and fishery environments under the global warming to the level of practical use for optimal fishery stock managements and adaptive fishing operations with low cost and low CO_2 emission leading to a sustainable fishery activity.

Target Area North Pacific Ocean offshore of Aomori prefecture

Accurate ocean environmental assessment and forecasting are required for adaptive fishery managements to climate change under global warming. In fact, dramatic changes in fishery resource distributions and abundance have occurred in association with climate change. We have been currently striving to develop; 1) an innovative coupled data assimilation system for atmosphere-ocean-lower trophic level ecosystem interactions, 2) a sophisticated downscaling approach toward a short to medium-range forecast of a better fishing ground, 3) robust estimates of long-term fishery-resource variabilities, and 4) enhanced support of data users, focusing on the neon flying squid in the North Pacific, which is a major target in Aomori prefecture. The result is applied to the identification and characterization of a habitat suitability index (HSI) of other species.

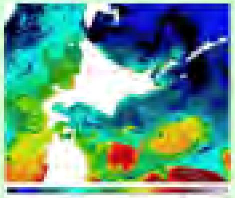
Theme1: New fishing ground survey method

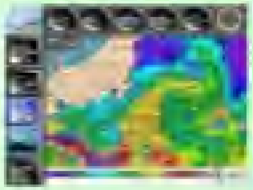
- Develop a high-resolution downscaling technique using the incremental 4DVAR

* Represent meso-scale eddy variabilities toward the better fishing ground survey

*Challenge to a medium-range regional forecast

- Improve the HSI model
- Future distribution an abundance of target species
- Develop a visualization technique for the practical use of model results





Theme 2: Long-term estimation of fishery resources

- Develop a coupled data assimilation system

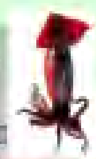
* Synthesize a large variety of observation data into models in order to minimize uncertainty of fishery resource prediction.

* Develop a multi-statistical model ensemble for a lower trophic level ecosystem and fishery resource estimations

- Predict fishery resource variabilities of target species
- Robust estimates of climate change impact on long-term fishery resource variabilities

Develop a medium-range pinpoint-like fishing ground survey

Apply to sea arrow



Establish a robust method of fishery-resource estimation

Establish a new fishery model suited to adaption for climate change

For fishery-resource savings for stable food supply, and promotion of efficient and environmentally-friendly "sustainable fishery"

Ongoing projects

- *An innovative method of forecasting ocean circulation and fishery-resource variability linked to climate change for operational use*

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Japan agency for Marine-Earth Science and Technology

National Research Institute of FarSeas Fisheries, Fisheries Research Agency

Meteorological Research Institute, Japan Meteorological Agency

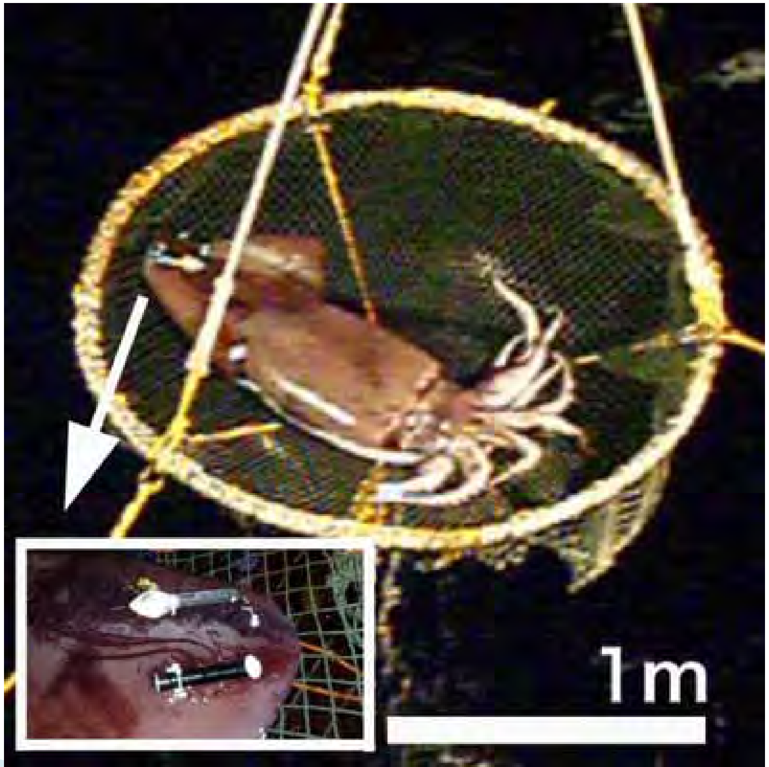
Aomori Prefectural Industrial Technology Research Center

Hokkaido University

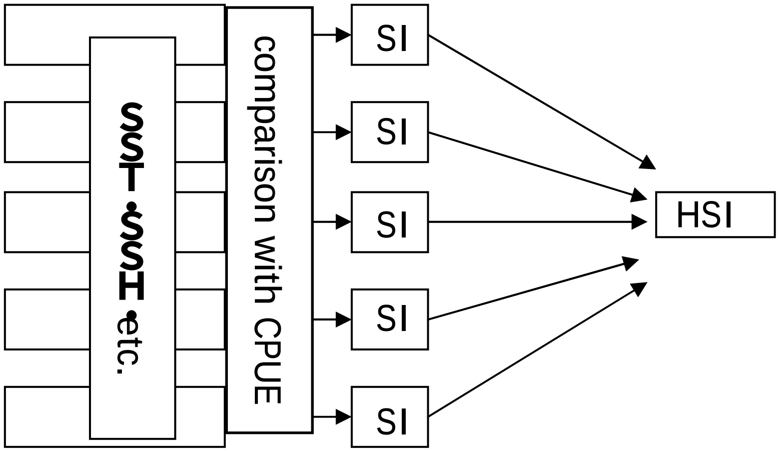
Kyoto University

Target of the project

- Neon Flying Squid
  - distributed in North Pacific
  - life time: 1year
- fishing area (shout time scale)
- Resource variability (long time scale)

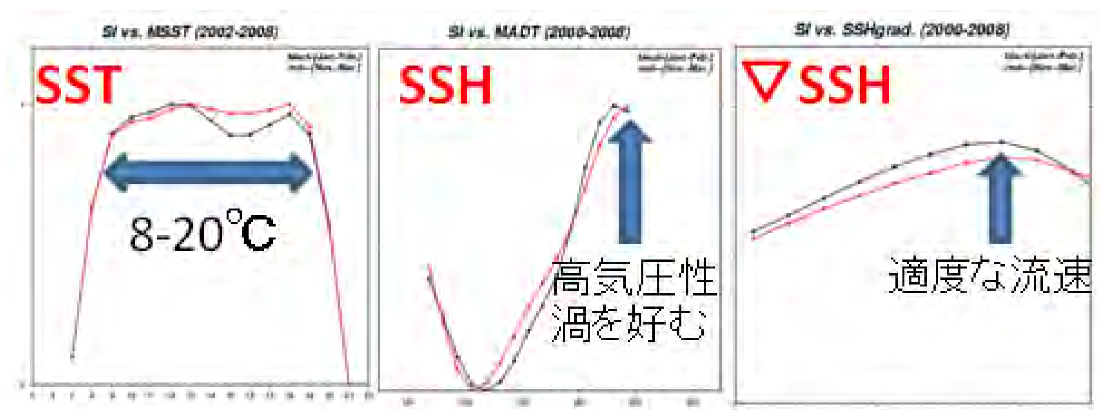


Estimation of potential fishing zone

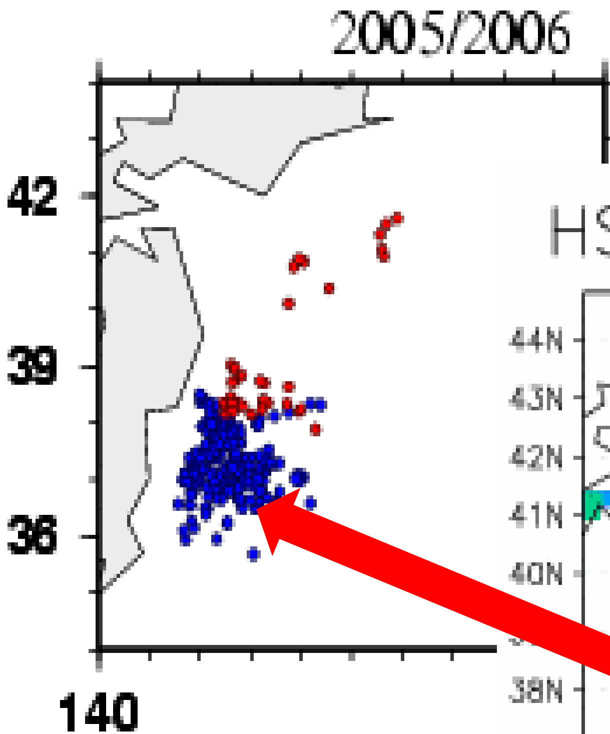


Habitat Suitability Index (HSI) model is developed to estimate the potential fishing zone.
In test version, satellite observation of sea surface temperature and sea surface height data is used as environmental inputs.

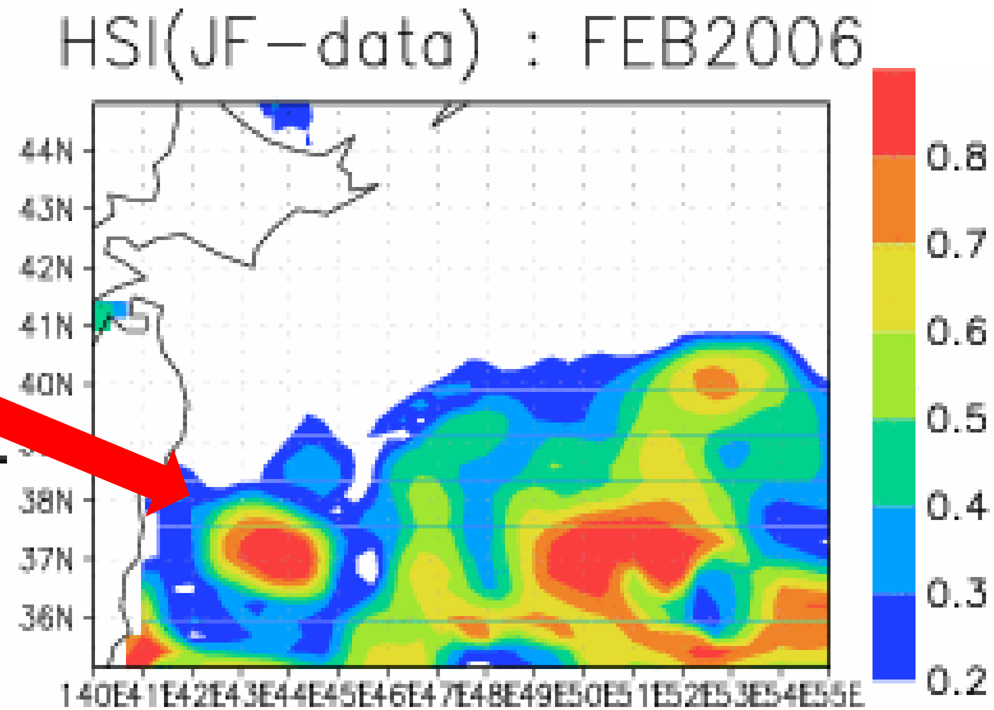
Suitability index for each environmental variables



Result of HSI model

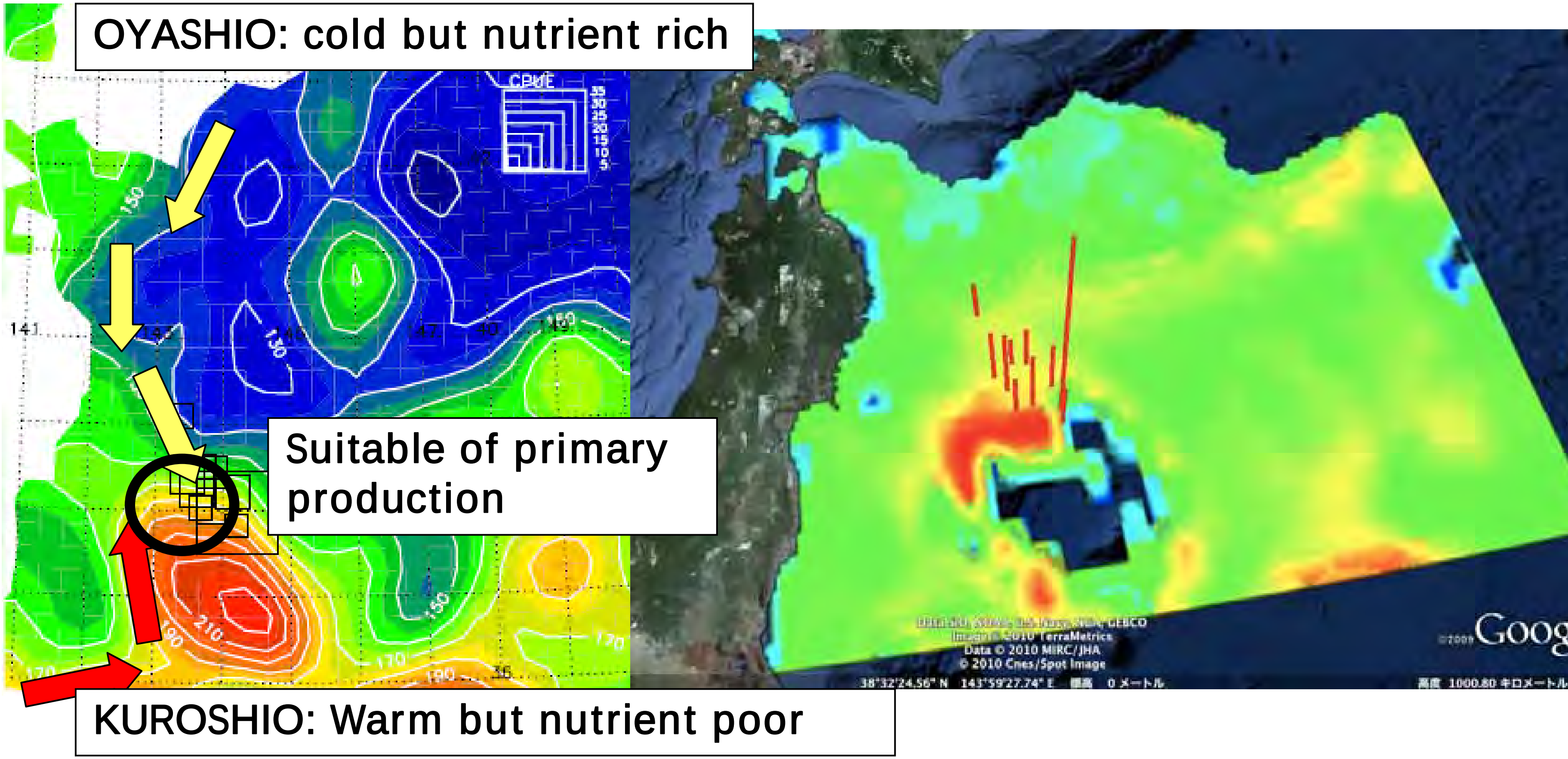


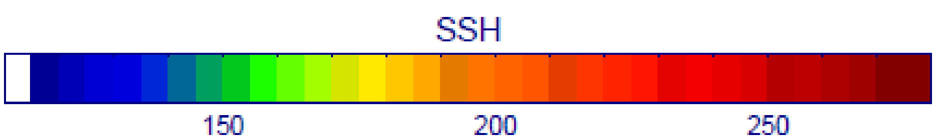
Fishing point in 2006



Estimated HSI value in Feb. 2006

Result of HSI model





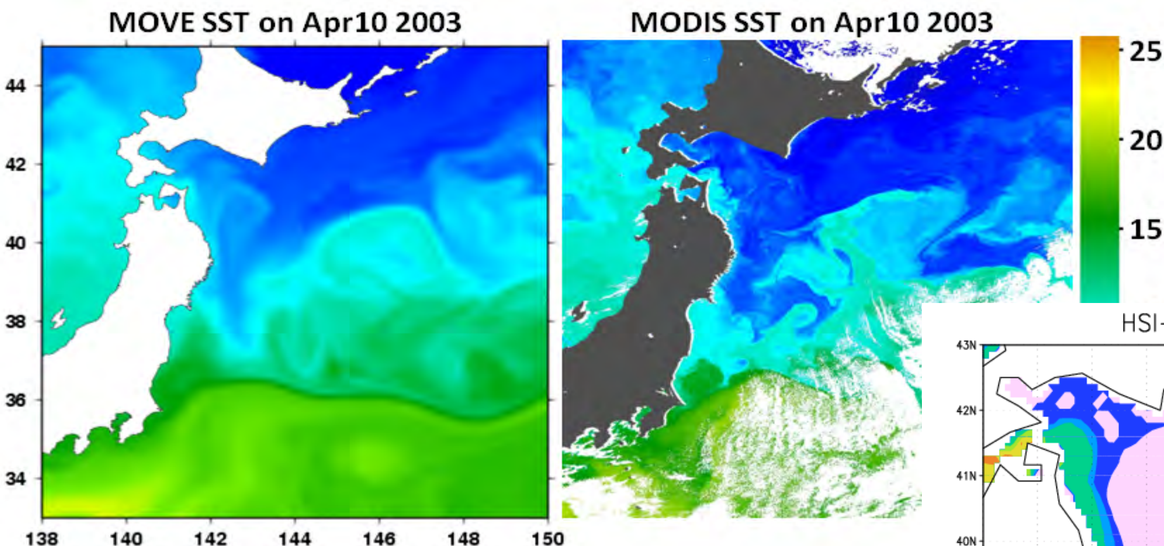
Primary production might be active in this high HSI region.

Estimation of PFZ

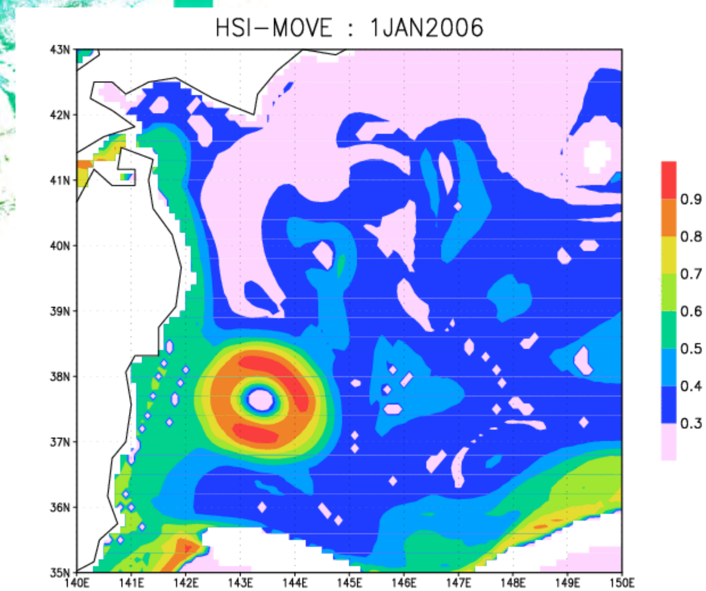
- In this project, the HSI model will be improved:
- Information of primary production directory
  - using ocean color data
  - using bio-geochemical model
- Information of subsurface ocean state
  - flying neon squid move vertically
  - using ocean model
  - using data assimilation product
- prediction using numerical model
  - mesoscale eddies must be resolved
  - few days~1week prediction

Development of advanced model

To utilize subsurface information, reanalysis dataset derived from MOVE (developed at MRI/JMA) is used.

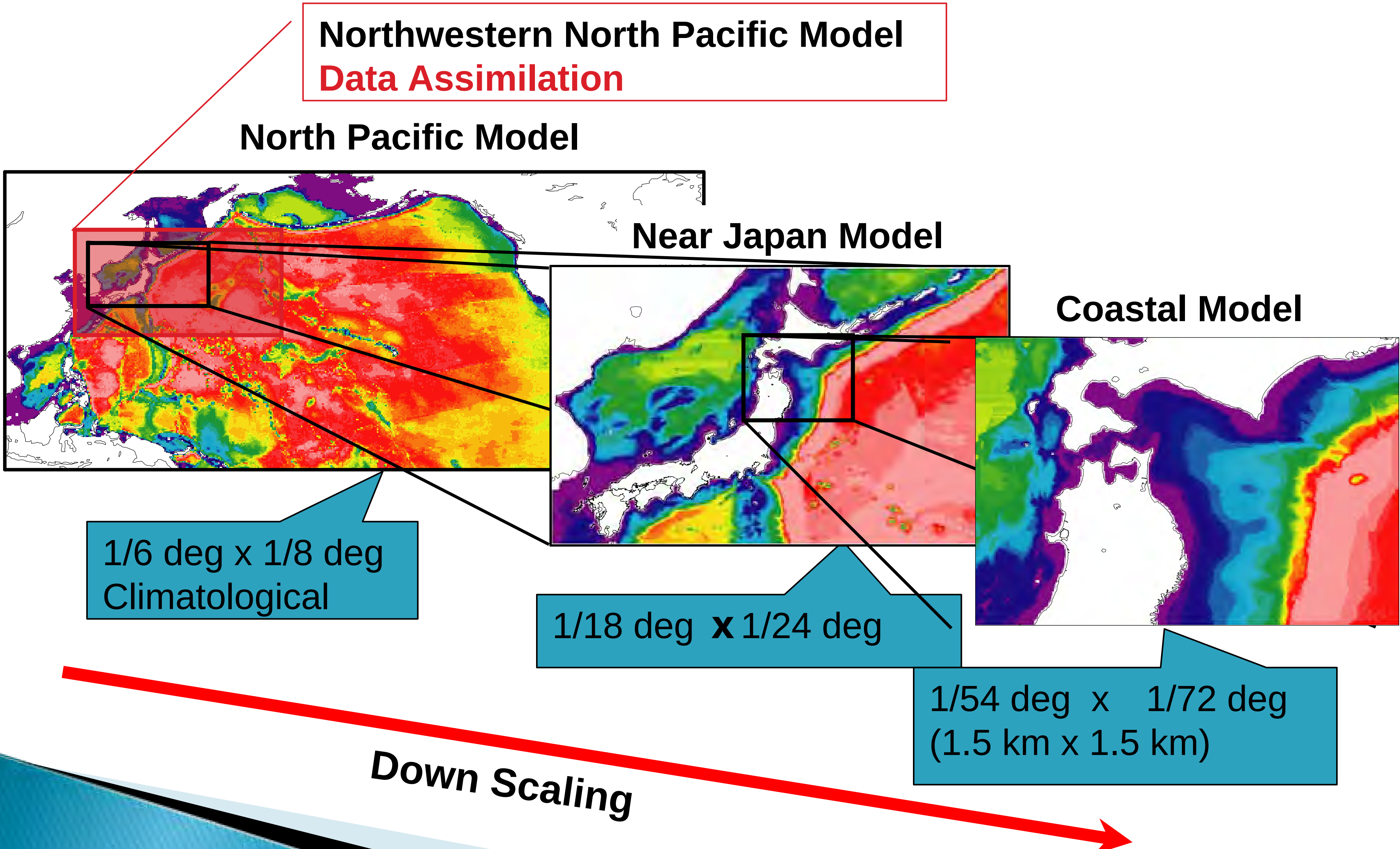


The detailed result will be presented in Session S3 (Fri.).
Igarashi et al. (S3-7774)



Daily HSI value in 2006

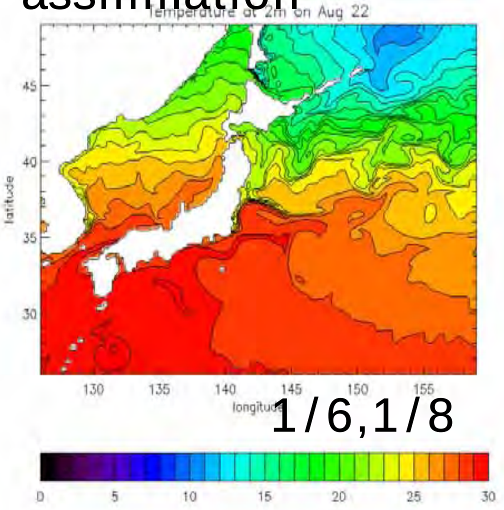
Down Scaling



new downscaling system

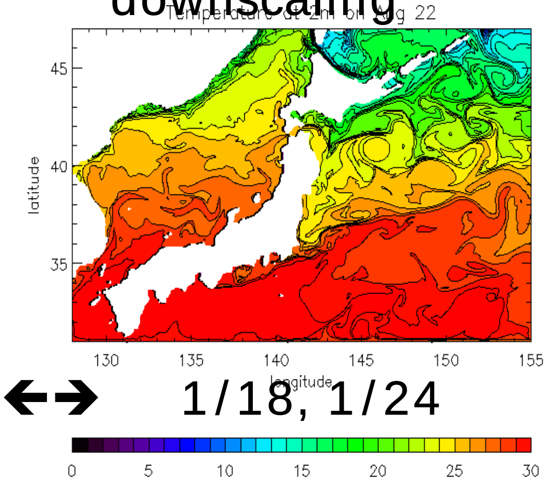
SST on Aug. 22,2003

assimilation



1/6,1/8 ←→ 1/18, 1/24

downscaling



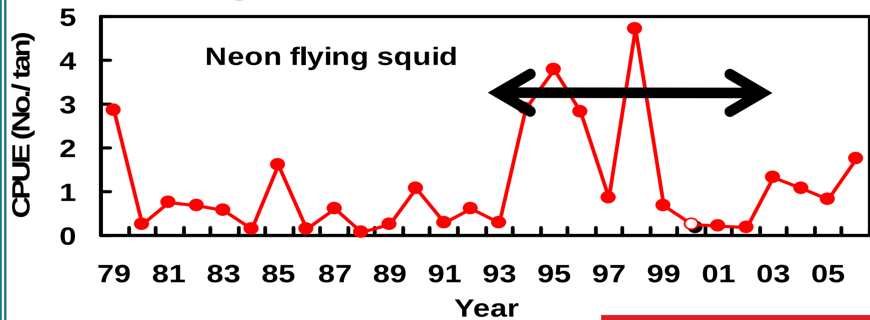
Instead of 1-way nesting, new downscaling system is developed using incremental 4DVAR approach.

Why Incremental 4DVAR?

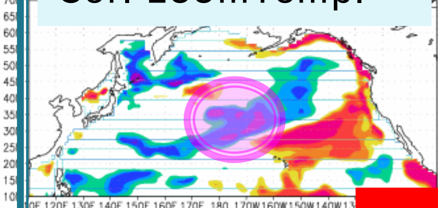
- In 1-way nesting, initial and boundary condition of inner model is estimated using coarse grid model.
    - ◆Difficult to obtain precise higher order moment, *e.g.* energy, heat flux etc.
    - ◆No warranty of the derived time series of inner model
- Using Incremental 4DVAR, state variables of coarse model is estimated so that time series of inner model fits for observation data.

prediction of resource variablity

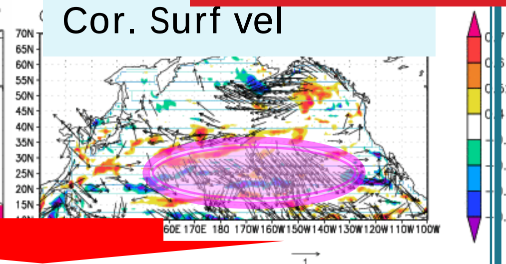
Interannual variability



Cor. 155mTemp.

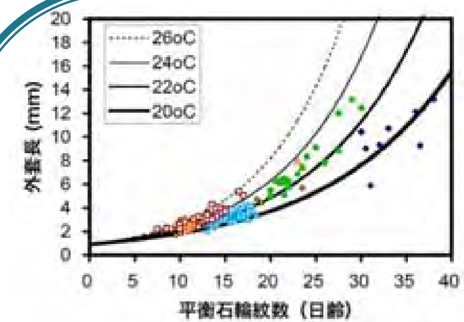


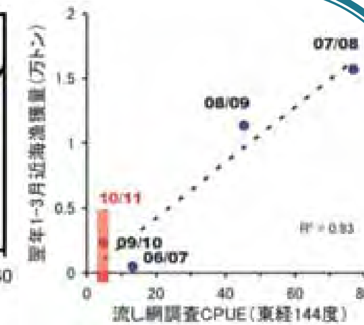
Cor. Surf vel



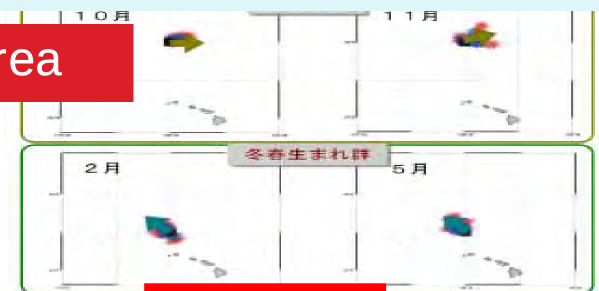
Choose key factor & area

Use reanalysis and predication incl. ecosystem model





Growth rate is controlled by the environment in the first few days.



Examine the environmental factor using particle tracking around incubation period

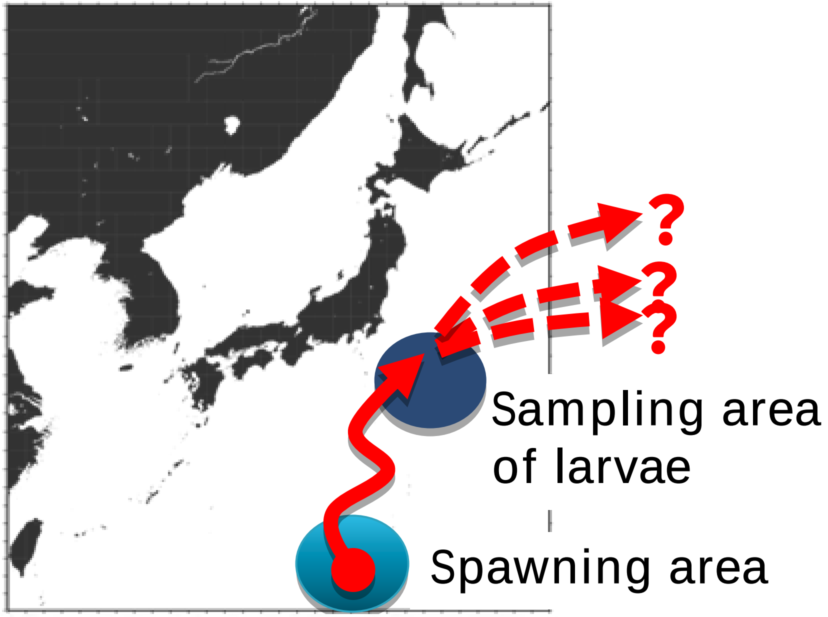
Development of prediction model of resource variability

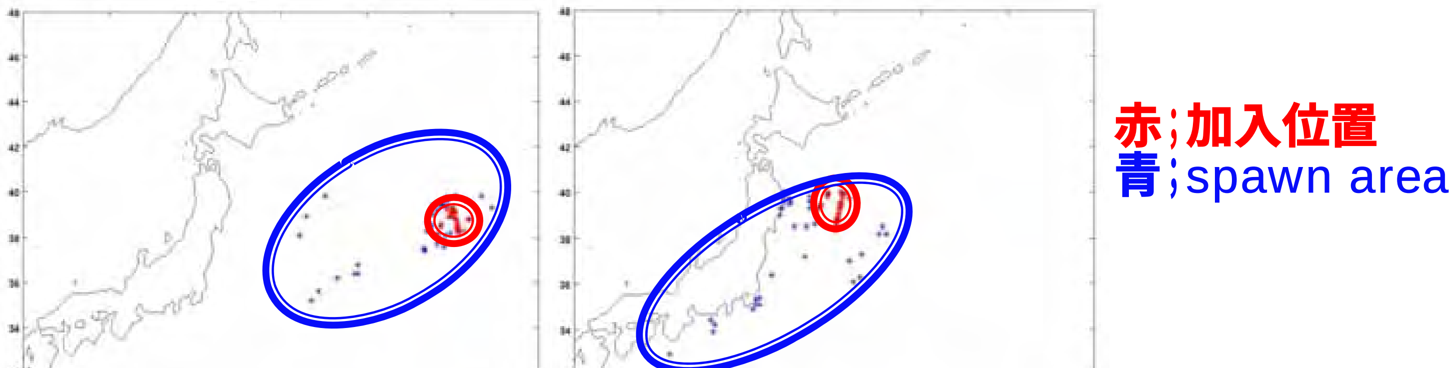
Analysis of environmental factor on hatching

Environment in hatching period

Forward & backward particle tracking using reanalysis dataset

Environment of spawning area





Identify the environmental factors for hatching

Kato et al. (FIS-P-7735) presented yesterday

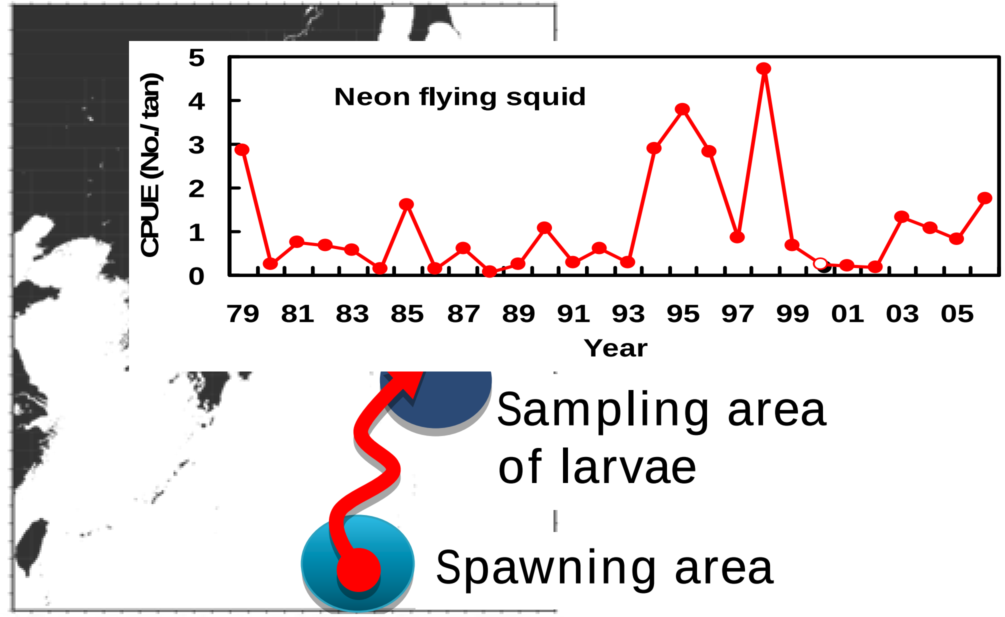
Chl-a rather than Temp.

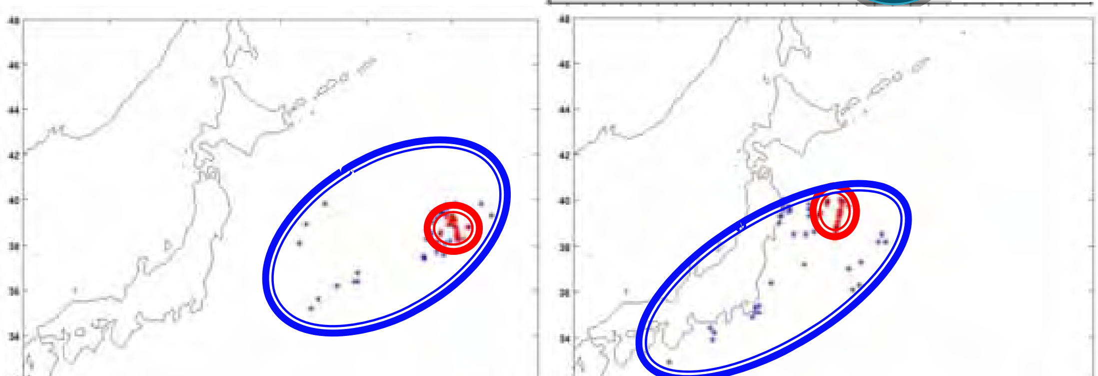
Analysis of environmental factor on hatching

Environment in hatching period

Forward & backward particle tracking using reanalysis dataset

Environment of spawning area





Identify the environmental factors for hatching

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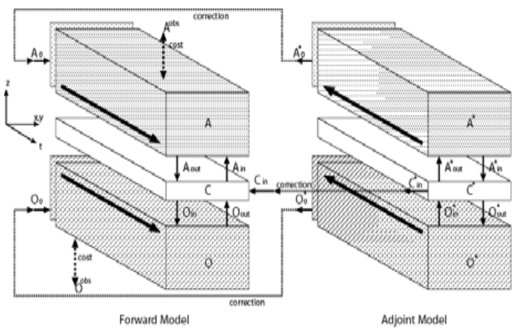
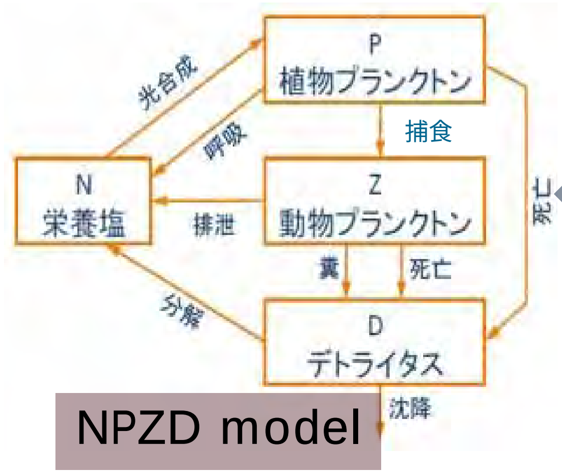
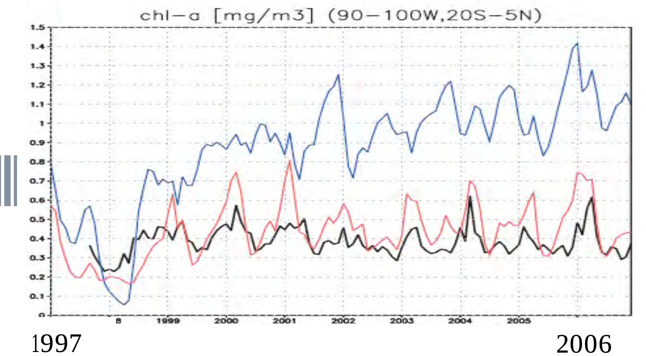
Chl-a rather than Temp.

Development of Data Assimilation system

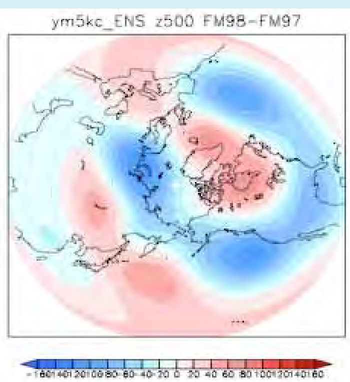
Coupling of Atmosphere-ocean physics-ocean ecosystem

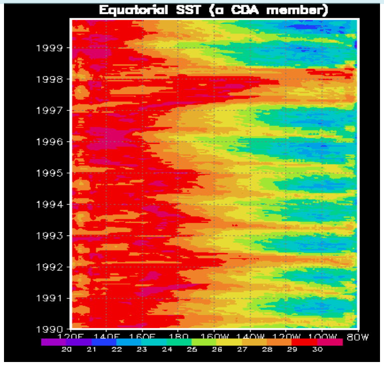


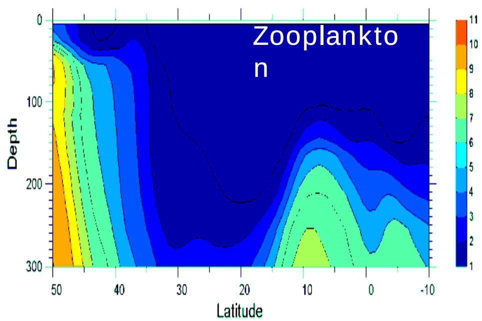




Integrated dataset of Atomsphere-ocean environment

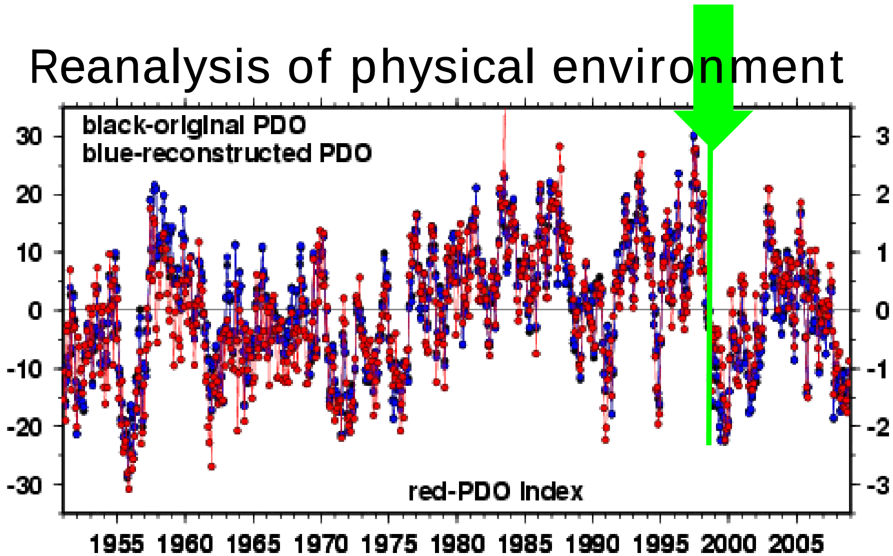




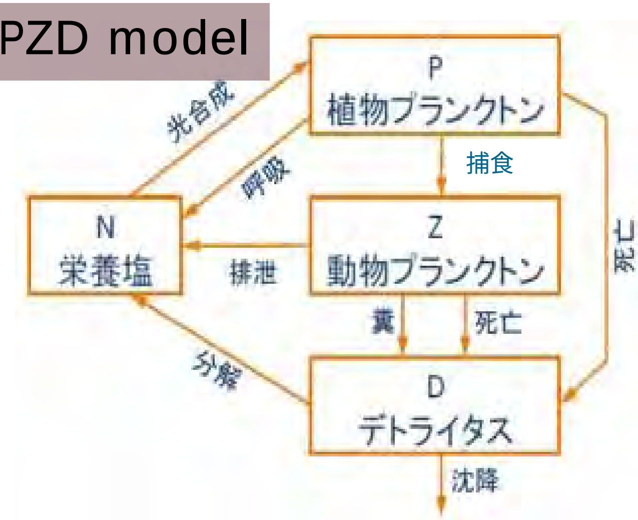


Reanalsys of ocean ecosystem

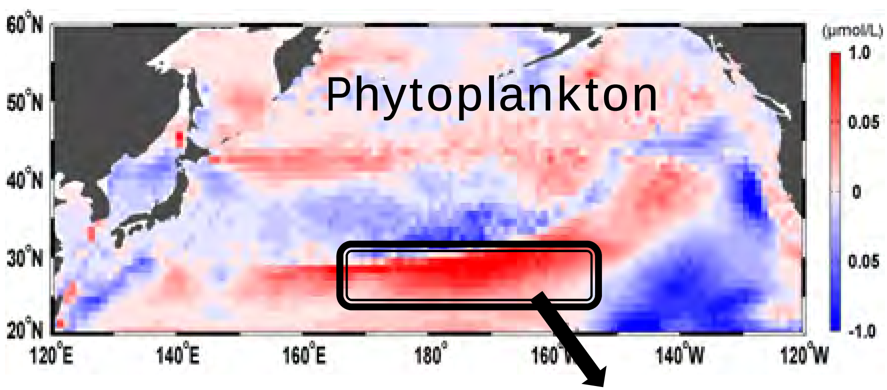
Reanalysis of physical environment

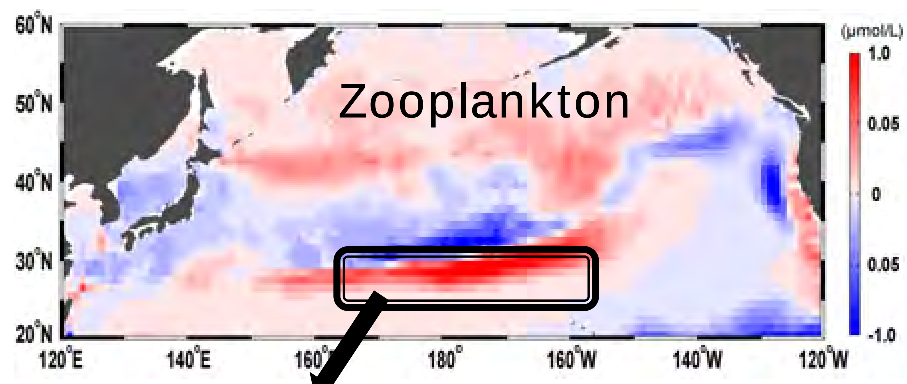


NPZD model



Difference of phytoplankton and zooplankton
(1996-1998) – (1999-2001)

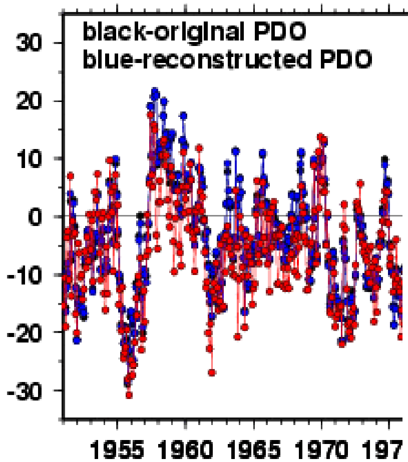


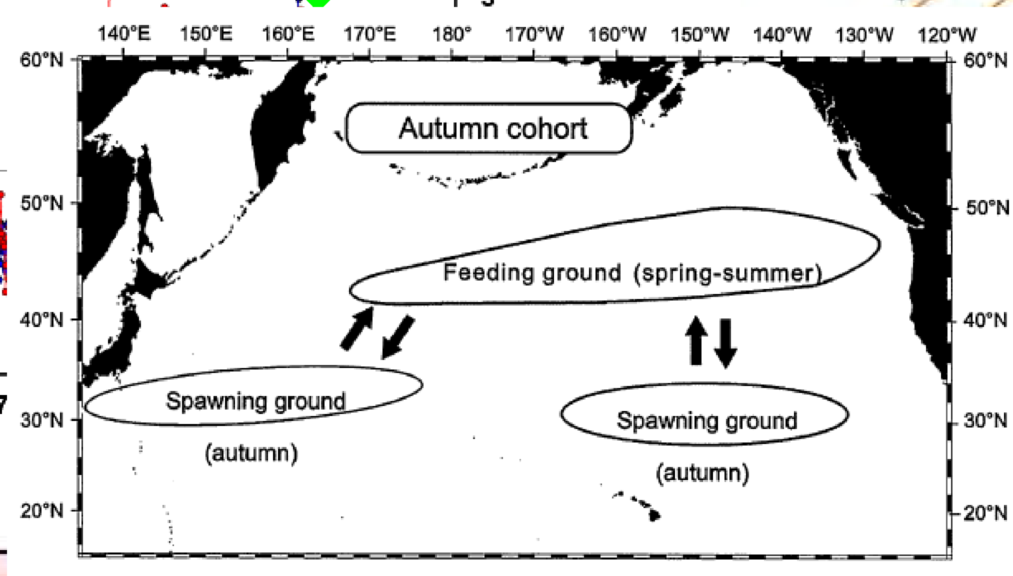


Decrees of planktons in this region leads the poor catches of neon flying squid.

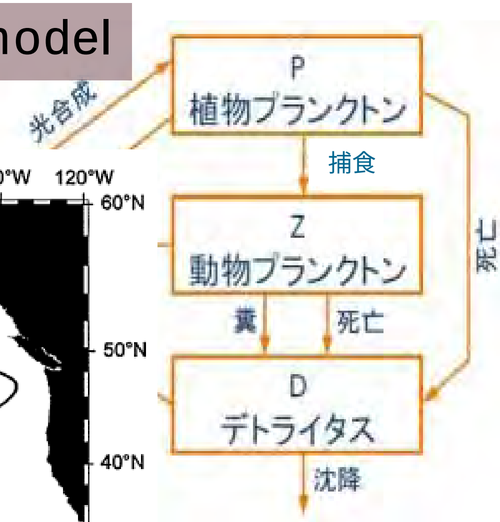
Reanalsys of ocean ecosystem

Reanalysis of physical environment





NPZD model



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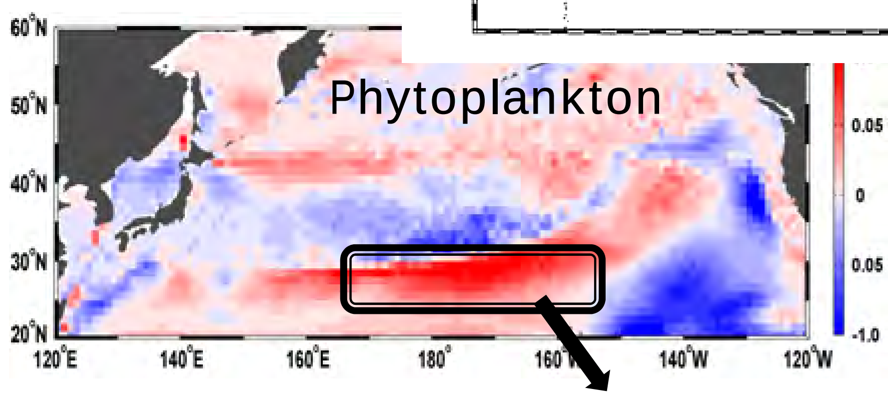
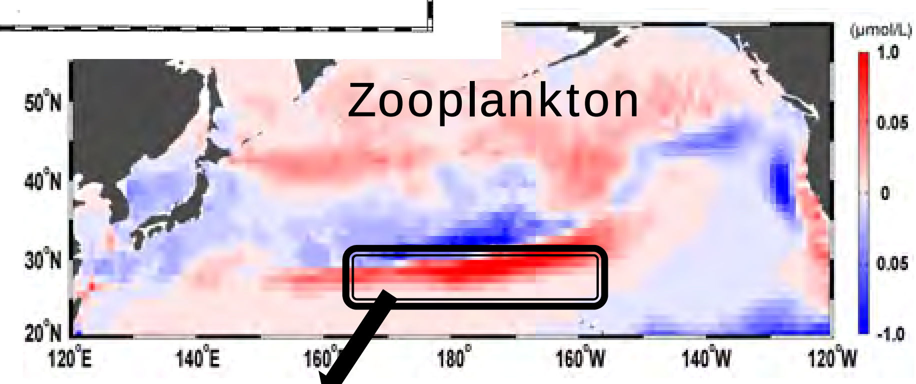
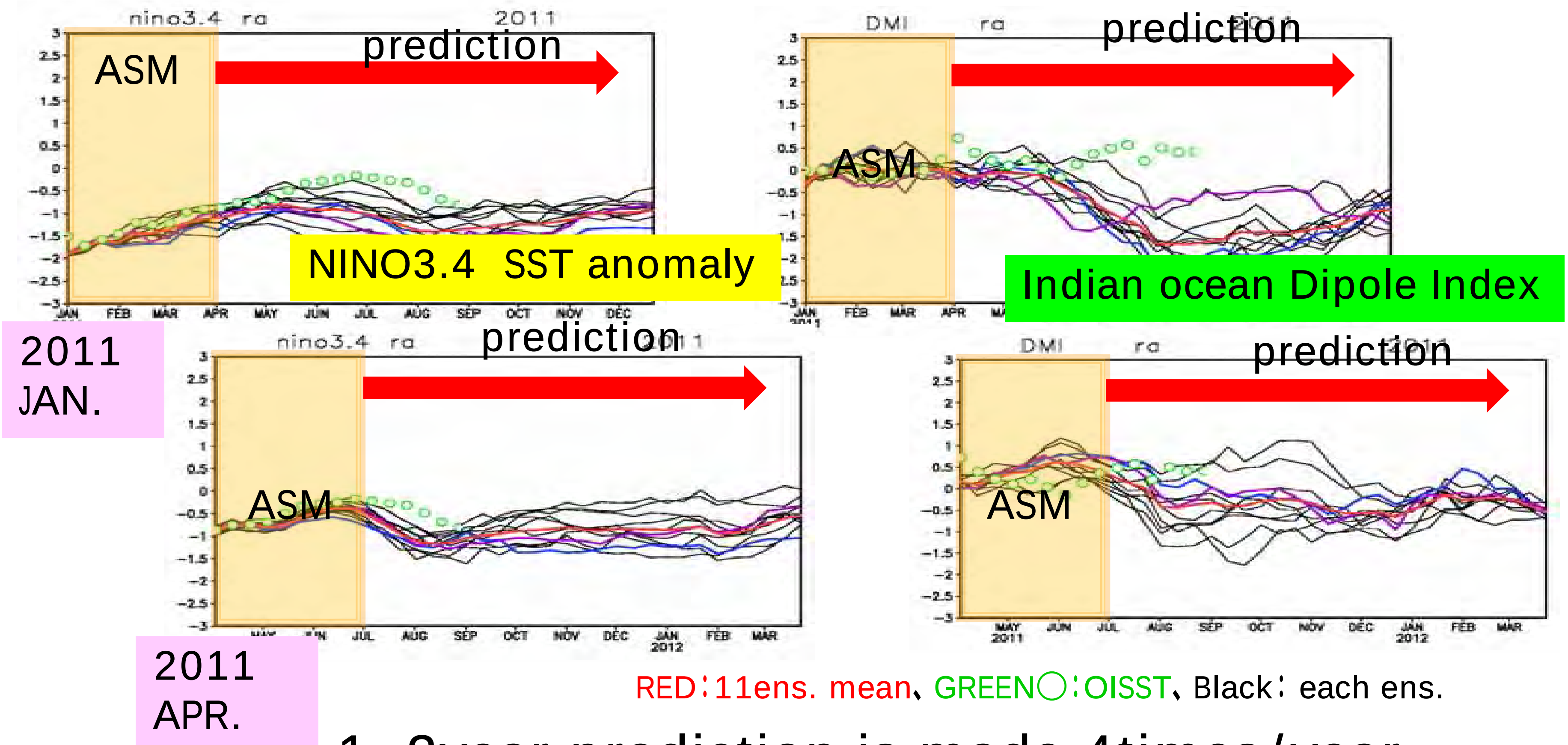




Decrees of planktons in this region leads
the poor catches of neon flying squid.

Prediction of climate variability using coupled data assimilation system



1~2year prediction is made 4times/year using Atmosphere-ocean coupled system

Summary

- Application of ocean forecasting system for fisheries is introduced following ongoing project.
- “ocean weather forecast” can be used for estimation and predication of potential fishing zone well.
- “ocean climate forecast” will be used for prediction of resource variability.