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Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future

Session 6 Climate change impacts on spatial distributions of marine fish and shellfish
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Predicting present and future distributions of yellowtail in the Japan Sea

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  target fish, overview

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Introduction

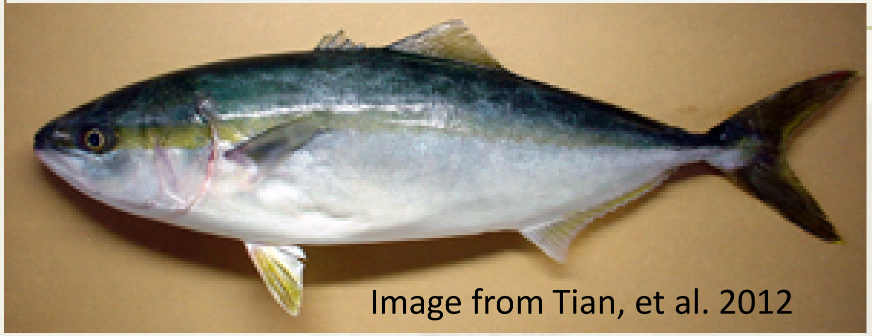
- Fishes in marine are not distributed randomly (Planque, B. & Loots, 2011*)

- To recognize the link between fish and other components of the ecosystem is an essential step to adopt ecosystem-based fisheries management (Johnson et al., 2013**)

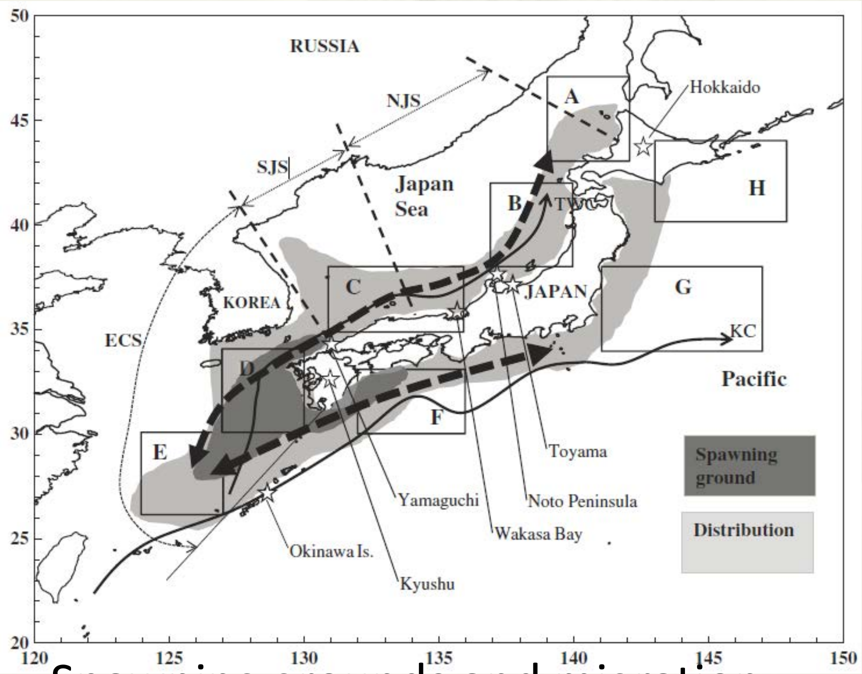
*Fish. Oceanogr. 20, 1–17 (2011) **Fish Fish. 14, 256–280 (2013)

Introduction Target species

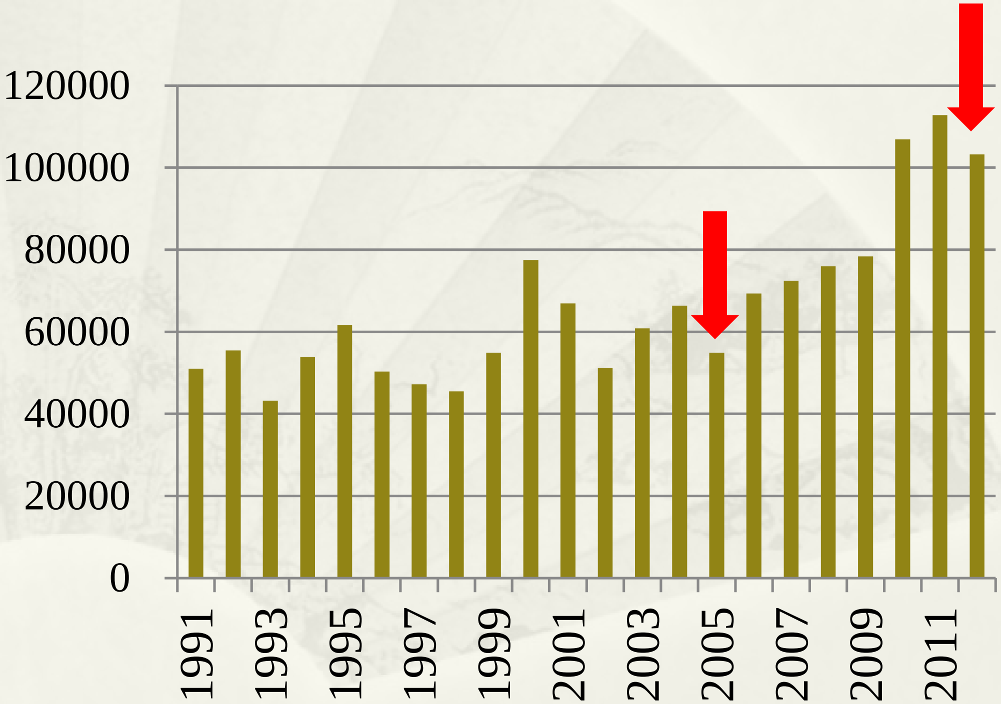
Seriola quinqueradiata (Temminck & Schlegel, 1845)



a pelagic, highly migratory and predatory fish



Spawning grounds and migration pattern (Tian, et al. 2012*)

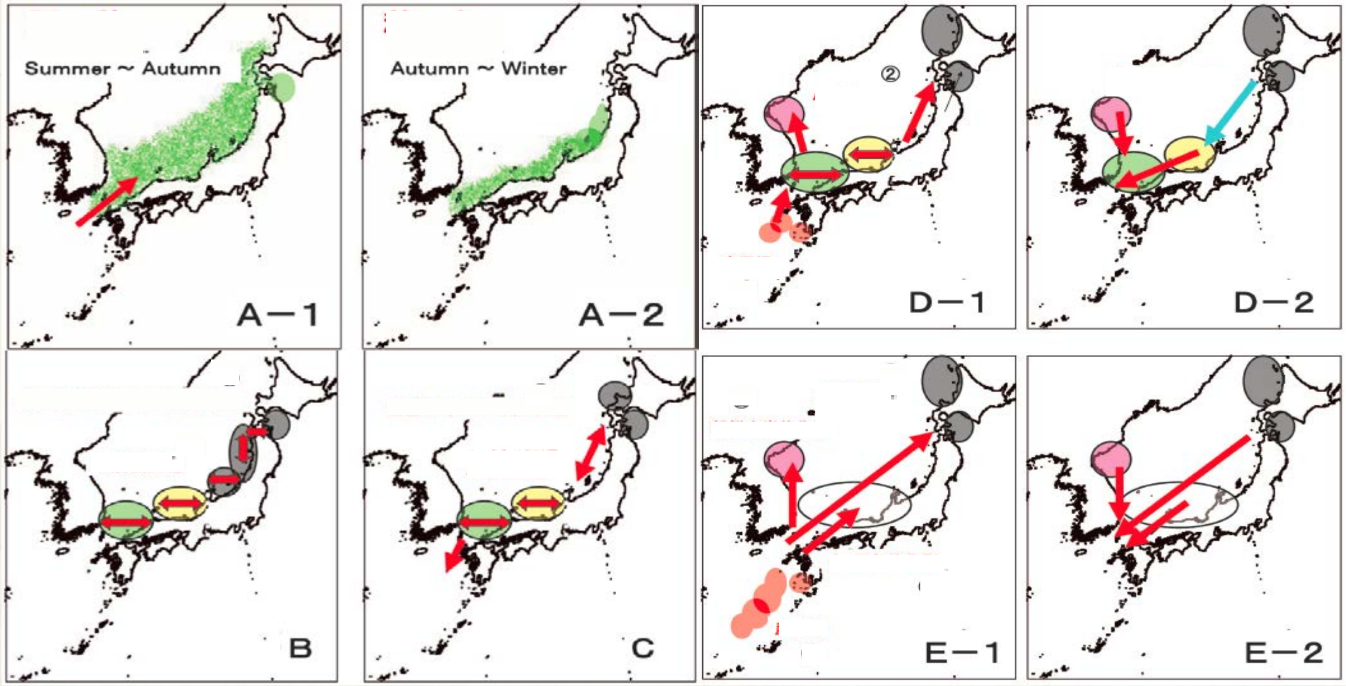


Annual landing trend of yellowtail (unit: ton)

Data source: Fisheries Agency and Fisheries Research Agency of Japan

*J. Mar. Syst. 91, 1–10 (2012)

Introduction Migration patterns in the Japan sea

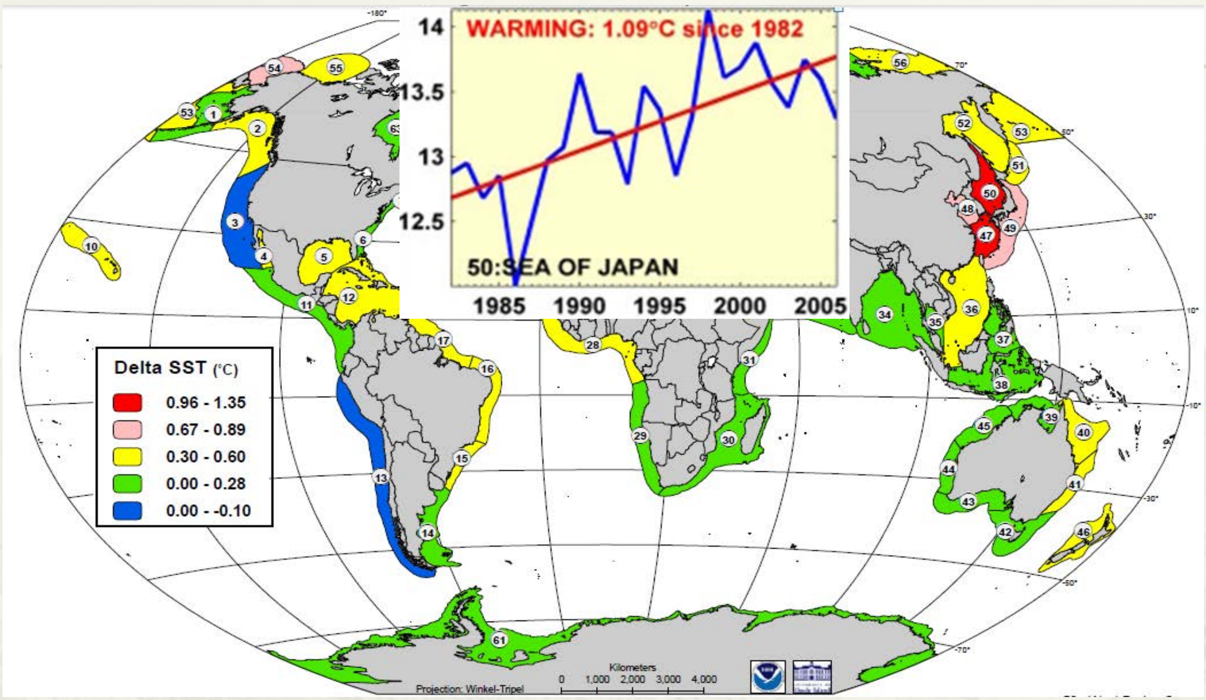


Migration patterns of yellowtail in Tsushima Warm Current Area (Watanabe et al. 2010*)
A 0 year old B 1 year old C 2 year old D 3 year old E 3+ year old

Relationship between the migration and environment is still unclear

*Bull. Fish. Res. Agen. 30, 1–10 3(2010)

Introduction Global warming in the Sea of Japan

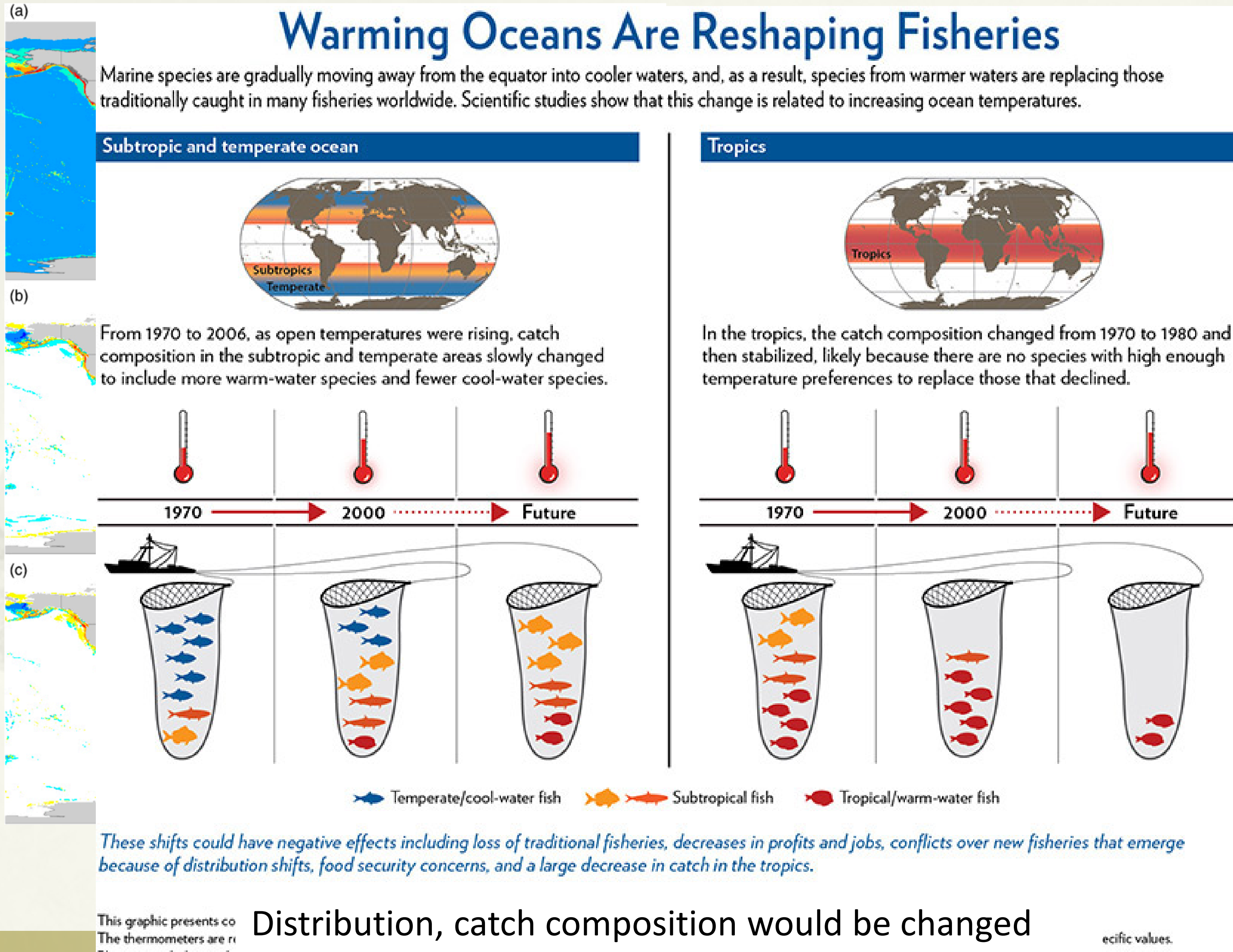


SST Trends in Large Marine Ecosystems: 1982 – 2006 (Belkin, 2009*)

The increase in sst is sure to alter physicochemical features of the sea thus affect ambient organisms

*Prog. Oceanogr. 81, 207–213 (2009)

Introduction Impacts of climate change on fishes



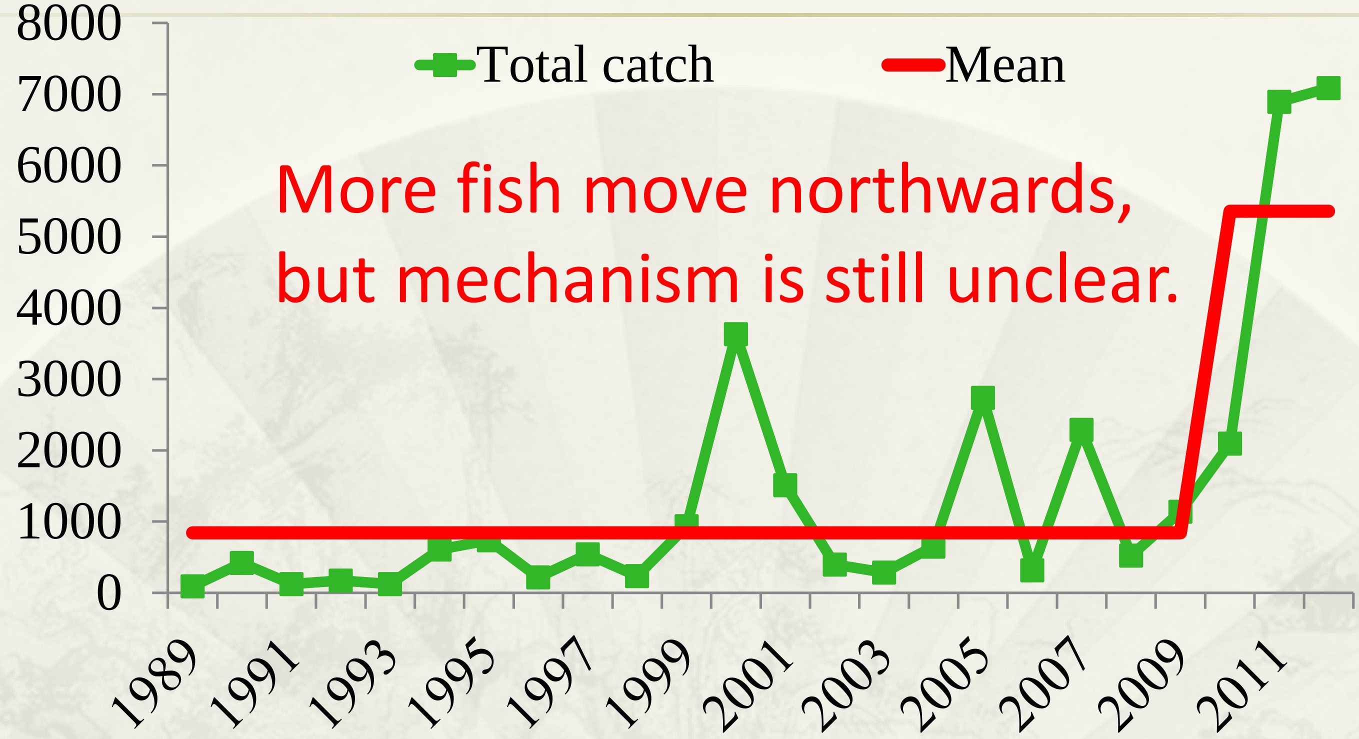
n

ng area

Distribution, catch composition would be changed

7, 365–8 (2013)

Introduction A phenomenon in Hokkaido



Total catch by set net in Hokkaido

The need to develop adaptation plans to minimize negative impacts

Objectives

- To construct habitat model to identify optimal habitat in the Sea of Japan
- To predict possible distribution of yellowtail in future under alternative scenarios of climate change

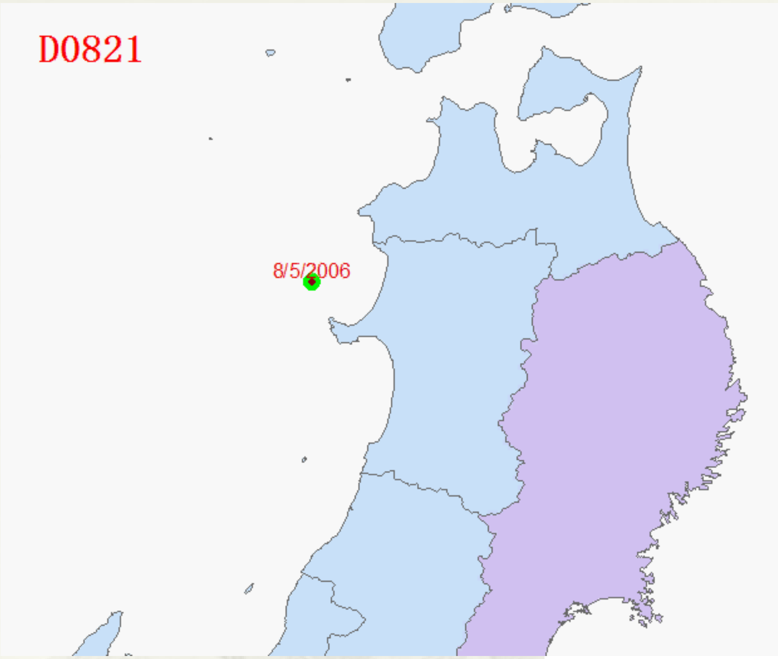
Data and methods

- Data
- ✓ Archival tagging data (0 and 1 year old fish)
- ✓ Environmental data (remotely sensed data)

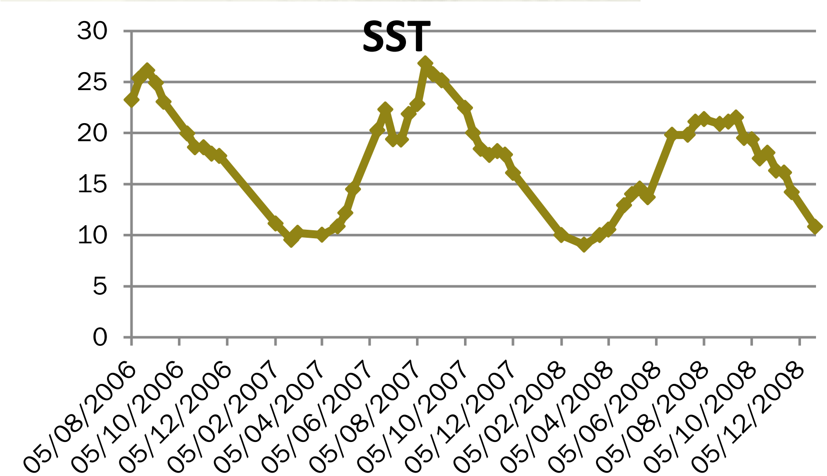
- Methods
- ✓ Species distribution models

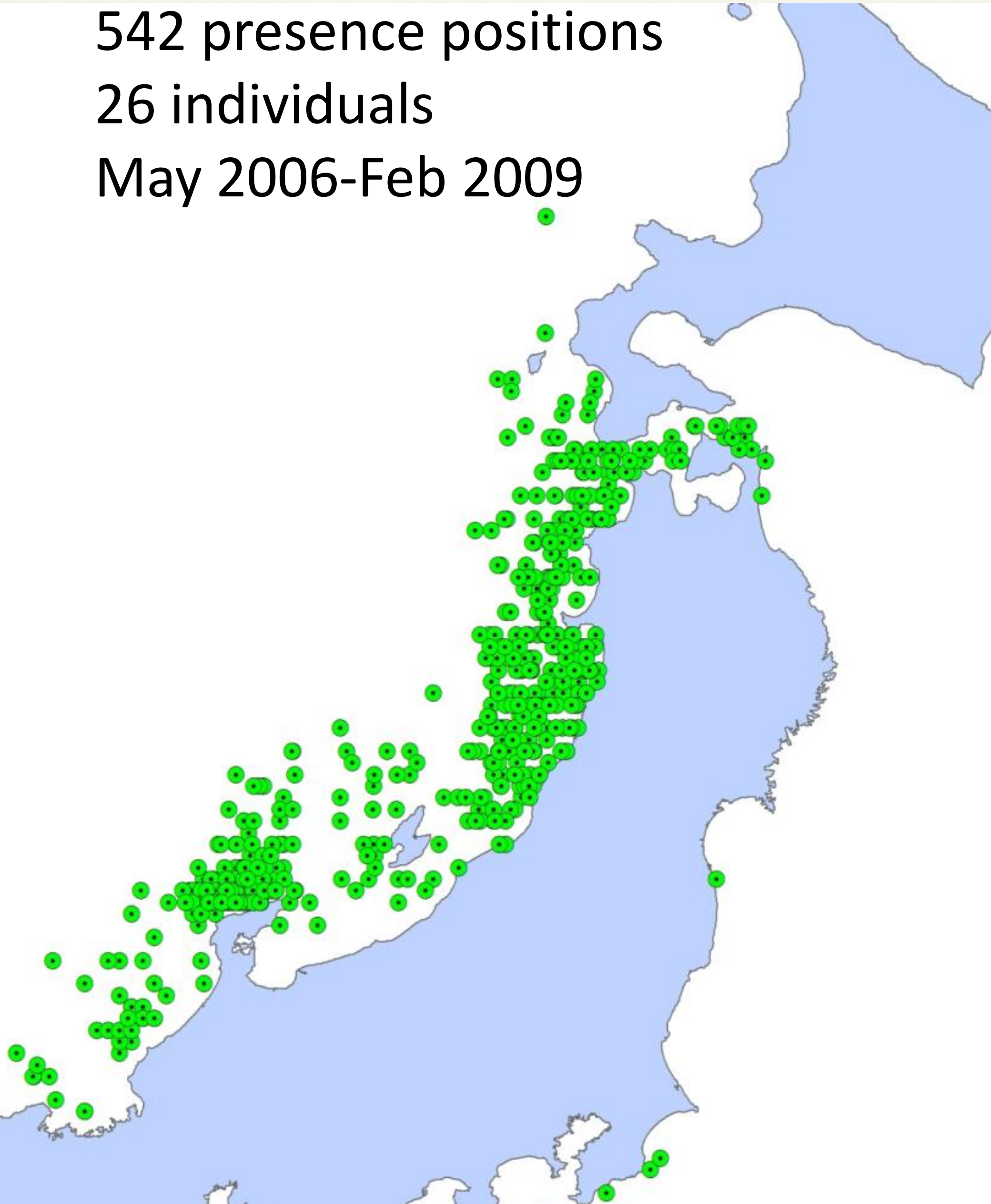
  (GLM, GAM, MaxEnt models)

Tagging data



542 presence positions
26 individuals
May 2006-Feb 2009





Environmental data

Data	Source	Spatial resolution	Temporal resolution
SST	Ocean color site	1km	Ten days (2006.1-2009.12)
Chla	Ocean color site	1km	Ten days (2006.1-2009.12)
Kd490	Ocean color site	1km	Ten days (2006.1-2009.12)
u	AVISO site	0.25 degree	Ten days (2006.1-2009.12)
v	AVISO site	0.25 degree	Ten days (2006.1-2009.12)
EKE	Derived from u, v	0.25 degree	Ten days (2006.1-2009.12)
SSH	AVISO site	0.25 degree	Ten days (2006.1-2009.12)
SSHA	AVISO site	0.25 degree	Ten days (2006.1-2009.12)
Bathymetry	NOAA	0.0167 degree	None

SST: sea surface temperature Chla: chlorophyll-a concentration Kd490: diffuse attenuation coefficient at 490-nm u: eastward sea water velocity v: northward sea water velocity EKE: eddy kinetic energy SSH: sea surface height SSHA: sea surface height anomaly

During processing, I resampled the data into 0.01 degree though it did not increase the spatial resolution

Results

GLM:

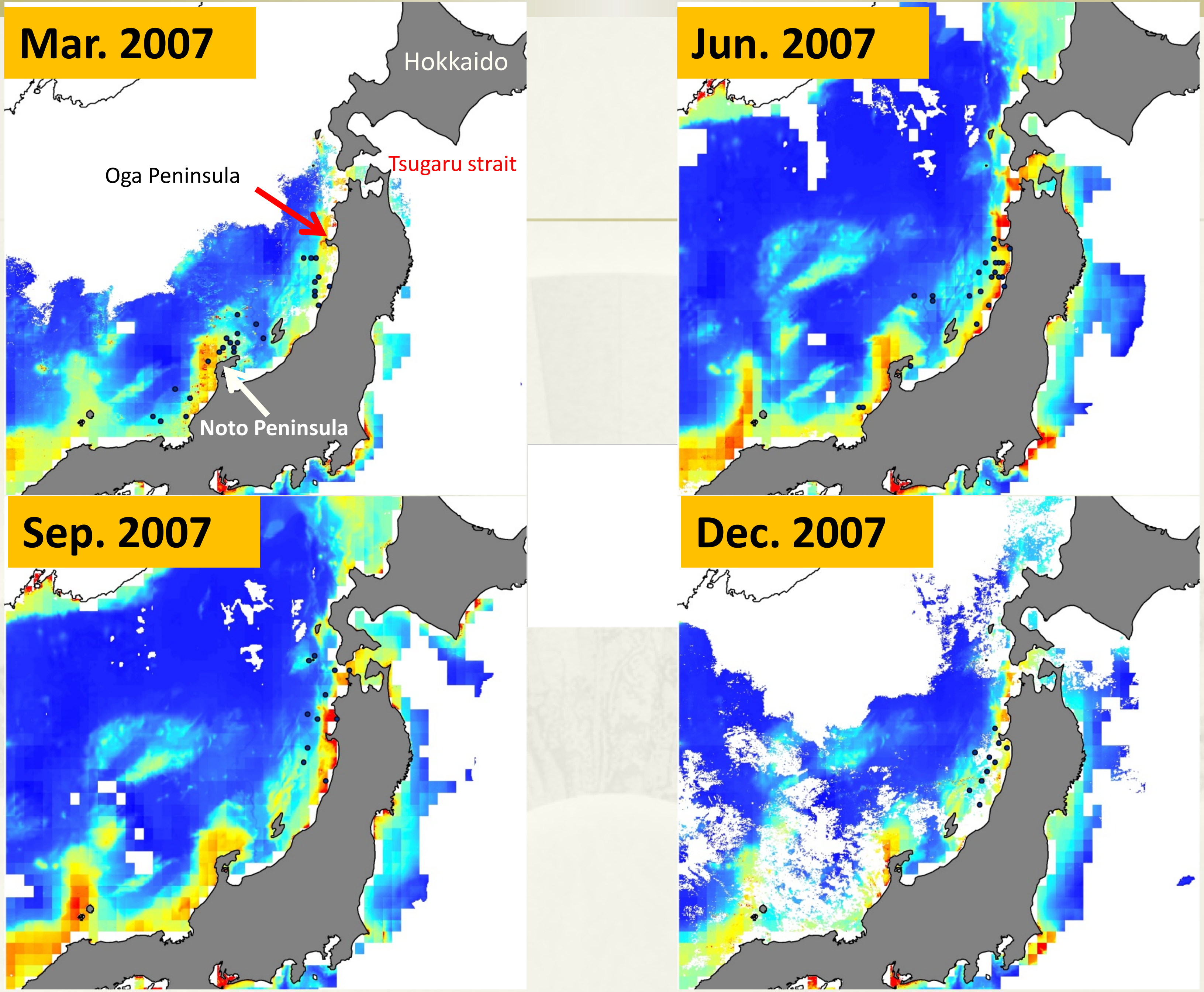
Presence ~ $\mathrm{EKE} + \mathrm{depth} + \mathrm{SSH} + \mathrm{u} + \mathrm{v} + \mathrm{SST} + \mathrm{Chla} + \mathrm{SSHA} + \varepsilon$ (without Kd490)

GAM:

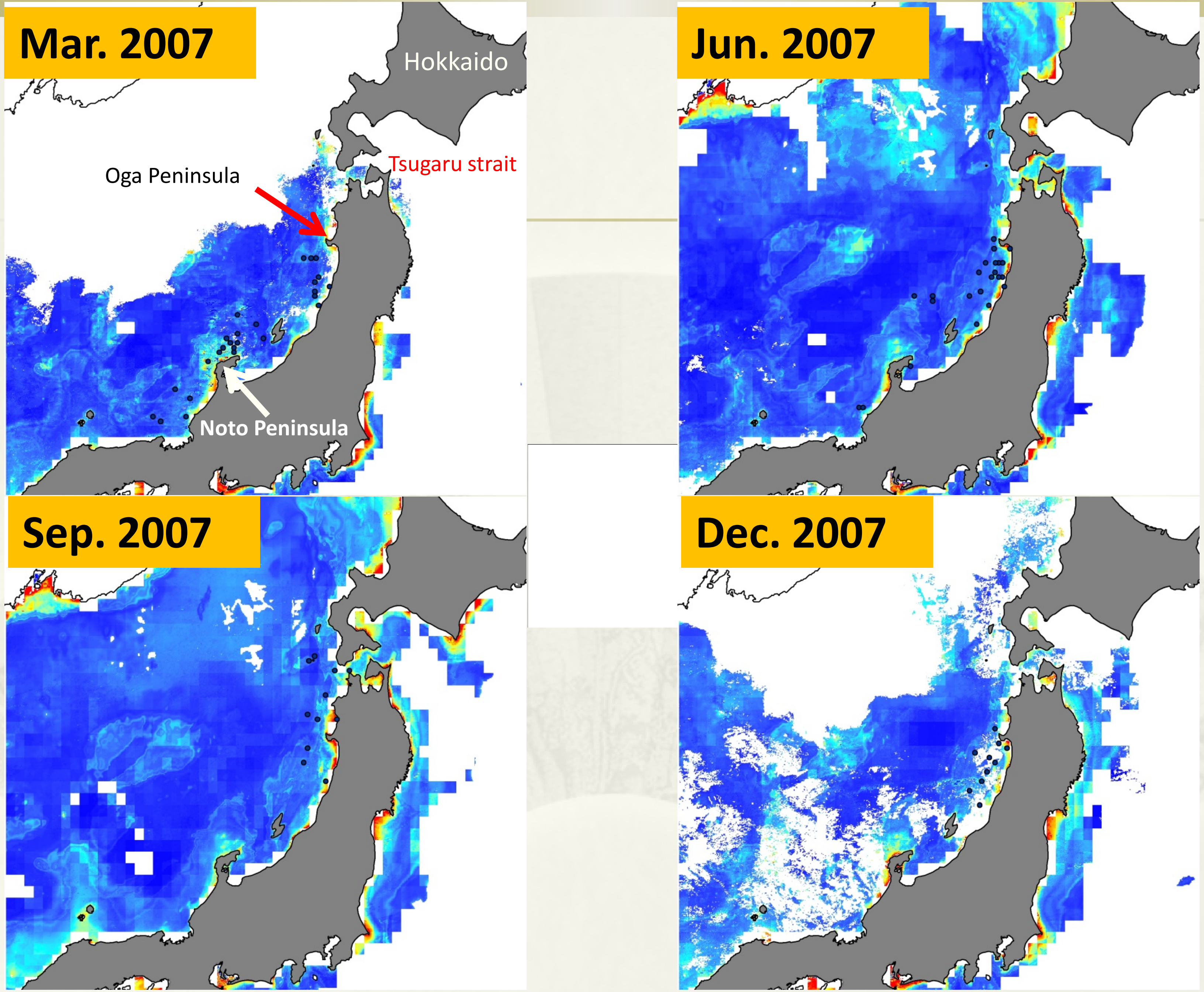
Presence~s(EKE)+s(depth)+s(SSHA)+s(SSH)+s(u)+s(v)+s(SST)+s(Chla)+s(Kd490) + ε

MaxEnt:

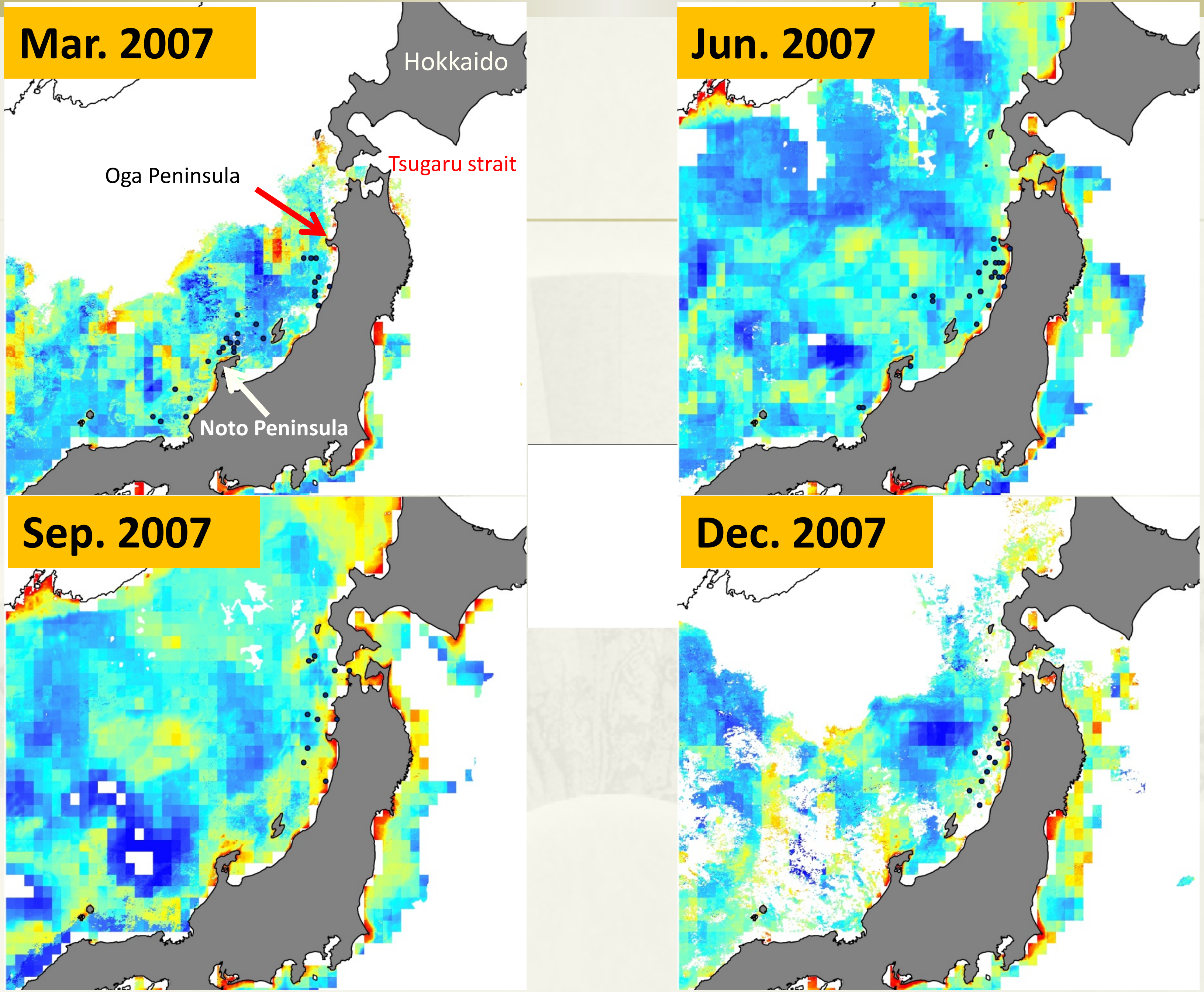
Presence~*f*(EKE, depth, SSHA,SSH, u, v, SST, Chla, Kd490)



Present probability map by **GLM**

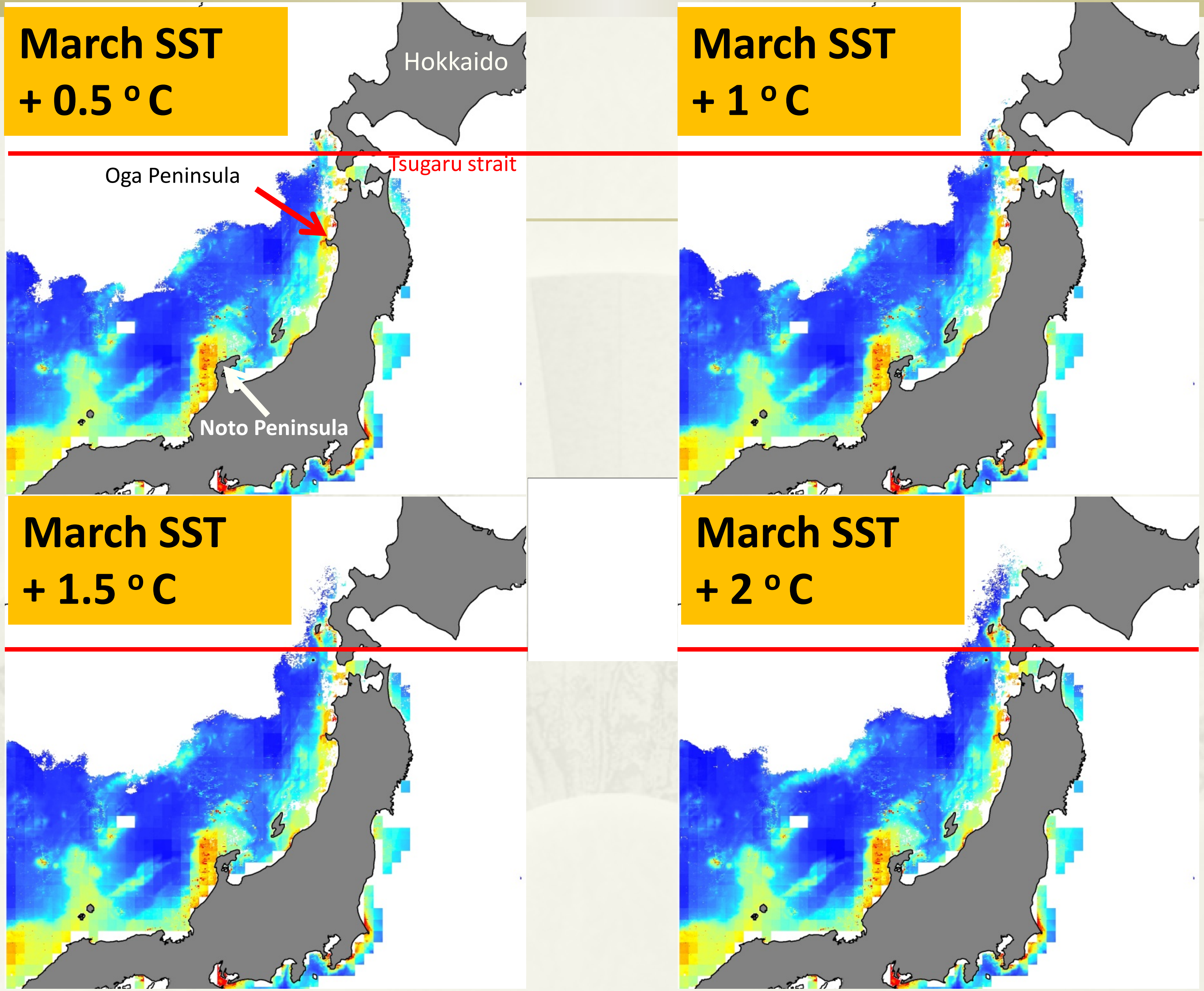


Present probability map by **GAM**

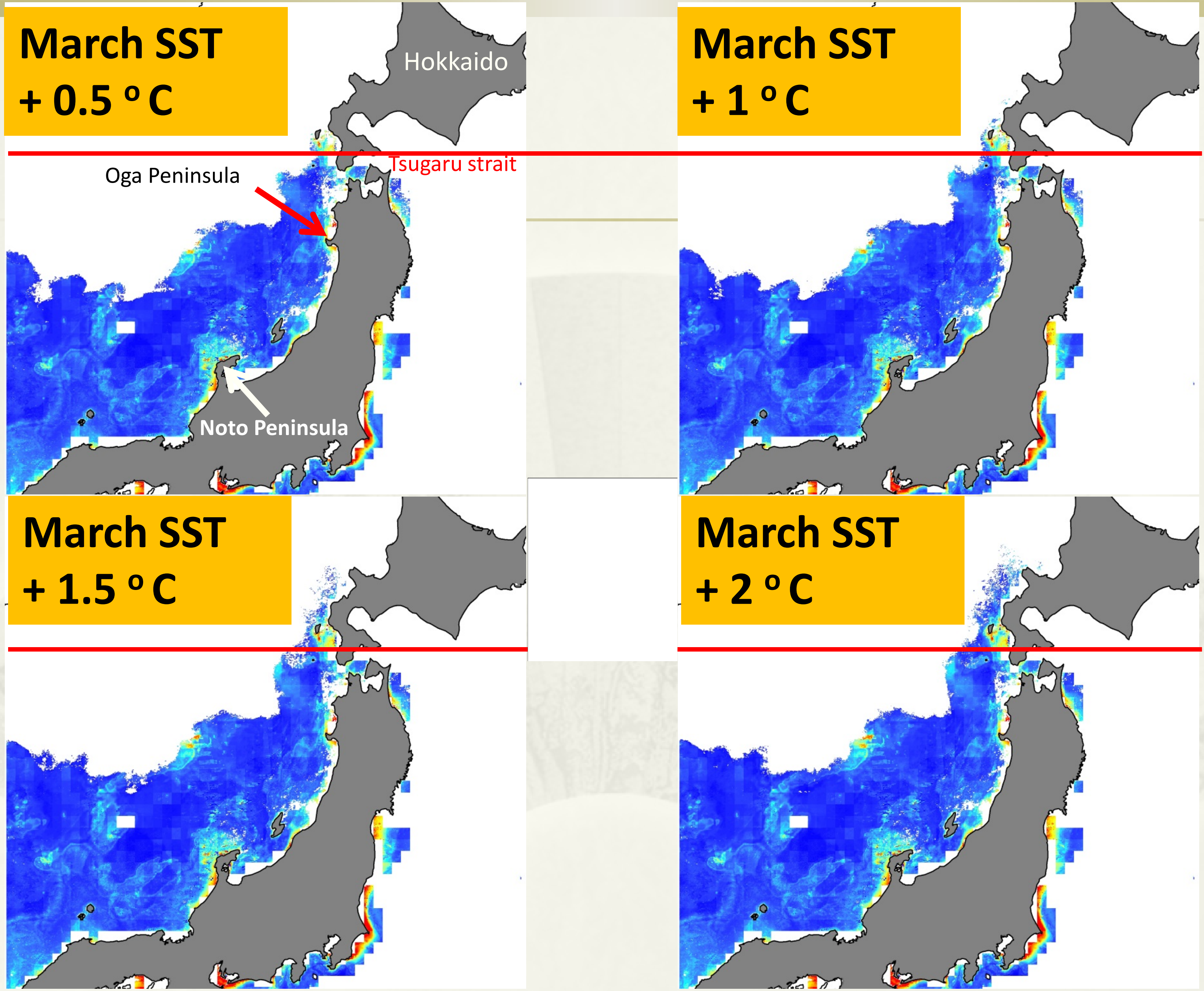


Present probability map by **MaxEnt**

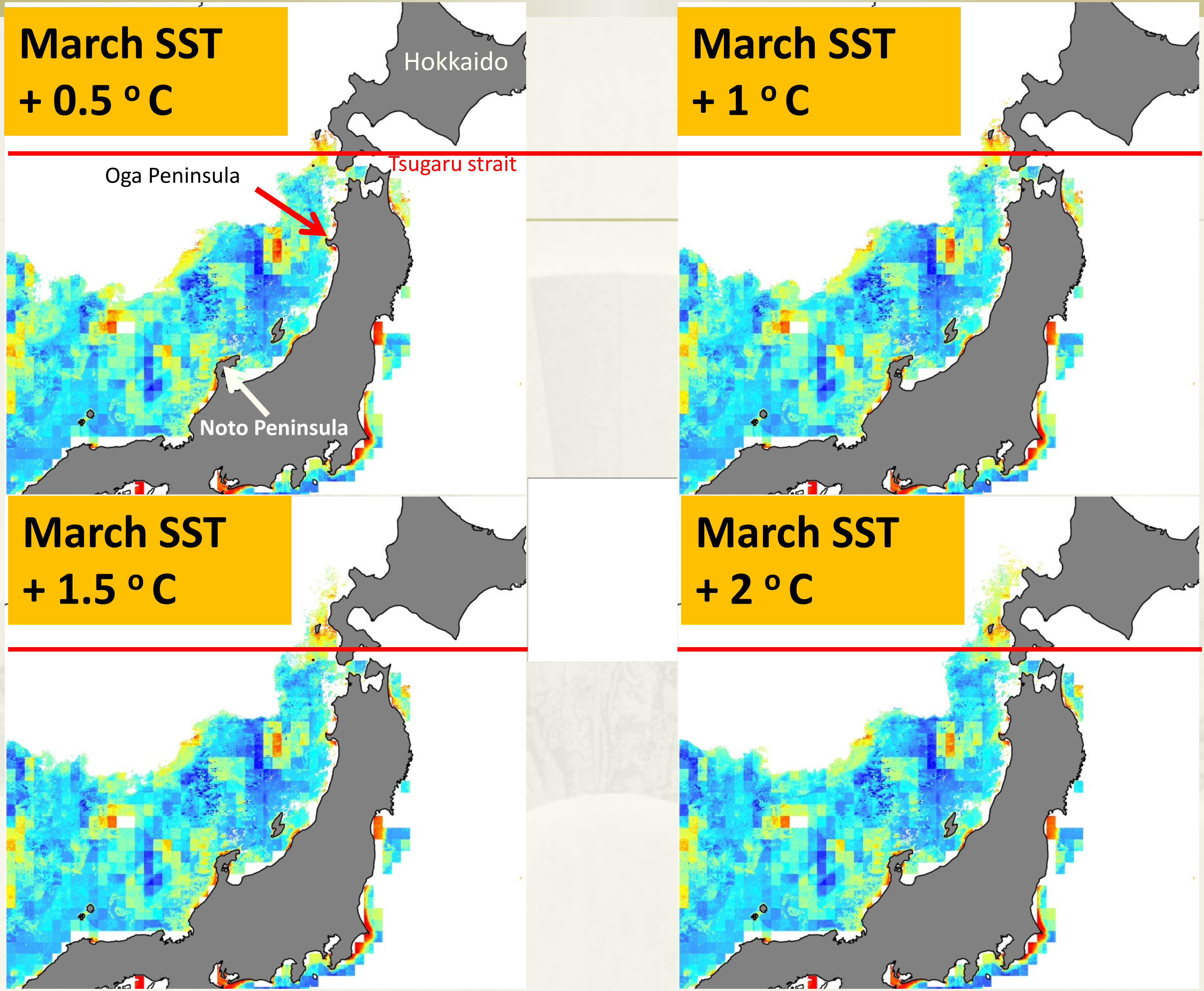
How about future distribution?



Future probability map by **GLM**



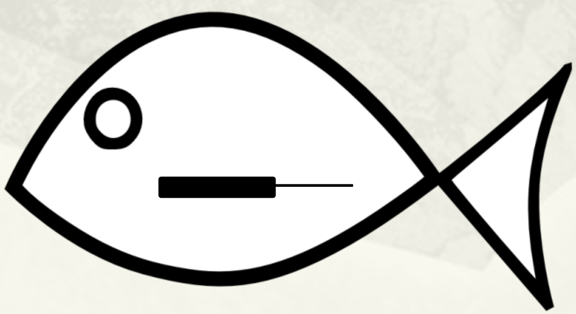
Future probability map by **GAM**



Future probability map by **MaxEnt**

Discussion

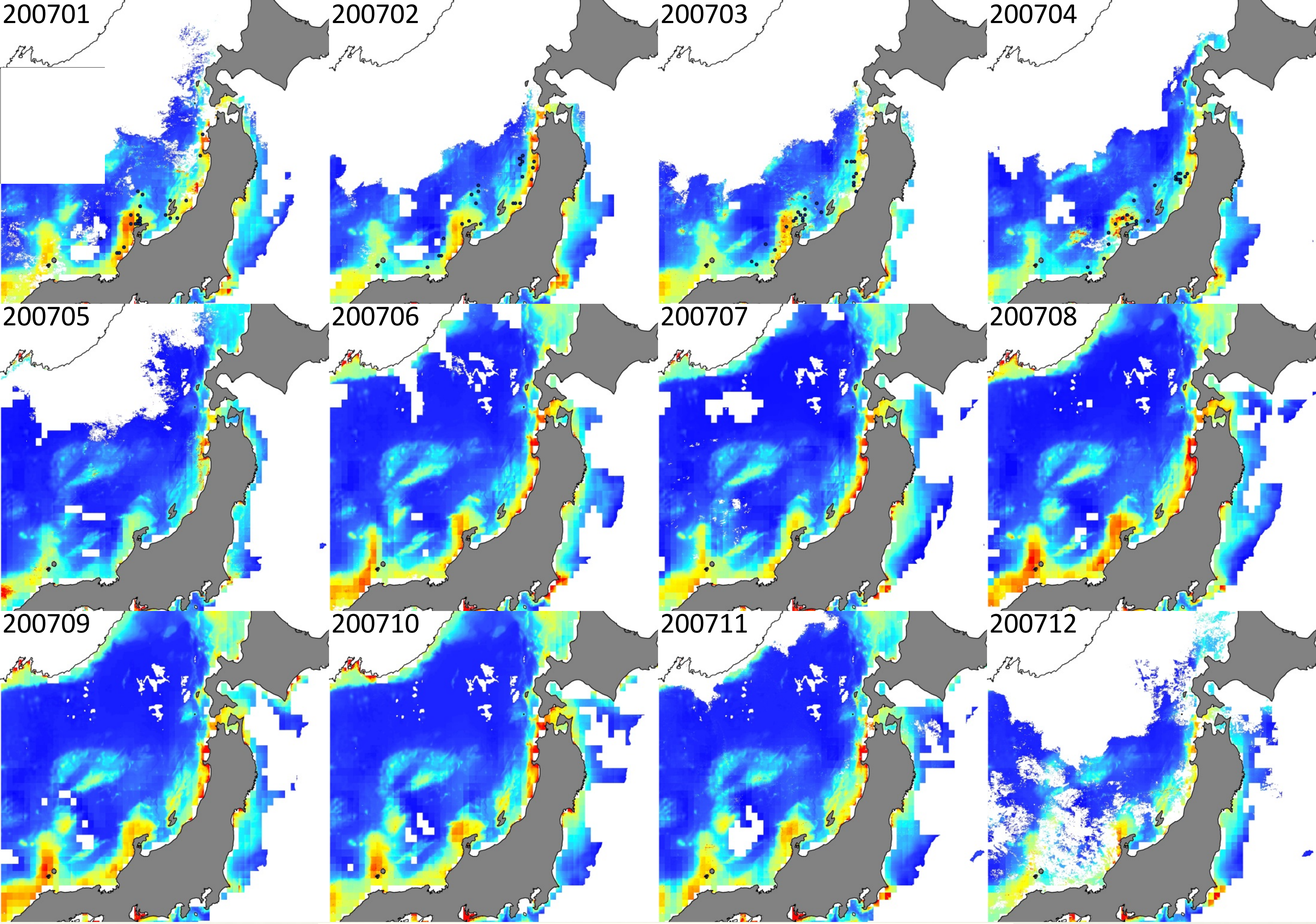
- From archival tagging data we can get useful information about spatial and temporal distribution of the fish, remote sensing data help us better understand marine environment. Archival tag plus remote sensing will lend us an edge in studying fishes' migration patterns and the environmental factors that control these patterns



Archival tagging data

+

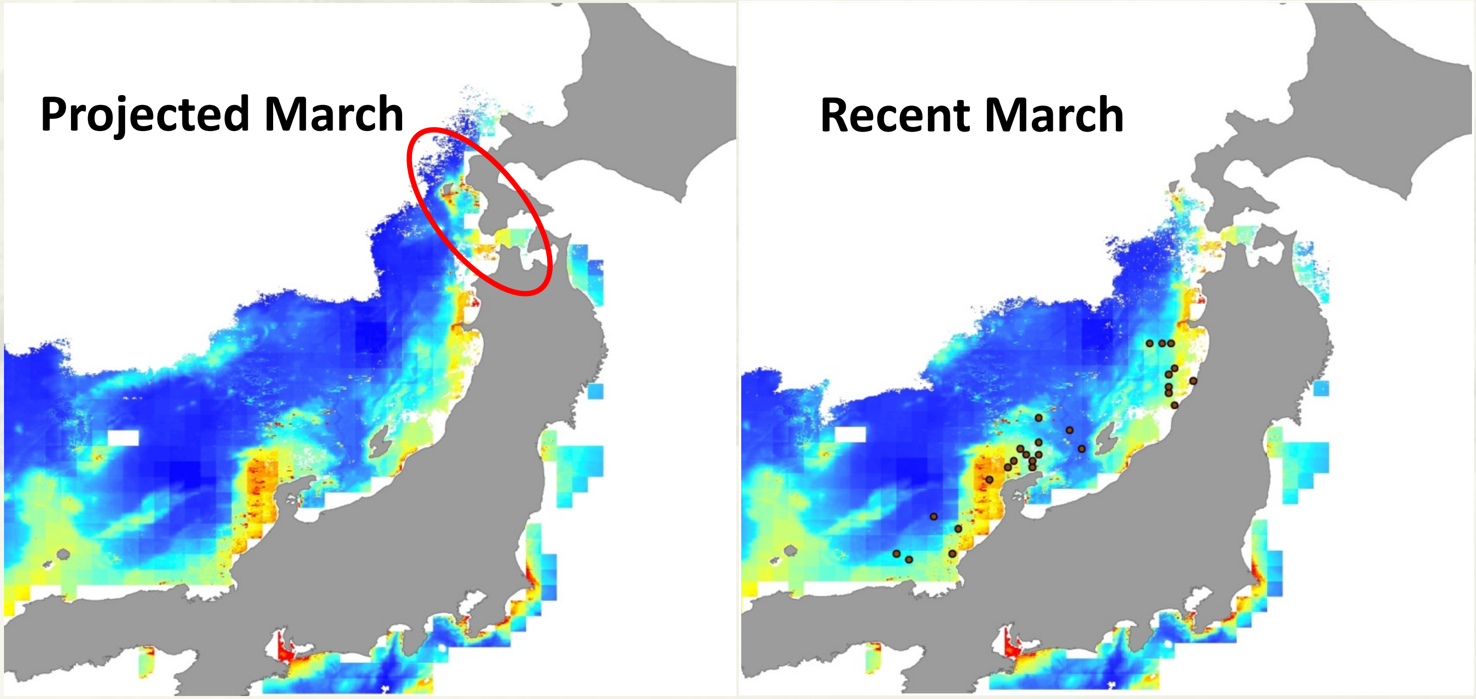
Remote sensing data



Monthly habitat change in 2007

Discussion

The geographical distribution of yellowtail in winter (overwintering area) is projected to change with thermal regimes and will extend northward with warming to the coast of Hokkaido by 2050 (Tian, et al., 2012)



Northward trends in March (winter)

*J. Mar. Syst. 91, 1–10 (2012)

Conclusion

* Archival tagging combined with satellite remote sensing have potentially far-reaching application in the understanding fishes and their relationship with physical environment

* As temperature increased, the distribution range of yellowtail in winter would move northward in future compared with recent status.

Future work

- Incorporating more environmental variables into future prediction

Acknowledge

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Thank you for your attention !

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