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Evaluating the impact of climate change on potential distribution of Japanese anchovy (*Engraulis japonicus*) using species distribution model

Shuhao Liu, Yang Liu*

Laboratory of Fisheries Oceanography
College of Fisheries, Ocean University of China
Qingdao, China
lshuhao666@gmail.com

Ocean University of China
Fisheries Oceanography Laboratory

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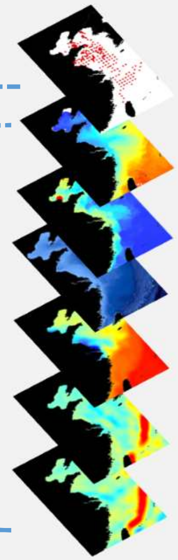
1
Compile database

Fishery data

2
Extract values

Environmental Variables



Fishery data
Catch per unit effort (CPUE), 2009-2015

Remote sensing data
Sea surface temperature (SST), sea surface chlorophyll-a (Chl-a)

Bathymetric data (Depth)

Numerical model data
Sea surface salinity (SSS), Meridional (V) and Zonal (U) current

CPUE as the response variable, SST, Chl-a, SSS,Depth, U and V as the predictor

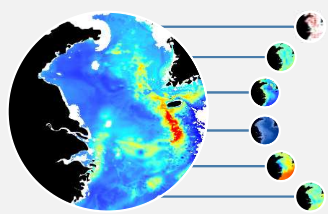
3
Model construction

$$g(Y) = a + \sum_{i=1}^{n} f_i(X_i) + \varepsilon$$

$$g(Y) = a + \sum_{i=1}^{n} \beta(X_i) + \varepsilon$$

Species distribution model (SDM):
Generalized additive model (GAM), Random forest (RF), Generalized linear model (GLM)

4
Model verification and prediction



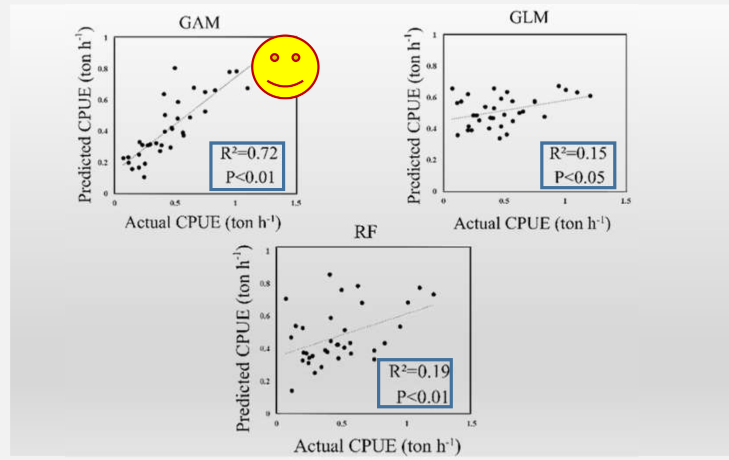
Predicted CPUE versus Actual CPUE

Deviance explained of three algorithm

Model	Predictor variable	AIC	p-value	Deviance explained
GAM	SSS Depth Lg(chlorophyll-a) SST U	217.53	7.7×10^{-14} ** 0.000197 ** 0.006866 ** 0.000302 ** 0.000800 **	36.7%
GLM	SSS Chlorophyll-a V	303.84	1.5×10^{-7} ** 0.008404 ** 0.000247 **	9.30%
RF	SSS Depth Chlorophyll-a SST U V			32.5%

**$p < 0.01$.

Predicted CPUE versus Actual CPUE in 2015



The GAM has best predictive performance

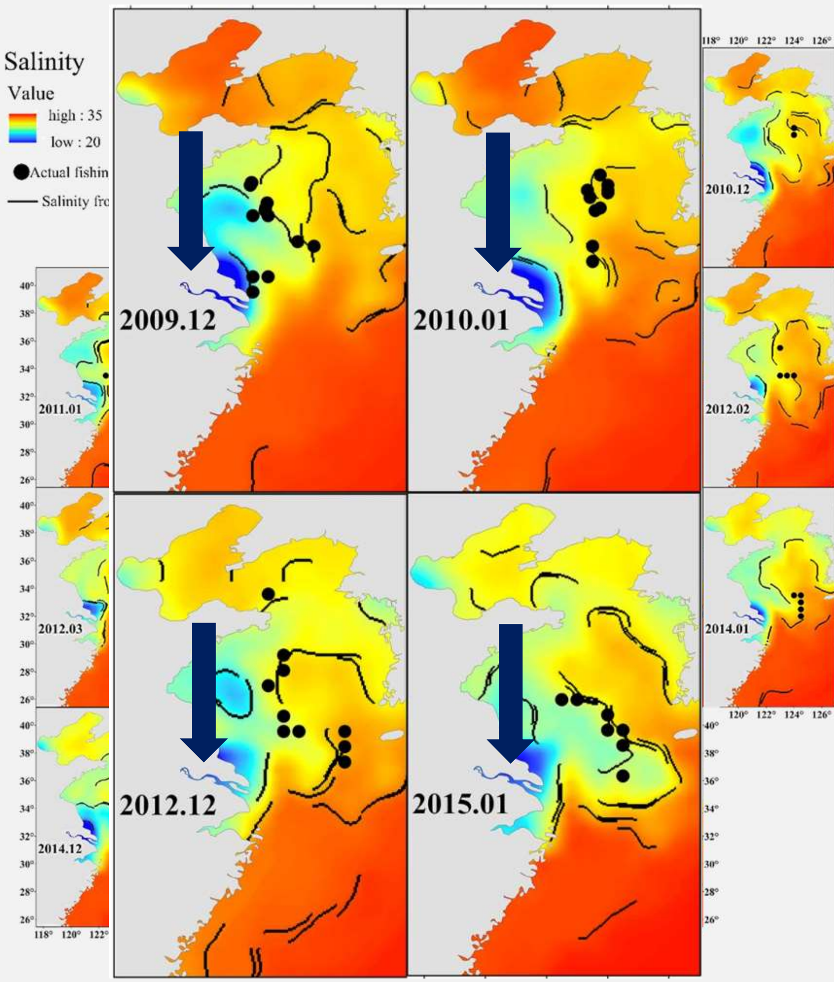
The importance of predictor variable based GAM

Predictor variable	AIC	p-value	Deviance explained
SSS	276.77	1.94×10^{-14} **	15.90%
Depth	314.08	7.57×10^{-6} **	9.03%
Lg(chlorophyll-a)	321.98	0.00023 **	7.35%
SST	325.63	0.00152 **	5.36%
U	329.54	0.00867 **	4.94%

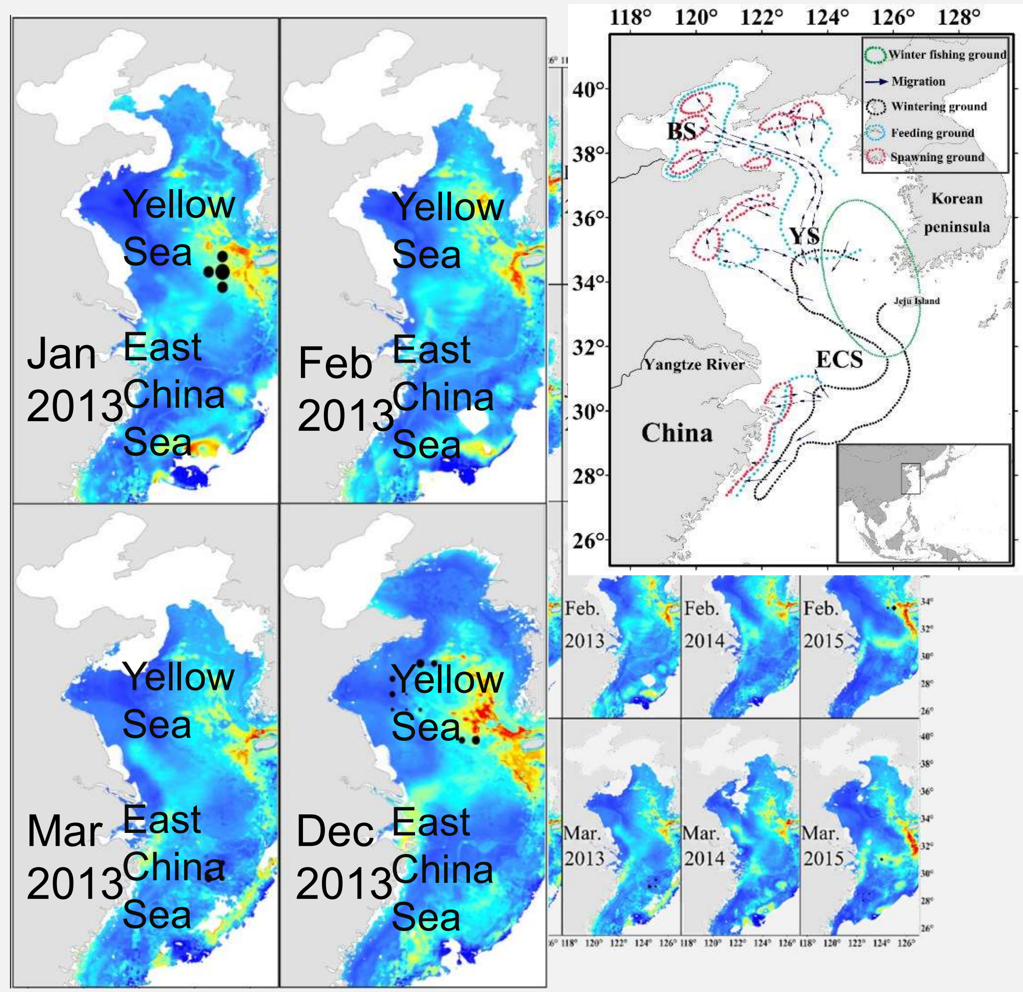
**$p < 0.01$.

The SSS is most important

The **salinity front** (contours) was detected as the **main sea surface feature** associated with wintering ground of Japanese anchovy



Predicted Japanese anchovy CPUE (ton h^{-1}) overlaid with actual fishing CPUE (black dots) in winter



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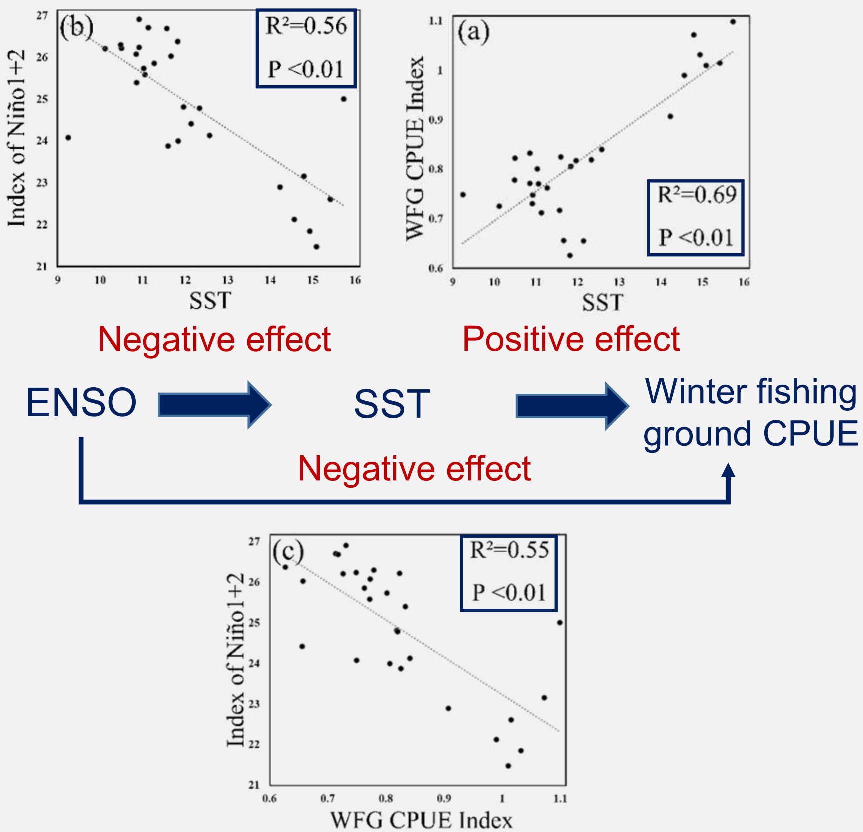
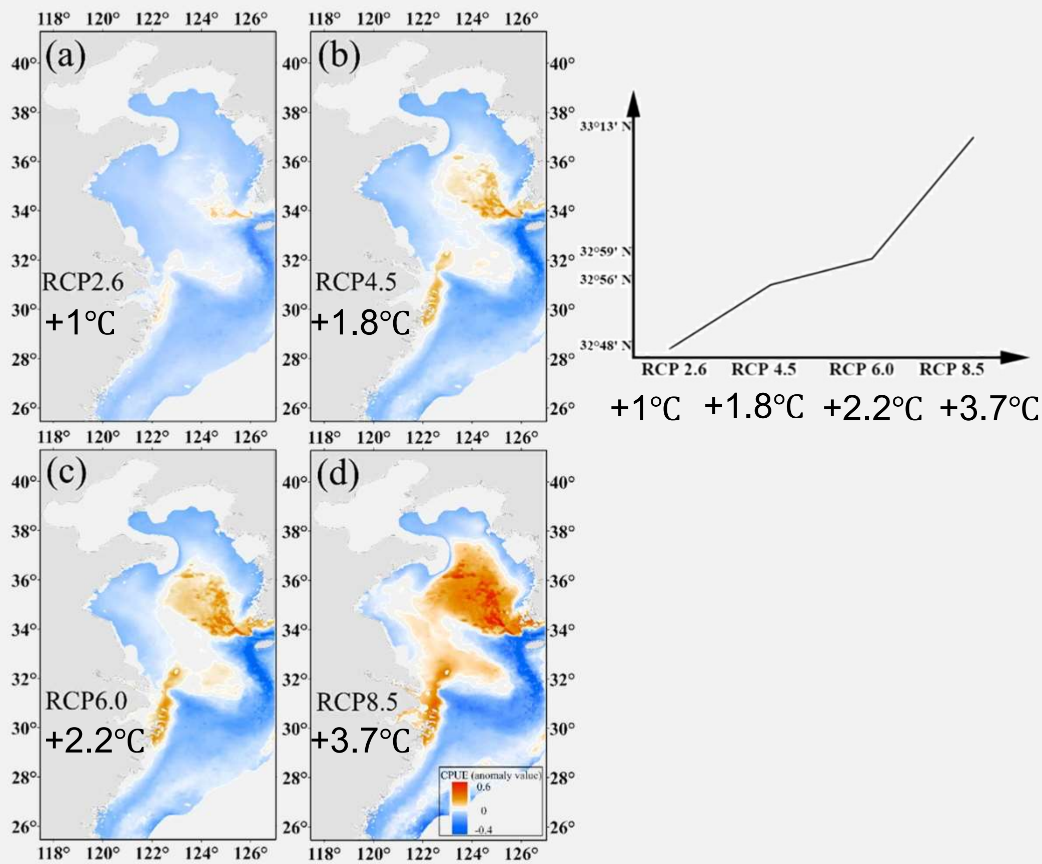


Wintering Japanese anchovy **northward habitat shift, relative abundance** would **increase** at end of the century.



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Summary

1.The generalized additive models (**GAM**) perform well in predicting potential distribution of wintering Japanese anchovy.

2.The abundance of Japanese anchovy was significantly influenced by **SST**, **SSS**, **feeding opportunity**, and **ocean currents**.

3.The **salinity front** was detected as the **main sea surface feature** associated with wintering ground of Japanese anchovy.

4.The impact of **ENSO** on the Japanese anchovy distribution is captured through its influence on the **SST** on the wintering fishing ground.

5.The rising temperatures will result in the wintering Japanese anchovy **northward habitat shift** and the **increasing relative abundance** by the end of the century.

Ocean University of China
Qingdao, China
lshuhao666@gmail.com

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