A statistical approach to identify optimal habitat suitability of neon flying squid in northwestern North Pacific by using satellite datasets and 3-D ocean data assimilation product

Hiromichi Igarashi[1], Toshiyuki Awaji[1,2], Masafumi Kamachi[1,3], Yoichi Ishikawa[1,2], Norihisa Usui[3], Yosuke Fujii[3], Takahiro Toyoda[3], Shuhei Masuda[1], Toshimasa Doi[1], Shiro Nishikawa[1], Yoshihisa Hiyoshi[1], Mitsuo Sakai[4], Yoshiki Kato[4], Sei-ichi Saitoh[5] and Shin-ichi Sato[6]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Kyoto University, [3]Meteorological Research Institute, Japan Meteorological Agency, [4]National Research Institute of Far Seas Fisheries, Fisheries Research Agency, [5]Hokkaido University, [6]Aomori Prefectural Industrial Technology Research Center

RECCA
Research Program on Climate Change Adaptation

outline

- Introduction
- Data and method
- Result: satellite-based HSI model
- Result: 3D-ODAP-based HSI model
- Concluding remarks

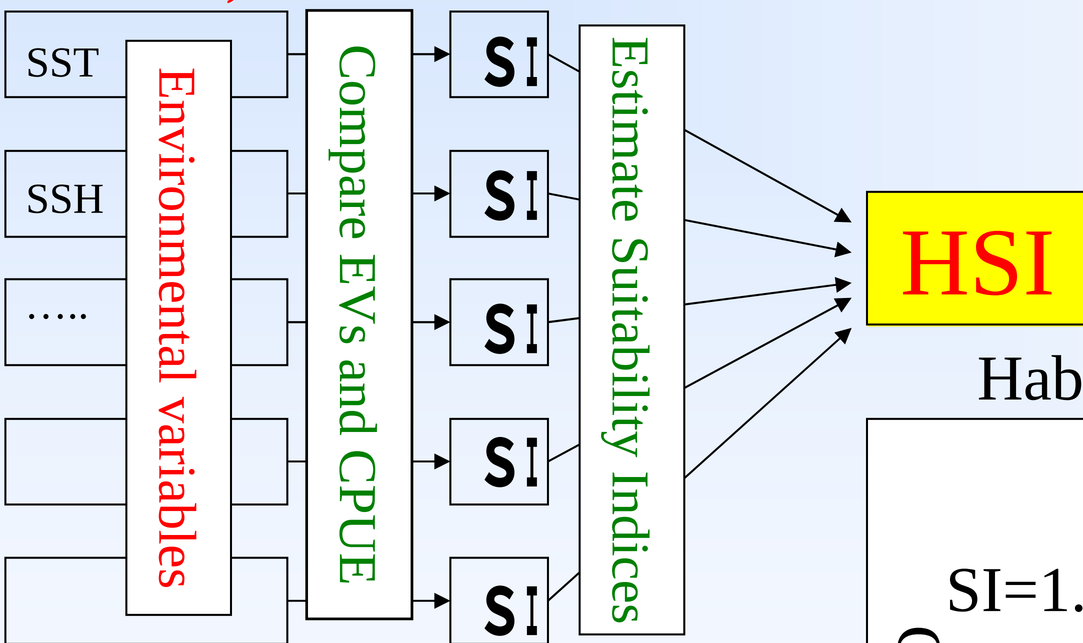
Introduction

- Neon flying squid has a wide-spread distribution in the North Pacific and plays an important role in the pelagic ecosystem.
- It is an international fishery resource with high commercial value and one of the main targets for the fishery in Aomori Prefecture.
- A good understanding of the habitat of the neon flying squid provides us useful information for identifying potential fishing ground.
- We have been currently striving to develop a habitat suitability model for adaptive fishing operations with low cost and low CO_2 emission in the on-going Japanese national research program “RECCA”.

RECCA
Research Program on Climate Change Adaptation

Habitat Suitability Index(HSI)model

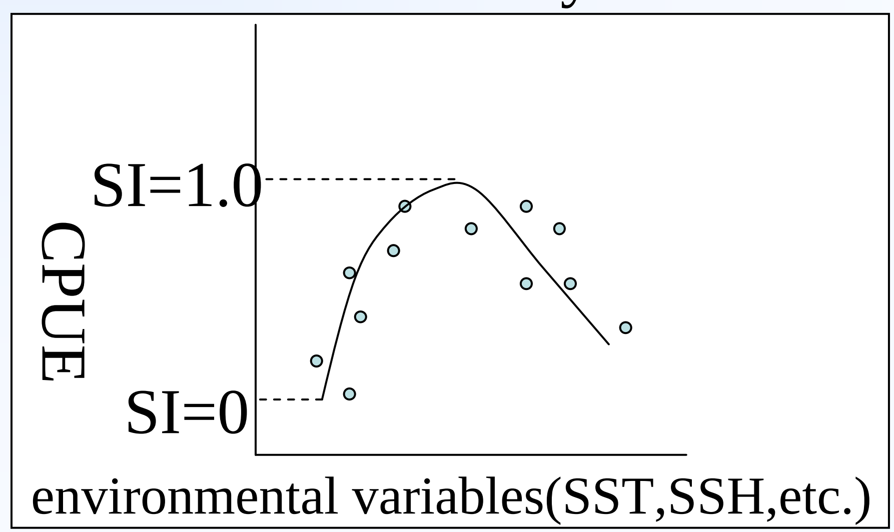
- is widely used as a tool for ecological impact assessment.
- describes the relations between fish abundance and environmental variables, estimates the level of habitat suitability as an HSI score ranging from **0 to 1**.



HSI=f(Si1, Si2, Si3, ･･･)

SI: Suitability index

Habitat Suitability Index

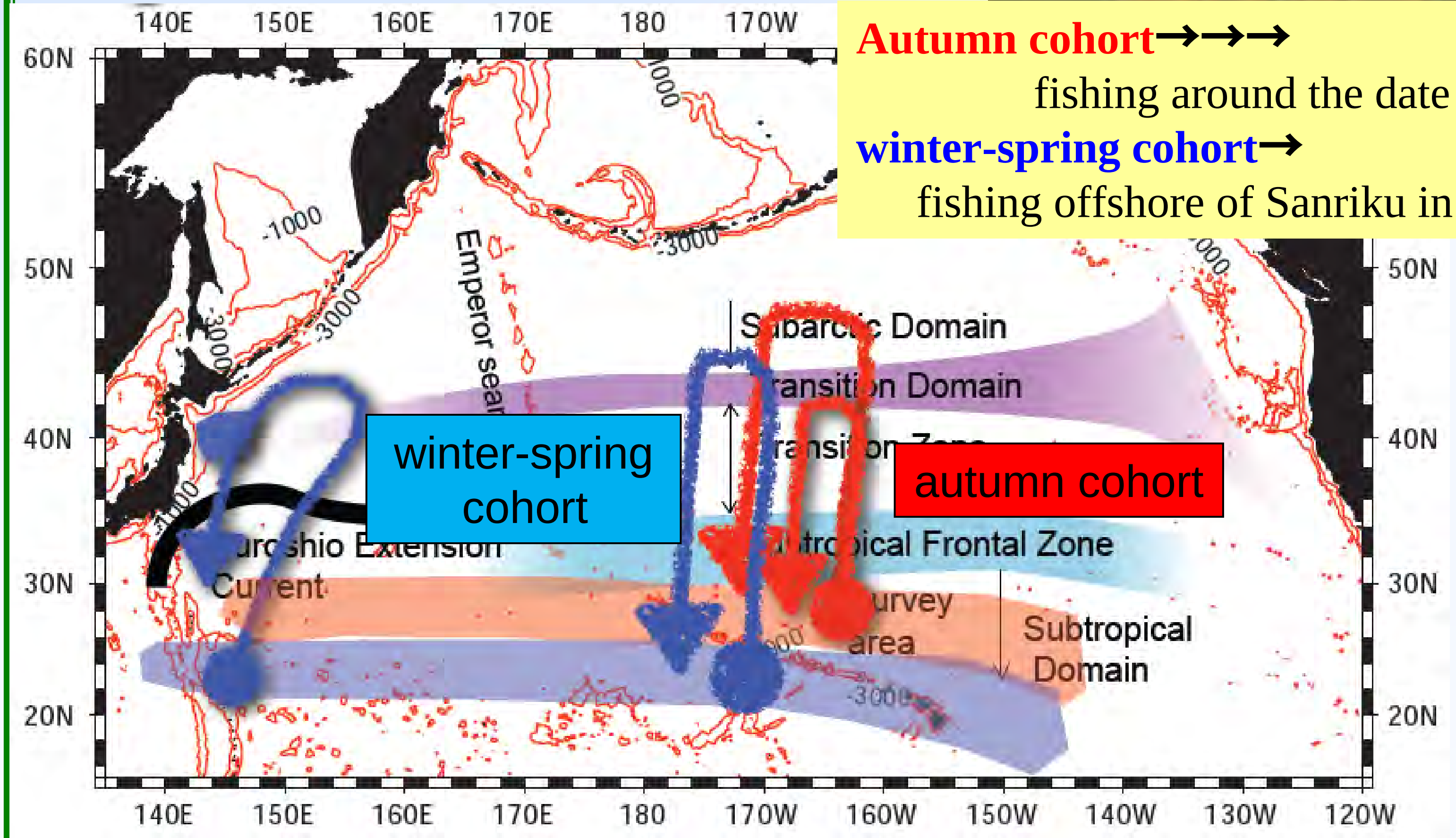


neon flying squid

(*Ommastrephes bartramii*)

- **widely distributed in the north Pacific**
- **1-year lifespan and seasonal migration**
- **important for pelagic ecosystem and Japanese fisheries**

Autumn cohort→→→
fishing around the date line in summer
winter-spring cohort→
fishing offshore of Sanriku in the next winter



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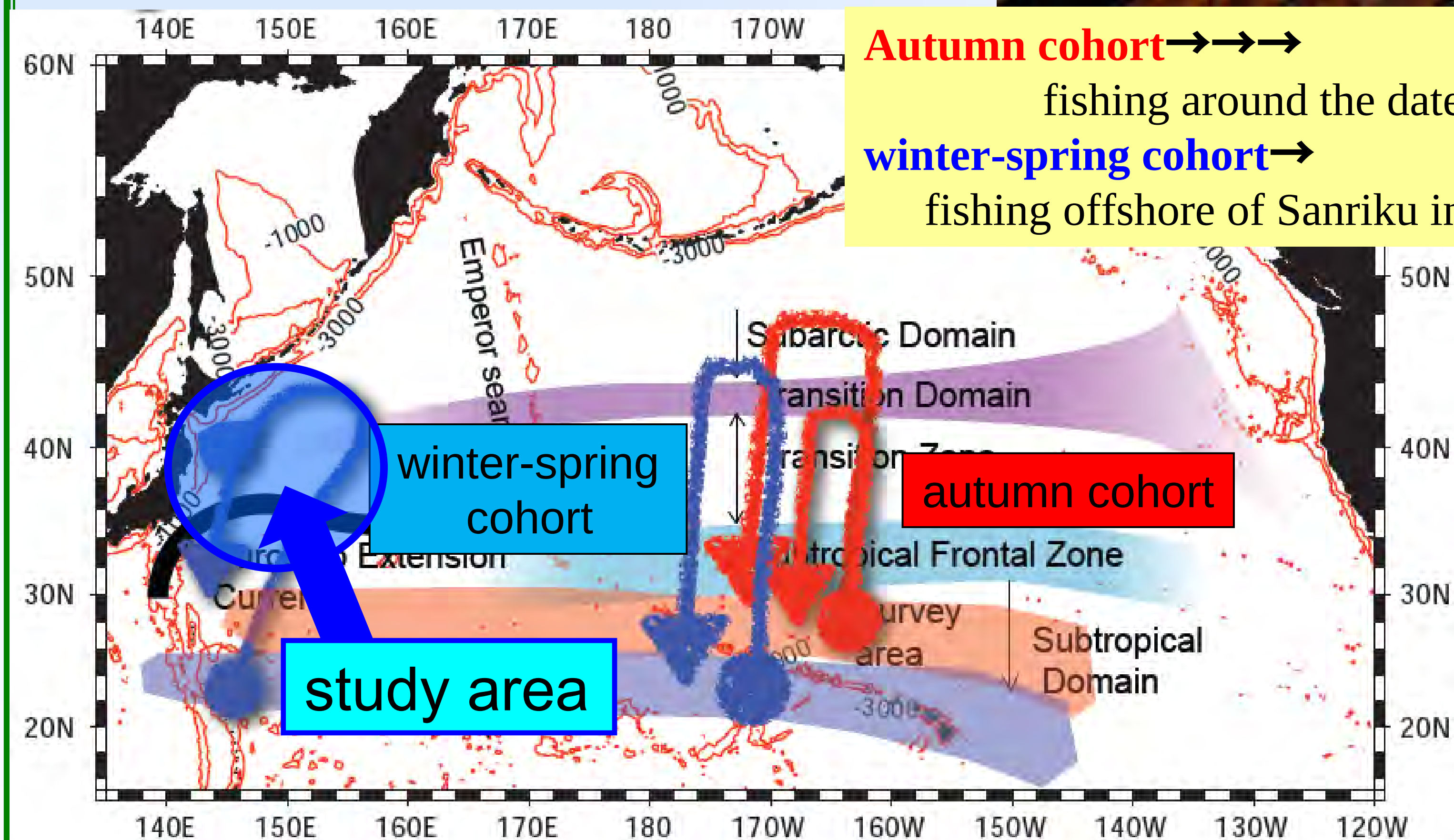
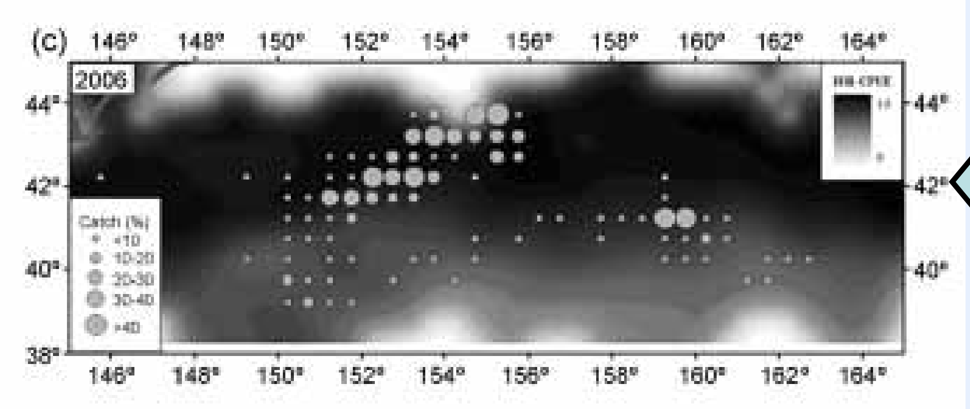


Evaluating HSI for neon flying squid around Kuroshio extension region （Tian et al.,2009）



Estimated HSI distribution(gray scale) and catch observation(○) in 2006

High HSI have little correspondence with high catch.

Monthly mean SST, T(35m),T(317m),SSS,SSH were used.

It is well-known that the meso-scale eddy activities strongly affect the ocean biogeochemical and fishery environments in this area, but this model doesn't have a potential to express them because of using just monthly mean values.

<Purpose>

In order to improve the HSI model to the level of practical use for adaptive fishing operations, we investigated the suitable habitat area for the winter-spring cohort east of northern Japan using satellite-based datasets and 3D-VAR ODA product, which can provide realistic fields of 3-dimensional ocean circulation and environmental structures including meso-scale eddies.

data

- Fishery data

  Commercial fisheries data of neon flying squid from January to February during **2001-2007**

  (by Aomori Prefectural Industrial Technology Research Center)

  the dates of fishing, fishing locations, CPUE(No./hour/machine)

- Satellite data

  daily sea surface temperature(SST)by Tohoku Univ.(0.1deg.)

  AVISO NRT Merged Absolute Dynamic Topography(MADT)

  (**1/3**deg., weekly → daily interpolated)

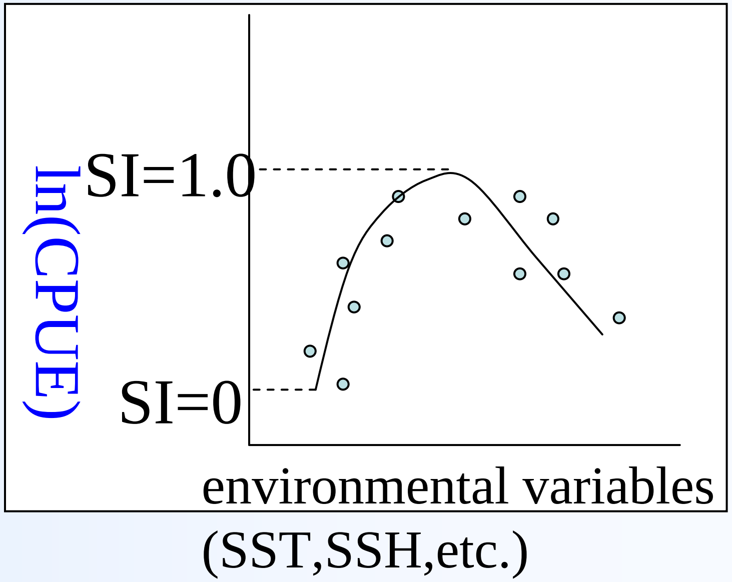
- 3D-VAR data assimilation product

  MOVE(MRI Multivariate Ocean Variational Estimation)

  Temperature, Salinity, Current velocity(U,V,W),SSH

  (0.1deg, vertical **54** levels, **5-**days → daily interpolated)

method



- Making SI curves

Spline smooth regression method was applied to the ln(CPUE)-each EV scatter plot, and SI was defined as,

$$SI = \frac{Y_{fit} - \min Y_{fit}}{\max Y_{fit} - \min Y_{fit}}$$

where Y_{fit} is the predicted ln(CPUE).

- HSI Modeling

Geometric mean model (equal weight)

$$HSI = \sqrt[n]{\prod_{i=1}^{n} SI_i}$$

- Validation

The following three correlation coefficients between the estimated HSI and the observed ln(CPUE) are calculated.

Pearson corr. coef./Kendall tau rank corr. coef./Spearman rank corr. coef.

procedure

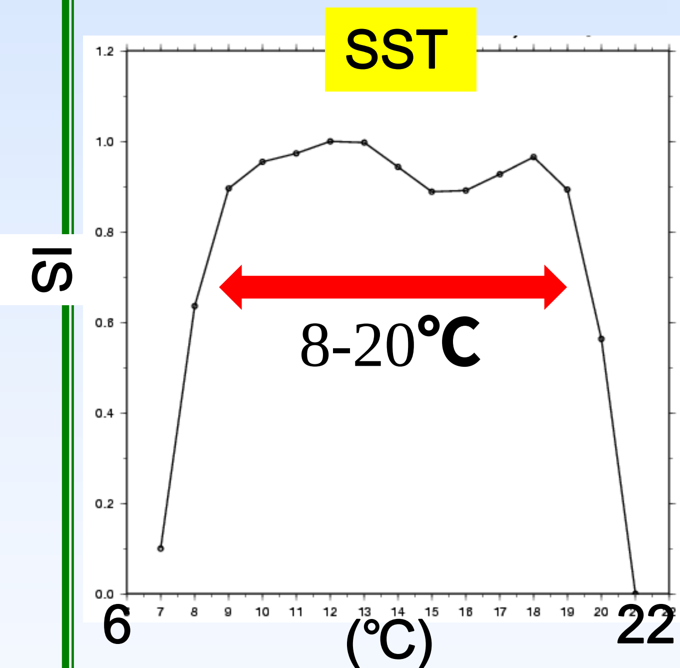
- satellite-based model (3 variables)
- MOVE-2D model (the same as above)
- Picking up the effective 3D environmental variables (T,S,U,V,W,V_{scal})
- MOVE-3D model (selected 7 variables)
- Validation

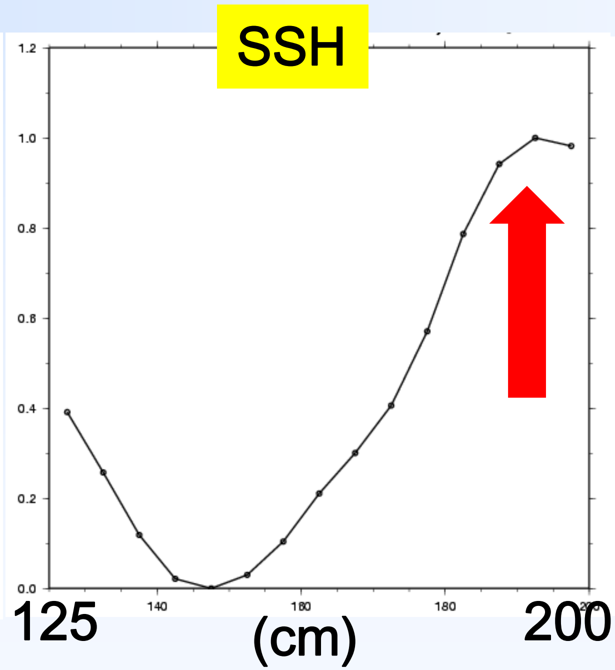
Results

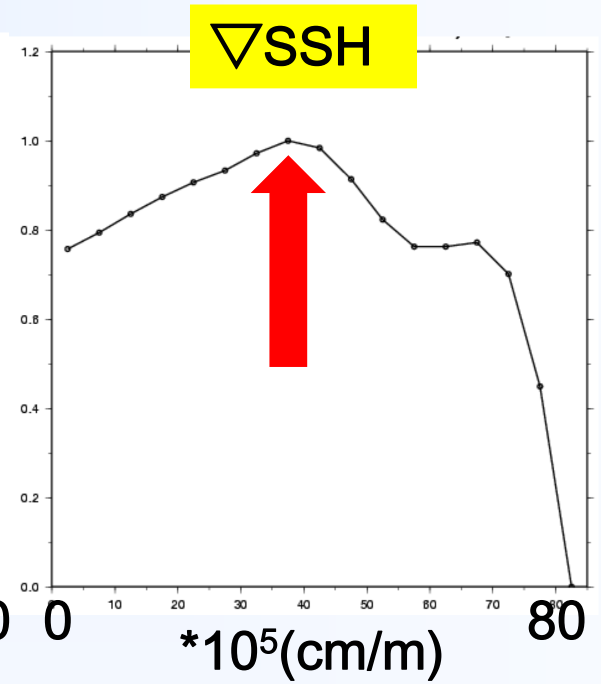
Satellite-based SI model

HSI model

$$HSI = \sqrt[3]{SI_{SST}\, SI_{SSH}\, SI_{\nabla SSH}}$$







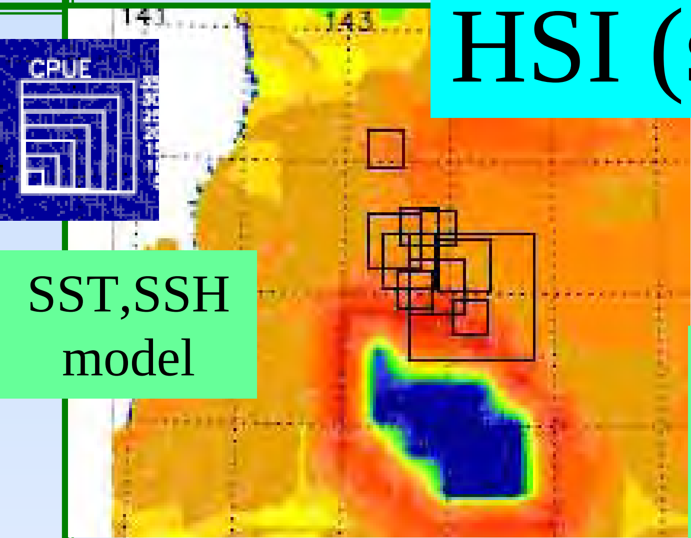
optimal SST range is 8-20℃.

two peaks correspond to cyclonic and anti-cyclonic eddies

an optimal ∇SSH (geostrophic current speed)

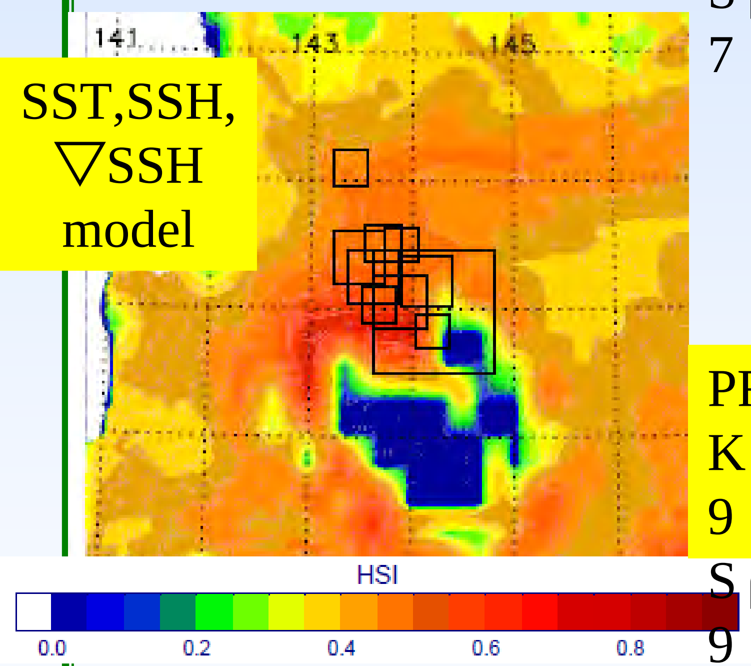
HSI (satellite)

SST,SSH model



PR:0.289
K τ :0.199
S ρ :0.297

SST,SSH, ▽SSH model

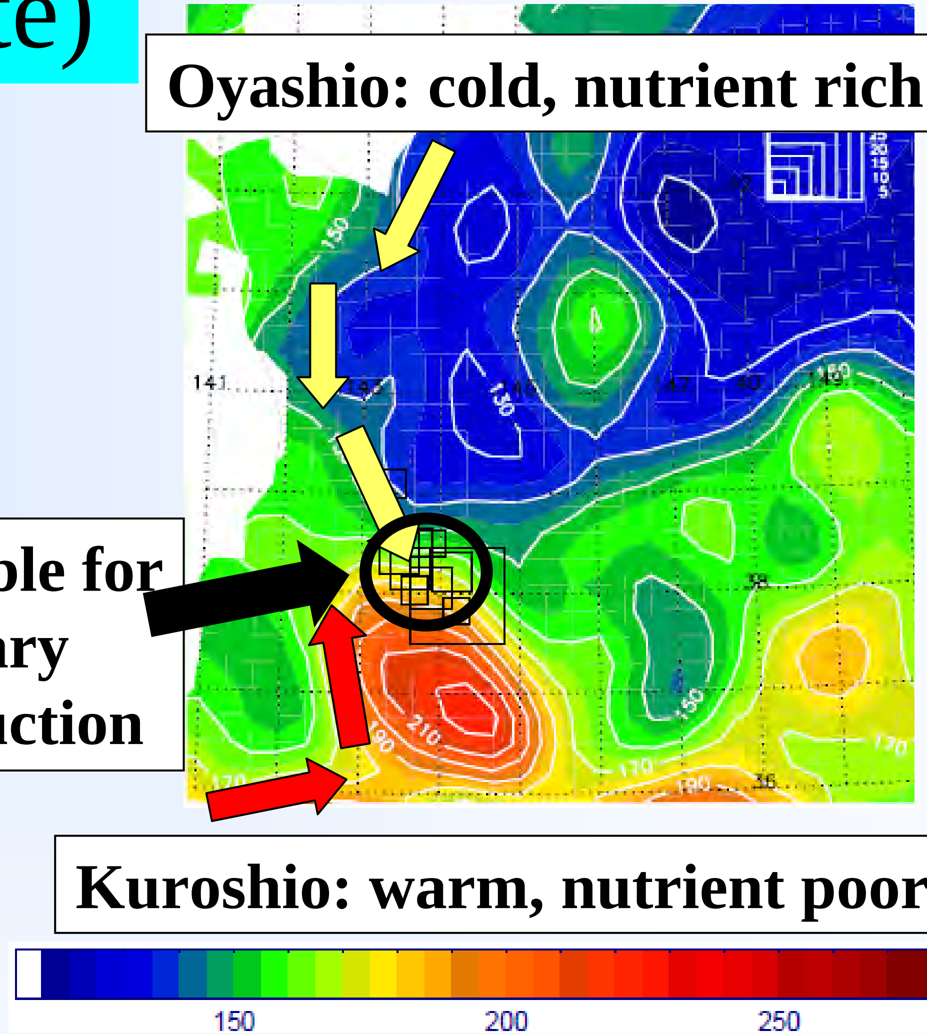


PR:0.305
K τ :0.209
S ρ :0.309

Estimated HSI map (15Feb.2007)

Oyashio: cold, nutrient rich

Suitable for primary production



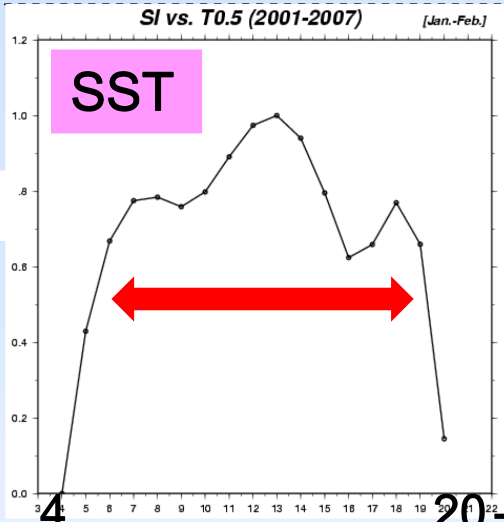
Kuroshio: warm, nutrient poor

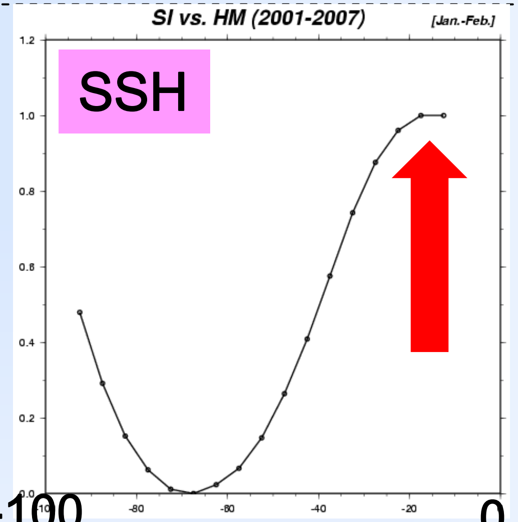
SSH map on 15Feb.2007

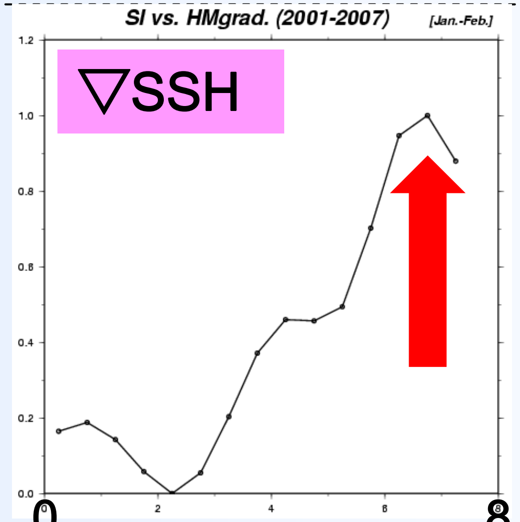
The mixture of Oyashio and Kuroshio and the local upwelling leads to high-productivity and high squid abundance.

MOVE SI model (2D)

SI







(Satellite)
PR:0.305
K τ :0.209
S ρ :0.309

PR:0.166
K τ :0.102
S ρ :0.152

(significant at 1%)

PR:0.227
K τ :0.132
S ρ :0.197

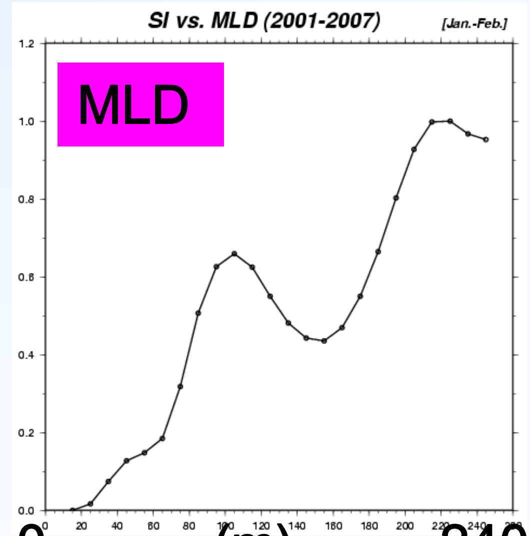
MOVE SI model(3D)

new input: mixed layer depth

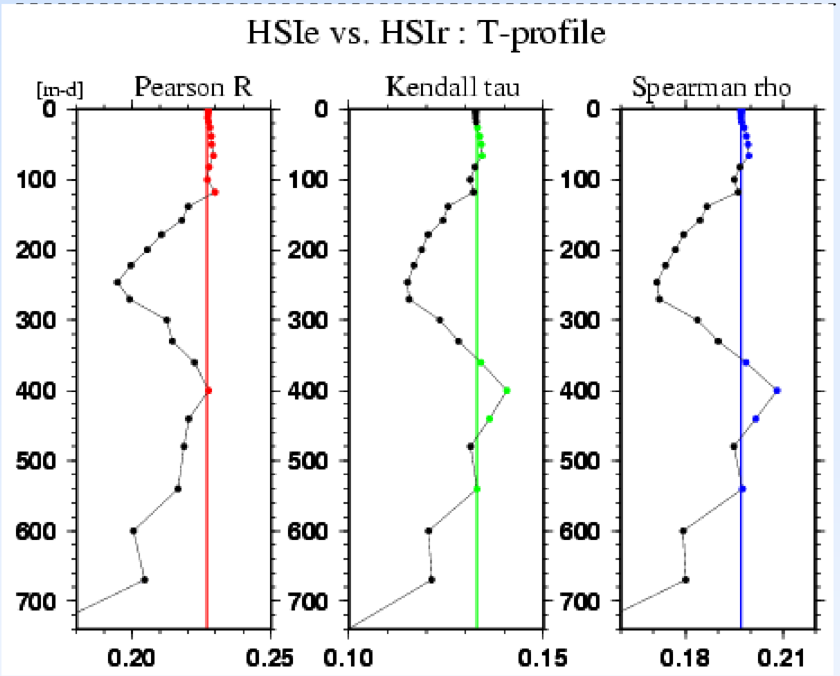
$$HSI = \sqrt[n]{\prod_{i=1}^{n} SI_i} \quad (n=3 \rightarrow n=4)$$

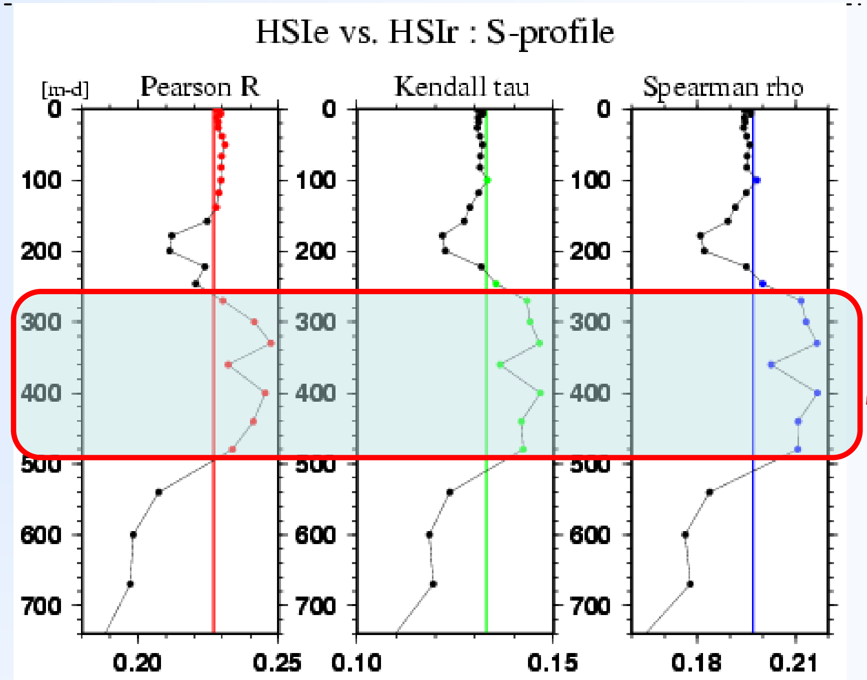
Nutrient supply from the deeper layer affects the feeding condition of neon flying squid.

Base-model: SST,SSH,∇SSH,MLD



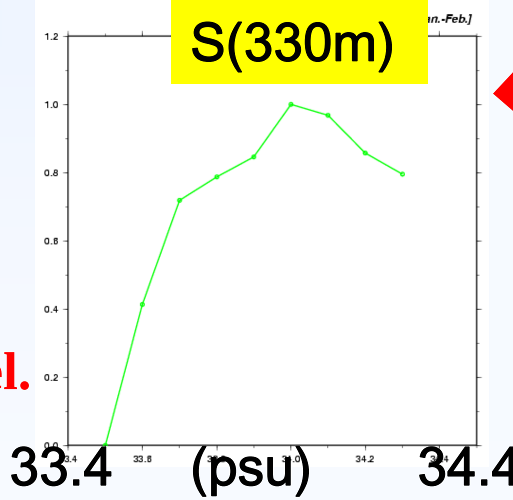
MOVE SI model (T,S selection)



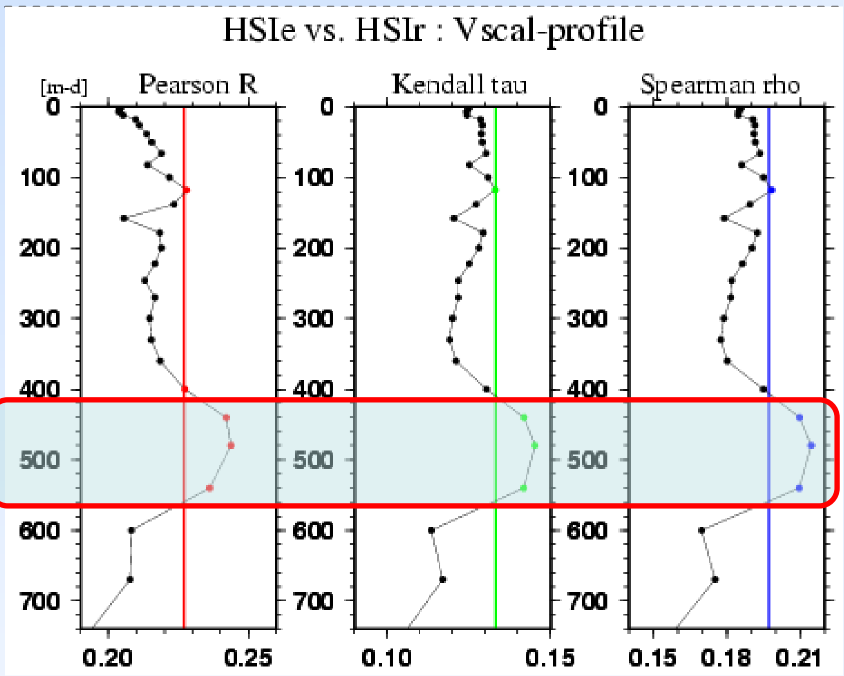


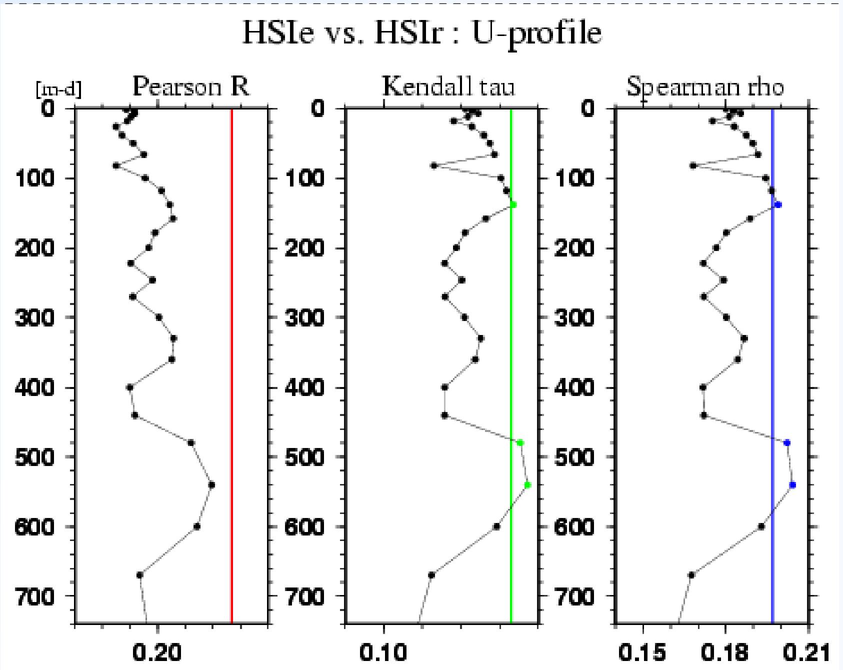
PR:0.227, K τ :0.132,
S ρ :0.197

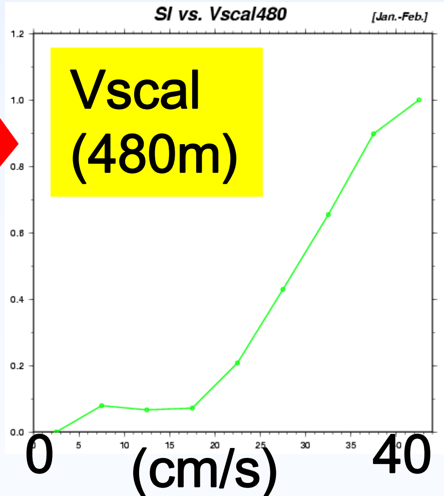
*T profile is similar to S profile.
*High corr.coef. can be seen in 300-500m-d in S.
*Higher salinity(330m) is preferable for squid.
S(330m) is selected as a new EV for MOVE-3D model.



MOVE SI model (Vscal, U selection)



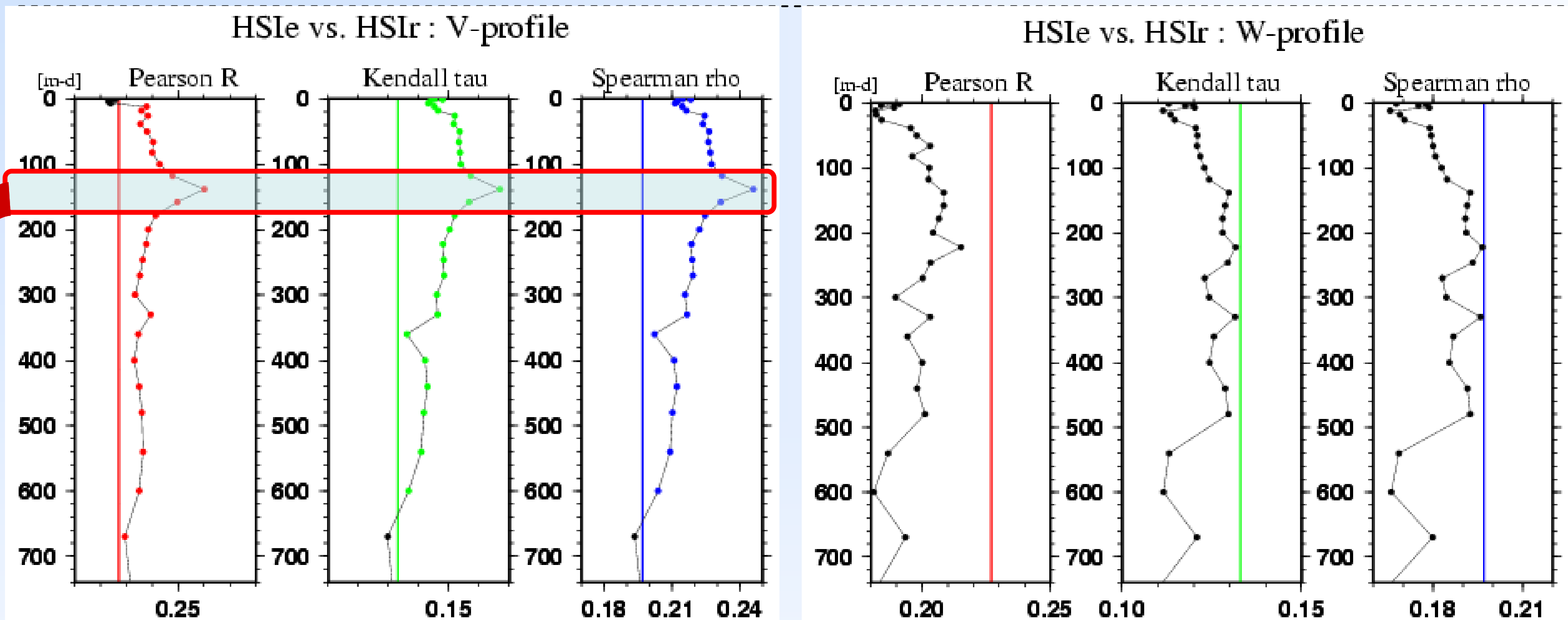


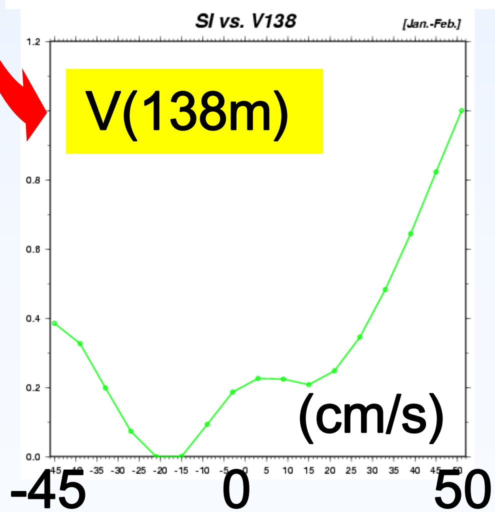


$$V_{scal} \equiv \sqrt{U^2 + V^2}$$

*Vscal profile is similar to U profile.
*High corr.coef. can be seen in 400-550m-d in Vscal.
*Higher Vscal(480m) is preferable for squid.
Vscal(480m) is selected for 3D-MOVE model.

MOVE model (V,W selection)



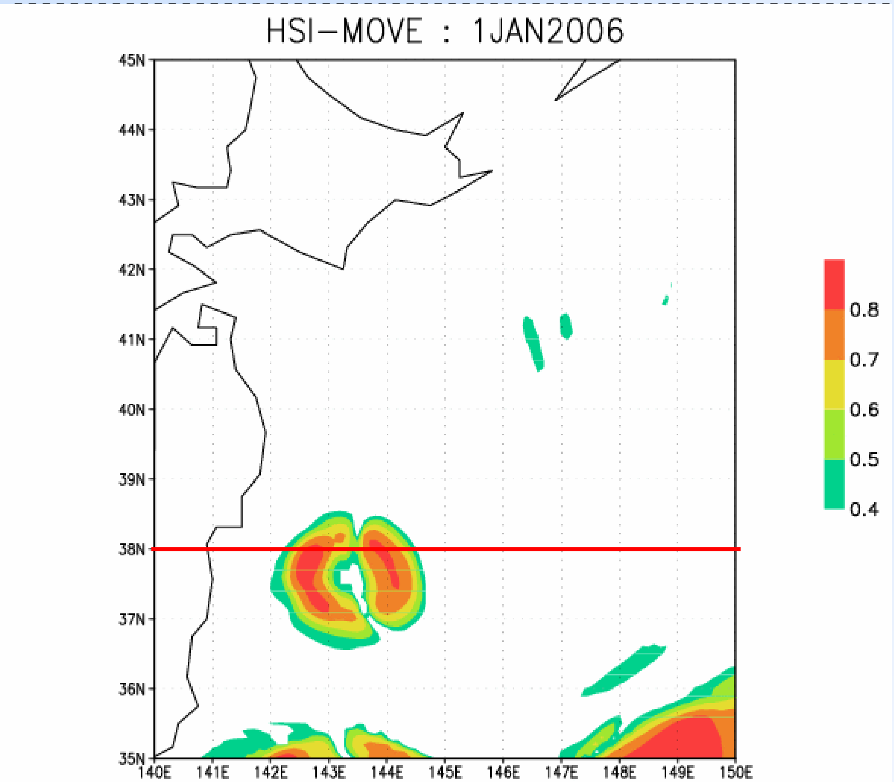


*High corr.coef. can be seen in V (all depth).
*Higher northward V(138m) is preferable for squid.
V(138m) is selected for 3D-MOVE model.

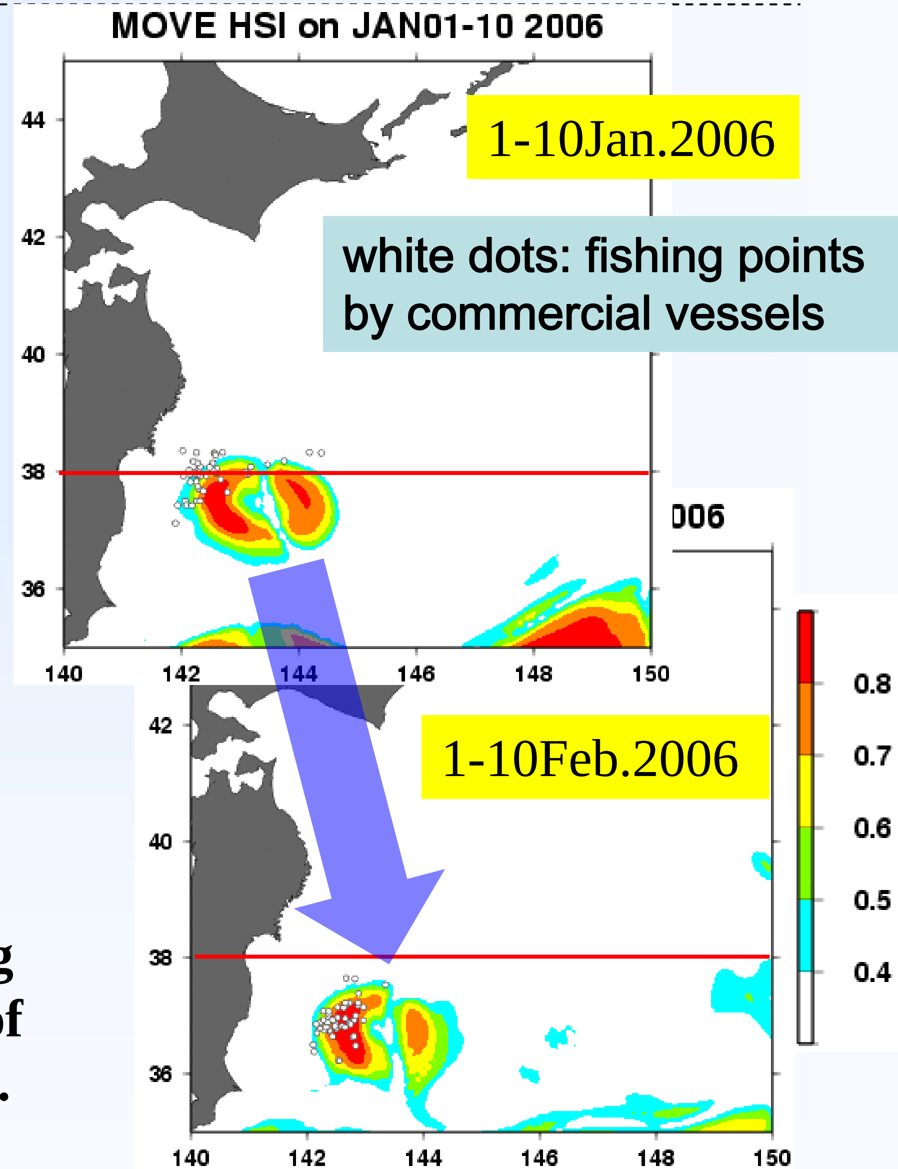
The north-south water mass transport is very important for regional primary productivity and subsequent feeding condition for neon flying squid.

HSI model (MOVE-3D)

SST,SSH,▽SSH,MLD, S330,Vscal480,V138



daily HSI map 1Jan.-28Feb.2006

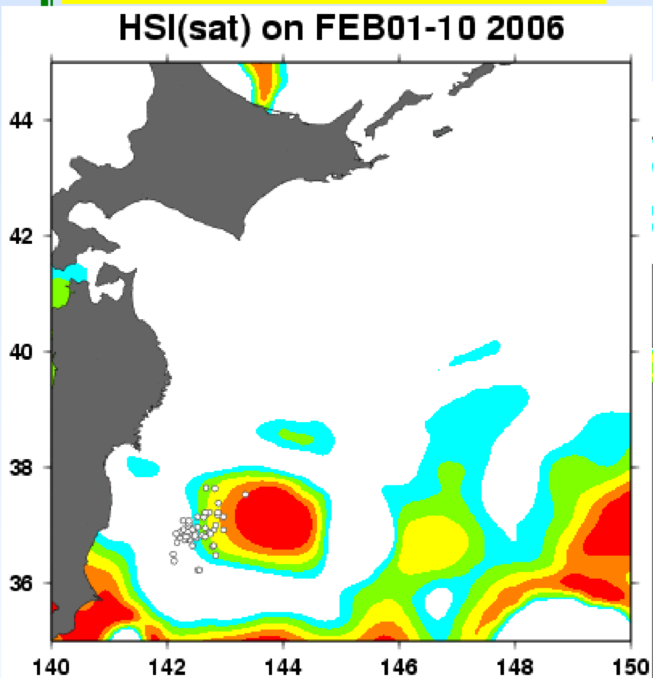


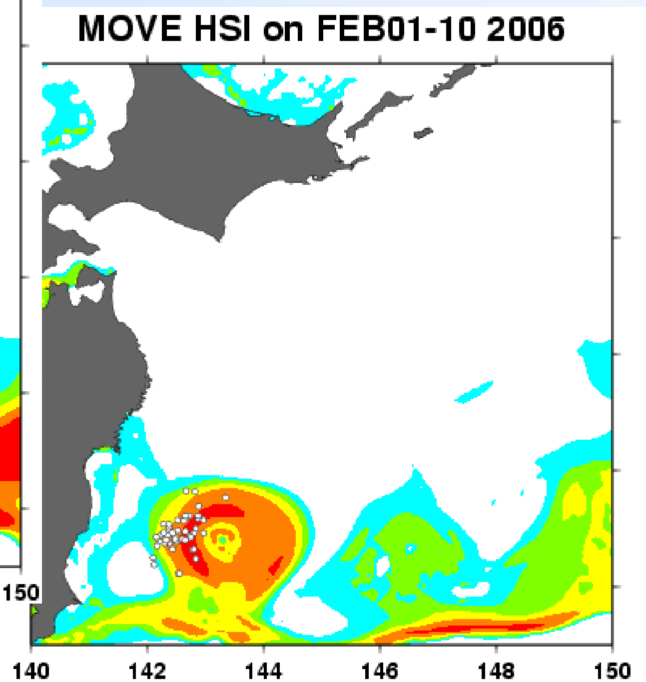
Southward transition of the actual fishing ground corresponding to the movement of the anti-cyclonic eddy is well-reproduced.

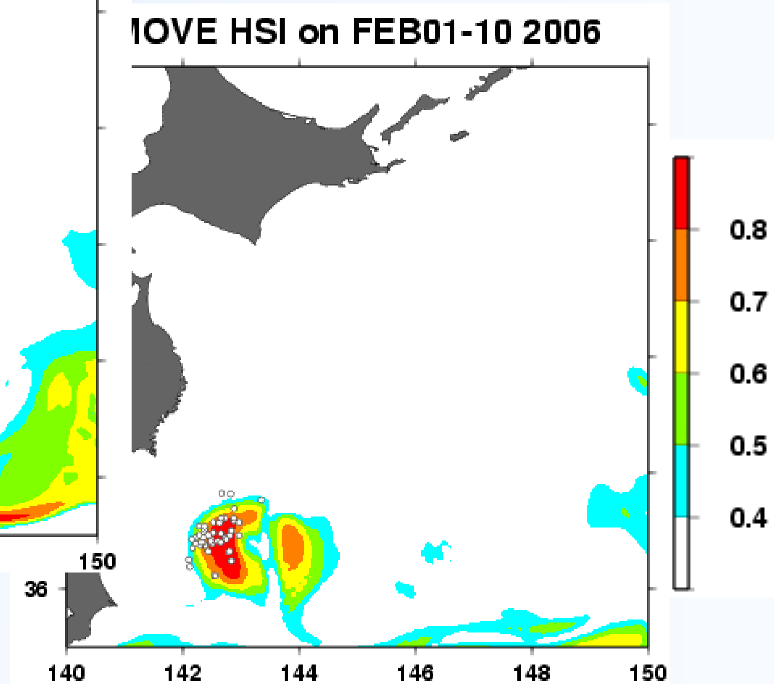
Comparing three models

(composite HSI map on 1-10Feb.2006)

Satellite-based model (SST,SSH,∇SSH)	MOVE-2D model (SST,SSH,∇SSH)	MOVE-3D model (SST,SSH,∇SSH, MLD,S330,Vscal480, V138)







white dots: fishing points by commercial vessels

Satellite-based model	MOVE-2D model	MOVE-3D model
PR:0.305	PR:0.166	PR:0.321
K τ :0.209	K τ :0.102	K τ :0.203
S ρ :0.309	S ρ :0.152	S ρ :0.295

concluding remarks

- The suitable habitat area for the winter-spring cohort east of northern Japan was investigated using satellite-based observational datasets and MOVE 3DVAR ODA product.
- HSI model by using MOVE data can expect to provide us realistic potential habitat fields of neon flying squid for practical use.
- The high HSI area is likely to locate the northern edge of anti-cyclonic eddies generated in the Kuroshio-Oyashio transition zone, which suggests the mixture of warm, nutrient-poor water in Kuroshio region and cold, nutrient-rich water in Oyashio region, and the local upwelling by meso-scale eddy activities leads to high-productivity and subsequent suitable habitat for neon flying squid.
- Mixed layer depth and V(N-S comp. of current speed)in the mixed layer are effective to improve the HSI model, which suggests the local nutrient supply from deeper layers and northward advection of water mass are important for feeding condition.