Application of GCOM-C1 datasets to sustainable development and management for ecosystem-based fisheries and aquaculture

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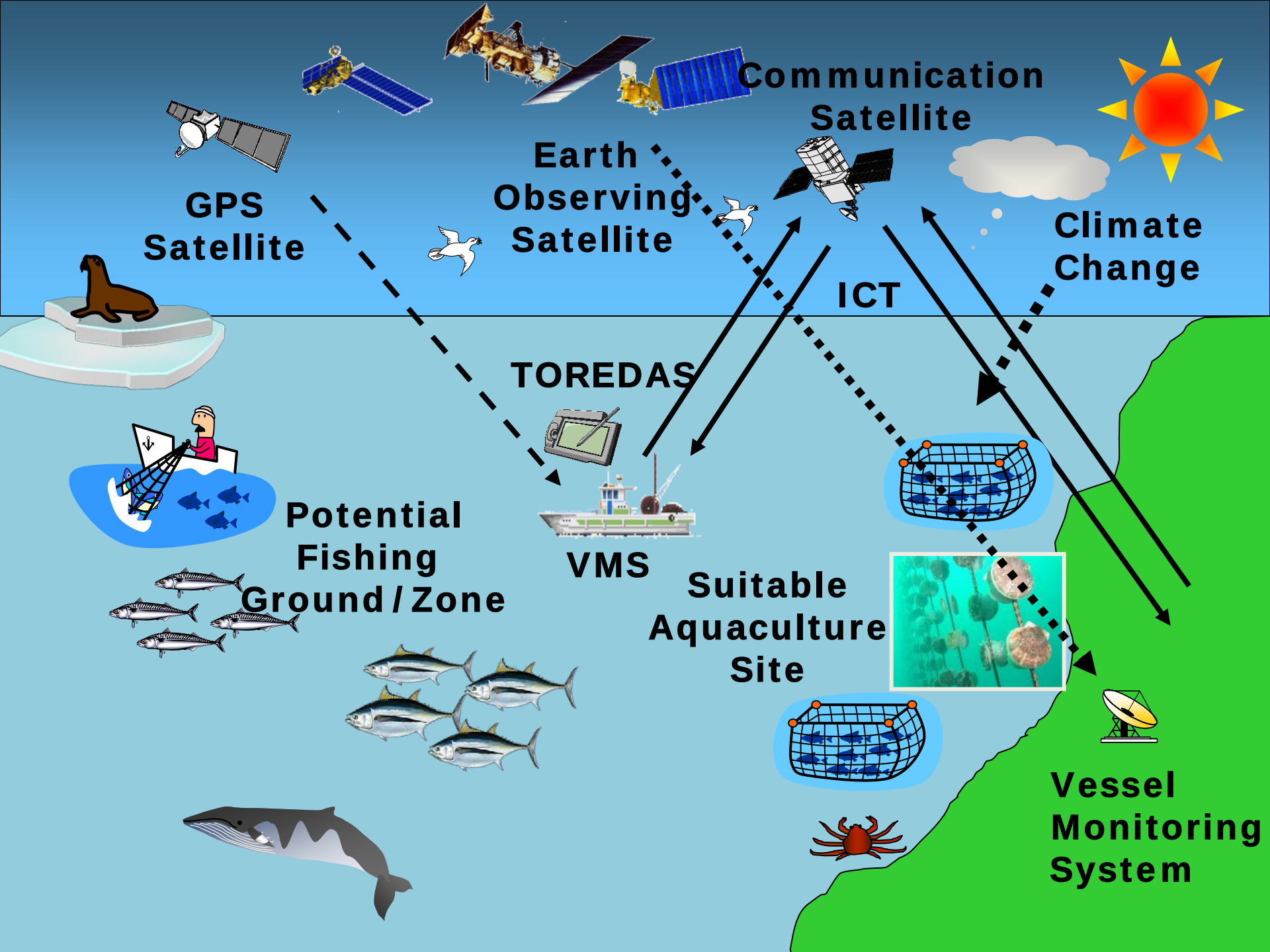

Communication Satellite
Earth Observing Satellite
GPS Satellite
Climate Change
ICT
TOREDAS
VMS
Potential Fishing Ground / Zone
Suitable Aquaculture Site
Vessel Monitoring System

Members (PI and Co-Pis)

- PI: Sei-Ichi **Saitoh** (Hokkaido University/ G&LI Inc.)
- Co-PI: Fimihiro **Takahashi** (G&LI Inc./ Hokkaido University)

  Satsuki **Matsumura** (FRA / G&LI Inc.)

  Yang **Liu** (Post-Doc, Hokkaido University)

  Chris **Aura** (Ph. D course, Hokkaido University)

  Xun **Zhang** (Ph. D course, Hokkaido University)
- Collaboration:

  Hideaki **Kidokoro** (Japan Sea National Research Institute, FRA)

  Katsuhisa **Baba** (Hakodate Fisheries Experimental Research Laboratory, Hokkaido)

Goals

- To develop spatial model of potential fishing ground（Zone) and suitable site for aquaculture and apply them to operational use for capture fisheries and aquaculture
- To promote new ICT fisheries business using satellite information

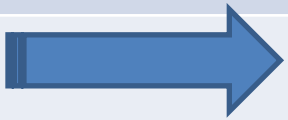
Japanese common squid

Todarodes pacificus

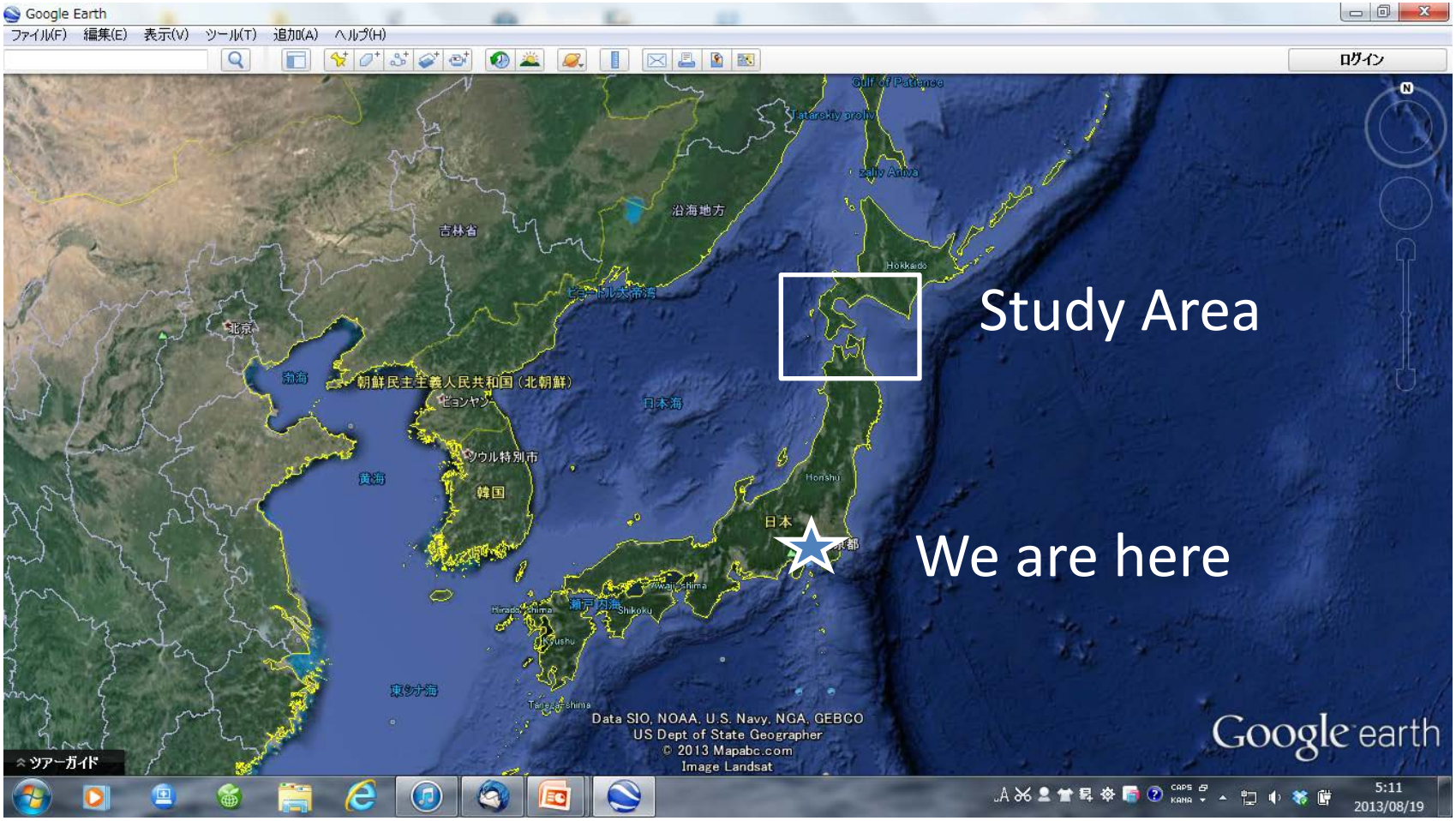
Activities

- Research cruise to obtain *in situ* coastal environment dataset (T/S *Ushio-Maru*)
- Analysis of fishing fleet position dataset and satellite remote sensing dataset (Pacific Saury and Japanese Common Squid)
- Development and verification of spatial model for scallop and kelp aquaculture site
- Analysis of climate change effect on suitable site of scallop and kelp aquaculture

Research Plan

Study	FY2013	FY2014	FY2015	FY2016
PFZ Japanese common squid				
Suitable Site Japanese scallop				
Information Service System Development				
GCOM-C1 Operational Use				

Study Area


Google Earth
ファイル(F) 編集(E) 表示(V) ツール(T) 追加(A) ヘルプ(H)
ログイン
Study Area
We are here
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer
© 2013 Mapabc.com
Image Landsat
Google earth
ツアーガイド
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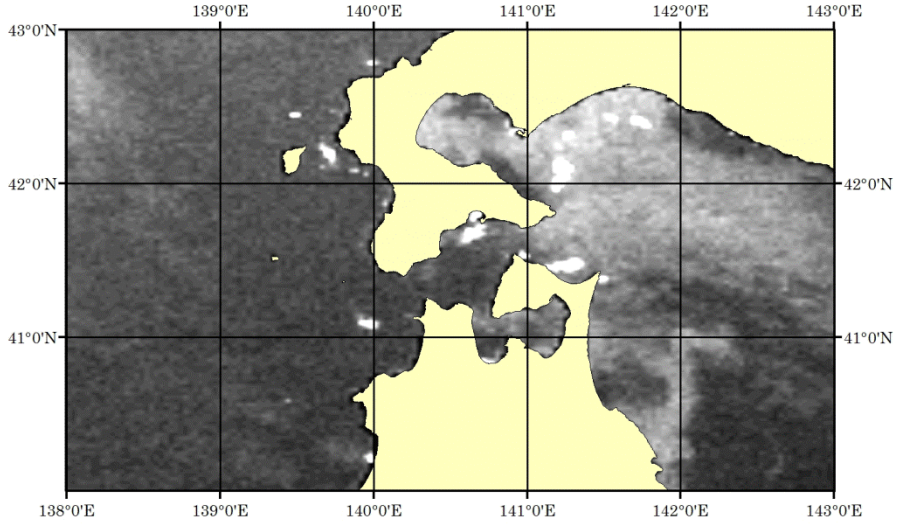
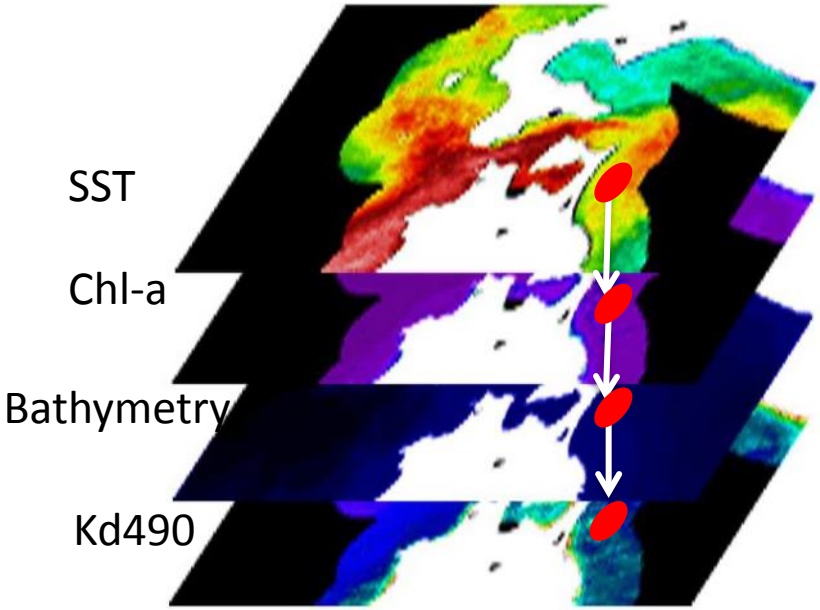
Our Previous Study

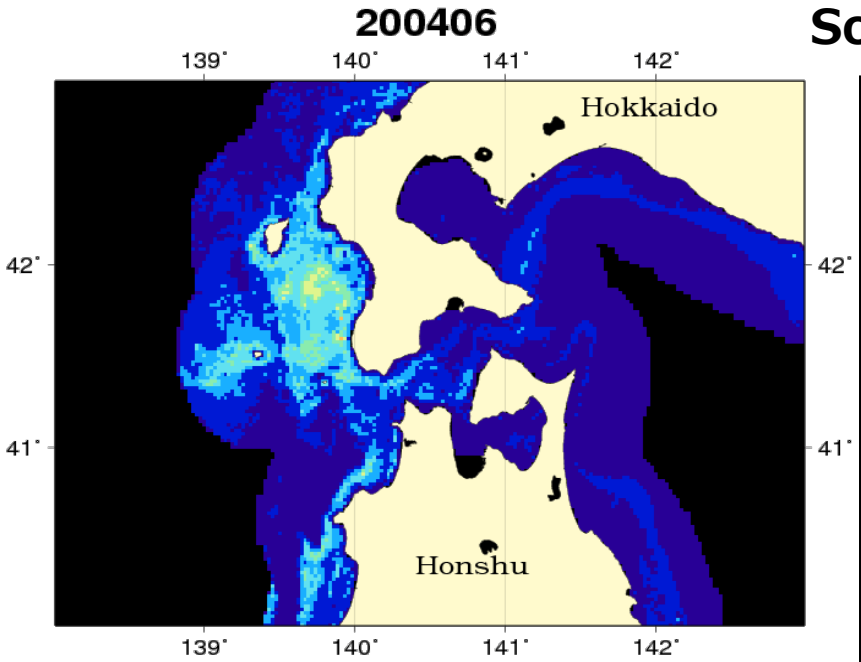
- Satellite-derived environmental layers were used to predict potential fishing zone (PFZ)
- Predictions had good quality but can hardly meet the daily requirements due to the low coverage of satellite-derived data (weather restrictions)



Nighttime visible data of Aug. 28th, 2012



Our Previous Study



Simulation of the prediction model using past monthly satellite-derived data(2004-2011)

Source of data used in our previous study

Data	Source	Spatial Resolution	Temporal Resolution	Period
Fishing location	DMSP/ OLS	2.7 km	Daily	2000-2002 (model) 2003 (comparison) 2004-2009 (simulation)
Nighttime SST	AVHRR MODIS	4 km	Daily	
Chl-a	SeaWiFS MODIS	1 km	Daily	
Kd490	SeaWiFS MODIS	1 km	Daily	
Depth	JODC	500 m		

Monthly simulations showed west-east moving patterns every year and these patterns are in agreement with the actual fishing distributions.

Objectives

- To improve our predictions and achieve applicable daily prediction of potential fishing zone in the coastal water, southwestern Hokkaido, Japan
- To understand how environmental factors influence the squid distribution
- To evaluate performance of the predictions by using DMSP/OLS nighttime visible data and NPP/VIIRS DNB(Day/Night band) data
- To facilitate the development of the local squid fisheries

Methods

Model: Boosted regression trees (BRT)

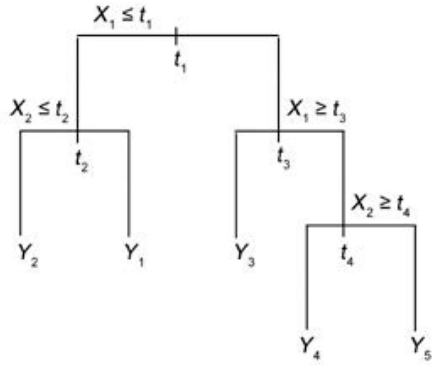
Combine the strengths of two algorithms

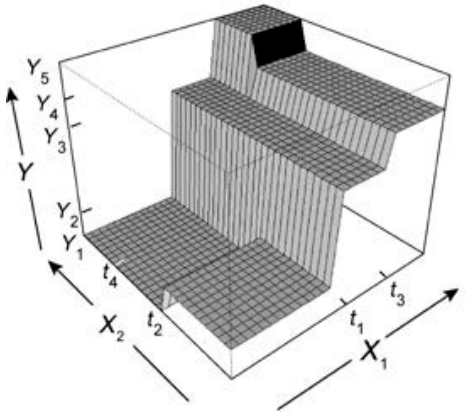
1. Regression Trees

(models relate response to predictors by binary splits)

2. Boosting

(combine many simple models to give improved predictive performance)





A single decision tree, with a response *Y*, two predictor variables, $X_1$and X_2 and split points t_1, t_2, etc. (Elith et al., 2008)

Performance evaluation

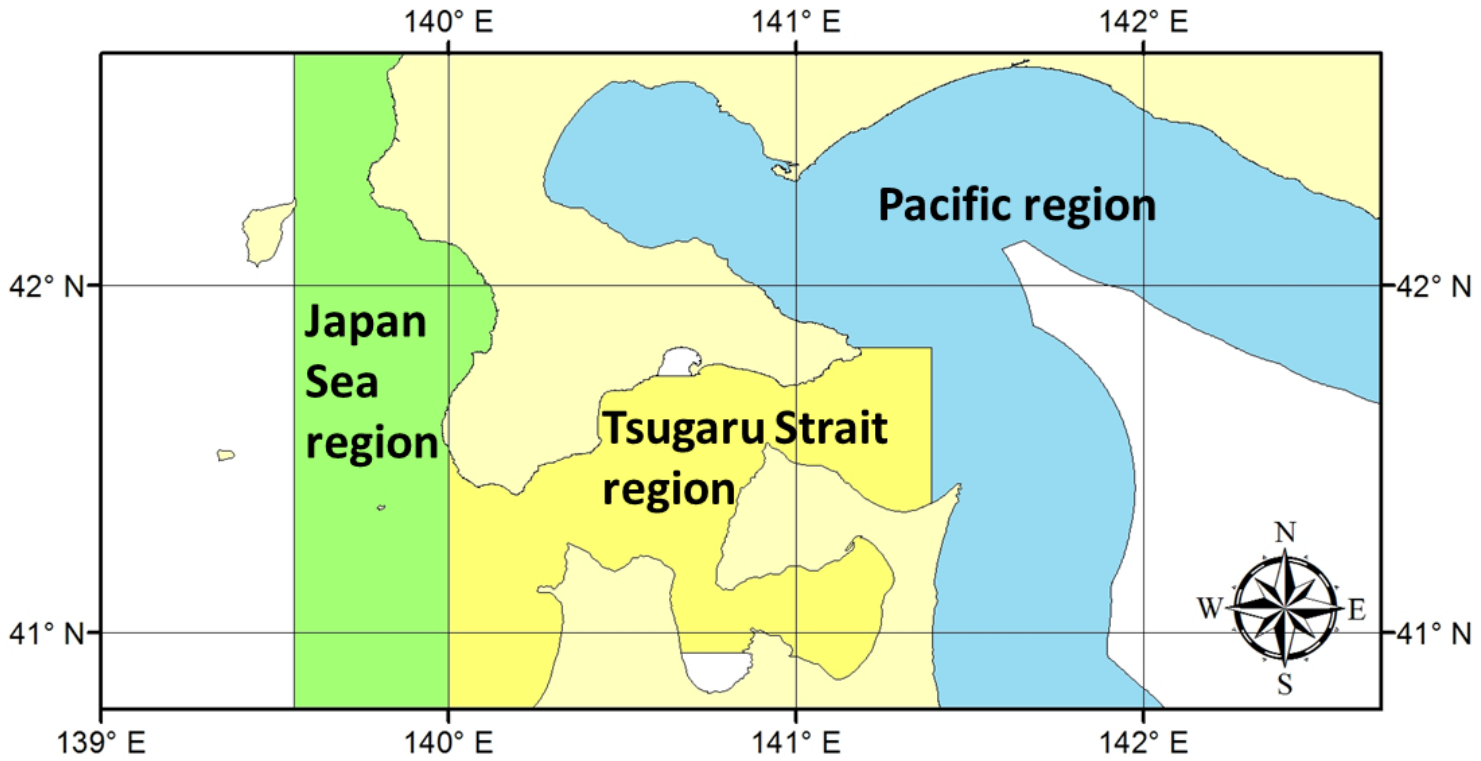
AUC

Area Under the Curve of the Receiver Operation Curve (ROC)

Point biserial correlation coefficient

Correlation between predicted values and occurrence(Presence/Absence) from the nighttime visible data

Sub-Area

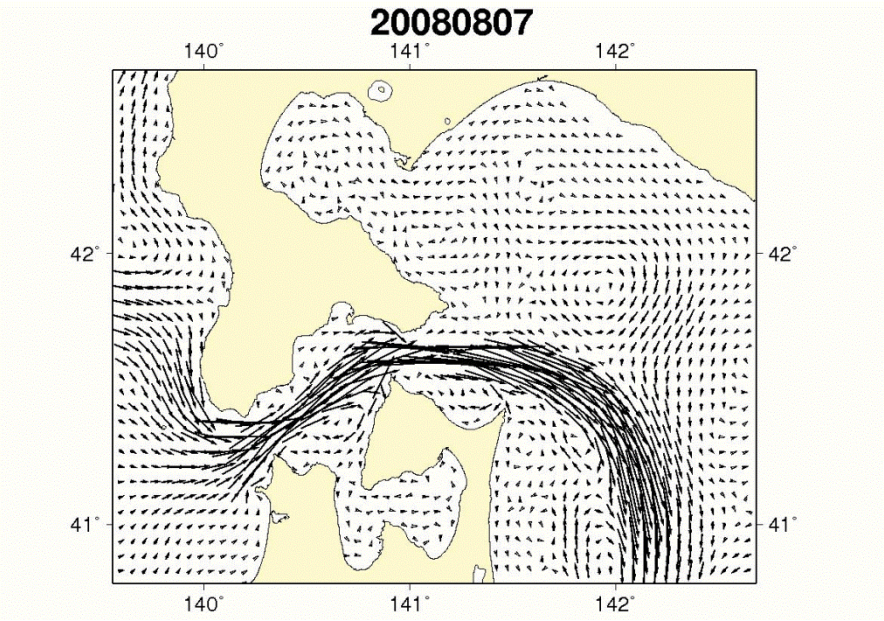


Daily *u, v,* temperature, salinity, EKE in different depth

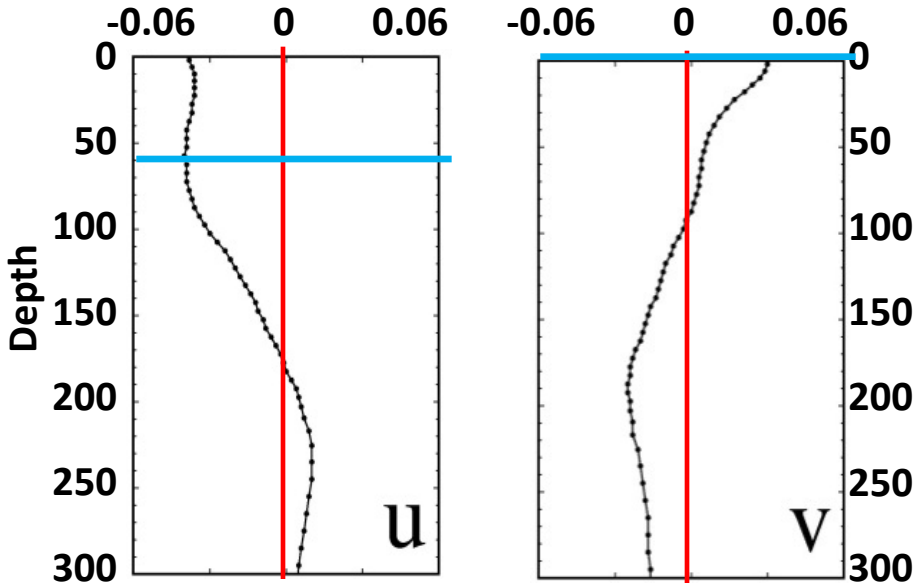
(4D-VAR data assimilation system, Kyoto University)

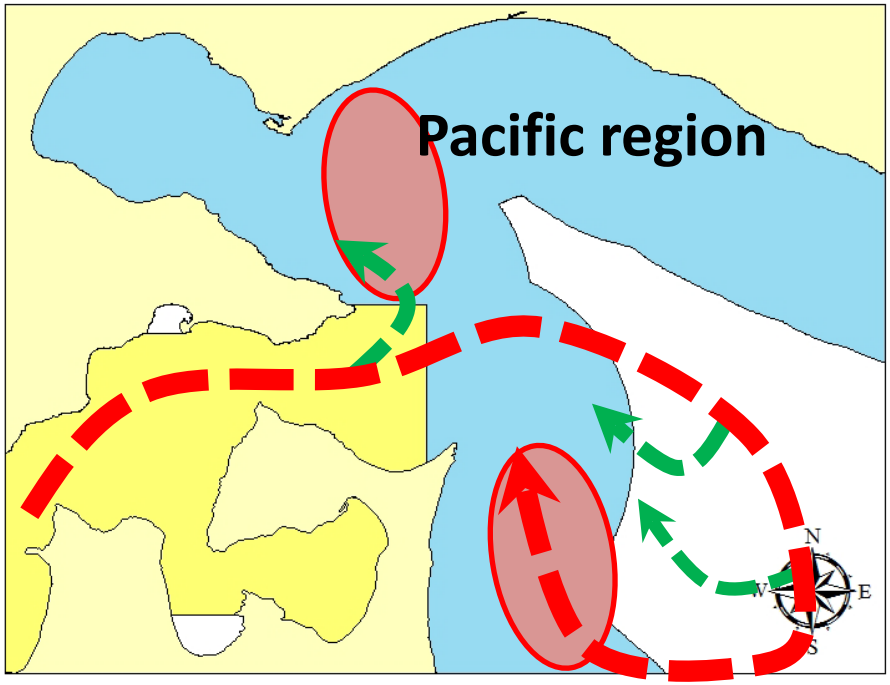
Bathymetry (JSFO)

Three regions were divided due to their different oceanographic features, depth of parameters are decided based on feasibility and our previous study on coefficient of correlations



Current (Depth: 2m)

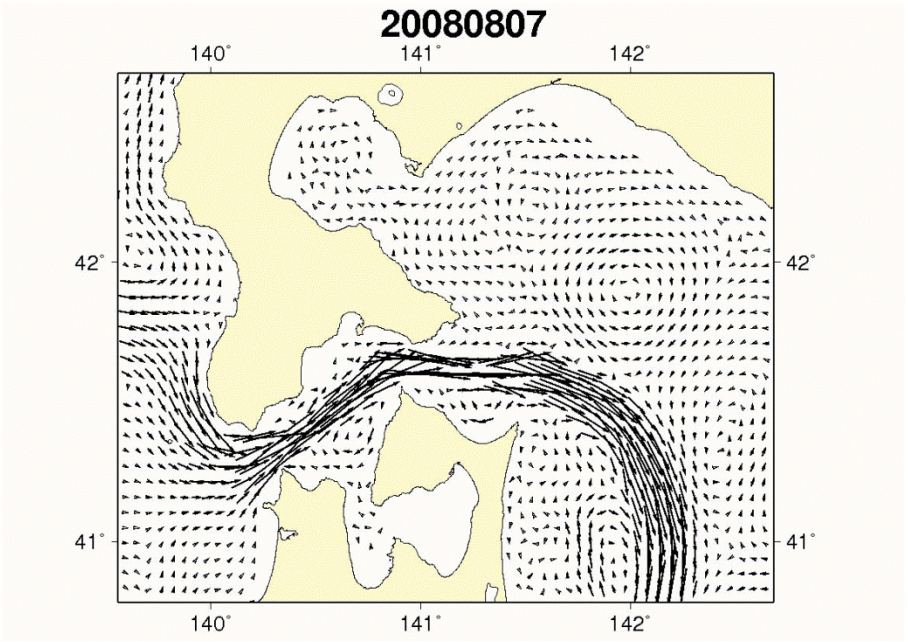




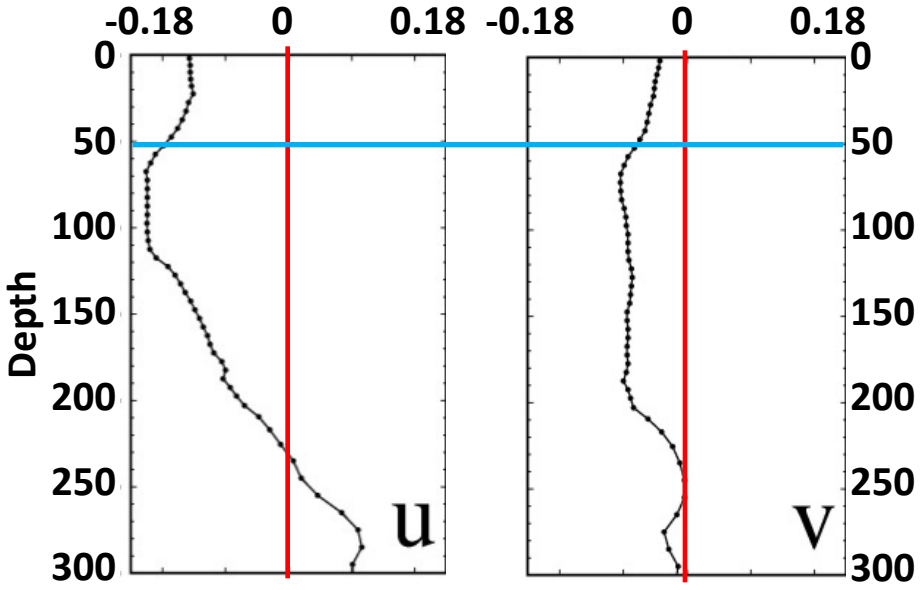
太平洋域

u(Negative) = 西向き
v(Positive) = 北向き

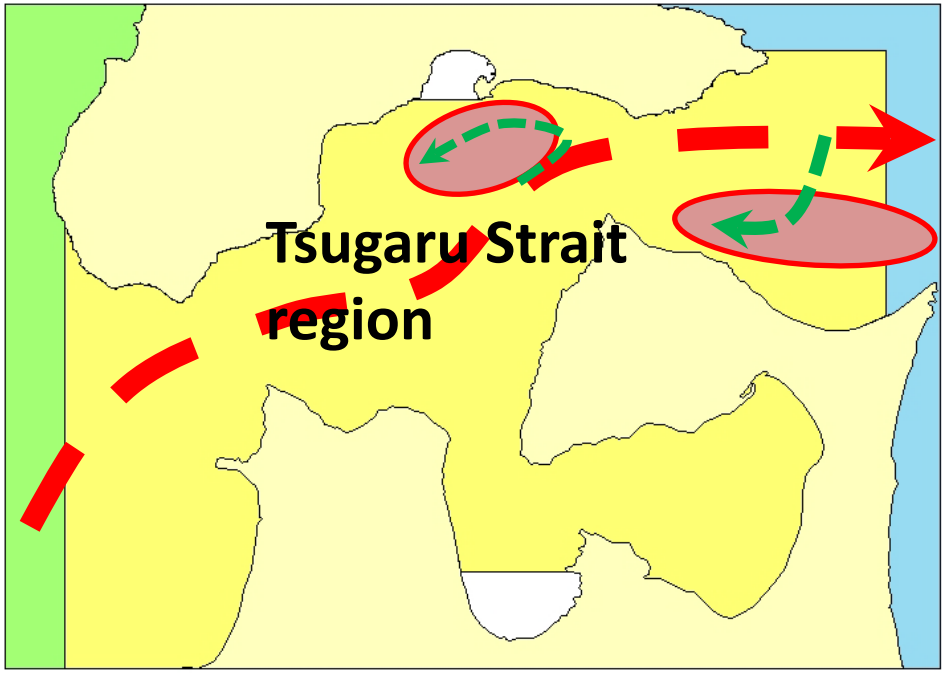
北西方向の反流域に
漁場が形成されやすい



Current (Depth: 50m)



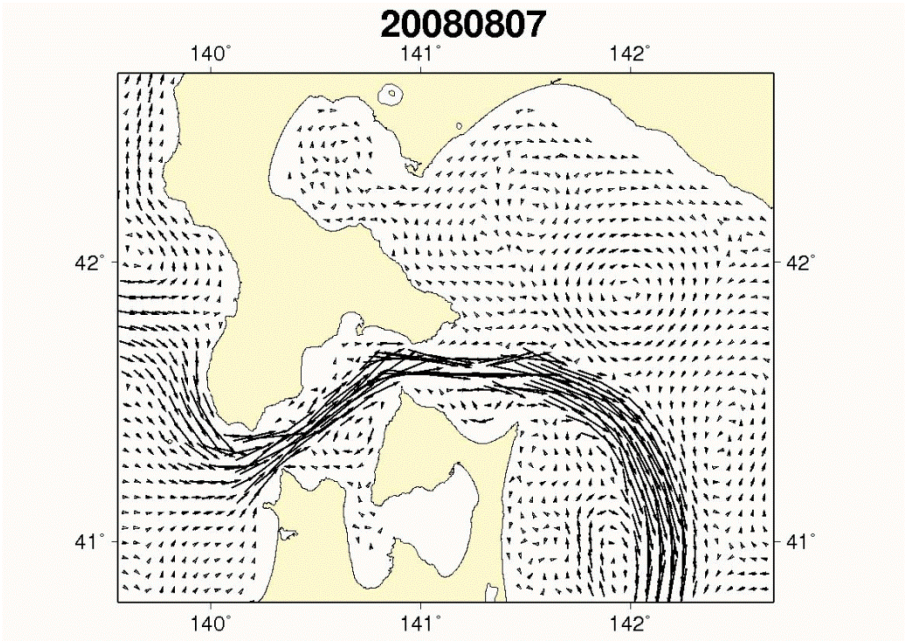
Tsugaru Strait region



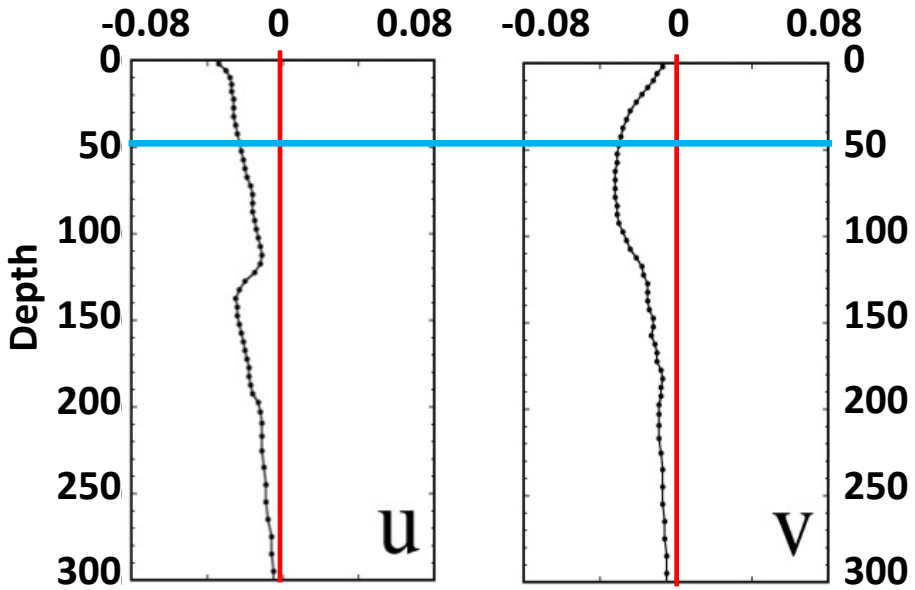
津軽海峡域

u(Negative) = 西向き
v(Negative) = 南向き

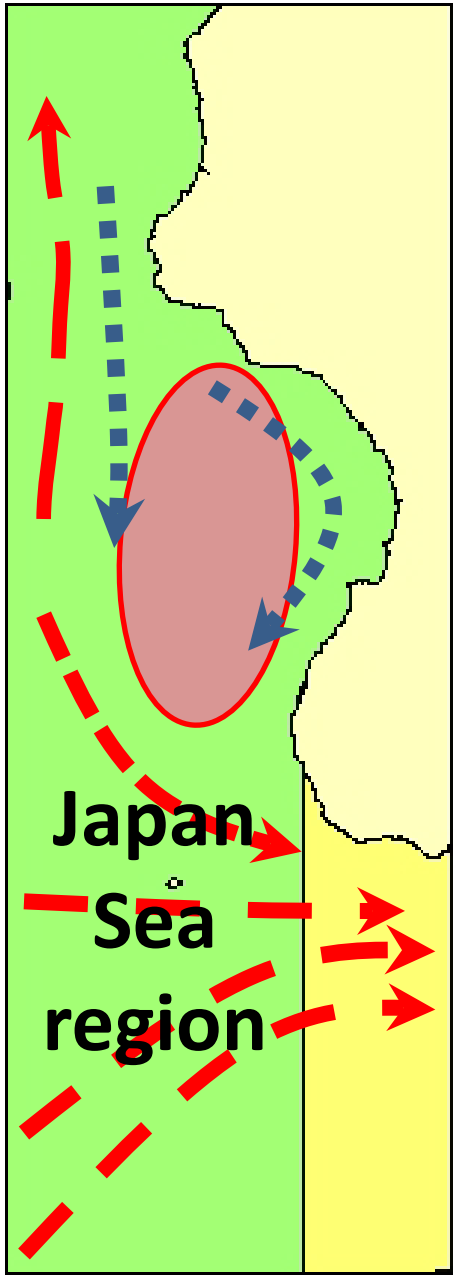
南西方向の反流域に
漁場が形成されやすい



Current (Depth: 50m)



日本海域



u(Negative) = 西向き

v(Negative) = 南向き

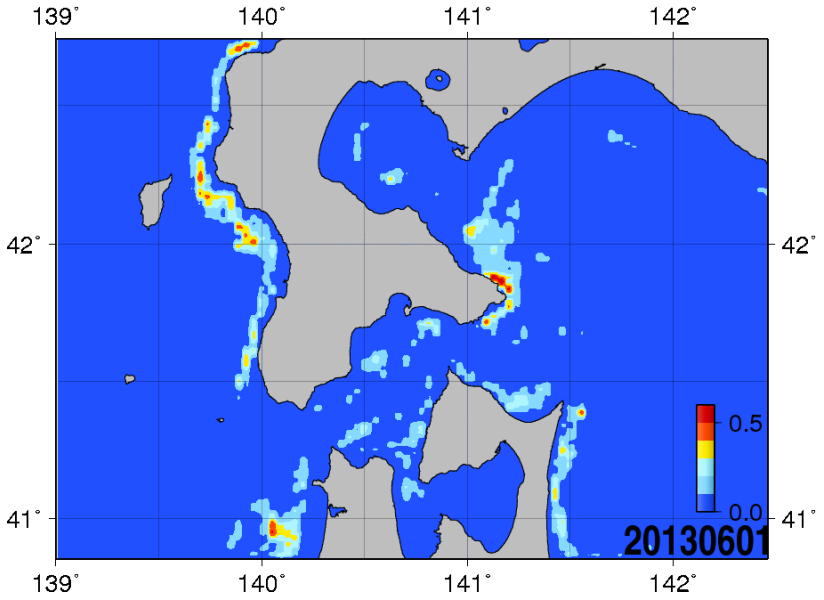
南西方向の反流域に漁場が形成されやすい

Results

Factors selection
(Base on correlation coefficient)

	Japan Sea	Tsugaru	Pacific
u	50m	50m	50m
v	50m	50m	2m
Temperature	50m	50m	100m
Salinity	50m	20m	50m
EKE	50m	50m	50m

Model	AUC	Correlation
4DVAR-based	**0.86**	**0.29**
Satellite-based	**0.82**	**0.23**



Predictions between June 1st and July 7th

AUC and correlation coefficient are used for model evaluation based on an independent OLS dataset.

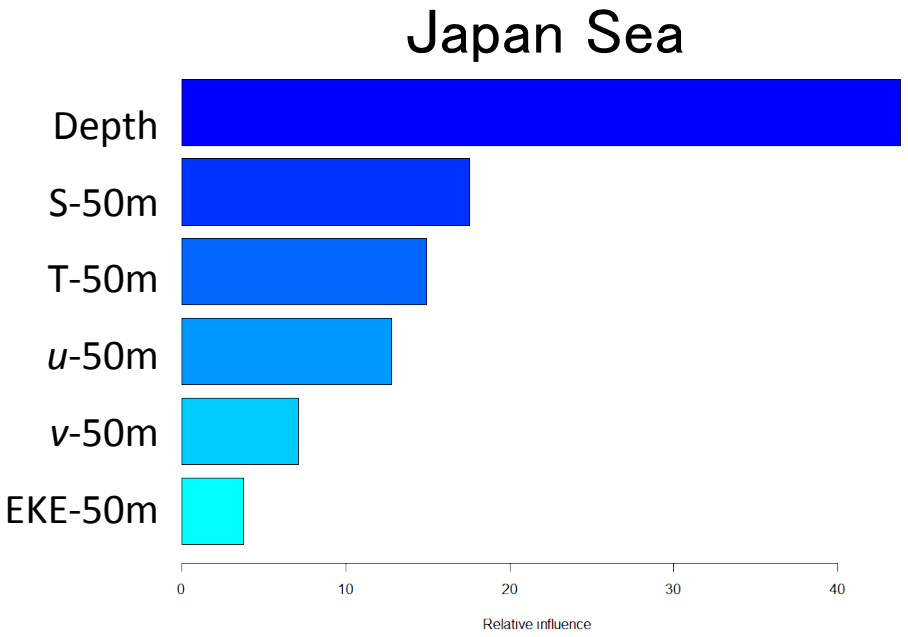
Both of these two statistical criterion suggested prediction using 4D-VAR dataset had better performance.

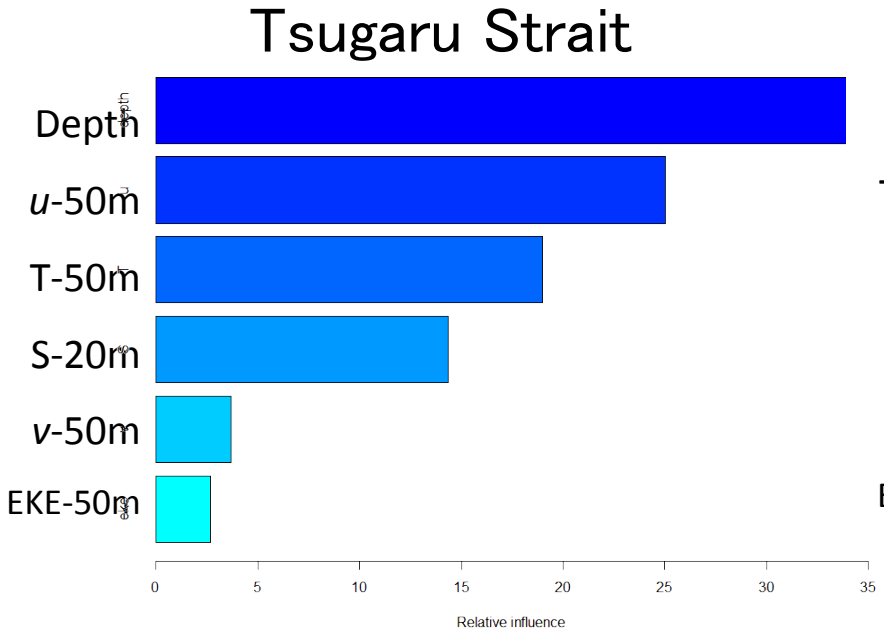
Results

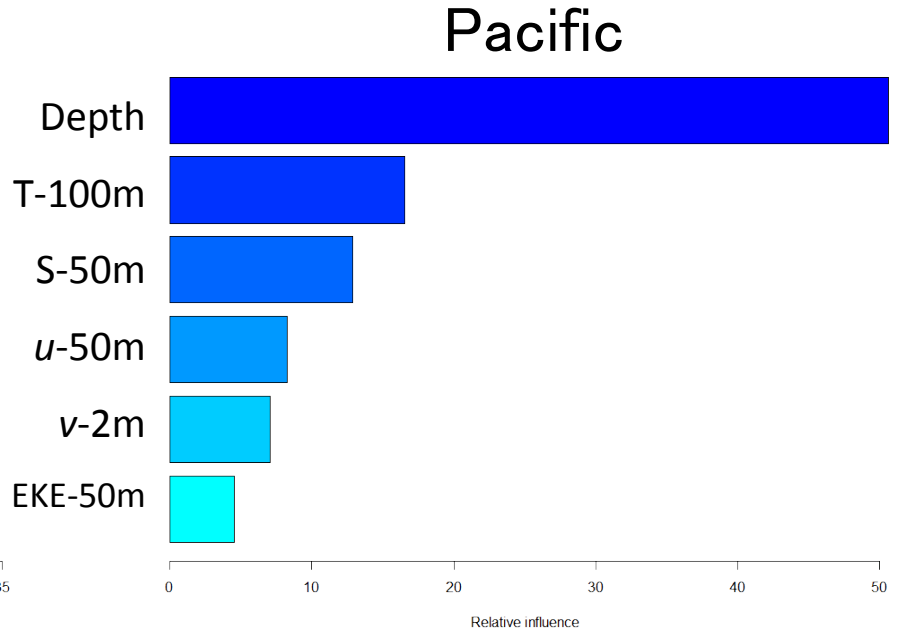
Relative influence of parameters indicated that bathymetry highly influenced squid distributions.

Currents in east–west direction have bigger effects on squid distributions than north–south direction.

Relatively, EKE had least impacts on squid distributions



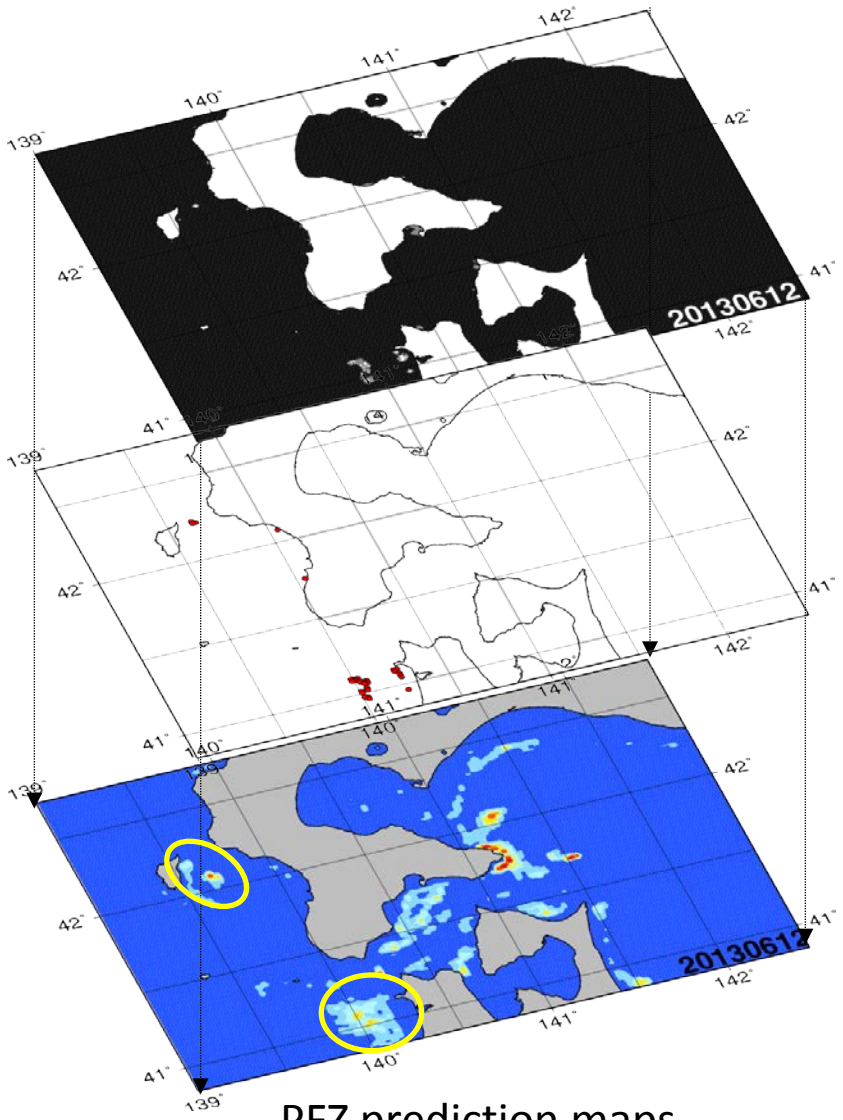




Methods

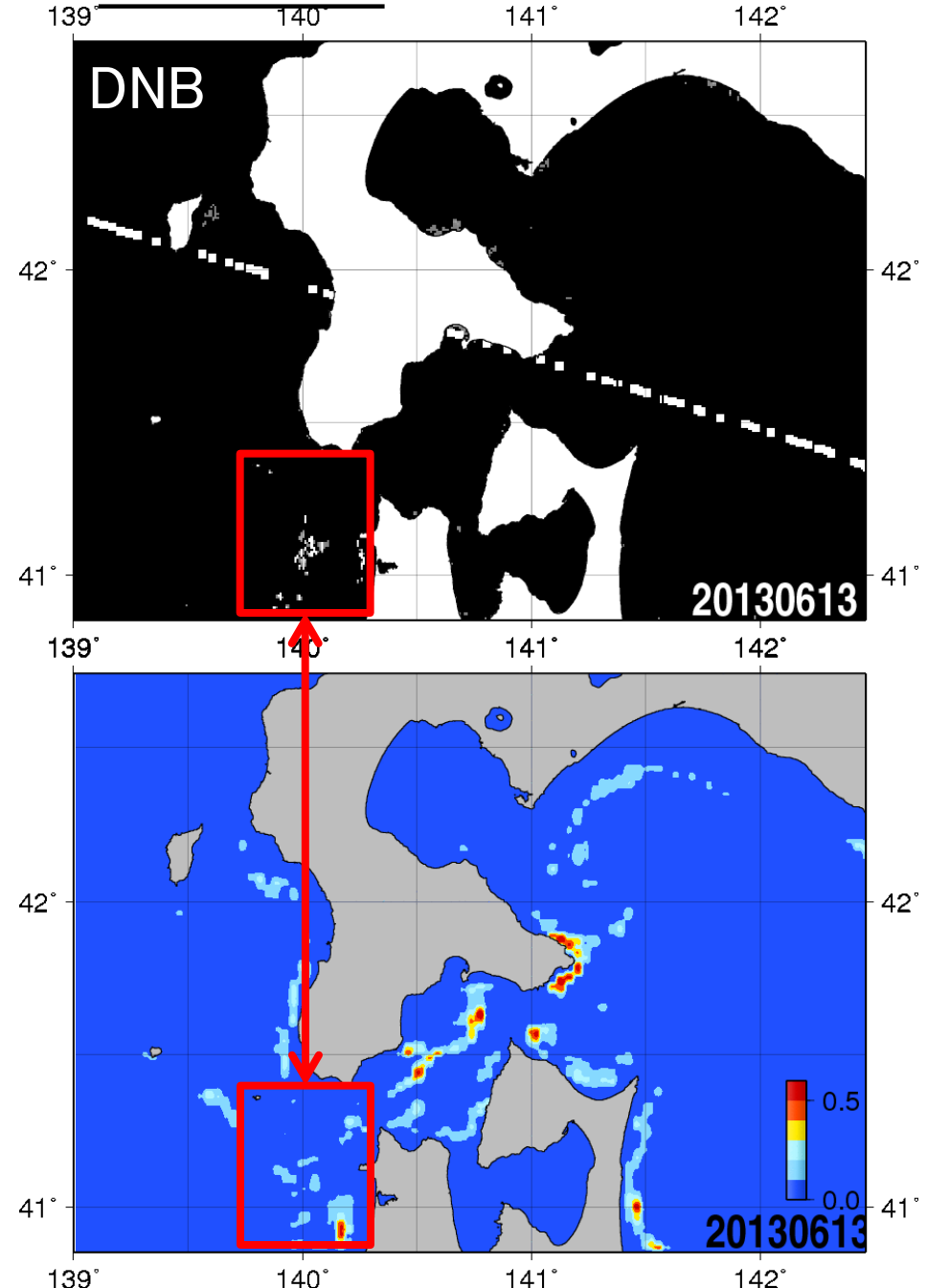
- **Extract the fishing locations from NPP/VIIRS nighttime visible images**
- **Overlap the actual fishing locations with prediction maps to extract the corresponding prediction value**
- **Calculate the percentage of hits in three different regions (Due to the low occurrence rate, prediction values are very low, we defined the value above 0.1 as the presence of the predictions)**

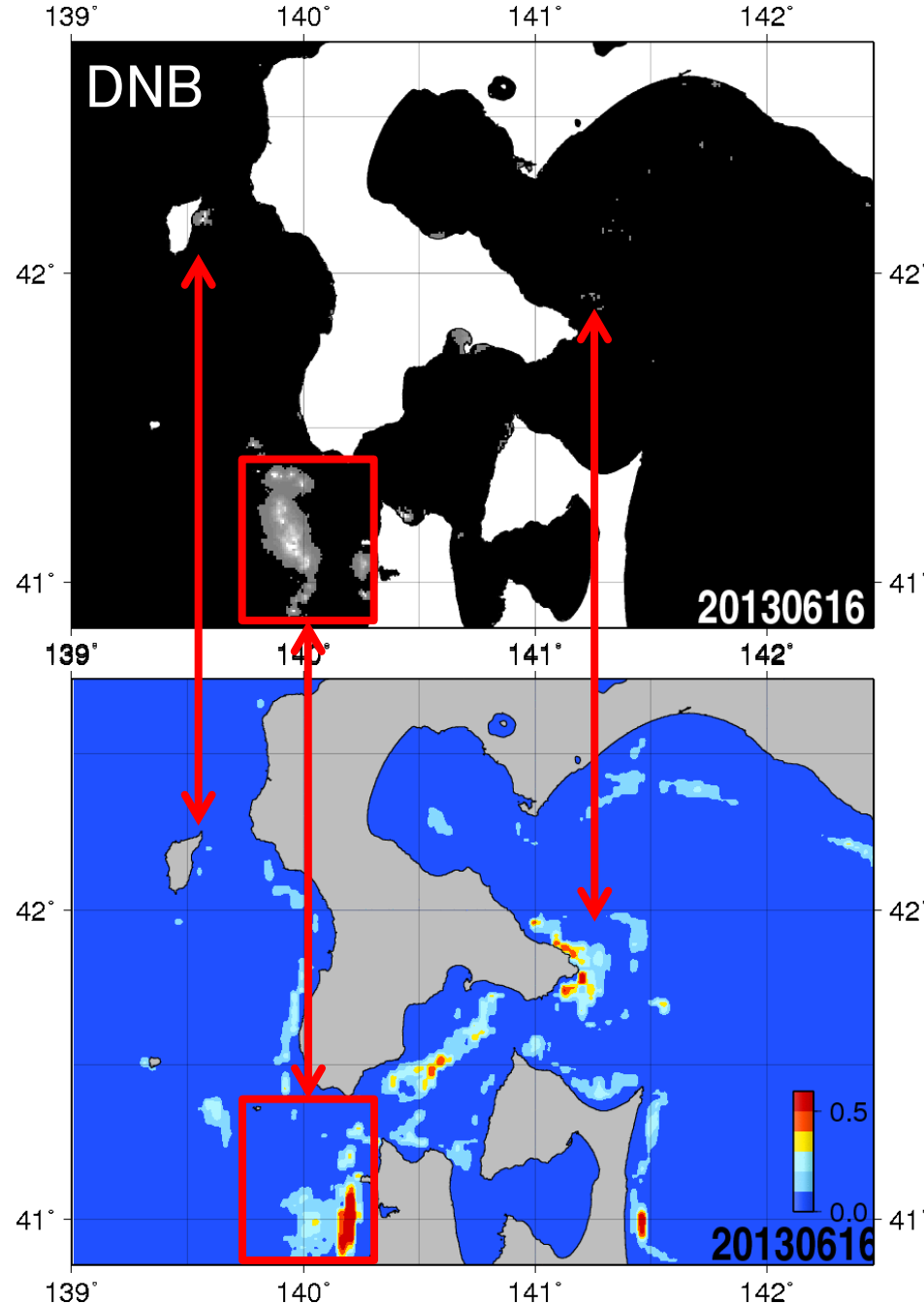
NPP/VIIRS nighttime images



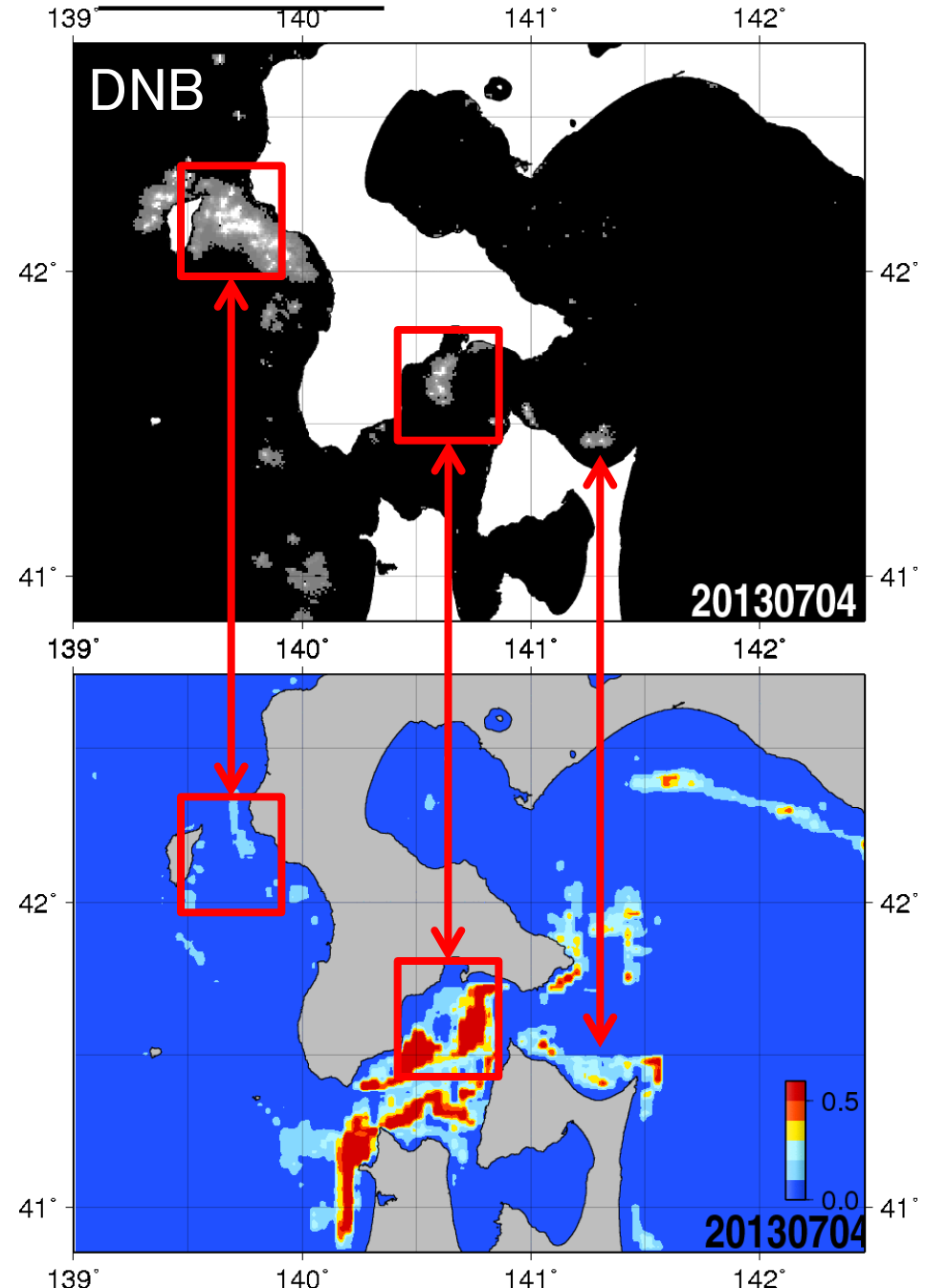
PFZ prediction maps

Results


DNB
20130613
0.5
0.0
20130613
139°
140°
141°
142°
42°
41°


DNB
20130616
0.5
0.0
20130616
139°
140°
141°
142°
42°
41°

Results


DNB
20130704
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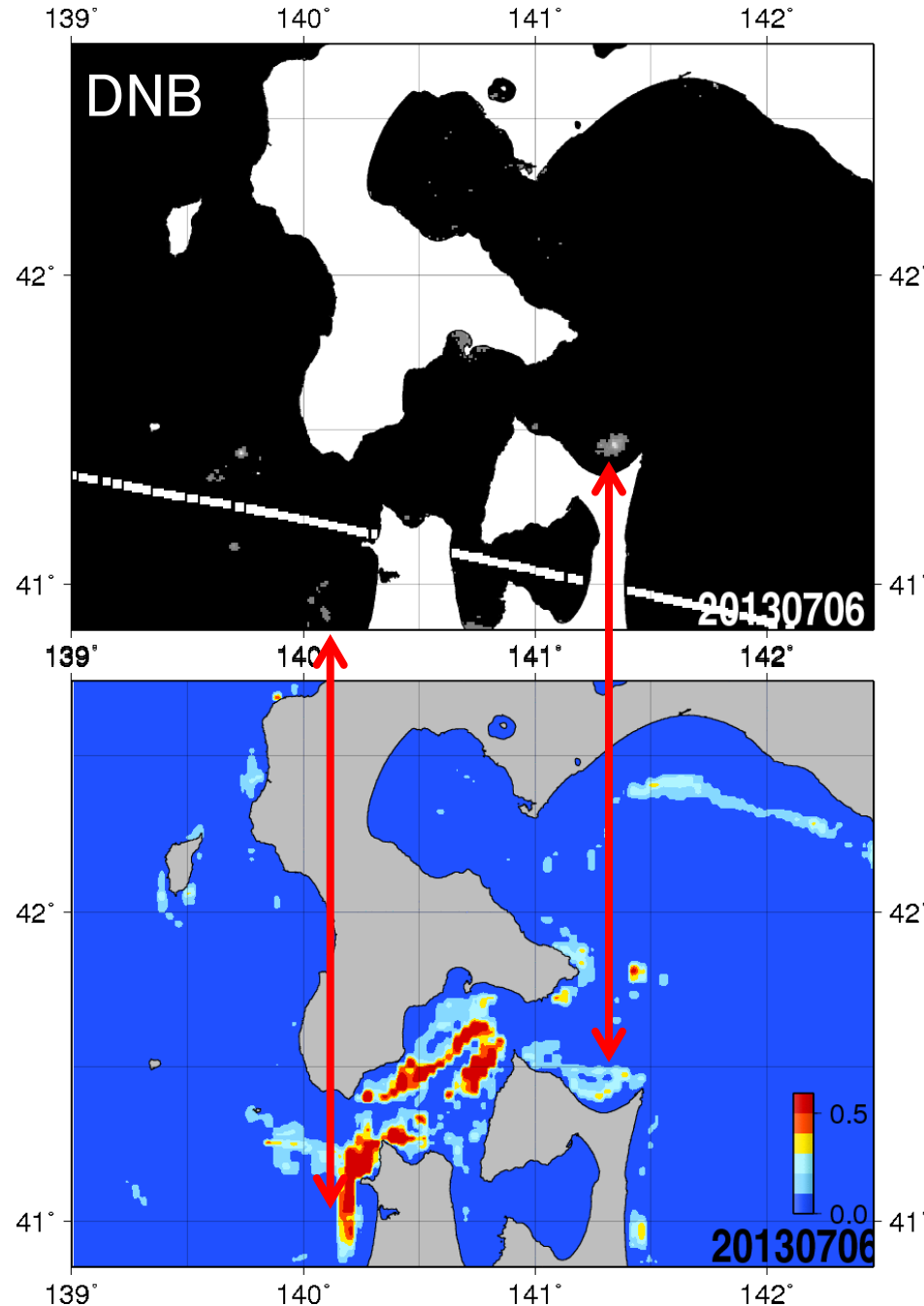
DNB
20130706
139°
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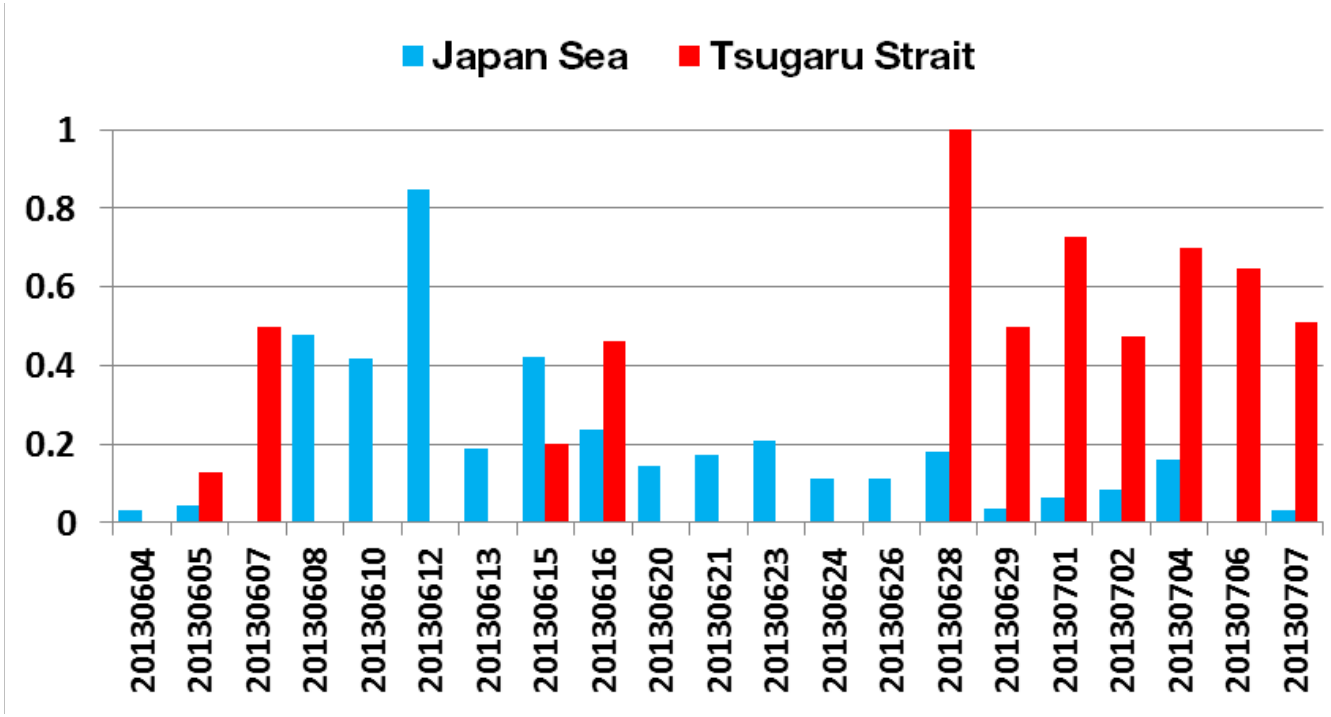
Results



Ratio of vessels' occurrences at high prediction value (>0.1), derived from the overlap between NPP/VIIRS data and our prediction map (Japan Sea and Tsugaru Strait)

Fishing activities gradually move to the Tsugaru Strait region in July, the sampling size for summer was much smaller than other period because very few DMSP/OLS data are available during summer season

Daily basis Data Flow to Fishermen

Buoy

Satellite

Meteorological

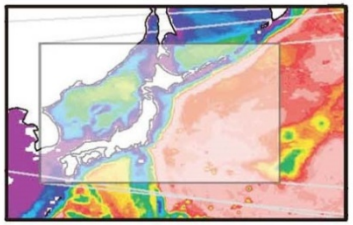
Earth Simulator

JAMSTEC

Data Assimilation

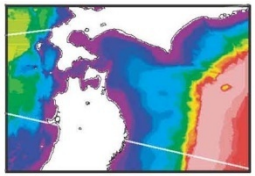
京都大学 KYOTO UNIVERSITY

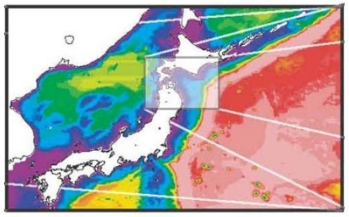
Kyoto Univ.



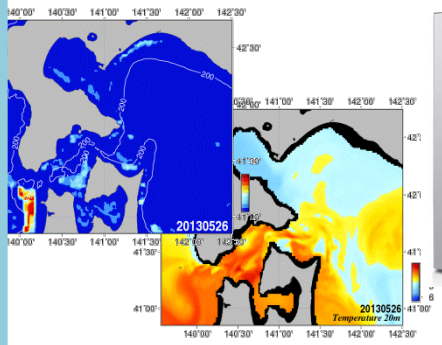
Boundary condition
(once / month)

Model Output
(Today + 5 days)





Prediction Map using spatial model
(Today + 3 days advance)

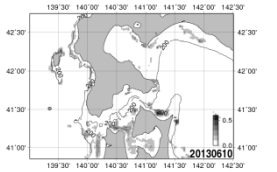


Internet/Cloud

Web Users

Hokkaido Univ.

Squid fishing Association



By e-mail

FAX

Operation of Fisheries Web Site

Fisheries Assoc.

北海道大学 HOKKAIDO UNIVERSITY

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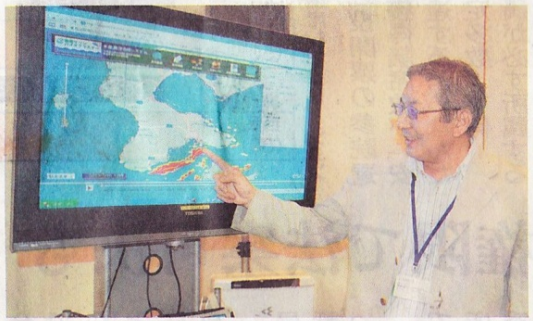


地図上に赤く染まるスルメイカの予測漁場を指す斉藤教授

北大などシステム 漁場直行で燃料節約

【函館】北大大学院水産科学研究院の斉藤誠一教授らの研究チームが、道南周辺海域のスルメイカの漁場を3日先まで予測して地図上に表示する「水産海洋地理情報システム（GIS）」を開発した。海水温や潮流のデータを基に計算するもので、沿岸漁業で本格的な漁場の短期予測は全国で初めて。18日に函館市内で開かれたフォーラムで発表し、インターネット上で公開を始めた。

同市を中心とした産学官連携事業「函館マリンバイオクラスター」の取り組みの一環。函館の主要水産物であるスルメイカを対象に、公立はこだて未来大や京大の研究者などと共同でシステムを開発した。

海洋研究開発機構横浜研究所が提供する海洋データを基に、人工衛星や海上ブイで測定した海水温、潮流、塩分濃度などの情報を加え、イカが好むとされる条件に当てはまる海域を予測し、地図上に色分けして示す。

6月のスルメイカ解禁後、システムは稼働しており、予測海域と人工衛星から確認できた漁船の位置は、ほぼ重なっているという。

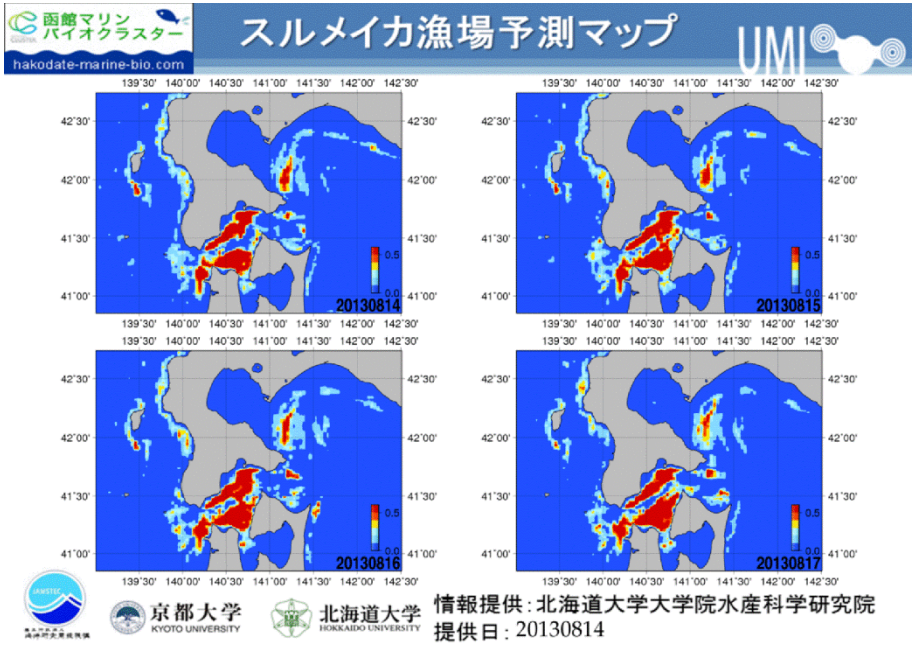
漁場予測は、漁業者の勘や経験によるところが大きいが、斉藤教授は「漁場まで直行できれば、燃料費の節約や二酸化炭素削減に役立つ」と期待する。今後は漁業者と情報交換を重ねて一層の精度向上を目指す。

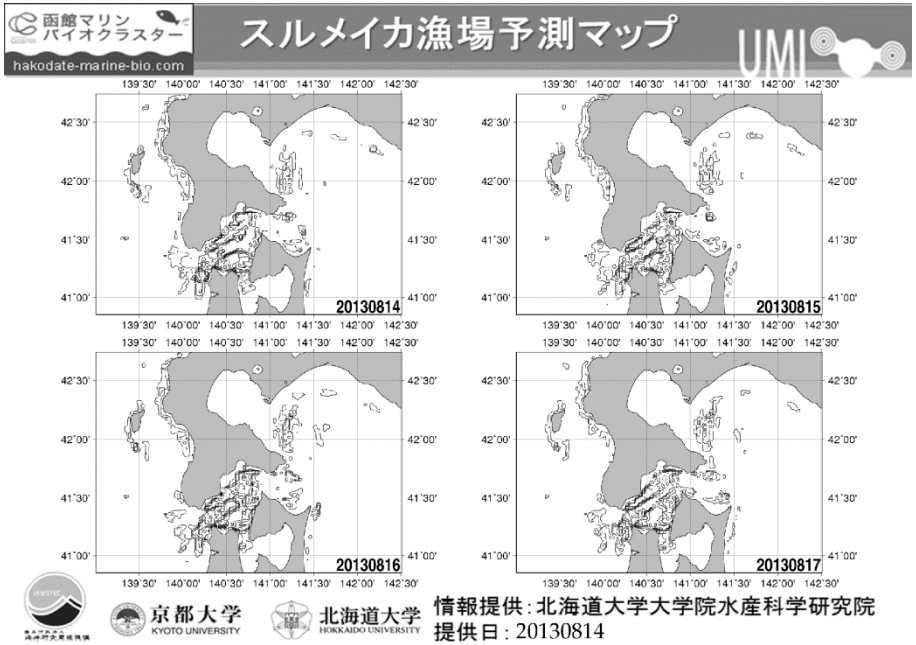
斉藤教授は、ネットを使わない漁業者も考慮し、22日以降、道南14漁協にファクスで情報提供していく計画だ。予測海域を公開している水産海洋GISのホームページのアドレスは、http://innova01.fish.hokudai.ac.jp/marineGIS/

Practical application of the prediction model

Our prediction maps(future 4 days) are sent to fishery association and fishermen in the morning every day through Email and Fax.

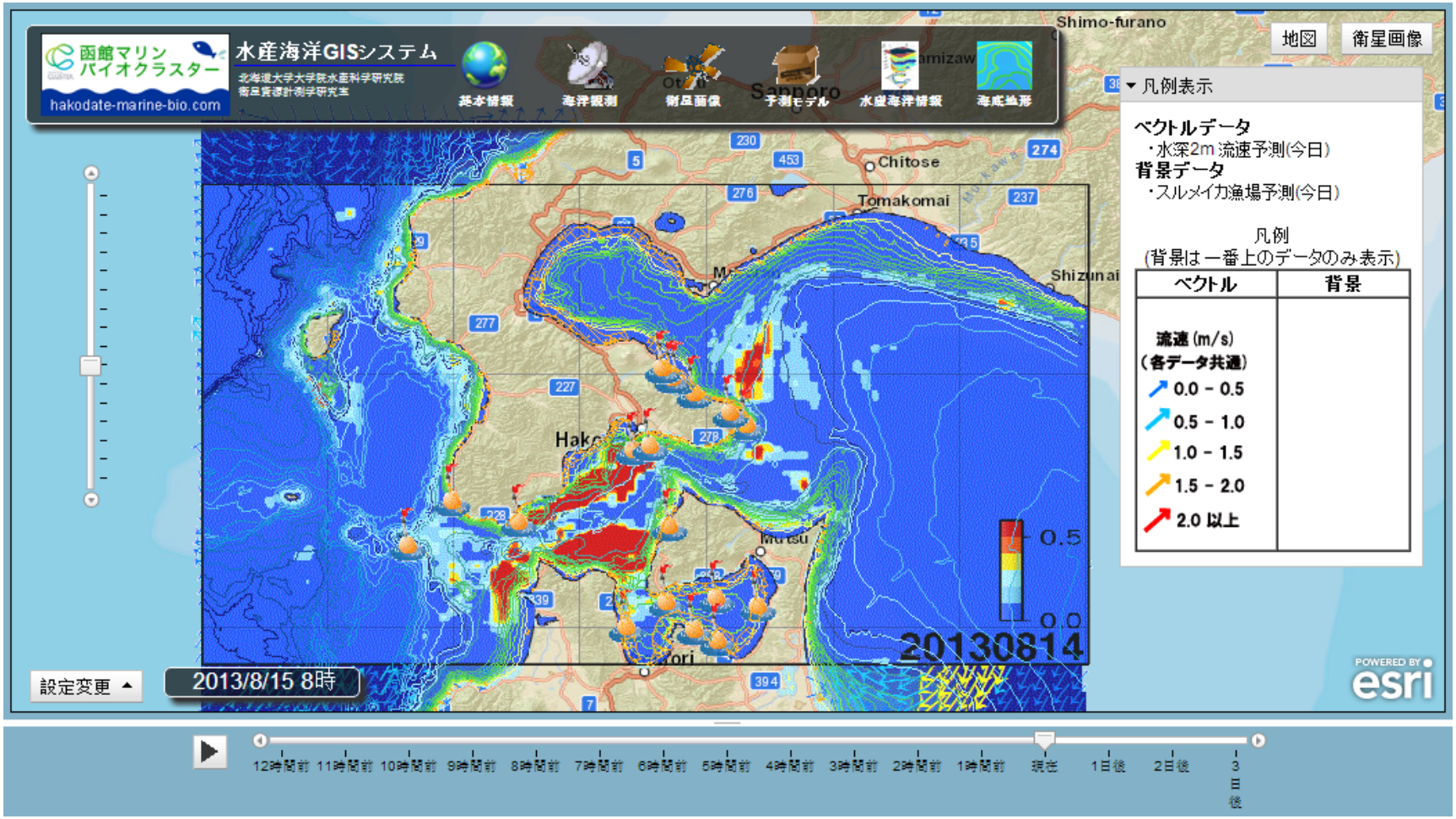
Useful information of sea water environment derived from the 4D-VAR data assimilation system (Kyoto University) are also sent to fishermen to help their decisions.



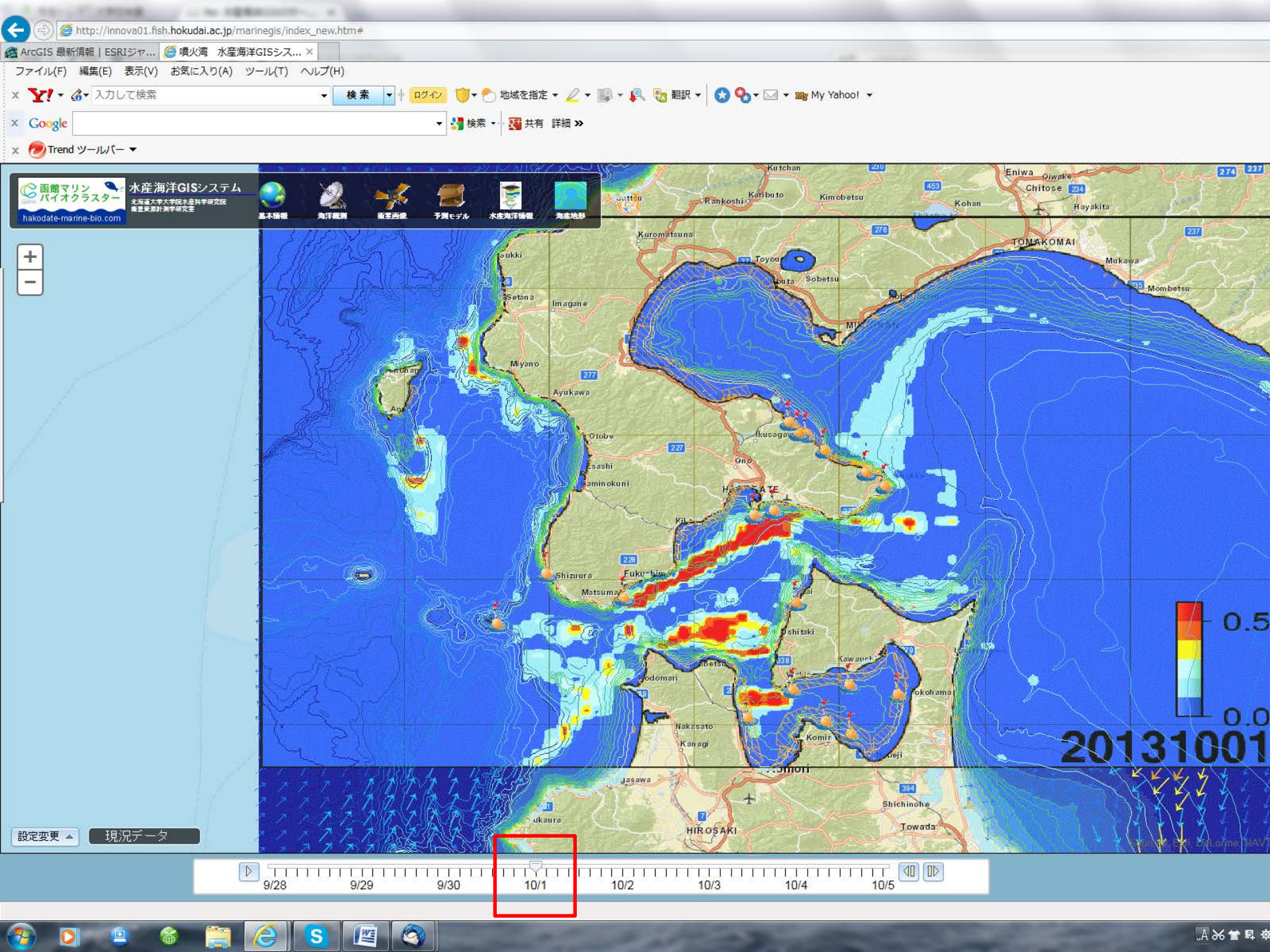


Practical application of the prediction model

Prediction map on our website



http://innova01.fish.hokudai.ac.jp/marinegis


http://innova01.fish.hokudai.ac.jp/marinegis/index_new.htm#
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Kimobetsu
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Hayakita
Kuromatsunai
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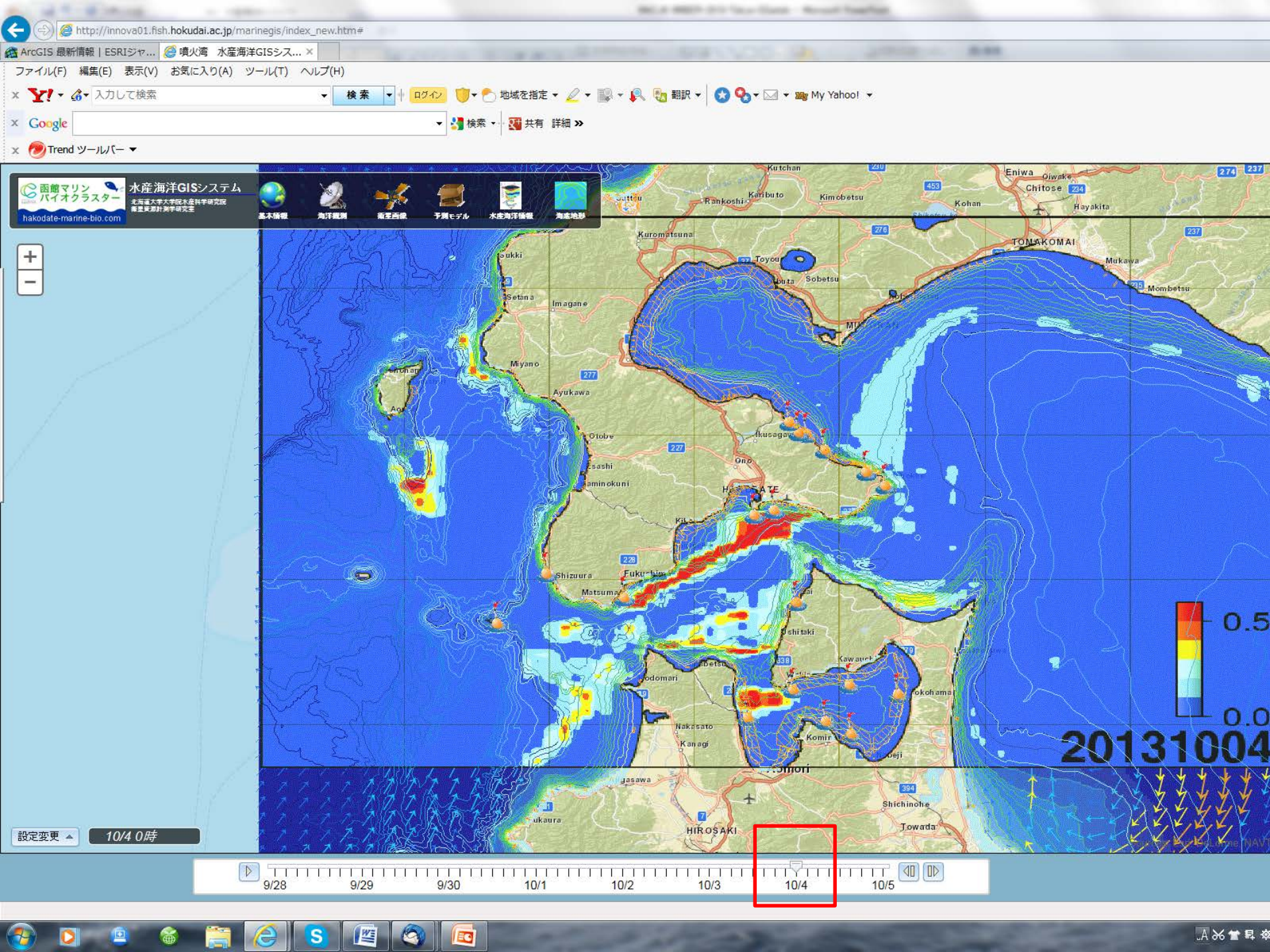
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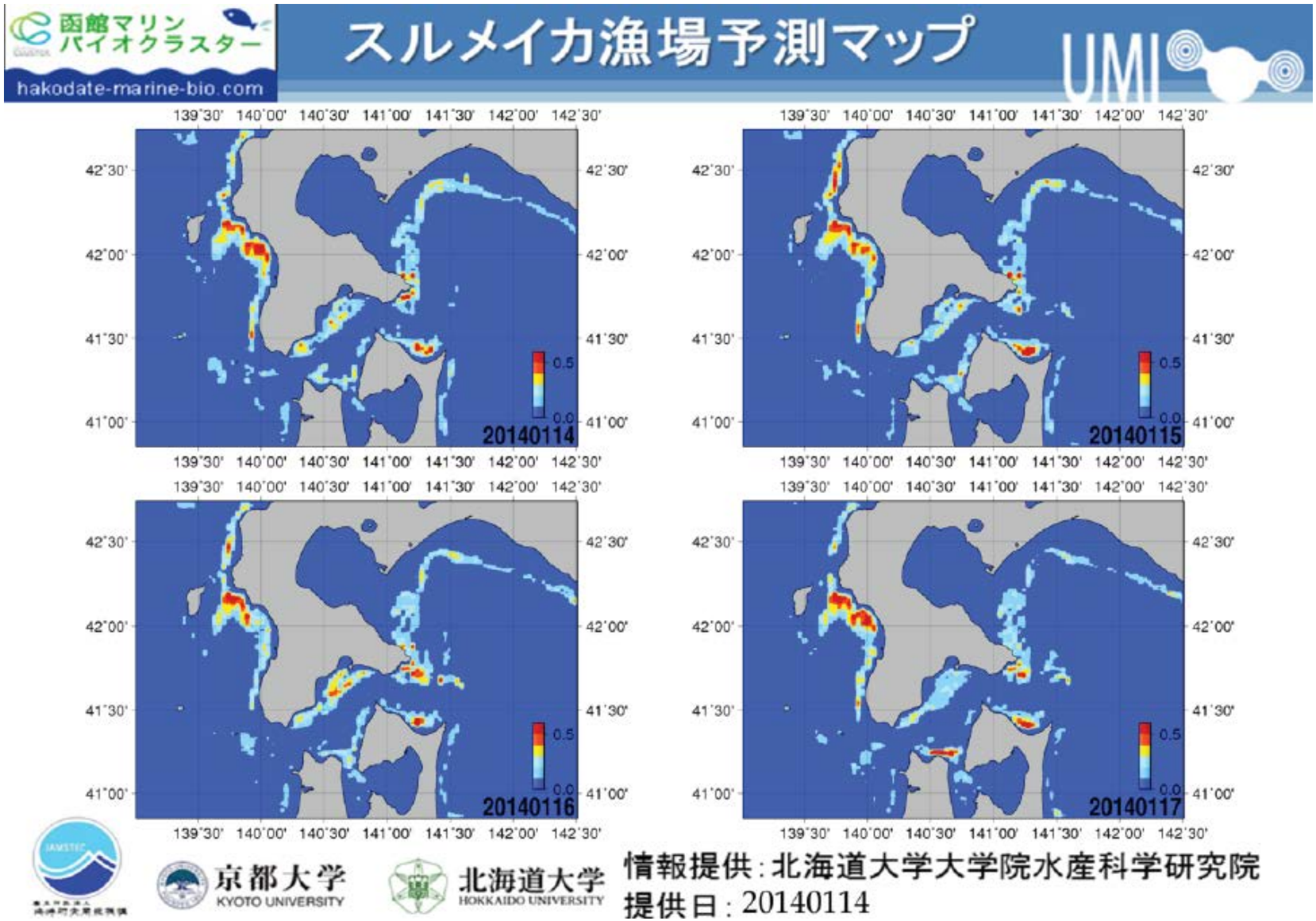
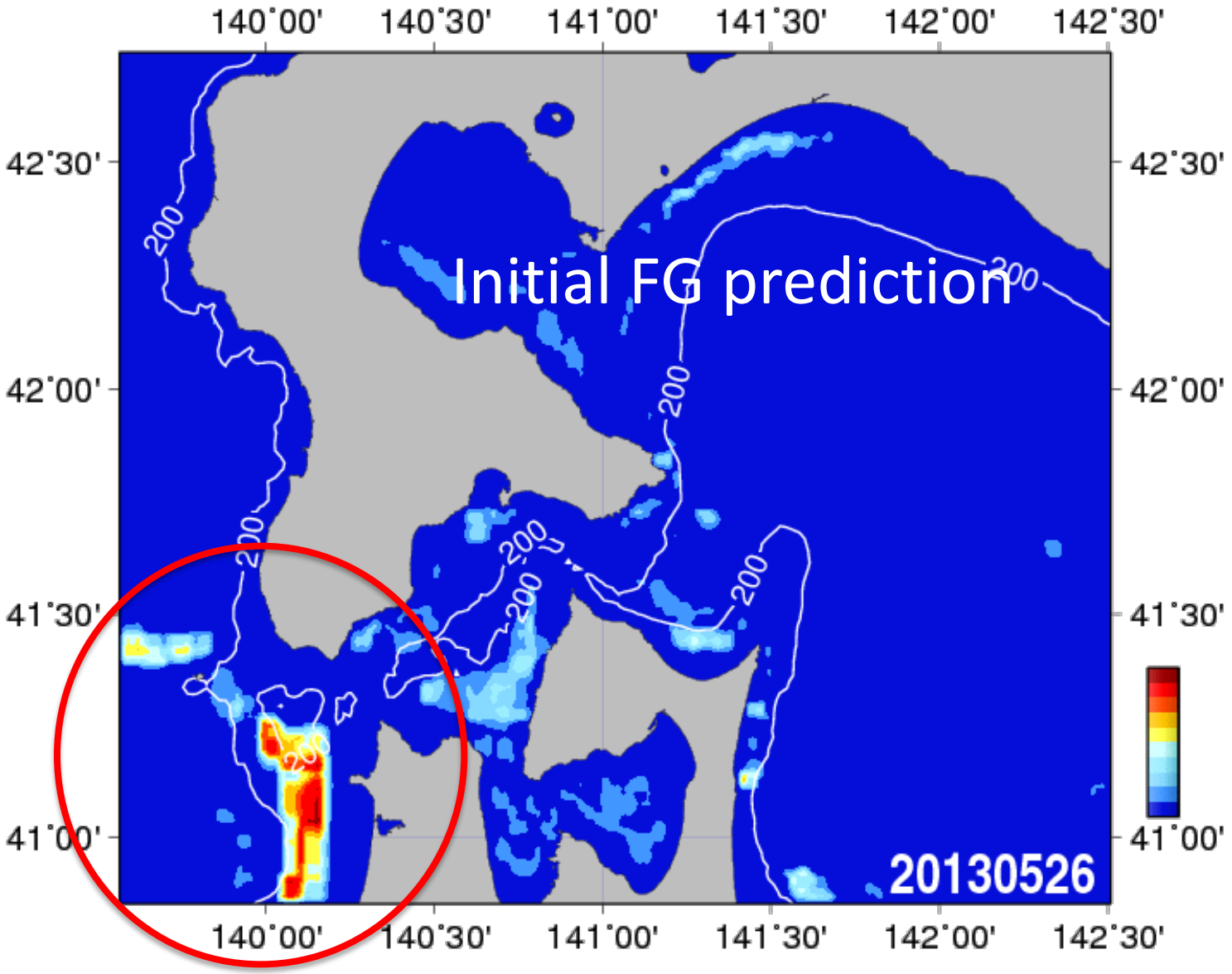
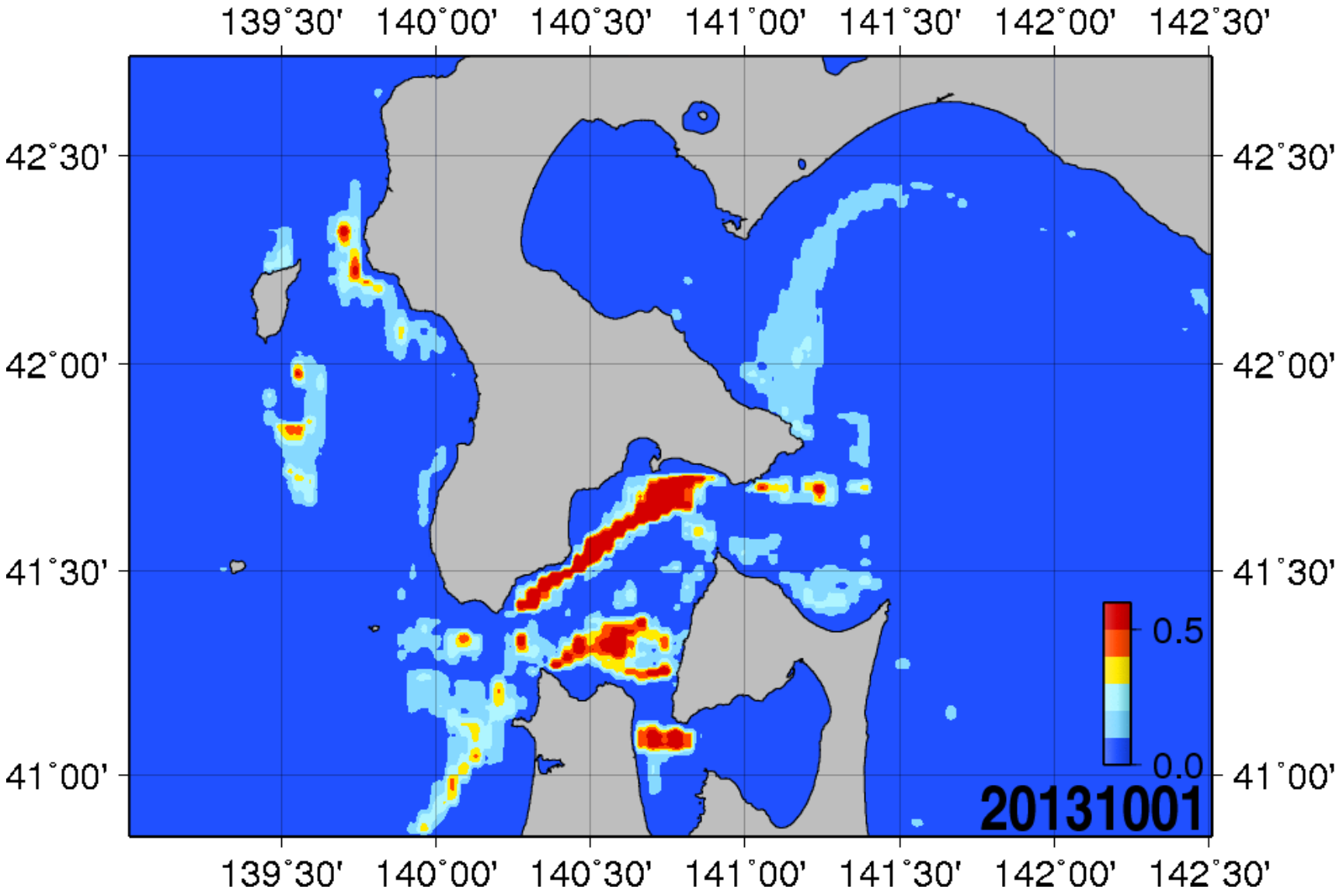
Today's prediction map(Jan.14-Jan.17)



PFZ Map（May 26-31, 2013)



PFZ Map（Oct. 1-31, 2013)



Conclusions

Performance of predictions were much improved by using 4D-VAR dataset, this approach have no weather restriction and it made the daily prediction available.

Our BRT model ascertained bathymetry is important for squid distribution and also figured out how other environmental factors influence squid behaviors.

The VIIRS/NPP “day-night band” was proved to be very useful for validating our prediction maps as it has better capacity of identifying squid fishing vessels. Models in the future based on this dataset will achieve more accurate predictions.

Now our prediction maps have been put into actual fishing, this study will be highly improved after more feedback are given by local fishermen.

Acknowledgements

- **“Hakodate Marine Bio Industrial-Cluster Project”** in the Regional Innovation Cluster Program (Global Type) from 2009 supported by the Grant-in-Aid for University and Society Collaboration from the Ministry of Education, Culture, Sports, Science and Technology (**MEXT**), Japan
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Thank you for your attentions